Ki'eki'e Ka'ū, kua makani; He umauma pā'ia e ke A'eloa

Majestic Ka'ū, of the windswept back; Whose chest is raised to meet the A'eloa (trades) Wind



DRAFT ENVIRONMENTAL IMPACT STATEMENT

Volume II of III (Appendices A-L)

Prepared by:



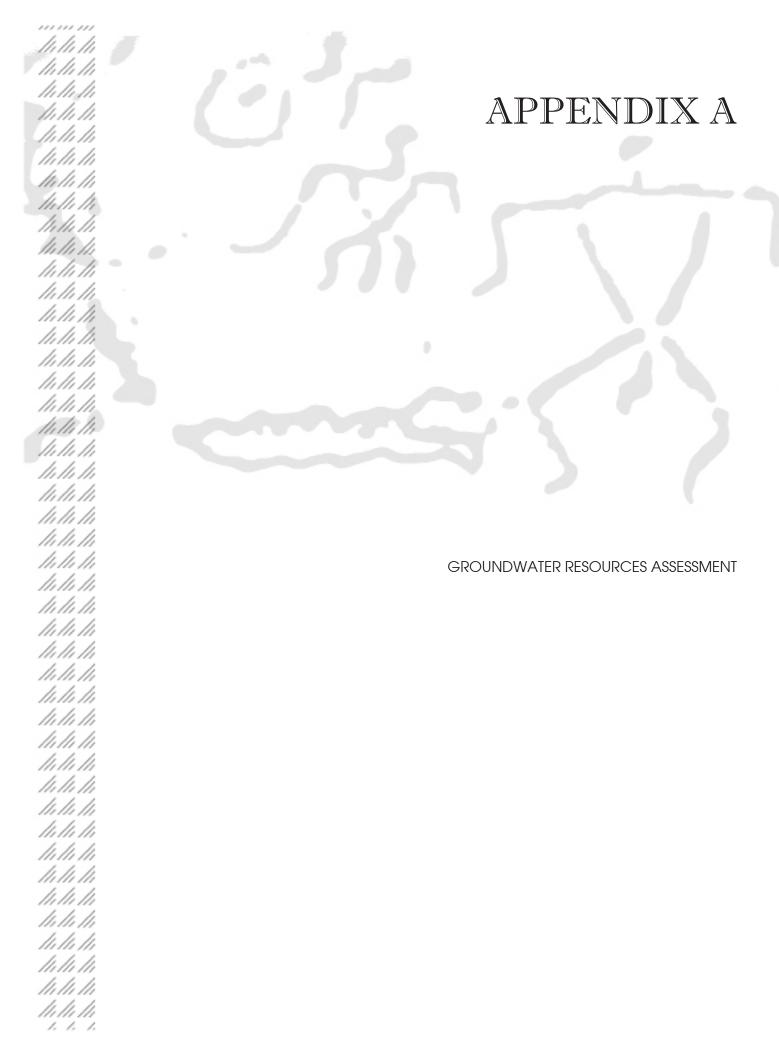
LIST OF APPENDICES

Volume 2 (this volume)

APPENDIX	Α	Groundwater Resources Assessment
APPENDIX	В	Marine Water and Anchialine Assessment
APPENDIX	C	Botanical Resource Assessment
APPENDIX	D	Wildlife Resources Assessment
APPENDIX	E	Cultural Impact Assessment
APPENDIX	F	Traffic Impact Analysis Report
APPENDIX	G	Traffic Noise Study
APPENDIX	Н	Air Quality Study
APPENDIX	ı	Civil and Electrical Infrastructure Assessment
APPENDIX	J	Geotechnical Engineering Report
APPENDIX	K	Property Demand & Supply Evaluation, Market Trend Analysis, and Project Acceptance Forecast
APPENDIX	L	Economic and Fiscal Impact Assessment

Volume 3

APPENDIX M Archaeological Inventory Survey



Assessment on the Potential Impact on Water Resources of the Proposed Kahuku Village Project in the Kau District of the Island of Hawaii

Prepared for:

Nani Kahuku Aina, LLC 99-1324 Koaha Place Aiea, Hawaii 96701

Prepared by:

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

Table of Contents

	743.0 5. 55.115.115	<u>Page</u>
Introdu	iction	1
Focus	on Groundwater Impacts	1
Propos	sed Water and Wastewater Systems	1
Ov	rerview	1
Po	table Water System	1
Bra	ackish Irrigation System	6
Go	olf Course Irrigation System	6
Ground	dwater Occurrence	6
Estima	ited Impacts on Groundwater	11
Ov	rerview	11
Ch	anges to Groundwater Flowrate	18
Ch	anges to Basal Groundwater Quality	18
Appen A	dix Unit Counts and Projections of Water Use and Wastewater Generation by Gray Hong Nojima & Associates, Inc.	
	List of Figures	
No.	T i t l e	<u>Page</u>
1	Location Map	2
2	Conceptual Master Plan	3
3	Aerial Photograph	4
4	Water Concept Plan	7
5	Irrigation Concept Plan	8
6	Mixing Line Analyses at Shoreline Site 1 - Kanonone Water Hole	13
7	Mixing Line Analyses at Shoreline Site 2 - Pohue Bay	14
8	Mixing Line Analyses at Shoreline Site 3 - Keliuli Bay	15
9	Mixing Line Analyses at Shoreline Site 4 - Ulua	16
10	Mixing Line Analyses at Shoreline Site 5 - Kahakahakea	17
	List of Tables	
No.	Title	Page
1	Summary of the Cumulative Supply Requirements of the Project's Three Systems	<u>1 age</u>
2	Data on Drilled Wells in the Region From the Files of the State Commission on	ŭ
	Water Resource Management	9
3	Water Quality of Groundwater in Wells, in Nearshore Anchialine Ponds, and as Shoreline Discharge	12
4	Estimated Changes to the Basal Groundwater Flowrate and Net Consumptive Use of Saline Groundwater	19
5	Calculated Changes in Nitrogen and Phosphorus in Groundwater Discharging Along the Project's Shoreline	20
6	Calculated Changes in Nitrogen and Phosphorus in Groundwater Discharging Along the Project's Shoreline for Different Natural Removal Rates in the Vadose Zone and Travel With Groundwater	23

i

Introduction

This report provides an assessment of the potential impact on water resources of the proposed Kahuku Village project in the shoreline area of TMK 9-2-01:72 in Kau, Hawaii. Figure 1 identifies the location of TMK 9-2-01:72 and Figure 2 presents the project's land use development plan prepared by PBR Hawaii in January 2011. At full build-out, the project would utilize 1975 acres and consist of about 1250 residential units, 500 hotel rooms, 125 acres of various civic land uses, an 18-hole golf course, and 500 acres for a Hawaiian Heritage Village. At present, the project site is completely undeveloped and access to it is by several unimproved (four-wheel drive) roads.

Focus on Groundwater Impacts

The entire project site consists of unweathered a'a and pahoehoe lava flows which are devoid of any significant ash, soil, or vegetative cover (Figure 3) and are therefore of extremely high permeability. Surface runoff as a continuous flow over any significant distance, even in the most extreme rainfall events, does not occur. Rainfall either evaporates or becomes groundwater recharge.

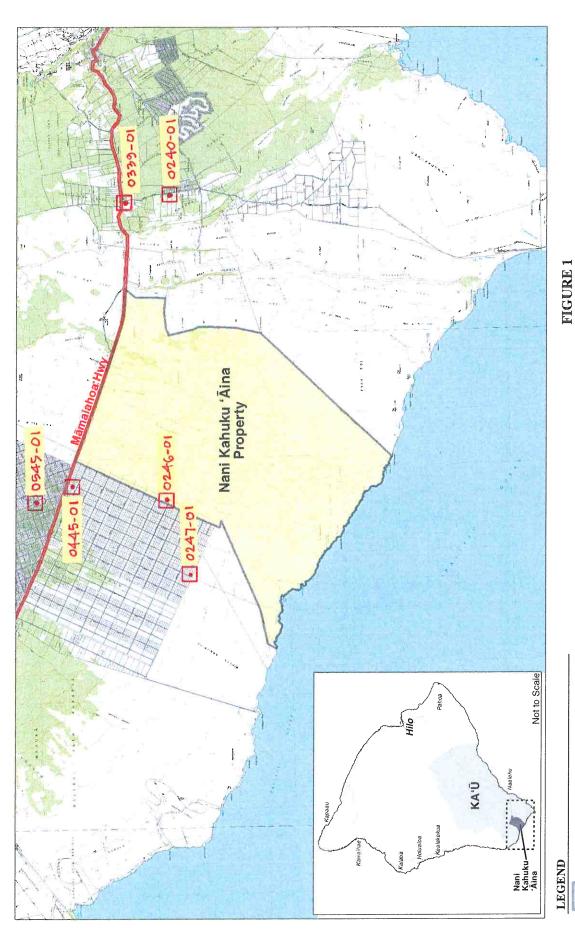
Development of the project will create impervious surfaces from which localized runoff will occur. However, all such runoff would be directed into undeveloped open space or conveyed to subsurface disposal in dry wells or seepage pits, ultimately becoming groundwater recharge. There would be no surface runoff discharging directly into the ocean at the shoreline from the project site after it is developed. For this reason, the assessment of the project's potential impacts on water resources focuses exclusively on groundwater. These potential impacts include: withdrawals of groundwater from wells for various uses; returns to groundwater in disposal wells; returns to groundwater due to excess landscape irrigation; and the change in water quality of rainfall recharge.

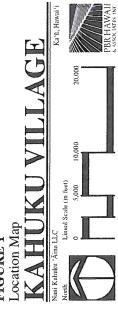
Proposed Water and Wastewater Systems

Overview. Water for the project would be supplied by three different systems: a potable system for within building and limited irrigation use; a brackish system for all other landscape irrigation; and a golf course irrigation system supplied by R-1 treated wastewater and supplemented, as needed, with water from the brackish irrigation system. Appendix A contains the projections of the supply requirements for these systems as prepared by Gray Hong Nojima & Associates, Inc. (GHNA). The project is to be developed in four phases. Table 1 provides the phase-by-phase supply requirements for these three water systems based on the GHNA projections in Appendix A.

<u>Potable Water System</u>. Due to the relatively dry and limited areal extent of the upgradient watershed, the flow of groundwater beneath the site is quite modest. Potable quality groundwater in limited quantities is only available near to and above Mamalahoa Highway from wells that would be 2000 feet deep and five miles from the project site. In view of this, the potable system will be supplied by saline groundwater pumped from wells and treated for potable use by reverse osmosis (RO) high pressure

o_11-10 - 1 -





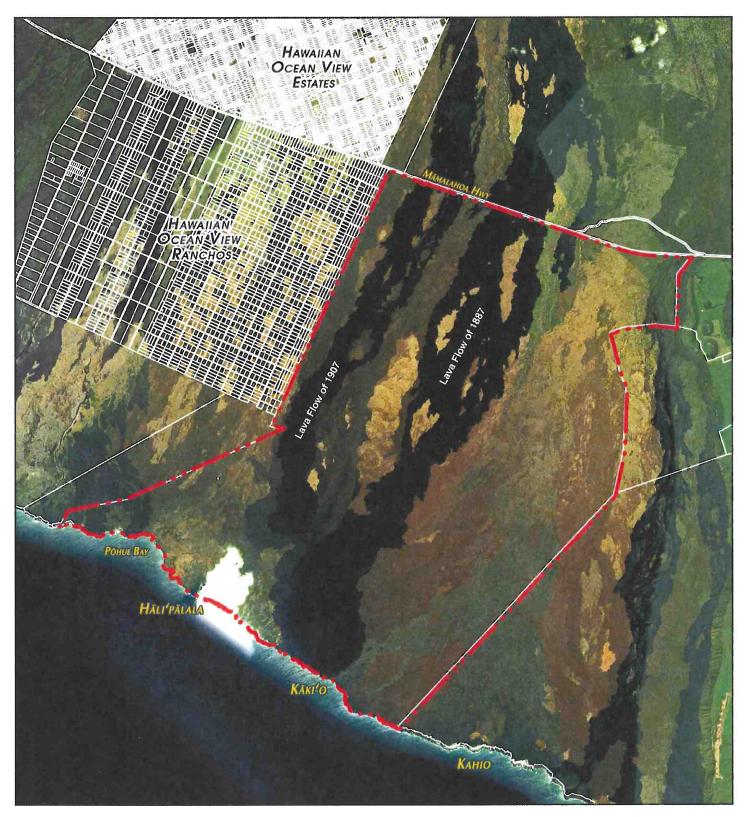
Source, U.S. Geological Survey (GIS), Hawai'i TMK, 2010 (GIS). Disclaimer: This graphic has been prepared for general planning purpos

Nani Kahuku 'Āina Property

2010 Hawai'i TMK

Major Road

Figure 2 Conceptual Master Plan



LEGEND

Nani Kahuku 'Äina Property

FIGURE 3 Aerial Photograph

KAHUKU VILLAGE

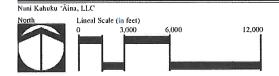


Table 1 Summary of the Cumulative Supply Requirements of the Project's Three Systems

I t e m	Phase 1	Phase 2	Phase 3	Phase 4
Tentative Development Period				
Potable System Supply Requirement				
Projected Average Demand (MGD)	0.178	0.470	1.026	1.093
 Required Maximum Day Supply 				
: MGD	.0275	0.725	1.576	1.691
: GPM	191	504	1094	1174
Brackish Irrigation System Supply Requirement			:	
 Projected Average Demand (MGD) 	0.166	0.491	1.000	1.056
 Required Maximum Day Supply 				
: MGD	0.274	0.810	1.650	1.742
: GPM	190	563	1146	1210
Golf Course Irrigation Requirement				
 Year-Round Average (MGD) 	0.000	0.672	0.672	0.672
 Required Maximum Day Supply 				
: MGD	0.000	1.109	1.109	1.109
: GPM	0	770	770	770
 Supply of R-1 Treated Wastewater 				
: MGD	0.064	0.181	0.420	0.439
Brackish System Supplement for GC Irrigation				
Average (MGD)	0.000	0.491	0.252	0.233
Maximum (MGD)	0.000	0.928	0.689	0.670

- Notes: 1. Average supply requirements for all three systems include a 12% allowance for losses and unmetered use.
 - 2. The maximum day factor for within building potable use is 1.5 times average. For all landscaping and golf course irrigation, it is 1.65 times average.
 - 3. The supply of R-1 treated wastewater is assumed to be 60% of the within-building potable use.

filtration. Figure 4 illustrates the layout of the potable system as prepared by GHNA. At ultimate build out, the system would consist of four 1000 GPM saline groundwater wells, four 400 GPM RO treatment trains, and three RO concentrate disposal wells. One of the supply wells, one of the treatment trains, and one of the disposal wells would provide standby capacity.

The raw water supply wells would be designed to draw water exclusively from beneath the brackish basal lens, so their salinity is expected to be in the range of 30 to 34 parts per thousand (PPT). Product recovery through the RO process is anticipated to be about 40 percent, meaning the remaining 60 percent would be RO concentrate with a salinity of about 50 to 60 PPT (for comparison, seawater is 34.8 PPT). The RO disposal wells would be designed to deliver the concentrate deeper into the saline groundwater zone than the raw water supply wells would draw from, thereby eliminating the possibility of recirculation of the concentrate back to the supply wells.

<u>Brackish Irrigation System</u>. Figure 5 is GHNA's illustration of the brackish irrigation system. It would consist of a linear array of wells along the 1000-foot elevation contour which would draw water from the top of the brackish basal lens. Each of the wells is tentatively sized at 300 GPM (0.432 MGD). At the project's full build-out, six such wells would be required (one as standby) for landscape irrigation and to supplement the R-1 supply for golf course irrigation.

Golf Course Irrigation System. The golf course would be irrigated with R-1 treated wastewater and brackish well water, the latter as needed to supplement the R-1 supply (also shown on Figure 5). To approximate the required brackish water supplement, it is conservatively assumed that the quantity of R-1 that will be available for golf course irrigation reuse will be 60 percent of the projected within-building potable water use. For this assumption, brackish groundwater would provide more than half the golf course's irrigation supply until sometime in the third phase of development (bottom of Table 1). At full build out, brackish groundwater would still provide about 35 percent of the golf course's irrigation supply.

Groundwater Occurrence

Based on the results of drilled wells in the region (their locations are shown on Figure 1 and Table 2 provides dimensions, water levels, and performance data) and on geophysical studies conducted for the project, groundwater beneath the project site and extending inland above Mamalahoa Highway occurs as a basal lens in hydraulic contact with saline water at depth and seawater at the shoreline. At inland locations just above and below Mamalahoa Highway (Wells 0545-01 and 0445-01, respectively), the groundwater is fresh (chlorides of 50 to 100 MG/L). Moving makai, the salinity of the basal groundwater increases. It is about 300 MG/L at 1000-foot elevation (Well 0246-01) and about 750 MG/L at 600-foot elevation (Well 0247-01).

MARCH 23, 2011



SCALE IN FEET





MARCH 23, 2011 KAHUKU VILLAGE

FIGURE 5 - IRRIGATION CONCEPT PLAN





Table 2

Data on Drilled Wells in the Region From the Files of the State Commission on Water Resource Management

Drawdown @ Flowrate (Feet @ GPM)		1.16 @ 350	No Data	No Data	? @ 50		No Data	0.5 @ 82
Chlorides (MG/L)		55	83	300	760			9
Water Level (Ft. MSL)		12.3	3.5	9.5*	7.8*		436	240
Open Hole (Feet)		59	20	0			0	50
Perforated Casing (Feet)		90	200	14			200	120
Solid Casing (Feet)		2171	1800	1041			1446	1520
Casing Diameter (Inches)		16	4	∞			4	10
Elev. at Bottom (Ft. MSL)		-71	-85	-12	0		-5	0
Total Depth (Feet)		2250	2020	1055	612		1946	1690
Ground Elevation (Ft. MSL)		2179	1935	1037	612		1944	1690
Year		2009	2006	1985	1992		1997	2000
Name	Wells Tapping Basal Groundwater	HOVE Haw'n Ocean View	nses	Hawaii Kau Ranch	FMT 1	Wells Tapping High Level Groundwater Near South Point Road	South Point Tank	Kau Citrus 1
State Well No.	Wells Tappi	0545-01	0445-01	0246-01	0247-01	Wells Tapp	0339-01	0240-01

Water levels are in error.

Based on groundwater levels and temperatures in the existing wells, the groundwater occurrence is actually more complex than the brief summary given above. Evidence of such complexity suggests that the underlying groundwater is not a homogenous water body with a gradual, mauka-to-makai increase in salinity:

- There appears to be a hydrologic disconnect between the 12.3-foot water level in the HOVE well (0545-01) and the 3.5-foot level in the USGS test hole (0445-01) a short distance downgradient. The HOVE water level is anomalously high.
- Pumped water temperature in the HOVE well was high, from 81.3° to 82.8° F. This suggests the effect of residual heat from Mauna Loa's southwest rift zone. Its high TDS to chloride ratio is another indication of the rift zone's impact. To the extent that data are available, none of the downgradient wells show a similar influence of the rift zone.
- The water in Well 0246-01 is colder than expectable. Its 67.8° F. pumped water temperature is 14° cooler and the upgradient HOVE well and also 10° cooler than the nominally downgradient FMT well (0247-01). As presented subsequently, its water is almost devoid of dissolved nitrogen, a very rare occurrence in Hawaiian groundwater.

As far as is known, Mauna Loa's southwest rift zone and coincident Pali O Mamalu fault scarp create a hydrologic boundary for the east end of the basal groundwater occurrence in and above the project site. Further east near South Point Road, two wells (Nos. 0240-01 and 0339-01) encountered high level groundwater. Geophysical results suggest this high level water, at least near Mamalahoa Highway, could extend most or all the way to the rift zone boundary.

Based on what is known or can plausibly be presumed, Mauna Loa's southwest rift zone is a barrier to groundwater flow. As such, it delineates the upper end of the watershed which contributes rainfall-recharge to basal groundwater that would be utilized and impacted by the project. For the purposes of this assessment, calculations of groundwater recharge have been made for a 4.25-mile wide, mauka-makai corridor which encompasses the entire width of the project site. Inland of the 1000-foot elevation contour, along which the irrigation wells would be developed, the area of this corridor is 30 square miles. At the shoreline, the total upgradient watershed in this corridor is 45 square miles. Rainfall-recharge calculations approximate the recharge at 3.2 MGD per mile of width at 1000-foot elevation and 3.7 MGD per mile of width as discharge into the ocean along the shoreline. These figures will be used as the pre-development flowrates in the assessments of the project's potential impacts on groundwater.

Table 3 is a compilation of water quality analyses of samples from a well above Mamalahoa Highway (No. 0545-01), wells makai of Mamalahoa (only Nos. 0246-01 and 0247-01 as a sample could not be retrieved from 0445-01), nearshore anchialine ponds, the shoreline, and offshore beyond the influence of groundwater discharge. The five shoreline locations for these samples are identified on Figure 2. A basic assumption is that groundwater in the inland portion of the watershed, as represented by a water sample from Well 0545-01, moves toward and ultimately discharges at the shoreline. Along this six-mile distance from Well 0545-01 to the shoreline, dissolved nutrients (nitrogen and phosphorus) may be supplemented by natural or anthropogenetic inputs along this route or may be consumed by natural processes. Which of these are occurring can be determined with a mixing line analyses. Such analyses for nitrogen and phosphorus are presented on Figures 6 to 10 for the five shoreline sites. The mixing line itself is created as the straight dilution of inland groundwater (Well 0545-01) and offshore seawater at each of the five sites. Intervening samples from wells, anchialine ponds, and at the shoreline will plot above the mixing line if their nitrogen or phosphorus levels have been supplemented along the six-mile travel distance. They will plot below the line if they have been depleted. The results on Table 3 and Figures 6 to 10 can generally be characterized as follows:

- The anomalous well water quality is clearly evident. Well 0246-01 is almost devoid of nitrogen, appears to be slightly enriched with phosphorus, and has a silica level which is less than half the concentrations in the other well samples. On the other hand, Well 0247-01, which is nominally downgradient of 0246-01, appears to be somewhat depleted of both nitrogen and phosphorus but has an expectable silica level.
- At Shoreline Site 1, which has a complex of nearshore anchialine ponds and is the site most likely to be influenced by activities in Hawaiian Ocean View Ranchos, both nitrogen and phosphorus are somewhat depleted.
- At Shoreline Site 5, the only other shoreline location with a nearshore complex of anchialine ponds, nitrogen is depleted but phosphorus is generally supplemented.
- At intervening Shoreline Sites 2, 3, and 4, nitrogen is generally unchanged or slightly depleted and phosphorus is either unchanged or slightly supplemented.

Estimated Impacts on Groundwater

Overview. As explained previously, discharge of surface runoff from the pre- and post-developed project site into the marine environment does not now and will not occur in the future. As such, impacts on water resources will be manifested exclusively in changes to the quantity and quality of groundwater moving to and discharging into the marine environment. The project will use and change the groundwater body which resides at and below sea level, referred to herein as basal groundwater or the basal lens. The project will also use and change, with its RO feedwater supply and concentrate disposal, the body of saline groundwater which exists below the basal lens. With proper well design, impacts on these two groundwater bodies will be separate and distinct and are treated as such in the calculations of impacts which follow.

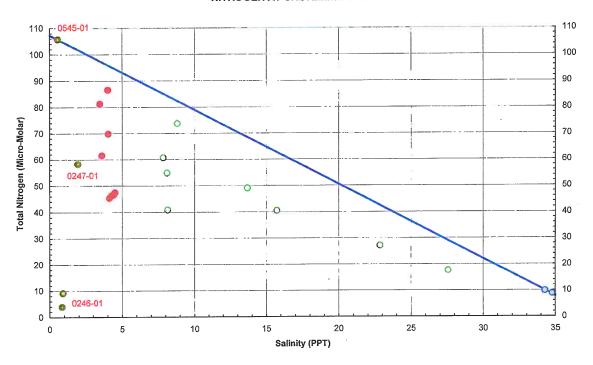
Table 3

Water Quality of Groundwater in Wells, in Nearshore Anchialine Ponds, and as Shoreline Discharge

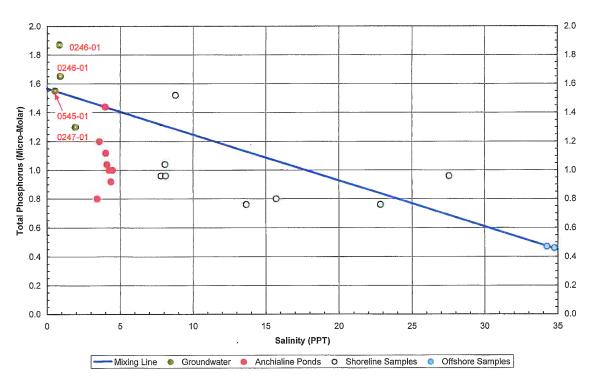
Sample	Sample Date	NO3 (μM)	NH4 (μM)	DON (µM)	TN (µM)	PO4 (μM)	DOP (µM)	TP (µM)	Silica (µM)	Salinity (PPT)
Wells (by State No.) : 0545-01	1-12-09	57.4	1.65	46.8	105.8	0.50	1.05	1.55	679	0.537
: 0246-01	3-03-11	0.15	2.10	6.90	9.15	1.20	0.45	1.65	299	0.897
: 0246-01	4-15-11	0.10	1.77	2.02	3.89	0.72	1.15	1.87	257	0.836
: 0247-01	3-03-11	48.2	3.80	42.7	94.8	2.16	0.92	3.08	836	2.135
: 0247-01	4-15-11	51.4	0.42	6.52	58.3	0.20	1.10	1.30	653	1.922
Shoreline Site 1 - Kanonone Water Hole										
Anchialine Pond Samples	4-19-09	38.4	3.12	45.1	86.6	1.36	0.08	1.44	671	3.995
	4-19-09	40.5	2.24	27.2	69.9	1.04	0.08	1.12	665	4.032
	4-19-09	45.8	2.08	33.4	81.3	0.56	0.24	0.80	687	3.442
	4-19-09	38.8	2.00	20.8	61.6	0.96	0.24	1.20	666	3.590
	3-03-11	35.3	0.36	10.8	46.4	0.32	0.68	1.00	595	4.276
	3-03-11	35.0	0.68	10.9	46.6	0.24	0.68	0.92	608	4.396
	3-03-11	41.2	0.32	6.00	47.5	0.52	0.48	1.00	613	4.495
	3-03-11	40.8	0.12	4.48	45.4	0.48	0.56	1.04	607	4.122
Shoreline Samples	4-19-09	34.3	1.92	24.5	60.7	0.64	0.32	0.96	574	7.820
·	4-19-09	34.6	1.04	19.2	54.9	0.64	0.40	1.04	570	8.085
	4-19-09	14.2	1.36	25.3	40.9	0.56	0.40	0.96	306	8.123
	3-03-11	40.1	12.7	21.0	73.8	0.64	0.88	1.52	491	8.793
	3-03-11	31.1	4.48	13.5	49.1	0.16	0.60	0.76	425	13.669
	3-03-11	26.8	2.92	10.8	40.6	0.20	0.60	0.80	383	15.713
	3-03-11	15.5	0.68	11.0	27.2	0.16	0.60	0.76	248	22.828
	3-03-11	8.20	1.28	8.16	17.6	0.16	0.80	0.96	140	27.559
Offshore Samples	4-19-09	0.60	0.35	8.81	9.76	0.14	0.33	0.47	19.0	34.27
Offshore damples	4-19-09	0.24	0.04	8.43	8.71	0.13	0.33	0.46	8.70	34.78
Shoreline Site 2 - Pohue Bay	4-10-00	0.27	0.04	0.10	0.71	0	1 0.00			
Shoreline Samples	4-19-09	1.75	0.41	8.53	10.7	0.21	0.20	0.41	88.3	31.32
Silorenne Samples	4-19-09	1.77	0.41	8.25	10.4	0.46	0.06	0.52	90.5	31.24
	4-19-09	1.77	0.08	8.11	9.96	0.19	0.22	0.41	77.5	31.85
	3-03-11	3.08	0.96	15.3	19.3	0.32	0.76	1.08	87.1	30.580
	3-03-11	1.24	0.68	8.92	10.8	0.02	0.68	0.92	53.4	31.980
	3-03-11	0.32	0.84	10.6	11.7	0.20	0.64	0.84	11.2	33.82
Offshore Samples	4-19-09	0.97	0.04	6.90	7.98	0.16	0.26	0.42	36.2	33.68
Olishore Samples	4-19-09	0.97	0.11	6.83	7.32	0.14	0.25	0.39	10.8	34.66
Shoreline Site 3 - Keliuli Bay	4-13-03	0.20	0.21	0.00	7.02	0.1-7	0.20	0.00	10.0	000
Shoreline Samples	4-19-09	0.85	0.32	6.46	7.63	0.19	0.20	0.39	34.3	33.67
Shoreline Samples	4-19-09	0.69	0.39	5.88	6.96	0.19	0.20	0.39	29.5	33.89
	4-19-09	0.66	0.39	7.12	8.09	0.18	0.20	0.40	29.5	33.97
Offichara Campilas			1	7.12	7.98	0.16	0.25	0.40	4.61	34.98
Offshore Samples	4-19-09	0.10	0.06		9.38	0.10	0.23	0.37	3.65	34.89
0	4-19-09	0.04	0.24	9.10	9.30	0.14	0.23	0.31	3.03	34.00
Shoreline Site 4 - Ulua		0.45	0.40	0.00	0.00	0.40	0.00	0.44	6.77	34.89
Shoreline Samples	4-19-09	0.15	0.19	6.29	6.63	0.18	0.23	0.41	1	1
	4-19-09	0.20	0.25	7.24	7.69	0.18	0.24	0.42	7.45	34.92
	3-03-11	1.40	0.84	10.6	12.8	0.20	0.64	0.84	9.28	34.03
Offshore Samples	4-19-09	0.06	0.31	7.48	7.85	0.21	0.20	0.41	3.87	35.01
	4-19-09	0.04	0.08	8.83	8.95	0.15	0.22	0.37	3.53	35.02
Shoreline Site 5 - Kahakahakea										
Anchialine Pond Samples	4-19-09	44.4	3.12	30.6	78.1	1.76	0.16	1.92	600	7.79
	4-19-09	54.9	1.92	25.8	82.6	1.28	0.32	1.60	595	8.10
	4-19-09	49.2	1.92	28.9	80.0	1.44	0.32	1.76	585	8.05
	4-19-09	55.7	2.64	26.6	84.9	0.80	0.40	1.20	580	8.01
	4-19-09	43.8	3.60	14.4	61.8	1.04	0.80	1.84	576	8.16
	3-03-11	47.2	0.20	18.7	66.1	0.40	0.72	1.12	532	6.06
Shoreline Samples	4-19-09	0.21	0.17	7.17	7.55	0.17	0.26	0.43	6.01	34.92
	4-19-09	0.17	0.12	8.46	8.75	0.15	0.25	0.40	4.92	34.97
	3-03-11	28.9	0.76	16.5	46.2	0.20	0.76	0.96	281	18.64
	3-03-11	5.20	0.84	19.6	25.6	0.16	0.76	0.92	47.5	31.84
Offshore Samples	4-19-09	0.15	0.09	7.74	7.98	0.18	0.22	0.40	5.97	34.93
	4-19-09	0.24	0.10	6.63	6.97	0.16	0.25	0.41	7.09	34.84

Notes: 1. Samples collected by Tom Nance of Tom Nance Water Resource Engineering and Steve Dollar of Marine Research Consultants.

^{2.} All analyses by Marine Analytical Specialists.

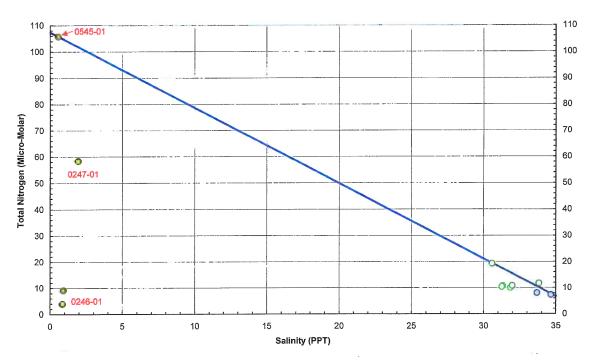


PHOSPHORUS AT SHORELINE SITE 1

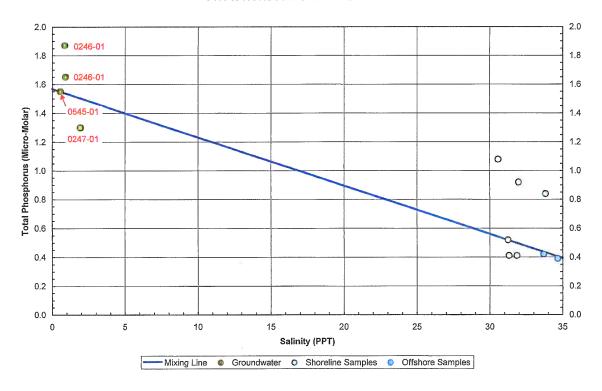


o_11-10

Figure 6
Mixing Line Analyses at Shoreline Site 1
Kanonone Water Hole

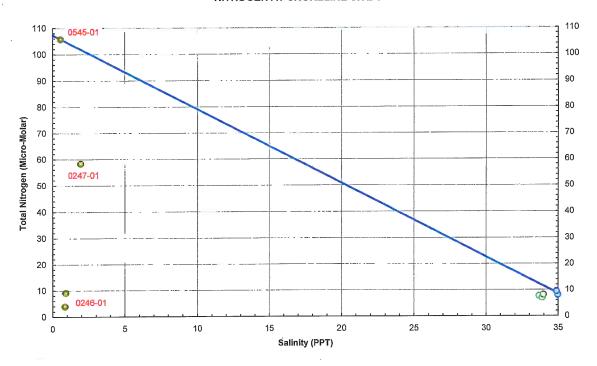


PHOSPHORUS AT SHORELINE SITE 2



o_11-10

Figure 7
Mixing Line Analyses at Shoreline Site 2
Pohue Bay



PHOSPHORUS AT SHORELINE SITE 3

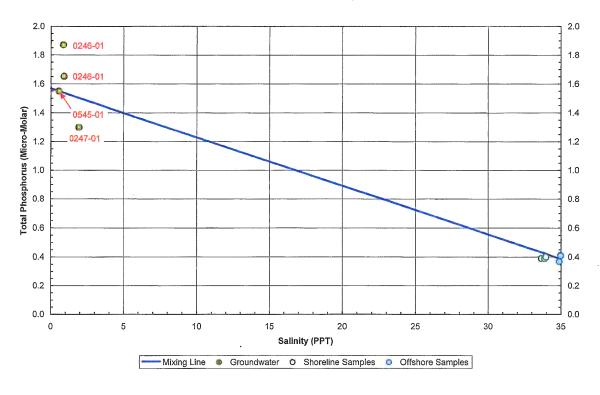
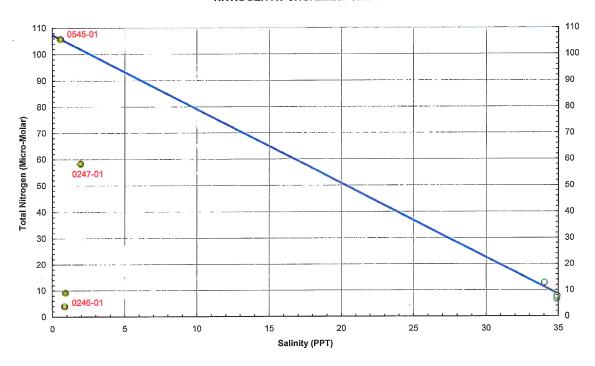
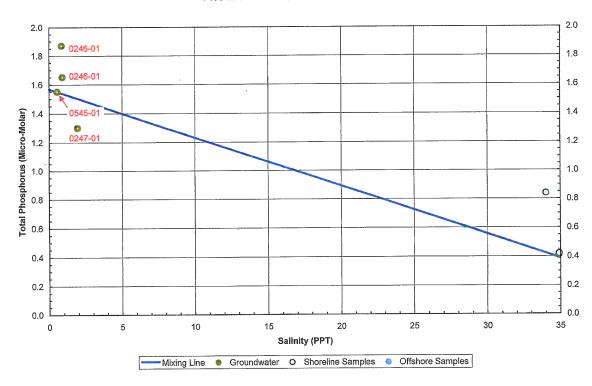


Figure 8
Mixing Line Analyses at Shoreline Site 3
Keliuli Bay

o_11-10

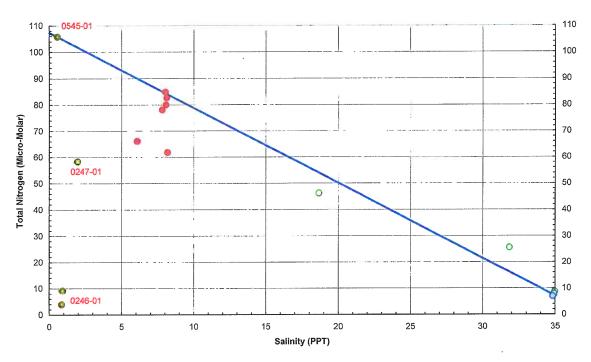


PHOSPHORUS AT SHORELINE SITE 4

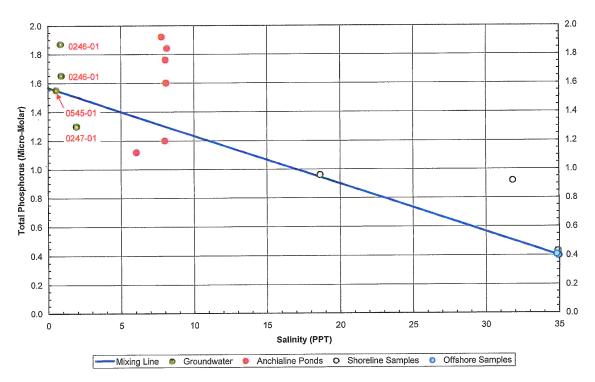


o_11-10

Figure 9
Mixing Line Analyses at Shoreline Site 4
Ulua



PHOSPHORUS AT SHORELINE SITE 5



o_11-10

Figure 10
Mixing Line Analyses at Shoreline Site 5
Kahakahakea

<u>Changes to Groundwater Flowrate</u>. Table 4 presents estimates of the anticipated changes to the flow of basal groundwater discharging at the shoreline by development phase. These estimates incorporate the following assumptions:

- The pre-development quantity of basal groundwater discharging along the 4.25-mile wide shoreline segment encompassing the project site is 3.7 MGD per coastal mile or 15.7 MGD.
- The withdrawals of basal groundwater from wells arrayed along the 1000-foot elevation contour
 will range from 0.166 MGD in Phase 1 to 1.289 MGD at full build-out (from Table 1). These
 withdrawals will be for landscape irrigation and to supplement irrigation of the golf course by R-1
 treated wastewater.
- An allowance of 12 percent for leakage and unmetered use has been incorporated into the
 potable and irrigation system supply amounts. It has been assumed that all 12 percent of this
 allowance returns to groundwater.
- Irrigation return flow will amount to 10 percent of the amount of applied irrigation for: potable
 water used for landscape irrigation; brackish water used for landscape irrigation; and R-1 effluent
 and brackish well water applied on the golf course.

For this set of assumptions, the reduction in basal flowrate discharging along the project's shoreline would only be around 0.7 percent in Phase 1 but would increase to 5.2 percent in Phases 3 and 4.

On the bottom of Table 4, withdrawals of saline groundwater, returns of RO (hypersaline) concentrate, and net consumptive use of saline groundwater are compiled by development phase. The net consumptive use of saline groundwater would be about 0.18 MGD in Phase 1 and increase to about 1.1 MGD at full build-out. Unlike the limited supply of basal groundwater, the supply of saline groundwater is essentially unlimited and, with proper well design, the amount of its consumptive use will have no impact on the overlying basal groundwater.

<u>Changes to Basal Groundwater Quality</u>. Table 5 presents estimated changes to the nutrient levels discharging in groundwater along the project's shoreline by development phase. The following set of assumptions are incorporated in these results:

- Nitrogen and phosphorus levels in pre-development groundwater are the same as in Well 0545-10 (Table 3).
- The quantities of withdrawals and returns to basal groundwater will be as compiled in Table 4.

Table 4

Estimated Changes to the Basal Groundwater Flowrate and Net Consumptive Use of Saline Groundwater

Flawrete Company	Flowrates	in MGD by	Developm	nent Phase
Flowrate Components	1	2	3	4
Pre-Development Basal Groundwater Flowrate in the 4.25-Mile Wide Corridor Encompassing the Project Site	15.7	15.7	15.7	15.7
Changes to the Flowrate of the Brackish Lens				
Withdrawals by Brackish Wells				
 For the Brackish Irrigation System 	0.166	0.491	1.000	1.056
To Supplement Golf Course Irrigation	0.000	0.491	0.252	0.233
Total Withdrawals	0.166	0.982	1.252	1.289
Returns to the Basal Lens				
 Leakage From the Potable System 	0.019	0.050	0.110	0.117
 Leakage From the Brackish System 	0.018	0.053	0.107	0.113
 Leakage From the Golf Course System 	0.000	0.072	0.072	0.072
Subtotal for Direct Leakage to Groundwater	0.037	0.176	0.289	0.302
Irrigation Returns				
 From Potable System Irrigation 	0.005	0.012	0.022	0.024
 From Brackish System Irrigation 	0.015	0.044	0.089	0.094
From Golf Course Irrigation	0.000	0.060	0.060	0.062
Subtotal for Irrigation Return	0.020	0.116	0.141	0.178
Total of Returns to the Basal Lens	0.057	0.292	0.430	0.480
Net Reduction of the Basal Flowrate	0.109	0.690	0.822	0.809
Resulting Post-Develpoment Discharge of Basal Groundwater Along the Shoreline				
Quantity	15.591	15.010	14.878	14.891
Percent Reduction	0.7	4.4	5.2	5.2
Withdrawals and Additions to Saline Groundwater				
Withdrawals for RO Desalinization	0.445	1.175	2.565	2.733
Return of RO Concentrate	0.267	0.705	1.539	1.640
Net Consumptive Use of Saline Groundwater	0.178	0.470	1.026	1.093

Table 5

Calculated Changes in Nitrogen and Phosphorus in Groundwater Discharging Along the Project's Shoreline

		Phase 1			Phase 2			Phase 3		Phas	Phase 4 - Full Build Out	d Out
Flowrate Components	Flowrate (MGD)	Nitrogen (lbs / day)	Phosphorus (lbs / day)	Flowrate (MGD)	Nitrogen (lbs / day)	Phosphorus (lbs/day)	Flowrate (MGD)	Nitrogen (lbs / day)	Phosphorus (lbs / day)	Flowrate (MGD)	Nitrogen (lbs / day)	Phosphorus (lbs/day)
Pre-Development Groundwater Discharging Along the Project Shoreline	15.7	201.4	6.28	15.7	201.4	6.28	15.7	201.4	6.28	15.7	201.4	6.28
Reductions Resulting From Withdrawals by the Brackish Wells	0.166	2.13	990.0	0.982	12.60	0.393	1.252	16.06	0.501	1.289	16.54	0.515
Additions by Leakage, Irrigation Returns, and Rainfall Recharge												
Rainfall Recharge	0.373	609.0	0.010	0.780	1.274	0.020	1.148	1.876	0.030	1.225	1.998	0.032
Leakage From Water Systems												
Potable	0.019	0.004	0.0000	0.050	0.012	0.0001	0.110	0.026	0.0002	0.117	0.027	0.0002
Brackish Irrigation	0.018	0.046	0.0004	0.053	0.136	0.0011	0.107	0.275	0.0021	0.113	0.290	0.0023
Golf Course : R-1 Wastewater Effluent	0.000	0.000	0.000	0.022	1.028	0.043	0:020	2.332	0.097	0.053	2.472	0.103
: Brackish Water Supplement	0.000	0.000	0.000	0.059	0.151	0.0012	0.030	0.077	900000	0.028	0.072	9000:0
Irrigation Return												
Landscaping Irrigated With Potable Water												
: Irrigation Supply	0.005	0.0001	0.0000	0.012	0.0003	0.0000	0.022	0.0005	0.0000	0.024	900000	0.000.0
: Fertilizer	ı	0.150	0.0013	ı	0.337	0.0028	ı	0.616	0.0051	ı	0.702	0.0058
Landscaping Irrigated With Brackish Water												
: Irrigation Supply	0.015	0.0038	0.0000	0.044	0.0113	0.0000	0.089	0.0228	0.0000	0.094	0.0241	0.000.0
: Fertilizer	1	0.265	0.0022	1	0.788	9900'0	1	1.597	0.0133	1	1.690	0.0141
Golf Course : Irrigation by R-1 Effluent	0.0000	0.0000	0.0000	0.0162	0.0756	900000	0.0375	0.1748	0.0015	0.0392	0.1828	0.0015
: Irrigation by Brackish Water	0.0000	0.0000	0.0000	0.0438	0.0112	0.0000	0.0225	0.0058	0.0000	0.0208	0.0053	0.0000
: Fertilizer	1	0.000	0.0000	ı	0.716	0.0060	ŀ	0.716	0.0060	ı	0.716	0900'0
Post-Development Groundwater Discharging Along the Project Shoreline	15.591	200.34	6.2279	15.010	193.34	5.9684	14.878	193.06	5.9348	14.891	193.04	5.9305
Percent Reductions	0.7	0.5	9.0	4.4	4.0	5.0	5.2	4.1	5.5	5.2	4.2	5.6

- 20 -

- The areas of landscape irrigation are as presented in Appendix A. Where acreages are not given, they have been back-calculated from the irrigation use amount.
- Nitrogen and phosphorus in fertilization of all landscaped areas, including the golf course, will be applied at 3 lbs/year/1000 ft² and 0.5 lbs/year/1000 ft², respectively. In reality, the use of R-1 effluent on the golf course could reduce the amount of applied fertilizer.
- Ten (10) percent of the applied nitrogen and two (2) percent of the applied phosphorus in the fertilizer and in the irrigation water will pass below the plant root zone. The balance will be taken up and incorporated into vegetative matter.
- RO-treated potable water will contain 10 μM as nitrogen and 0.15 μM as phosphorus.
- R-1 treated wastewater effluent will have 2000 μM as nitrogen and 150 μM as phosphorus. This
 is representative of the concentrations of existing R-1 treatment plants in the State.
- For both direct leakage and irrigation return, nutrients are naturally removed during the downward travel through the vadose zone (unsaturated lavas) and movement with the basal groundwater to discharge along the shoreline. Removal of nitrogen and phosphorus by natural processes will be 80 and 95 percent, respectively.
- One-third of the 25 inches of year of rainfall over the 1975-acre project site presently becomes groundwater recharge (that is equivalent to 1.22 MGD). As development occurs, the quantity of groundwater recharge will remain essentially the same but the nutrient levels in this post-development recharge will be increased by 70 μM in nitrogen and 2 μM in phosphorus. In reality, the limited data on the quality of surface runoff from developed areas indicates that actual nutrient levels will be less.

Based on the set of assumptions and calculations incorporated into Table 5, the amount of nitrogen and phosphorus in groundwater withdrawn by the brackish wells will be greater than the amounts returned to groundwater by leakage from the three water systems, by irrigation return from landscaped areas, and by locally generated surface runoff that becomes groundwater recharge. The projected net reductions of nitrogen and phosphorus are generally of the same magnitude as the projected reductions in groundwater flow discharging at the shoreline. What this means is that there will be little change in nitrogen and phosphorus concentrations in the shoreline discharging groundwater.

To see how sensitive the assumptions made in compiling Table 5 are to the final results, the natural removal rates in the vadose (unsaturated) zone and in groundwater flowing to the shoreline have

been varied. In Table 5, removals of 80 and 95 percent for nitrogen and phosphorus were assumed. These have been varied as follows:

- Alternative 1: Natural removals are reduced to 70 percent for nitrogen and 90 percent for phosphorus.
- Alternative 2: Natural removal rates are reduced to 60 percent for nitrogen and 85 percent for phosphorus.

Table 6 compares these results. For Alternative 1, the reductions of nitrogen and phosphorus would ultimately be about one-half of the calculated reductions in Table 5. For Alternative 2, the nutrient reductions would be significantly less.

Table 6

Calculated Changes in Nitrogen and Phosphorus in Groundwater Discharging Along the Project's Shoreline for Different Natural Removal Rates in the Vadose Zone and Travel With Groundwater

		Phase 1			Phase 2			Phase 3		Phase	Phase 4 - Full Build Out	d Out
Flowrate Components	Flowrate (MGD)	Nitrogen (lbs / day)	Phosphorus (lbs / day)	Flowrate (MGD)	Nitrogen (lbs / day)	Nitrogen Phosphorus (lbs / day)	Flowrate (MGD)	Nitrogen (lbs / day)	Nitrogen Phosphorus Ibs / day) (Ibs / day)	Flowrate (MGD)	Nitrogen Phosphorus (lbs / day) (lbs / day)	Phosphorus (lbs / day)
Pre-Development Groundwater Discharging Along the Project Shoreline	15.7	201.4	6.28	19.7	201.4	6.28	15.7	201.4	6.28	15.7	201.4	6.28
Reductions Resulting From Withdrawals by the Brackish Wells	0.166	2.13	0.066	0.982	12.60	0.393	1.252	16.06	0.501	1.289	16.54	0.515
As Presented on Table 5: Natural Nitrogen and Phosphorus Removals in the Groundwater Environment of 80 and 95 Percent, Respectively						***************************************						
 Post-Development Discharge 	15.591	200.34	6.2279	15.010	193.34	5.9684	14.878	193.06	5.9348	14.891	193.04	5.9305
Percent Reduction	0.7	0.5	9.0	4.4	4.0	5.0	5.2	4.1	5.5	5.2	4.2	5.6
Alternative 1: Natural Nitrogen and Phosphorus Removals in the Groundwater Environment of 70 and 90 Percent, Respectively												
Post-Development Discharge	15.591	200.88	6.2418	15.010	195.61	6.0498	14.878	196.92	9060.9	14.891	197.13	0960.9
Percent Reduction	0.7	0.3	9.0	4.4	2.9	3.7	5.2	2.2	3.0	5.2	2.1	2.9
Alternative 2: Natural Nitrogen and Phosphorus Removals in the Groundwater Environment of 60 and 85 Percent, Respectively												
Post-Development Discharge	15.591	201.41	6.2557	15.010	197.88	6.1312	14.878	200.78	6.2464	14.891	201.22	6.2615
Percent Reduction	0.7	0.0	0.4	4.4	1.7	2.4	5.2	0.3	0.5	5.2	0.1	0.3

Appendix A

Unit Counts and Projections of Water Use and Wastewater Generation by Gray Hong Nojima & Associates, Inc.

9,796 1975.0

1,750

124

637

ACRES

CAPITA

CINITS

ACRES

CAPITA

UNITS 28

ACRES 594

UNITS 885

ACRES 656

2,746

531

UNITS

ACRES 602.0

CAPITA 2,304

UNITS 276

TOTAL

PHASE '

280

SUBTOTAL

PHASE 4

PHASE 3 CAPITA 4,110

PHASE 2 CAPITA

2.0

00

00

00

00

00

00

00

5.0 20.0 25.0

330.0 20.0 350.0 1475.0 03/31/11 2984-00 10.0 75.0 20.0 5.0 5.0 5.0 5.0 473.0 37.5 2.0 24.0 9.0 45.0 417.5 ACRES TOTAL
UNITS | CAPITA | ACRES 676 100 960 360 450 2,546 1,830 1,680 480 20 500 7,966 05 64 05 05 054 CAPITA 1,370 TOTAL 0 0 1,550 000 200 08 088 UNITS ₆ 0000 881 100 DATE: JOB NO: 110.0 0 0.0 0.0 0 ACRES 92.0 9.0 13.5
 PHASE 3
 PHASE 4

 UNITS | CAPITA | ACRES | UNITS | CAPITA | ACRES
 000000 637 00 197 380 0 PHASE 4 88 440 CAPITA 38 20 0 8 0 0 38 20 UNITS 38.0 27.0 44.5 312.5 25.0 36.0 11.0 **456.0** 0 6 33.0 10.0 45.0 90.0 ACRES 100 4,110 238 364 28 1,714 PHASE 3 UNITS | CAPITA 840 260 128 696 100 4 450 0 22 22 32 474 130 149 149 885 0 0 486 330.0 37.0 0 16.0 159.5 62.0 16.0 14.0 11.0 278.5 0 330.0 10.0 10.0 ACRES PHASE 2 160 154 154 140 1,026 840 400 480 0 PHASE 2 CAPITA 400 480 0 Unit Count and Area Summary 250 2 2 2 3 40 531 281 UNITS UNITS Nani Kahuku Aina LLC 12.5 39.5 11.0 25.0 88.0 10.0 10.0 75.0 20.0 5.0 5.0 5.0 5.0 473.0 5.0 20.0 25.0 0.0 UNITS | CAPITA | ACRES UNITS CAPITA ACRES Kahuku Village 1,830 00 304 10 10 474 2 6 2 2 2 2 1,370 120 112 28 44 09 160 PHASE 1 PHASE 1 0 28 30 92 0 0 9 100 100 100 HAWAIIAN HERITAGE CENTER SUBTOTAL Fishing Village Learning Village/Hula Mound Amphitheater AMENITIES/SUPPORT USES
18 hole GC and Clubhouse
Maintenance Facility/WW/TP R-X: Single Family
R-I: Oceanfront Lots
R-2: Golf Estates
R-2: Sestates
R-3: Sestates
MR-1: Oceanfront Condo
MF-2: Golf Villas
Community Parks USE VISITOR ACCOMODATIONS RESIDENTIAL/LODGING MIXED-USE VILLAGE
VMX: Village Mixed Us
Village Green
Commercial KAHUKU VILLAGE Marine Science Lab Archeo Preserve Heritage Institute PROJECT: SUBJECT: LEARNING AREA Visitors Center SUPPORT USES Maintenance F CLIENT: Camp Sites Eco-lodge RESIDENTIAL /A Facility

55.5 84.0 44.0 40.0 932.5

PROJECT: CLIENT:	Kahuku Village Nani Kahuku Aina LLC	Kahuku Village Nani Kahuku Aina LLC Ootshio Wictor Princeling Woods and Source Docested	9	7												۵۶	DATE: JOB NO:	03/31/11
Canada and	odane mater, ii	ingation water and sev	Nei Delli	and														T NSCHO
NATIONA VILLAGE - TAKE 1	ו אוניין													SEWER DEMAND	AND			
USE VISITOB ACCREMING DATIONS	POTABLE DEMAND	IRRIGATION DEMAND	STIND	UNITS ACRES DE	DENSITY PC	POTABLE	POTABLE	BRACKISH	~	UNITS	ACRES CA	CAPITA RATE	TE UNIT	Dry I/I	Average Daily, gpd	Maximum Daily, gpd	Wet I/I	Peak Flow, gpd
Hotel	300 gpd/unit	500 gpd/unit	0	0	0.0	0		0	Ť	o	c		200 and/unit	c	č	c	c	0
		SUBTOTAL	٥	0		0	0	0	0	0	0	0		0	0	0		0
RESIDENTIAL																		
R-X. Single Family	350 gpd/unit	750 gpd/unit	ନ (12.5	2.4	10,500	22,500			30	12.5		320 gpd/unit	900	10,200	48,600	15,625	64,225
R-1: Oceanifort Lots		/50 gpd/unit	7 28	39.5	0.7	9,800	21,000			78	39.5		320 gpd/unit	260	9,520	45,360	49,375	94,735
R-3 Estates		750 apd/unit	- =	0.11	9.0	2,450	9 250	5,250		r ‡	110		320 gpd/unit	140	2,380	11,340	13,750	25,090
MF-1: Oceanfront Condo		300 apd/unit	0	000	0.0		0,2,0			= =	0.07		320 gpa/unit 200 gpd/upit	077	3,740	17,820	31,250	49,070
MF-2: Golf Villas		500 gpd/unit	0	0.0	00	0	,	0		0	000		320 apd/unit	c	0 0	o c	0 0	0 0
Community Parks	5gpp/ 200 people	50% At @ 4,000 gpd/acre	i	00		0	i	0		0	0.0	0	5 gpd/person	0	0	0	0	0
		SUBTOTAL	76	88		26,600	51,750	6,250	0	76	88	304		1,620	25,840	123,120	110,000	233,120
COMMERCIAL		,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,																
VMX: Village Mixed Use	Z,000 gpd/acre	1,000 gpd/acre	0	00		0		0 (0	0.0		300 gpd/unit	0	ó	0	0	0
Commercial	1 000 and/acre	1,000 gpu/acie		0.0		000		0 00		0 0	00		5 gpd/person	0	0	0	0	0
Civic	1,000 gpd/acre	1,000 apd/acre		0 0		000, 1		000.4 0		> C	0. c	09 0	80 gpd/person	800	13,600	64,800	2,000	008'69
VA Facility	2,000 gpd/acre	1,000 gpd/acre		00		0		0		0	0.0		250 apd/person	0 0	òċ	0	o c	- C
		SUBTOTAL	0	4		4,000	0	4,000	0	0	4			800	13,600	64,800	6,000	69.800
AMENITIES/SUPPORT USES	- 1																	
18 hole GC	15,000 gallons	100 acres @6,000 gpd/acre		0		0 0		0		0	0							
Maintenance Facility	aidoad oot iddb c.	25% Al @4,000 gparacre		⊃ ư		0 0		0 00		0 0	01	0 1	25 gpd/member	0	0	0	0	0
WWTP				າທ		000,1		2,000		> C	വവ	വവ	20 gpd/person	£ 5	125	525	6,250	6,775
Main Road 1 Imgation - 120' ROW		10,000 If @2 5 gpd/ft						25,000		•	,	•	100100000000000000000000000000000000000	3	3	676	0,230	27,0
Main Road 2 Imgation - 60' ROW		25,000 If @1.0 gpd/ft						5,000	******						-			
iviairi Road 3 Imgation - 5.		15,000 if @1 0 gpd/ft SUBTOTAL	0	10		6.000	0	5,000	o	0	Ę	ę		Ç	250	4 050	42 500	43 650
TOTAL			76	102		36,600	51.750	54.260	0	76	102	474		2 370	20 000	188 970	427 500	246 470
														2,510	000,00	0.00,001	121,000	310,470
HAWAIIAN HERITAGE AREA	AREA				_	WATER DEMAND	AND							SEWER DEMAND	dNP			F
L G	L		-		8			IRRIGATION		l I	1 1	łl			Average	Maximum		Peak
Fishing Village	힞	20% AI @2 000 craft	UNITS ACRES	ACRES	4	_	POTABLE	BRACKISH	쥰	- 1	ACRES CA			Dry I/I	Daily, gpd	Daily, gpd	Wet I/I	Flow, gpd
Learning Village	100app/ 200 people	20% AI @2 000 apd/acre	100	2 52		15,000		3,000	-	0 5	2 4	500	5 gpd/person	1,000	2,000	6,000	12,500	18,500
Amphitheater		20% AI @2,000 gpd/acre	3	2		2,500		800		<u> </u>	5 0		S and/person	7 500	5,750	15,000	35,750	169,500
Hentage Institute	હ	20% AI @2,000 gpd/acre		70		2,000		8,000		0	23		20 gpd/person	500	2,500	10,500	25,000	35.500
Visitors Center	Sgpp/ 400 people	20% AI @2,000 gpd/acre		S		2,000		2,000		0	2		5 gpd/person	2,000	4,000	12,000	6,250	18,250
Camp Sites	50gpp/ 20 workers +	zu% Al @z,uuu gparacre		s u		400		2,000	-	0 0	ıcı		25 gpd/person	100	009	2,600	6,250	8,850
Eco-Lodge	300 apd/unit	300 and/unit	100	, E		30,000		30,000		5 5	ה ל		32 gpd/person	7 250	1,850	8,250	6,250	14,500
Maintenance Facility			3	2.0		15,000		15,000		3 0	2 6		20 apd/aniit	5000	22,000	102,000	25,000	3,550
		SUBTOTAL	200	144		70,400	ũ	93,800	0	200	4		100000000000000000000000000000000000000	9,160	53,950	233,150	180,000	413,160
						DEMAND	CINA											
-					8	0		IRRIGATION	T	-		-		SEWER DEMAND	Average	Maximum		Peak
			UNITS	ACRES	<u>к</u>	ш	POTABLE	BRACKISH	F-4	UNITS	ACRES CA	CAPITA		Dry I/I	Daily, gpd	Daily, gpd	Wet I/I	Flow, gpd
GRAND TOTALS - PHASE	, .		276	246		107,000	51,760	148,050	0	276	246	2,304		11,520	93,640	422,120	307,500	729,620
		MAX DAILY DEMAND (1.5 for Potable, 1.65 for Irrigation)	r Potable,	1.65 for Irrig	ation)	160,600	85,388	244.283	0				POTENTIAL R-1 AVAILABLE	AVAIL ABLE	74.512			
				12% L	12% Losses	19,280	10,247	29,314	0						80% ADD			
			101	TOTAL MDD + LOSSES	SSES	479,760	95,534	273,596	0						SEWER			
			٠	TOTAL BRACKISH	XISH		20,03%	273.596										
				TOTAL WATER	(ATER			548 990										
				:				1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1										

PROJECT:	Kahuku Village															Č	į	03/34/44
CLIENT:	Nani Kahuku Aina LLC	na LLC														ξ <u>ς</u>	IOB NO:	2984-00
SUBJECT:	Potable Water, I	Potable Water, Irrigation Water and Sewer Demand	rer Demar	þ												3		PHASE 2
KAHUKU VILLAGE - PHASE 2	ASE 2					WATER DEMAND	AND						SE	SEWER DEMAND	9			
L Q	i i		l 1		Ш		R	RRIGATION	П	H	1 1	1 1			Average	Maximum		Peak
VISITOR ACOMMODATIONS	POTABLE DEMAND	I IKKIGALION DEMAND	CNITS	ACRES DE	DENSITY	POTABLE	POTABLE	BRACKISH	<u>5</u>	UNITS ACI	ACRES CAPITA	NTA RATE	E UNIT	Dry I/I	Daily, gpd	Daily, gpd	Wet I/I	Flow, gpd
Hotel	300 gpd/unit	500 gpd/unit	250	37	8.9	75,000		125,000		250	37	840 2	200 gpd/unit	4,200	54,200	254,200	46,250	300,450
RESIDENTIAL						2000		120,000		700	70	040		4,200	54,200	264,200	46,250	300,450
R-X: Single Family	350 gpd/unit	750 gpd/unit	70	28.5	2.5	24,500	52.500		I			1	20 and/unit	1 400	23 800	113 400	35.675	140 025
R-1: Oceanfront Lots	350 gpd/unit	750 gpd/unit	28	39.5	0.7	008'6	21,000						20 apd/unit	560	9.520	45.360	49,375	04 735
R-2: Golf Estates	350 gpd/unit	750 gpd/unit	117	170.5	0.7	40,950		87,750					20 apd/unit	2.340	39.780	189.540	213 125	402,665
R-3 Estates	350 gpd/unit	750 gpd/unit	37	87.0	0 4	12,950	27,750						320 gpd/unit	740	12,580	59,940	108,750	168,690
MF-1: Oceanfront Condo	200 gpd/unit	300 gpd/unit	22	16.0	3.4	11,000	16,500						00 gpd/unit	770	11,770	55,770	20,000	75,770
MF-2 Golf Villas	300 gpd/unit	500 gpd/unit	20	14.0	3.6	15,000		25,000					20 gpd/unit	200	16,700	80,700	17.500	98 200
Community Parks	5gpp/ 200 people	50% AI @ 4,000 gpd/acre	ļ	110		200		22,000		0	11.0	28	5 gpd/person	140	280	140	13,750	13,890
		SUBTOTAL	367	367		114,700	117,750	134,750	0		-	,330		6,660	114,430	544,850	468,125	1,002,975
COMMERCIAL																		
VMX: Village Mixed Use	2,000 gpd/acre	1,000 gpd/acre	0	0.0		0		0		0	0.0	-	300 and/unit	c	c	c	c	Ic
Village Green		1,000 gpd/acre		0.0				0	_	0	0.0		5 and/herson	o c	0 0	o c	o c	0 0
Commercial	1,000 gpd/acre	1,000 gpd/acre		14.0		14,000		14,000		0	140		80 and/nerson	2 800	47 600	226.800	17 500	244 300
Oivic	1,000 gpd/acre	1,000 gpd/acre		0.0		0		0	*****	0	00		80 and/nerson	į	0	000,022	9	2000
VA Facility	2,000 gpd/acre	1,000 gpd/acre		0.0		0		0		0	00	0 0	250 gpd/person	0	ō	0 0	0 0	- c
		SUBTOTAL	0	14		14,000	0	14,000	0	0	14		-	2.800	47.600	226.800	17.500	244 300
AMENITIES/SUPPORT USES																		1
18 hole GC	15,000 gallons	100 acres @6,000 gpd/acre		327		15,000		000'009	L	0	327							
Clubnouse	5 gpp/ 400 people	25% AI @4,000 gpd/acre		ო		2,000		3,000		0	ო		25 apd/member	2.400	14.400	62,400	3 750	66 150
Maintenance Facility				2		10,000		10,000		0	2	2	20 apd/person	25	125	525	6.250	6775
A MM				2		1,000		10,000		0	2		20 apd/person	25	125	525	6.250	6 775
Main Road 1 Imgation - 120' ROW	o' ROW	10,000 If @2.5 gpd/ft						25,000	_					ì	2		9)
Main Road 2 Impation - 60' ROW	ROW	25,000 If @1.0 gpd/ft						15,000										
מושונו אספת כי ווווקפווטון - סס	200	15,000 II @ 1 gpant	•	,			,	10,000										
TOTAL		SUBIOIAL	0	340		28,000	0	673,000	0	0		490		2,460	14,650	63,450	16,250	79,700
IOIAL			607	768	_	231,700	117,750	348,750	0	209	768 3	3,220		16,100	230,880	1,089,300	538,125	1,627,426
HAWAIIAN HEBITAGE AREA	BEA																	
· TOWN THE WAY THE WAY TO A TOWN	5					WATER DEMAND	AND						몽	SEWER DEMAND	g.			

HAWAIIAN HEDITAGE ADEA	YEV																
	5				WAIER DEMAND	WAND		_				.,	SEWER DEMAND	GNI			
					DOMESTIC	ď	IRRIGATION						-	Average	Maximum		Peak
USE	POTABLE DEMAND	IRRIGATION DEMAND	STINO	ACRES	POTABLE	POTABLE	BRACKISH	1-4	UNITS AC	ACRES CAPITA	TA RATE	LINI	1/200	Daily and	Daily and	\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\	Poor Hold
Fishing Village	5gpp/ 200 people	20% AI @2,000 gpd/acre		10	1,000		4.000	L	6		-1	5 and/	1 000	2000	900	12 500	10 500
Leaming Village	100gpp/ 150 people	: 20% At @2,000 apd/acre	100	75	15,000		30,000		, 6	2,		o apal/ponon	001	2,700	0,000	12,00	000,000
Amphitheater	Sonof 500 people) (0 0		000,00		3 '			ino dhavbeisoil	06/	00,401	02/2/	93,750	169,500
Company	adhay and heahle			7	2,500		800		0			5 gpd/person	2,500	2,000	15,000	2,500	17.500
Hentage Institute	20gpp/ 100 workers			20	2,000		8,000		0	50		20 apd/person	200	2.500	10.500	25,000	35,500
Visitors Center	5gpp/ 400 people			22	2,000		2,000		0		400	5 apd/person	2,000	4.000	12,000	6 250	18 250
Marine Science Lab	20gpp/ 20 workers +	 20% AI @2,000 gpd/acre 		2	400		2.000		0	5			100	900	2,600	6.250	0,000
Camp Sites	50gpp/ 50 people			ហ	2.500		2 000			ı vo		32 and/hereon	250	1 850	8 250	0,2,0	4 500
Fco-l odge	300 and/timit	300 and/unit	100	00	00000		000		,			Speriod Services	000	000	00,400	0,200	2000,
000000000000000000000000000000000000000	111111111111111111111111111111111111111	1000	2	0			20,000		3	7		Zoo gpa/unit	2,000	22,000	102,000	25,000	127,000
Maintenance Facility				2.0	15,000		15,000		0	7	10 2	20 gpd/person	20	250	1,050	2.500	3,550
		SUBTOTAL	200	144	70,400	ေ	93,800	0	200	144 1,8	,830		9,150	53,950	233,150	180,000	413,160
					WATER DEMAND	WAND						,	SEWER DEMAND	NN			F
					DOMESTIC	环	RRIGATION							Average	Maximum		Peak
			UNITS	ACRES	POTABLE	POTABLE	BRACKISH	R-1	UNITS AC	ACRES CAPITA	TA		Dry I/I	Daily, god	Daily, and	Wet I/I	Flow and
GRAND TOTALS - PHASE 2	2.2		807	302	302,100	117,769	1,040,550	0	807	902 5.0	6.050		8	284,830	1.322.450	718.126	2 040 575
		MAX DAILY DEMAND (1.6 for Potable, 1.65 for Irrigation)	r Potable,	1.65 for Irrigation)	453,150	184,288	1,716,508	0			ď.	POTENTIAL R-1 AVAILABLE	VAILABLE	227 884			
				12% Losses	54,378	23,346	206,025	0						80% ADD			
			TOTA	TOTAL MDD + LOSSES	205	217,602	1,922,936	0						SEWER			
				TOTAL POTABLE		725,130											
			-	TOTAL BRACKISH			1,922,938										
				O AL WAIEK			2,548,058										

03/31/11 2984-00 PHASE 3 DATE: JOB NO:

Kahuku Village Nani Kahuku Aina LLC Potable Water, Irrigation Water and Sewer Demand PROJECT: CLIENT: SUBJECT:

KAHUKU VILLAGE - PHASE 3	SES					WATER DEMAND	WAND							SEWER DEMAND	AND			F
					F	DOMESTIC	-	RRIGATION	l						Average	Maximum		Peak
USE	POTABLE DEMAND	IRRIGATION DEMAND	UNITS	ACRES DENSITY	L.	POTABLE	POTABLE	BRACKISH	<u>چ</u>	UNITS ,	ACRES	CAPITA	RATE UNIT	Dry I/I	Daily, apd	Daily, god	Wet I/I	Flow, apd
VISITOR ACOMMODATIONS										1	1	J			18:7	18:7		5
Hotel	300 gpd/unit	500 gpd/unit	200	75	6.7	150,000		250,000		200	75	1,680	200 gpd/unit	8,400	108,400	508,400	93,750	602,150
		SUBTOTAL	200	7.5		150,000	0	250,000	0	200	76	1,680		8,400	108,400	508,400	93,750	602,150
RESIDENTIAL																		
R-X: Single Family	350 gpd/unit	750 gpd/unit	135	55.5	2.4	47,250	101,250			135	55.5	540	320 apd/unit	2.700	45,900	218.700	69,375	288.075
R-1 Oceanfront Lots	350 gpd/unit	750 gpd/unit	8	84.0	0.7	21,000	45,000			9	84.0	240	320 apd/unit	1,200	20,400	97 200	105,000	202 200
R-2: Golf Estates	350 gpd/unit	750 gpd/unit	291	483.0	90	101,850		218,250		291	483 0	1,164	320 gpd/unit	5,820	98,940	471,420	603,750	1.075.170
R-3 Estates	350 gpd/unit	750 gpd/unit	37	87.0	0.4	12,950	27,750			37	870	148	320 gpd/unit	740	12,580	59,940	108,750	168,690
MF-1. Oceanfront Condo	200 gpd/unit	300 gpd/unit	140	410	3.4	28,000	42,000			140	410	392	200 gpd/unit	1,960	29,960	141,960	51,250	193,210
MF-2. Golf Villas	300 gpd/unit	500 gpd/unit	180	50.0	36	54,000		000'06		180	20.0	504	320 gpd/unit	2,520	60,120	290,520	62,500	353,020
Community Parks	5gpp/ 200 people	50% AI @ 4,000 gpd/acre		22.0		1,000		44,000		0	2.0	26	5 gpd/person	280	260	280	2,500	2,780
		SUBTOTAL	843	823		266,050	216,000	352,250	0	843	803	3,044		15.220	268,460	1.280.020	1.003.125	2.283.145
COMMERCIAL																		
VMX: Village Mixed Use	2,000 gpd/acre	1,000 gpd/acre	149	33.0		66,000		33,000		149	33.0	596	300 gpd/unit	2,980	47,680	226,480	41,250	267,730
Village Green		1,000 gpd/acre		20				2,000		0	20	100	5 gpd/person	200	1,000	200	2,500	3,000
Commercial	1,000 gpd/acre	1,000 gpd/acre		24.0		24,000		24,000		0	24.0	960	80 gpd/person	4,800	81,600	388,800	30,000	418.800
Oivic	1,000 gpd/acre	1,000 gpd/acre		0.0		0		0		0	0.0	0	80 gpd/person	0	0	0	0	0
VA Facility	2,000 gpd/acre	1,000 gpd/acre		450		000'06		45.000		0	450	450	250 apd/person	2.250	114 750	564 750	56 250	621 000
		SUBTOTAL	149	104		180,000	0	104,000	0	149	104	2,106	50	10,530	245.030	1.180.530	130,000	1.310,530
AMENITIES/SUPPORT USES																		
18 hole GC	15,000 gallons	100 acres @6,000 gpd/acre		327		15,000		600,000	l	0	327							T
Clubhouse	5 gpp/ 400 people	25% AI @4,000 gpd/acre		ო		2,000		3,000		0	ო	480	25 apd/member	2.400	14.400	62.400	3.750	66.150
Maintenance Facility				10		15,000		15,000		0	9	10	20 gpd/person		250	1,050	12,500	13,550
WWTP				10		2,000		10,000		0	10	10	20 apd/person	50	250	1,050	12 500	13.550
Main Road 1 Irrigation - 120' ROW	>	10,000 If @2.5 gpd/ft						25,000									į	
Main Road 2 Imgation - 60' ROW		25,000 lf @1.0 gpd/ft						25,000										
Main Road 3 Imgation - 60' ROW		15,000 If @1 0 gpd/ft						15,000										
		SUBTOTAL	٥	360		34,000	0	693,000	0	0	350	900		2,600	14,900	64,500	28,750	93,260
TOTAL			1,492	1,352	-	630,050	218,000	1,398,260	0	1,492	1,332	7,330		36,650	536,790	3,033,450	1,255,625	4,289,076
HAWAIIAN HERITAGE AREA	REA					WATER DEMAND	MAND							SEWER DEMAND	ONA			

HAWAIIAN HERITAGE AREA	AREA				WATER DE	DEMAND		F					SEWER DEMAND	TAND			
					DOMESTIC		RRIGATION	Ī						Average	Maximum		Peak
USE	POTABLE DEMAND	IRRIGATION DEMAND	UNITS	ACRES	POTABLE	POTABLE	BRACKISH	4.	STINO	ACRES C	CAPITA	RATE	Dr VI	Daily and	Daily and	Wet [/]	Flow and
Fishing Village	5gpp/ 200 people	20% AI @2,000 gpd/acre		10	1,000		4,000		0	10	200	/pap g	1 000	2,000	0009	12 500	18 500
Learning Village	100gpp/ 150 people	20% AI @2,000 gpd/acre	100	75	15,000		30,000		100	75	150	100 apd/person	750	15.750	75.750.	93 750	169 500
Amphitheater	2gpp/ 500 people	20% AI @2,000 gpd/acre		2	2,500		800		0	7	200	5 gpd/person	2,500	5,000	15,000	2,500	17,500
Heritage Institute	s	20% AI @2,000 gpd/acre		20	2,000		8,000		0	20	9	20 gpd/person	200	2,500	10,500	25,000	35,500
Visitors Center	5gpp/ 400 people	20% AI @2,000 gpd/acre		S	2,000		2,000		0	22	400	5 gpd/person	2,000	4,000	12,000	6,250	18,250
Marine Science Lab	+	20% AI @2,000 gpd/acre		S	400		2,000		0	S	20	25 gpd/person	100	009	2,600	6,250	8,850
Camp Sites	50gpp/ 50 people			S	2,500		2,000		0	S	20	32 gpd/person	250	1,850	8,250	6,250	14,500
Eco-Lodge	300 gpd/unit	300 gpd/unit	100	20	30,000		30,000		100	20	400	200 gpd/unit	2,000	22,000	102,000	25,000	127,000
Maintenance Facility				20	15,000		15,000		0	2	5	20 gpd/person	20	250	1,050	2,500	3,550
		SUBTOTAL	200	144	70,430	a	93,800	0	200	14	1,830		9,150	53,950	233,150	180,000	413,150
			-			DEMAND							SEWER DEMAND	TAND			
					DOMESTIC	*	RRIGATION							Average	Maximum		Peak
			UNITS	ACRES	POTABLE	POTABLE	BRACKISH	R-1	UNITS	ACRES C	CAPITA		Dry I/I	Daily, and	Daily, and	Wet I/I	Flow, and
GRAND TOTALS - PHASE 3	ISE 3		1,692	1,496	750,450	215,000	1,483,060	0	1.692	1.476	9.160		46.800	630.740	3.266.600	1.435.626	4.702.226
	4	MANY DAILY DEMAND (4 E for Dotable 4 EE for Industrial	r Octoble 4	CE for bringshop	A 250 076	000 000	400 200				-	TO HAVE A CONTINUE OF	1	1			

	- Constitution of the Cons									,		1			
			DOMESTIC	R	IRRIGATION							Average	Maximum		Peak
	UNITS ACRES	ACRES		POTABLE	BRACKISH	R-1	UNITS	ACRES CAPITA	CAPITA		Dry I/I	Daily, and	Daily, and	Wet I/I	Flow, and
GRAND TOTALS - PHASE 3	1,692	1,692 1,496		215,000	1,483,060	0	1,692	1,476	9,160		46,800		3,266,600	1,435,625	4,702,226
MAX DAILY DEMAND (1.5 for Potable, 1.65 for Irrigation)	or Potable,	1.65 for Imigation	**	368,400	2,483,533	0			P	POTENTIAL R-1 AVAILABLE	VAILABLE	552,592			
		12% Losses		42,768	286,624	0						80% ADD			
	4TOT	TOTAL MDD + LOSSES	· Com	399,168	2,759,158	0						SEWER			
		TOTAL POTABLE		1,675,924											
	•	TOTAL BRACKISH	_		2,755,166										
		TOTAL WATER	~		4,335,080										

GRAND TOTALS - PHASE 4 - FULL BUILDOUT

MAX DAILY DEMAND (1.5 for Potable, 1.65 for Imgation)

MAX DAILY DEMAND (1.5 for Potable, 1.65 for Imgation)

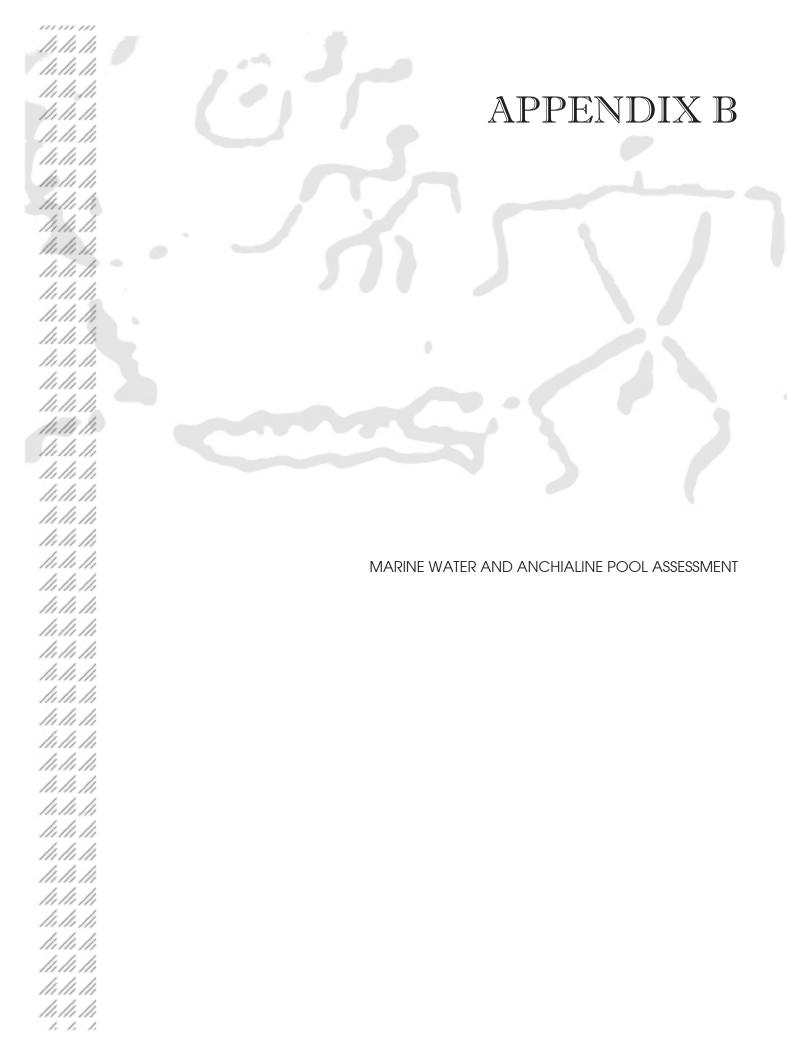
MAX DAILY DEMAND (1.5 for Potable, 1.65 for Imgation)

TOTAL MAD POTABLE

TOTAL WATER

2,850,632

PROJECT:	Kahuku Village																DATE:	03/31/11
ے	Potable Water, Ir.	Potable Water, Irrigation Water and Sewer Demand	ver Dem	and												Phys	JOB NO: 2984-00 PRASE 4 - FULL BUILDOUT	2984-00 3UILDOOUT
KAHUKU VILLAGE - PI	GE - PHASE 4 - FULL BUILDOU?	Dout				WATER DEMAND								SEWER DEMAND	AND			
ŭ	C. C				-	DOMESTIC	ſ	IRRIGATION							Average	Maximum		Peak
VISITOR ACOMMODATIONS	FOLABLE DEWAND	IRRIGATION DEMAND	SLIND	ACRES	DENSITY	POTABLE	POTABLE	BRACKISH	R-1	SLINO	ACRES	CAPITA	RATE UNIT	Dry I/I	Daily, gpd	Daily, gpd	Wet I/I	Flow, gpd
Hotel	300 gpd/unit	500 gpd/unit	500	75	67	150,000		250,000		200	75	1,680	200 gpd/unit	8,400	108.400	508.400	93.750	602.150
RESIDENTIAL		SUBTOTAL	200			150,000	0	250,000	0	200	75	1,680		8,400	108,400	508,400	93,760	602,150
R-X Single Eamily		750 cadheat							Ī									
R-1. Oceanfront Lots	350 and/unit	750 and/unit	35 6	55.5	2 4 7	47,250	101,250			135	55.5	540	320 gpd/unit	2,700	45,900	218,700	69,375	288,075
R-2. Golf Estates		750 and/unit		`	~ «	701,850	45,000	010		8 2	840	240	320 gpd/unit	1,200	20,400	97,200	105,000	202,200
R-3: Estates		750 and/init			0 0	000,101	0	062,812	_	787	483.0	1,164	320 gpd/unit	5,820	98,940	471,420	603,750	1,075,170
MF-1 Oceanfront Condo	200 gpd/unit	300 apd/unit		410	4 4	28,250	36,250°			7.2	179.0	စ္တ ရွ	320 gpd/unit	1,500	25,500	121,500	223,750	345,250
MF-2 Golf Villas		500 gpd/unit			r (C)	54,000	42,000	000 00		5 6	0 14	385	200 gpd/unit	1,960	29,960	141,960	51,250	193,210
Community Parks	oble	50% AI @ 4,000 gpd/acre			3	1,000		80,000		8 0	2 6	50.0	320 gpavunit 5 and/nerson	2,520	60,120	290,520	62,500	353,020
		SUBTOTAL	881	933		279,350	244,500	388,250	0	881	895	3.240		16 200	281.820	300	7,000	3,000
COMMERCIAL												2		10,400	070,107	1,541,000	1,110,120	2,403,320
VMX: Village Mixed Use	2,000 gpd/acre	1,000 gpd/acre	169	37.5		75,000		37,500	Ī	169	37.5	676	300 and/unit	3 380	54 080	756 990	16 075	2000 755
Village Green		1,000 gpd/acre		2.0				2.000	_	C	200	100	5 and/hereon	005,5	000,4	000,002	40,073	303,733
Commercial	1,000 gpd/acre	1,000 gpd/acre		24.0		24,000		24,000		» c	24.0	99	80 and/berson	200	000	200	2,500	3,000
Civic		1,000 gpd/acre		06		000'6		000.6		· c	0 6	98	80 and/person	4,000	009'19	388.800	30,000	418,800
VA Facility	2,000 gpd/acre	1,000 gpd/acre		45.0		90,000		45,000		· c	45.0	250	250 and/person	1,000	30,000	145,800	11,250	050,751
		SUBTOTAL	169			198,000	0	117.500	c	169	73	25450	zoo gparperson	2,250	114.750	564,750	56,250	621,000
AMENITIES/SUPPORT USES								200		2		2,040		12,730	282,030	1,366,730	146,876	1,503,605
18 hole GC	15,000 gallons	100 acres @6,000 gpd/acre	-	327	-	15,000		800 000	T		207				4911			
Clubhouse	5 gpp/ 400 people	25% Al @4,000 gpd/acre		i "		2,000		000,500		o c	350	001	Condimension To	0	00,	0	1	
Maintenance Facility				10		15,000		15,000		· ·	, C	5 5	20 apd/norger	2,400	14,400	62,400	3,750	66,150
WWTP				9		2,000		10,000		0	2 6	5 5	20 and/nerson	200	250	1,050	12,500	13,550
Main Road 1 Imgation - 120' ROW	_	10,000 if @2 5 gpd/ft						25,000		,	2	2	included of	2	230	OCO.I	000:71	000,51
Main Road 2 Impation - 60' ROW		25,000 If @1.0 gpd/ft						25,000										
S TOURS OF THE PROPERTY OF THE		13,000 II @ I.D gpant	•	350		24.000	ć	15,000		_								
TOTAL		70000	4 550	1		34,000	0 000	693,000	0	0	320	200		2,500	14,900	64,500	28,750	93,250
			200,1	0/4/0		000,100	244,500	1,448,763	0	1,660	1,437	7,966		39,830	687,150	3,271,430	1,387,500	4,658,930
HAWAIIAN HERITAGE AREA	4REA					WATER DEMAND	MAND						3	SCIATED DERAMA	CMV			
						DOMESTIC		IRRIGATION	Ī				•	SCAVEN DEIN	AND AND			
USE	위	IRRIGATION DEMAND	UNITS	ACRES		POTABLE	POTABLE	BRACKISH	<u>4</u>	UNITS	ACRES C	CAPITA	RATE UNIT	li vo	Daily and	Daily and	11/04 1/1	Feak Floring and
Fishing Village		20% AI @2,000 gpd/acre		10		1,000		4,000		1	۱_	4	Bab	1 000	2,000	9500 S	12 500	18 500
Amphitheotor	100gpp/ 150 people	20% AI @2,000 gpd/acre	100	75		15,000		30,000		100	75		100 gpd/person	750	15,750	75.750	93.750	169 500
Heritage Institute		20% At @2,000 gpa/acre		∾ 8		2,500		800		0	2		5 gpd/person	2,500	5,000	15,000	2,500	17,500
Visitors Center		20% At @2,000 gpwacte		8 "		2,000		8,000		0	8		20 gpd/person	200	2,500	10,500	25,000	35,500
Marine Science Lab	+	20% At @2,000 and/acre		י ער		2,000		2,000		0	ı,		5 gpd/person	2,000	4,000	12,000	6,250	18,250
Camp Sites	50gpp/ 50 people			ı ıc		2500		2,000		-	ຄ		25 gpd/person	100	009	2,600	6,250	8,850
Eco-Lodge	300 gpd/unit	300 gpd/unit	100	8 9		30,000		30,000		5 5	ი ლ	00 P	32 gpa/person	250	1,850	8,250	6,250	14,500
Maintenance Facility				2		15.000		15,000		3 -	3 °		20 aparami	2,000	22,000	102,000	25,000	127,000
		SUBTOTAL	200	144		76,400	0	33,835	0	200°	1 44		Spurperson	9.150	250	733 150	780,000	3,550
	VALUE OF THE PROPERTY OF THE P													6, 6	2000	200,100	200,001	419,100
						WATER DEMAND							<i>J</i>	SEWER DEMAND	AND			
			STINITS	ACBES	710	DOTABLE	Г	IRRIGATION	1	+					Average	Maximum		Peak
CRASSIO TOTAL & BEARE & BITT OF CRASSION	CC SEC SEC VED	20136		200		CINE	PO ABLE	BRACKISH	ž	- 1		CAPITA		Dry I/I	Daily, gpd	Daily, gpd	Wet I/I	Flow, gpd
	7 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	MANY DAILY DEMAND (4 E for Body 4 of F	1,70U	1,619		731,755	244,600	1,642,660		1,750	1,581	9,796	48,980	48,980	741,188	3,504,580	1,567,500	6,072,080
	-	MAN DAIL! DEMAND (1.5 IG	r Potable,	1.55 TOF ICT	or imgation)	1,097,626	453,425	2,545,208					POTENTIAL R-1 4	AVAILABLE	222,330			
			TOT	TOTAL MDD + LOSSES	OSSES	1,229,340	464.836	336,426 7,860,639	5 6						30% ADD			
				TOTAL POTABLE	TABLE	With the same of t	1,581,176	Company							SEWER			
				JOINTAGE NATUE	noise		200000000000000000000000000000000000000											



ASSESSMENT OF THE MARINE AND ANCHIALINE POOL ENVIRONMENTS

KAHUKU VILLAGES,

KA'U, HAWAII

Prepared for:

Mr. Valentine Peroff Nani Kahuku Aina, LLC 99-1324 Koaha Place Aiea, Hawaii 96701

Prepared by:

Marine Research Consultants, Inc. 1039 Waakaua Pl. Honolulu, HI 96822

May 2011 EXECUTIVE SUMMARY

Planning is underway for development of Kahuku Villages, a multi-land use project located within the Ka'u District approximately seven miles north of Ka Lae (South Point) on the southwestern shoreline of the Island of Hawaii. The project site consists of 16,547 acres, which extends from the shoreline mauka. Of this area, about 15,000-acres (93%) will be untouched and remain as open space. The concept for Kahuku Villages centers on recognition and appreciation of the value of the natural and cultural resources of the land, and will provide for the long-term stewardship and preservation of these resources. In order to conserve and protect these resources, approximately 600 acres along the coast will be set aside for the proposed Hawaiian Heritage Center and a Shoreline Conservation Management Area. None of the proposed land uses includes any direct alteration of the coastal areas or nearshore waters.

Part of the planning process for the Kahuku Villages project includes an assessment of the existing marine and aquatic settings. The rationale of this assessment was to evaluate the composition and condition of the existing marine environment in terms of water chemistry, coral reef community structure, and anchialine pool composition. The existing conditions of the marine and anchialine pool environments reflect the effects of naturally occurring groundwater input prior to the commencement of any new construction activities. Combining this information with estimates of changes in groundwater and surface water flow rates and chemical composition that could are predicted to result from the proposed Kahuku Villages project provides a basis to evaluate the potential future effects to the marine and anchialine pool environments.

Field investigations of the nearshore marine and anchialine pool environments off of the Kahuku Villages Project site were carried out in April 2009 and March 2011. The assessment of water chemistry was carried out by evaluating data from 92 water samples that were collected at six ocean transect sites and in anchialine pools along the shoreline. Water samples were collected on transects perpendicular to shore, extending from the shoreline to distances of approximately 100-200 m offshore. Analysis of fourteen water chemistry constituents included all specific constituents in DOH water quality standards. Several nutrients (silica, nitrate + nitrite, orthophosphate, total nitrogen and total phosphorus) displayed strong horizontal gradients at several ocean transect sites with highest values closest to shore and lowest values at the most seaward sampling locations. Correspondingly, salinity was lowest closest to the shoreline, and increased with distance from shore. These gradients were most pronounced at the northern boundary of the project site off the Kanonone Pond area and Pohue Bay, and weakest on the transects off the central-southern region of the project where the shoreline is composed of basalt cliffs. These patterns are indicative of groundwater efflux at the shoreline, producing

a zone of mixing where nearshore waters are a combination of ocean water and groundwater.

Water chemistry constituents that are not major components of groundwater (organic nitrogen and organic phosphorus) did not display as distinct gradients with respect to distance from the shoreline, or depth in the water column. Chlorophyll a was elevated in nearshore samples only on transects off of Kanonone Pond and Pohue Bay with decreasing values moving seaward. Turbidity did not vary throughout the sampling regime, and was essentially constant at low values from the shoreline to the stations farthest from shore. Water chemistry constituents that displayed distinct horizontal gradients also showed consistent variation between surface and near-bottom (deep) samples, with higher nutrient values and lower salinity in surface water relative to bottom water. Nearshore mixing of groundwater and ocean water creates a buoyant surface lens of low salinity, high nutrient water that is evident throughout the nearshore region fronting the project site.

The coastal area of Kahuku Villages contains a series of anchialine ponds. These ponds have no surface connection to the ocean, and are essentially an atmospheric exposure of the water table. Water within the ponds consists of a mixture of seaward flowing groundwater and landward flowing seawater, and as such the composition of water within the ponds responds to tidal changes. Measured salinities of 4-5‰ indicate pond water consisted of about 10-15% ocean water and 85-90% with corresponding nutrient concentrations with respect to mixing of groundwater and open coastal waters. For unknown reasons, water samples collected in 2011 had consistently lower values of PO₄³⁻ and NH₄+ than samples collected from the same pools in 2009. Water clarity in all anchialine pools was exceptionally good, indicating that even though nutrient concentrations are elevated, plankton blooms are not occurring in anchialine pools. The lack of plankton growth in the presence of high nutrients is a result of short residence time of water in the pools, and grazing by native pond biota.

Application of a hydrographic mixing model to the water chemistry data was used to indicate if increased nutrient concentrations in nearshore waters are the result of mixing of natural groundwater with oceanic water, or are the result of inputs from activities on land. The model indicates that at the time of sampling there were no external subsidies of NO_3 - nitrogen to the ocean at any of the ocean transect sites, indicating that the observed gradients are the result of natural processes of mixing of groundwater and ocean water.

Evaluating water chemistry using DOH specific criteria for Open Coastal Waters indicates many of the measurements in the nearshore areas off the Kanonone Pond and Pohue Bay areas exceed standards, particularly for NO₃-. As these standards do not take into account mixing of high nutrient groundwater with ocean water in the nearshore zone, such exceedances are expected. Area specific DOH water quality standards for West Hawaii do not presently extend to the Ka`u District. If the West

Hawaii specific criteria are applied to the data collected off of the Kahuku Villages site, there would be no exceedance of the standards.

Characterization of the existing marine communities was carried out using traditional photo-transect and visual censusing methods. The physical structure of the nearshore marine habitat consists of a narrow reef bench or terrace that terminates in a slope that extends to abyssal depths. Coral communities in the area are typical of the assemblages found throughout West Hawaii, with the reef bench populated predominantly by two major species (*Pocillopora meandrina* and *Porites lobata*). Overall coral cover in the area was about 50% of bottom cover, with all areas of hard bottom beyond the surf zone occupied with healthy coral. A distinguishing feature of the reef was the occurrence of several exceptionally large colonies of *P. lobata* on the order of several centuries old. Overall, coral communities in the area are flourishing, with little indication of any reduction from any stress conditions, including catastrophic storms. Populations of reef fish in the area also appeared typical of West Hawaii reefs, although there was evidence of high fishing pressure. The nearshore habitats of the Kahuku Villages site also represents an important area for nesting of Hawksbill turtles.

Observations of anchialine pool biota indicated the presence of all representative native species (particularly shrimp), and importantly, a lack of exotic fish species. Invasive exotic species have been shown to be a major factor in degradation of anchialine pools in other areas of West Hawaii. The lack of these invasive species at the present time points to the importance of maintaining the existing conditions of the anchialine pools throughout the development process.

Engineering analysis conducted by Tom Nance Water Resource Engineering indicate that there will be only small reductions in both groundwater discharge and nutrient discharge to the nearshore ocean over present conditions with full build-out of the planned project. As the results of the assessment of existing marine environment indicates that at present groundwater has essentially no effect on marine community structure owing to physically driven mixing processes, the small changes in groundwater dynamics associated with the project do not present a mechanism for future negative effects.

Overall, results of the water chemistry analysis and characterization of marine and anchialine pool biotic communities indicates that the Kahuku Villages area probably represents as close as possible to a pristine coastal area unaffected by most activities of man. As these existing communities have developed in response to natural inputs from land, the projected changes brought about by the project do not present the potential for significant change relative to the present. Planning of the Kahuku Villages project focuses on continued maintenance and stewardship of these natural resources to preserve them in the present pristine condition. As a result, as long as best management practices are utilized to avoid any unforeseen impacts during the construction and operational phases of the project, there is no rationale

to indicate the potential for negative impacts to the marine and anchialine pool environments.

TABLE of CONTENTS

EXECUTIVE	
SUMMARY1	
I. INTRODUCTION AND PURPOSE	6
II. CHARACTERIZATION OF WATER CHEMISTRY	8
A. METHODS	8
B. RESULTS	9
1. Horizontal Stratification	9
2. Vertical Stratification	11
3. Anchialine Pool Water Chemistry	11
4. Conservative Mixing Analysis	13
5. Compliance with DOH Criteria	15
III. EVALUATION OF BIOTIC COMMUMITIES	16
A. METHODS	16
B. RESULTS	
1. Offshore Physical Setting	18
2. Benthic Community Structure	19
3. Reef Fish Community Structure	22
4. Threatened or Endangered Species	
5. Anchialine Pools	24
IV. DISCUSSION and CONCLUSIONS	28
IV. SUMMARY	33
REFERENCES CITED	36

I. INTRODUCTION AND PURPOSE

Planning is underway for development of Kahuku Villages, located within the Ka'u District approximately seven miles north of Ka Lae (South Point) on the southwestern shoreline of the Island of Hawaii. The project site consists of 16,547 acres, which extends from the shoreline mauka. Of this area, about 15,000-acres (93%) will be untouched and remain as open space. An extensive network of trails and open space will connect the mauka and makai areas, as well as provide lateral shoreline access through the project. The concept for Kahuku Villages centers on recognition and appreciation of the value of the natural and cultural resources of the land, and will provide for the long-term stewardship and preservation of these resources. Revenue generating land uses will be balanced with and help to fund resource stewardship and preservation efforts.

The site possesses several notable natural and cultural resources including numerous archaeological sites, historic trails, numerous anchialine pools, and varied pristine coastal and marine resources, including nesting areas for the endangered Hawksbill turtle. In order to conserve and protect these resources, approximately 600 acres along the coast will be set aside for the proposed Hawaiian Heritage Center and a Shoreline Conservation Management Area. The Hawaiian Heritage Center is proposed to encompass the lands surrounding Pohue Bay and Keliuli Bay (Figure 1). The Hawaiian Heritage Center will formalize and perpetuate the research and education programs already conducted onsite, enable expansion of programs, and promote an awareness and appreciation for the many natural and cultural resources that the Kahuku ahupua`a possesses. Facilities that may be developed within the Hawaiian Heritage Center include a visitor's center, classrooms, meeting space, laboratories, dormitory housing for researchers and students, a caretaker's residence, comfort stations, and campgrounds.

A shoreline conservation management area extending from about 300 feet to more than 1,000 feet inland from the shoreline is proposed for all shoreline frontage of the project site, and a management plan specifying measures to protect coastal resources in the area will be developed.

Residential, commercial and visitor uses will be confined to a Mixed-Use Villages in the makai portion of the site. The Mixed-Use Villages encompasses about 1,185 acres, and will consist of neighborhoods serving commercial establishments, single and multi-family residential units, an 18-hole golf course, two hotel sites, parks, civic uses, and a Veteran Administration Facility. A total of approximately 1,075 residential units are proposed, including single-family units, multi-family units, live-work units, senior housing, and estate lots.

The two sites for visitor accommodations would be designed to be consistent with the rural character of the region. Buildings would be low-rise and setback from the shoreline by a shoreline conservation buffer. It is envisioned that the visitor accommodations would cater to individuals with a desire to experience the natural setting and rich cultural and natural resources.

The 18-hole golf course will be located on the periphery of the Villages core, and will be designed and operated to meet strict environmental standards to ensure minimal impact on near shore waters, such as Audubon certification which require courses to comply with standards for operation including environmental planning, wildlife and habitat management, outreach and education, chemical use reduction and safety, water conservation, and water quality management.

While all planning and construction activities will place a high priority on maintaining the existing pristine nature of the coastal and marine environments, it remains necessary to address any potential impacts that may be associated with the planned project. None of the proposed land uses includes any direct alteration of the coastal areas or nearshore waters. The potential exists, however, for the project to affect the composition and volume of groundwater that flows beneath the project site, as well as possible effects of surface runoff that may emanate from the project during rare storm events. As all groundwater that could be affected by the project subsequently reaches the ocean, it is recognized that there is potential for the project to affect the marine environment.

In the interest of addressing these concerns and assuring maintenance of existing environmental quality, baseline fieldwork for an marine environmental assessment and potential impact analysis of the nearshore areas off the Kahuku Villages property was conducted in April 2009 (subsequent additional sampling was conducted in March 2011). The rationale of this assessment was to evaluate the composition and condition of the existing marine environment, particularly in terms of water chemistry, coral reef community structure, and anchialine pool composition. As the existing conditions of the marine and anchialine pool environments are the result of input of naturally occurring factors, particularly groundwater input, the characterization involves evaluating the effects that this input has on water quality at the present time, prior to the commencement of any new construction activities. Combining this information with estimates of changes in groundwater and surface water flow rates and chemical composition that could result from the proposed Kahuku Villages project provides a basis to evaluate the potential future effects to the marine and anchialine pool environments. Predicted changes in groundwater composition and flow rates have been supplied by Tom Nance Water Resource Engineering (TNWRE 2011). Results of the combined evaluations indicate if, and to what degree, there is the potential for negative effects to the marine and aquatic environments from the proposed Kahuku Villages project.

II. CHARACTERIZATION OF WATER CHEMISTRY

A. METHODS

Six transect survey sites were established off of Kahuku Villages between the northern end of the project site off of the Kanonone Pond area (KV-1) and near the southern boundary of the property (KV-6). Transect Site KV-2 was located through Pohue Bay; Site KV-3 was located in Keliuli Bay; Site KV-4 was located south of the Ulua Fishing camp; and Site KV-5 was located off a complex of anchialine ponds that occur near the shoreline on the southern section of the project (Figure 1).

Water quality was evaluated at each site on transects that were oriented perpendicular to the shoreline and depth contours. Water samples were collected at six locations (eight on Transect KV-1) on each transect from just seaward of the shoreline to approximately 100 meters (m) offshore (0, 2, 5, 25, 50, and 100 m {200 m on Transect KV-2}). Such a sampling scheme was designed to span the greatest range of salinity with respect to potential freshwater efflux at the shoreline. Sampling was more concentrated in the nearshore zone because this area is most likely to show the effects of shoreline modification. At sample locations where water depth exceeded 1 m, samples were collected at two depths; a surface sample was collected within approximately 10 centimeters (cm) of the sea surface, and a bottom sample was collected within 50 cm of the sea floor. At sampling sites where water depth was less than one meter, a single sample from within 10 cm of the surface was collected at each station. In addition, samples were also collected from representative anchialine pools and Kanonone Pond located along the shoreline of Kahuku Villages (Figure 1).

Water quality parameters that were evaluated included the eleven specific constituents for

Open coastal waters (Chapter11-54, Section 06 (b) of the State of Hawaii Department of Health (DOH) Water Quality Standards. These criteria include: total nitrogen (TN), nitrate + nitrite nitrogen ($NO_{3^-} + NO_{2^-}$, hereafter referred to as NO_{3^-}), ammonium nitrogen (NH_{4^+}), total phosphorus (TP), Chlorophyll a (Chl <u>a</u>), turbidity, temperature, pH and salinity. In addition, silica (Si) and orthophosphate phosphorus ($PO_{4^{-3}}$), were also reported because these constituents are indicators of groundwater input and mixing, as well as biotic activity.

Fieldwork was conducted on April 14-15, 2009 using an inflatable boat launched from the shoreline in Pohue Bay. A small replicate subset of near-shore and anchialine pool samples was also collected on March 3, 2011. Samples from the shoreline to 10 m offshore were collected by a swimmer working from shore. Near bottom samples were collected using a 1.8 liter Niskin sampling bottle. The bottle is lowered to the desired sampling depth with spring-loaded endcaps held open so water can pass freely through the bottle. At the desired sampling depth, a weighted

messenger released from the surface triggers closure of the endcaps, isolating a volume of water.

All water samples were collected in triple-rinsed one-liter linear polyethylene bottles. Subsamples for nutrient analyses were immediately placed in 125-milliliter (ml) acid-washed, triple rinsed, polyethylene bottles and stored on ice. Analyses for Si, NH₄+, PO₄³⁻, and NO₃- were performed on filtered samples with a Technicon Autoanalyzer using standard methods for seawater analysis (Strickland and Parsons 1968, Grasshoff 1983). TN and TP were analyzed in a similar fashion following digestion of unfiltered samples. Total organic nitrogen (TON) and total organic phosphorus (TOP) were calculated as the difference between TN and dissolved inorganic N (NO₃- + NH₄+), and TP and dissolved inorganic P (PO₄³⁻), respectively.

Water for other analyses was subsampled from 1-liter polyethylene bottles and kept chilled until analysis. Chl *a* was measured by filtering enough water through glass-fiber filters to detect color; pigments on filters were extracted in 90% acetone in the dark at -20° C for 12-24 hours. Fluorescence before and after acidification of the extract was measured with a Turner Designs fluorometer. Salinity was determined using an AGE Model 2100 laboratory salinometer with a readability of 0.0001% (ppt). Turbidity was determined using a 90-degree nephelometer, and reported in nephelometric turbidity units (NTU) (precision of 0.01 NTU).

In-situ field measurements of continuous vertical profiles of water temperature, salinity, dissolved oxygen and pH were acquired at each sampling station using a RBR Model XR-42 CTD calibrated to factory standards (precision of 0.01° C, 0.001%, 0.001% O₂ saturation, and 0.001 pH units).

All fieldwork was conducted by Dr. Steven Dollar, David Chai and Tom Nance. All laboratory analyses were conducted by Marine Analytical Specialists located in Honolulu, HI (Labcode: HI 00009). This analytical laboratory possesses acceptable ratings from EPA-compliant proficiency and quality control testing.

B. RESULTS

1. Horizontal Stratification

Tables 1 and 2 show results of all water chemistry analyses for samples collected off the Kahuku Villages site on April 14, 2009. Table 3 shows results for water samples collected on March 3, 2011. Tables 1 and 3A shows concentrations of dissolved nutrients in micromolar (μ M) units; Tables 2 and 3B shows concentrations in micrograms per liter (μ g/L). Concentrations of eight dissolved nutrient constituents in surface and near bottom samples are plotted as functions of distance from the shoreline in Figure 2. Values of salinity, turbidity and Chl a as functions of distance from shore are shown in Figure 3.

Several patterns of distribution are evident in Tables 1 and 2 and Figures 2 and 3. It can be seen in Figure 2 that the dissolved nutrients Si and NO_{3} , and to a much lesser degree PO_{4} ³-,

show substantial elevation in concentration in the samples near the shoreline, with progressively decreasing concentrations with distance from shore. Salinity displays the opposite trend, with sharply lower concentrations in the samples near the shoreline, and increasing values with distance from shore (Figure 3). While the gradients of Si, NO₃- and salinity occurred on all transects, the greatest peak in nutrients and lowest salinity of shoreline samples occurred at Transect KV-1, located at the northern boundary of the Kahuku Villages property off the Kanonone Pond complex. Following Transect KV-1, the steepest gradients are at Transect KV-2, 3 and 5, while there is little indication of horizontal stratification on Transects KV-4 and 6. Beyond about 50 m from the shoreline, horizontal gradients of dissolved nutrients and salinity are not clearly evident on any transect, and concentrations are uniformly low to distances of 100 m from shore (Figures 2 and 3, Tables 1 and 2).

These patterns are a result of concentrated input of groundwater to the ocean at or near the shoreline fronting some areas of the Kahuku Villages project site. Low salinity groundwater, which typically contains high concentrations of Si, NO₃-, and PO₄³- percolates to the ocean at the shoreline, resulting in a nearshore zone of mixing. In many areas of the Hawaiian Islands, particularly off the coast of West Hawaii, such groundwater percolation results in steep horizontal gradients of increasing salinity and decreasing nutrients with distance from shore.

While groundwater discharge to the ocean is typical along much of the coastline of West Hawaii, there is a high degree of variability in the effect of groundwater input to the ocean. The variability is a result of both topographic and geologic structure of the shoreline area, as well as mixing with marine waters by oceanographic processes in the nearshore zone. Such variability is evident in the differences between groundwater signatures at the six transect sites at Kahuku Villages. Transect Site KV-1, located at the northern end of the property displays values of Si and NO₃- that are two orders of magnitude higher than the shoreline value at Transects KV-4 and 6, located in the central-southern portion of the property.

Water chemistry parameters that are not associated with groundwater input (NH₄+, TON, TOP) show a pattern of decreasing concentration with respect to distance from the shoreline only on Transect KV-1. On Transects KV-2-6 concentrations of NH₄+, TON and TOP are generally similar throughout the horizontal range of the transects (Figures 2 and 3, Tables 1 and 2).

Similar to the patterns of dissolved inorganic nutrients, the distribution of Chl a also displays peaks near the shoreline with steeply decreasing gradients with distance from shore only on Transects KV-1 and 2 (Figure 3, Table 1). Turbidity did not show a pattern of elevated values in the samples collected near the shoreline. Turbidity of

all samples from the shoreline to the stations farthest from shore was consistently low, with a range of 0.05 to 0.24 NTU (Table 1, Figure 3).

2. Vertical Stratification

Tables 1 and 2 and Figures 2 and 3 also show concentrations of water chemistry parameters as functions of distance from shore in samples collected from surface and deep water. It can be seen in Tables 1-2, and Figures 2-3 that for the constituents that displayed distinct horizontal gradients, there is also distinct variation between surface and near-bottom (deep) samples. Surface values of Si and NO₃-were substantially higher than deep values, while corresponding values of salinity were lower in surface samples relative to deep samples. While the difference between surface and deep samples was not as large as with Si and NO₃-, there is also a slight indication of a pattern of differences in surface and deep concentrations of PO₄³-, but not for TOP and TON. Nearshore mixing of groundwater and ocean water creates a buoyant surface lens of low salinity, high nutrient water that is evident throughout the nearshore region fronting the project site (Tables 1 and 2). With the lack of physical mixing in terms of waves and currents (at least during the time of field sampling), the stratified water column persists along the entire length of some of the sampling transects off of the Kahuku Villages property.

Nutrient constituents not associated with groundwater input (NH₄+, DON and DOP) do not exhibit any consistent discernible relationship with respect to vertical stratification. Likewise, turbidity and Chl *a* also showed no consistent trend with surface values not consistently elevated relative to bottom values (Tables 1-2, Figure 3).

3. Anchialine Pool Water Chemistry

Water chemistry constituents (nutrients, salinity, pH and turbidity) from 10 anchialine pool water sampled in 2009 are shown in Tables 1 and 2, while results from samples from 6 pools sampled in 2011 are shown in Table 3. While it is recognized that water chemistry parameters in anchialine pools fluctuate at several time scales, it was beyond the scope of the present baseline survey to ascertain the absolute values of temporal fluctuation caused by diurnal tidal cycles, direct rainfall, solar warming, wind and possibly seasonal changes in groundwater discharge. Rather, chemical parameters were used to establish if the pools on the Kahuku Villages site fit within the "average" ranges of west Hawaii anchialine pools, or if they represent anomalous environments.

Salinities of all pools ranged from 4.4% to 6.1%. During both surveys salinities were measured at low tide so it can be expected that these values represent the low end of the range of tidal variation in ocean water dilution. Salinity can be expected to oscillate with the tidal cycle; at high tide salinity will be maximized owing to greatest inland excursion of seawater.

Maciolek and Brock (1974) found that the average salinity of 289 anchialine pools in West Hawaii was 7‰, while average salinity of the pools on the Kahuku Village site was 4.4‰ in 2009 and 5.1‰ in 2011. The slightly lower average for the Kahuku Village pools measured for this project relative to measurements in 1974 may reflect differences owing to state of tide, but it is appears that the Kahuku Village pools do not represent anomalies in terms of salinity.

In general, dissolved inorganic nutrient concentrations (Si, NO_3^- , PO_4^{3-}) of pond waters are substantially higher that ocean waters, while salinity was lower than ocean water (Tables 1-3). Concentrations of inorganic nutrients and salinity were of the same order of magnitude in all ponds. The average concentration of NO_3^- was 43.6 μ M, with a maximum value of 55.7 μ M and a minimum of 24.4 μ M. Average concentration of Si was 626 μ M, with a maximum value of 670 μ M and a minimum of 576 μ M. Of note is that turbidity and ChI a in ponds were generally similar to the values in nearshore ocean samples (Tables 1-2).

Sampling of ponds in 2011 showed some similarities and some differences between sample values from 2009 (Tables 1-3). While the average pond value of NO_3 - in 2011 (42.8 μ M) is very similar to 2009 (43.6 μ M), there are order of magnitude difference between years for PO_4 ³⁻ and NH_4 + with values in 2011 consistently lower. There is no apparent explanation of the large differences in PO_4 ³⁻ and NH_4 + between survey years. Average salinity in the ponds was very similar between sampling events (4.38‰ in 2009; 4.93‰ in 2011).

The pH of all pools was similarly representative of "normal" pond waters. The range of pH (7.99-8.27) indicates that metabolic activity is not generating CO₂ to an extent that the water column can be considered uninhabitable by pond organisms.

Inspection of the Kahuku Village anchialine pools indicated that water columns in all ponds were exceptionally clear. Even pools with surface algal mats had underlying clear water columns. Turbidity measurements in 2009 ranged from 0.07 to 0.20 ntu, with an average of 0.13 ntu. These low turbidity values also indicate that the pond water columns are largely devoid of suspended sediment and planktonic organisms.

The dominant trend in nutrient characteristics in anchialine pools is that concentrations of all inorganic nutrients [nitrate + nitrite ($NO_{3^-} + NO_{2^-}$), silica (Si), orthophosphate (PO_4^{3-})] are one to two orders of magnitude higher than ocean water (Tables 1-3). This pattern indicates the overwhelming contribution of groundwater, compared to ocean water, to the nutrient concentrations of anchialine pools. In addition, the concentrations of ammonium nitrogen(NH_4^+) which is an organic form of nitrogen, not typically found in high concentration in groundwater relative to ocean water, is also an order of magnitude greater in the pools than in most ocean samples. It is important to note that although nutrient

concentrations in the ponds are high, water column plankton concentrations are low, with the mean value of Chl a in ponds of $0.07\mu g/L$. While the elevated nutrient concentrations in the pools indicated that they are not nutrient limited, phytoplankton growth is restricted owing to the rapid turnover of water in the ponds relative to plankton growth rates. This characteristic of many young anchialine ponds is an important consideration in evaluating the effects of shoreline development on pond ecosystem function.

4. Conservative Mixing Analysis

A useful treatment of water chemistry data for interpreting the extent of material input from land is application of a hydrographic mixing model. In the simplest form, such a model consists of plotting the concentration of a dissolved chemical species as a function of salinity (Officer 1979, Smith and Atkinson 1992, Dollar and Atkinson 1992). The concept of using such mixing models which scale nutrient concentrations to salinity has been recently used by the State of Hawaii Department of Health for establishing a unique set of water quality standards for the West Coast of the Island of Hawaii [Hawaii Administrative Rules, §11-54-06 (d)]{although the geographical boundaries of these unique standards does not extend to the Ka'u district}.

Comparison of the curves produced by the distribution of data with conservative mixing lines provides an indication of the origin and fate of the material in question. If the parameter in question displays purely conservative behavior (i.e., no input or removal from any process other than physical mixing), data points should fall on, or near, the conservative mixing line. If however, external material is added to the system through processes such as leaching of fertilizer nutrients to groundwater, data points will fall above the mixing line. If material is being removed from the system by processes such as biological uptake, data points will fall below the mixing line.

Figure 4 shows plots of the concentrations of Si, NO₃-, PO₄³-, and NH₄+ as functions of salinity for the samples collected at each ocean transect station and anchialine pool in April 2009 and March 2011. Each graph also shows conservative mixing lines constructed by connecting the end-member concentrations of open ocean water deemed to be beyond the influence of land (collected 200 m offshore of Pohue Bay at a depth of approximately 33 meters), and groundwater concentration from an upland potable well located in Hawaiian Ocean View Estates (HOVE 0545-01).

Dissolved Si represents a check on the model as this material is present in high concentration in groundwater, but is not a major component of fertilizer or other man-made materials. In addition, Si is not utilized rapidly within the nearshore environment by biological processes. It can be seen in Figure 4 that data points for all ocean transect sites as well as all anchialine pools fall in a linear array on, or very close to the conservative mixing line.

Linear regression of the concentrations of Si as a function of salinity indicates that for all six transects, there are significant R² (proportion of variation explained) indicating that the concentration of Si is dependant on salinity (R² = 0.99; F=0.00). The Y-intercept of the regression of Si as a function of salinity can be interpreted as the expected concentration at a salinity of zero. As groundwater has salinity close to zero (0.537‰, Table 1-2), the Y-intercept can be used to evaluate the relationship between upslope groundwater and groundwater that is entering the ocean at the shoreline. For the potable Hawaiian Ocean View Estate (HOVE) well sampled upslope of Kahuku Villages, the concentration of Si was 679 μ M, which would equal a Y-intercept of 690 μ M. The upper and lower 95% confidence limits of the Y-intercepts of the regression lines of Si in ocean samples vs. salinity for the combined three transects are 731and 740 μ M, which is slightly higher than the intercept of the well and seawater concentrations. It is also apparent that there is no substantial difference in the slopes of mixing lines between samples collected in 2009 compared to 2011.

Concentrations of Si from anchialine pool water samples are also shown as functions of salinity in Figure 4. While all pool data points lie in the vicinity of the mixing line, there is a general trend of pool samples from 2009 lying slightly above the mixing line, while samples from 2011 lie below the mixing line. While the bounds of the confidence limits for the regression are slightly different than the value from a single well sample, this result still supports the assumption that Si is behaving as a conservative tracer and that well water sampled from the upslope well is similar in composition to groundwater entering the ocean and ponds at Kahuku Villages.

The plots of concentrations of NO₃- in ocean samples versus salinity show a slightly different distribution than Si, although the regression statistics are identical ((R2 = 0.99; F=0.00) (Figure 4). In general, most of the ocean data points for all transects fall below the mixing line. Only two data points from Transect 5 are on or above the line. In addition, there is distinct upward concave curvilinearity in the distribution of ocean data points. Such upward curvilinearity suggest biotic uptake within the nearshore ocean. Curvilinearity is most pronounced at the nearshore area of Transect site 1, which was located on the reef flat off of Kanonone Pond at the northern boundary of the Kahuku Villages property. The upper and lower confidence limits of the Y-intercepts of the concentrations of NO₃- for the combined six transects is 41.3-43.9 µM, while the concentration of NO₃ in upslope potable water is 57 µM. Hence it can be concluded that at present there is no subsidy of NO₃- to the ocean shoreline other than that of pristine unaltered natural groundwater. Rather, there is a depletion of NO₃ in the nearshore ocean relative to what would be expected from simple conservative mixing of groundwater and ocean water. With respect to the anchialine pools, data points plotting concentrations of NO₃- versus salinity fall in a wide array that are primarily below the mixing line. Such a wide distribution indicates that there are other processes besides mixing of ocean water and groundwater occurring in the ponds to alter the nutrient

composition. As most of the data points lie below the mixing line, it is likely that photosynthetic uptake of NO₃- is occurring in the ponds. The scatter of data points between sampling years suggests that there were no significant differences in pond chemistry between 2009 and 2011.

 PO_4^{3-} is also a major component of fertilizer and sewage. However, PO_4^{-3} is usually not found to leach to groundwater to the extent of NO_3^{-} , owing to a high absorptive affinity of phosphorus in soils or rock. It can be seen in Figure 4 that the difference in the concentrations of PO_4^{3-} in groundwater (0.50 μM) and ocean water (0.12 μM) are relatively small compared to the differences of two or three orders of magnitude between concentrations of Si and NO_3^{-} in groundwater and ocean water. As a result, the mixing line for PO_4^{-3} is nearly flat, and the data points from samples collected in the ocean area scattered above and below the mixing line. While the pattern for PO_4^{-3} is less pronounced than for Si and NO_3^{-} there is still a highly significant regression value ($R^2 = 0.82$, F = 0.001) indicating that the concentration of PO_4^{-3} is dependent on salinity.

When the concentrations of PO_4^{-3} in anchialine pools are plotted versus salinity, there is a substantial difference between 2009 and 2011. Data points from 2009 extend from the mixing line upward to a value of approximately 1.8 μ M, which is nearly three fold higher than would be expected on the basis of mixing of groundwater and ocean water. There is no such excursion of data points from pond samples collected in 2011. This pattern indicates that there were subsidies of PO_4^{3-} entering the ponds from sources other than naturally occurring groundwater in 2009 but not in 2011. The elevation of several of the ocean sampling points above the conservative mixing line in 2009 suggest the subsidy evident in the anchialine pools may have also been mixed into the nearshore ocean.

The other form of dissolved inorganic nitrogen, NH_{4^+} , shows a different relationship than Si and NO_{3^-} , but a similar relationship to PO_{4^-3} . Plots of concentrations of NH_{4^+} versus salinity exhibit only a weak linear trends with respect to salinity (Figure 4), although linear regression of concentrations of NH_{4^+} vs. salinity is significant ($R^2 = 0.73$; F=0.003). As with $PO_{4^{-3}}$, there is a distinct difference in the values of pond samples collected in 2009 and 2011, with substantially higher values in the earlier year. These results suggest that during 2009, some factor other than pure mixing of groundwater and ocean water was responsible for increasing the concentrations of $PO_{4^{-3}}$ and NH_{4^+} (but not NO_{3^-} and Si) in the anchialine pools. Whatever the cause of the subsidies, they were not apparent in 2011.

5. Compliance with DOH Criteria

Tables 1 and 2 also show samples that exceed DOH water quality standards for open coastal waters under "wet" and "dry" conditions. The distinction between application of wet and dry criteria is based on whether the survey area is likely to receive less than ("dry") or greater than ("wet") 3 million gallons of freshwater input

per mile per day. DOH standards include specific criteria for three situations; criteria that are not to be exceeded during either 10% or 2% of the time, and criteria that are not to be exceeded by the geometric mean of samples. All of these criteria area based on comparing replicate data sets collected as time-course series. So evaluation of the "10% or 2% of the time" and "geometric mean" criteria for the small data set presently acquired is not statistically meaningful. However, comparing sample concentrations to these criteria provide an indication of whether water quality is near the stated specific criteria.

Boxed values in Tables 1 and 2 indicate measurements which exceed the DOH 10% standards under "dry" conditions, while boxed and shaded values show measurements which exceed DOH 10% standards under "wet" conditions. On Transect 1, values of NO₃-, NH₄+ and TN exceeded both the wet standards within 2 m of the shoreline, and the dry standards within 10 m of the shoreline. On Transect 2, within Pohue Bay, values of NO₃- exceeded dry standards up to 50 m of the shoreline, while NH₄+ exceeded dry 10% standards up to 100 m from shore. No samples exceeded standards on Transects 4 and 6. No values of turbidity or Chlorophyll *a* exceeded any of the DOH standards.

As naturally occurring groundwater contains elevated nutrient concentrations relative to open coastal water (particularly for NO₃-, and TN), input of naturally occurring groundwater is likely a factor in the exceedances of DOH standards, as the general standards presently do not include considerations for such natural factors. As the area of study for this project consists of a pristine environment with respect to effects from human factors, the exceedance of DOH standards for open coastal waters reflect natural conditions. Considerations of the effects of naturally occurring groundwater mixing in the nearshore ocean have been applied to a special set of DOH standards for West Hawaii, although at present the geographical boundaries for these conditions does not extend to the Ka'u district, and as such they are not applicable to the Kahuku Villages project. If the West Hawaii specific criteria were applied to the data collected for the present assessment, there would be no exceedances for nitrate nitrogen, which is the chemical constituent that is most commonly affected by human land use activities. Thus, it is important to understand that exceedance of water quality standards does not necessarily indicate impaired waters, particularly in areas near the shoreline where measurable groundwater input occurs. State of Hawaii Department of Health Water Quality standards exempt anchialine pools from meeting specific water quality criteria, including inorganic nutrients, likely because it is well recognized that nutrient concentrations vary substantially in pool waters owing to groundwater input.

III. EVALUATION OF BIOTIC COMMUMITIES

A. METHODS

All field work was conducted using SCUBA equipment working from a 12-oot inflatable boat launched from the shoreline of Pohue Bay. Several methods were employed in the collection of qualitative and quantitative data. Qualitative reconnaissance surveys covering the entire coastal area fronting the development parcel were conducted by slowly towing a diver behind the boat. These surveys were useful in making comparisons between areas, identifying any unique or unusual biotic resources, and providing a general picture of the physiographic structure and benthic assemblages occurring throughout the region of study. Following the preliminary survey, six quantitative transect sites were surveyed offshore of the development area, at the approximate same locations as the water quality transects (see Figure 1). At each site, two line transects were conducted at areas deemed representative of the community which corresponded to the generalized major reef zones of West Hawaii. Each transect is designated by the station location and the depth. For example Transect 1-15 is located at station KV-1 at a depth of 15 feet.

Transects were 50 meters (m) (~165 feet) long and were oriented parallel to the shoreline. Beginning at the origin of the transect a surveying tape was laid out over the reef surface parallel to depth contours. A PVC quadrat frame with dimensions of one meter by two-thirds meter was sequentially placed over ten random marks on the transect tape so that the tape bisected the long axis of the frame. At each quadrat location a color digital photograph recorded the segment of reef area enclosed by the quadrat frame. In addition, a diver with knowledge of the taxonomy of resident species visually estimated the percent cover and occurrence of organisms and substrate types within the quadrat frame. Only macrofaunal species greater in size than approximately 2 centimeters were noted; no attempt was made to identify and enumerate cryptic species dwelling within the reef framework, or nocturnal species that inhabit the reef surface only at night.

Following the period of field work, quadrat photographs were projected onto a grid and units of bottom cover for each species and bottom type were calculated. This information was combined with the *in-situ* cover estimates and the combined assessment provided the data base for the benthic community structure analysis. Species diversity was calculated using the Shannon-Wiener Index, and can be equated with the equitability, or dominance, of distribution of the species occurring on each transect.

The practical advantages of photo-transects are numerous: most species can be easily and accurately identified from digital photographs, and the digitized data provides a permanent record for subsequent time-series comparisons. Also, photoquadrat sampling is rapid and efficient with respect to time and data collected, which is an important consideration under conditions where underwater time is restricted by cost and depth. All photo-quadrats are presented in Appendix A of this report.

Quantitative assessment of reef fish community structure was conducted in concert with the benthic assessments. As the transect tape was being laid along the bottom, all fishes

observed within a band approximately 2 m wide along the transect path were identified to species and enumerated. Care was taken to conduct the fish surveys so that the minimum disturbance by divers was created, ensuring the least possible dispersal of fish. Only readily visible individuals were included in the census. No attempt was made to seek out cryptic species or individuals sheltered deep within the reef framework.

Location of all anchialine pools was determined by walking the entire development shoreline and coastal zone. Each pool was numbered and classified according to pond type and size. In some instances where a group of ponds was connected, the point of division into separate ponds was somewhat arbitrary.

Anchialine pool biota was assessed by inspecting each pond and noting conspicuous fauna and flora. Observed species were categorized in four abundance classes (Rare; Uncommon; Common and Abundant). Ponds were disturbed as little as possible during collections so any organisms that inhabit the sediment column might have been overlooked. All ponds were surveyed during daylight hours, while representative ponds were inspected at night to ensure that all species groups present were observed.

B. RESULTS

1. Offshore Physical Setting

While the physical setting of the offshore region varies somewhat throughout the length of the development, most of the area is characterized by the typical descriptive pattern of the nearshore environments of West Hawaii (Dollar 1985, Dollar and Tribble 1995). The shoreline consists of either vertical sea cliffs formed when lava flows reached the sea, or sloping sand and cobble beaches. Several black sand and coral cobble beaches occur on the property, while Pohue Bay is the only well-defined white sand beach. Keliuli Bay is the only other well-defined shoreline feature consisting of a narrow steep-sided bay at the base of a cinder cone.

Underwater topography is characterized by a narrow basaltic shelf terminating in a shelf break that descends as a sharp sandy slope devoid of most biota that extends to abyssal depths. A characteristic of most of the offshore area is the paucity of reef flat or intertidal shallows, as most of the coastline drops off to a depth of 10 to 15 feet at the base of the shoreline cliffs. A relatively unique feature of the development area is the narrowness of the nearshore reef terrace or platform and proximity of the

reef slope drop-off to the shoreline. In many areas the nearshore platform is only 50 to 70 feet wide, and within 100 feet of the shoreline the offshore slope reaches depths greater than 200 feet.

The nearshore terrace is the major site of early reef development and provides the settling surfaces for reef corals, which comprise the dominant benthic biota. Near the shoreline in areas where lava flows have reached the ocean, topographic features such as caves and arches are common. The seaward edge of the nearshore reef terrace along much of the development shoreline is composed of steep vertical basalt cliffs. Figures 5 through 9 show representative characteristics of the offshore areas that are described above.

A final point in regard to the physical structure of the marine environment is that in general, the geologically young age of the island of Hawaii limits the development of true "cora1 reefs." Rather, the majority of offshore benthic ecosystems are more accurately "coral

communities". The distinction is that, for the most part, corals are growing on substrata composed of basaltic rock, rather than on calcareous rock of organic origin.

2. Benthic Community Structure

The majority of the offshore environment fronting the proposed Kahuku Village consists of the "typical" West Hawaii nearshore zonation scheme which has been described in detail by Dollar (1982) and Dollar and Tribble (1993). This zonation pattern is formed in response to the range of natural variability of environmental stress, predominantly wave energy, exerted on the different regions of the reef. Three zones, each characterized by a distinctive substratum type, depth range, range of physical conditions, and single dominant coral species make up the coral community. Twelve quantitative survey transects were conducted at 6 reef survey sites. Benthic community survey data are summarized in Table 4. Survey transects were selected to characterize the dominant zonation patterns of biota, primarily reef corals and reef fish communities. Overall, coral cover on all transects averaged 50.3% of bottom cover. Mean coral cover on the 15-foot depth transects was 45.6%, with a range of 32.6% to 56.5%. On the 30-foot deep transects, there was a mean of 55.0% coral cover, with transect cover ranging from 44.6% to 67.5%. Number of coral species on 15-foot transects ranged from 5 to 7, while on the 30-foot transects, number of species ranged from 3 to 7.

The most shoreward reef zone is comprised of the seaward continuation of the basaltic shoreline and boulder terraces. Owing to the shallow depth and proximity to the shoreline, this region receives most of the force of breaking waves and surge. In some areas very close to the shoreline, these forces are so extensive that corals and other macro organisms are essentially absent. Beyond the wave-break impact

zone coral cover can be considered extensive. *Pocillopora meandrina*, a sturdy hemispherical branching species is the dominant coral colonizer of the nearshore basalt platform. This species has a small adult colony size of short densely packed branches. Such a growth form is adapted to settle in areas too harsh, in terms of wave scour and physical abrasion, for other species and rapidly colonizes newly cleared surface. It is commonly found growing on the vertical walls of the sea cliffs and boulders near the shoreline (Figures 5 and 6). The shallowest transects (15 foot depths) at all of the Kahuku Village survey stations traversed such a *Pocillopora* meandrina-platform zone (Table 4A). In some regions of the nearshore reef, the seaward edge of basalt platform terminated in a vertical face several meters high that terminated in a lower reef terrace covered with accumulated fragments of broken coral colonies (Figure 5). Transect data revealed that transect coral cover in the shallow nearshore zone ranged from about 33% to 56% (Table 4A). Within the shallow zone, Pocillopora meandrina comprised about 22% of bottom cover and 48% of coral cover. The other dominant coral species that occurred in the nearshore zone was Porites lobata, which comprised about 16% of bottom cover and 36% of coral cover. Montipora capitata and M. patula accounted for about 5% of bottom cover and 13% of coral cover. Hence, these four species made up 97% of coral cover in the shallow nearshore zone (Table 4A).

Seaward of the edge of the shallow surge zones, the bottom is predominantly a flat basaltic terrace, interspersed with lava extrusions and sand channels. The reef terrace varies from about 200 to 400 feet wide, with a depth range of about 20 to 50 feet. As mentioned above, however, a characteristic of the Kahuku Village offshore region is a very narrow reef terrace. The major "reef-building" zone terminates in a sharp break in incline that continues as a deep reef slope. The dominant coral in this region is *Porites lobata* which assumes a variety of growth forms, although this area is colonized by the largest diversity of coral species (Figures 7 and 8). The most common growth forms are flat encrusting plates or dome-shaped structures. Some of these large dome-shaped structures are up to several meters in diameter and height, making them several centuries old and representing some of the largest colonies observed in the Hawaiian Islands (Figure 9). The occurrence of these huge colonies suggests that the area has not been subjected to the upper end of extreme storm events which result in the near complete removal of corals on nearshore reef terraces in West Hawaii (Dollar 1982).

Transects at the 30 foot depth traversed typical *Porites lobata*-reef bench environment. It can be seen in Table 4B that total coral cover in the *P. lobata*-reef building zone ranges from about 45% to 62% of bottom cover. Typically, at the seaward edge of the reef, bench, the slope of the bottom increases and substratum consists primarily of unconsolidated rubble and sand. These deeper parts of the reef bench and the upper reef slope (below about 60 feet in depth) provide the most stable environment in terms of destructive force from wave stress (Figure 9). In such areas of minimal wave stress where there is enough solid substrata for coral settlement to take place, the fragile branching species *Porites compressa*

(commonly called "finger coral") dominates bottom cover. In some areas *Porites* compressa covers the reef slope in the form of dense interconnected thickets that extend to a depth of approximately 60-90 feet, and can extend for hundreds of square meters. Coral cover in areas of these thickets is the highest on the entire reef. Transect 1-30 traverses an area with about 44% bottom cover of *Porites compressa* (Table 4B, Figure 8). While Porites compressa is a dominant coral on the reef shelf, Porites lobata is the species with overall highest cover on all of the 30-foot transects, accounting for 27% of bottom cover and 49% of coral cover. Pocillopora meandrina also occurs on the reef flat, but in much lower abundance than on the nearshore boulder areas (Table 4B). The mats of *P. compressa*, however, are highly susceptible to severe damage from breaking waves. Observations of damaged P. compressa thickets observed throughout areas of West Hawaii indicate recent impact of large breaking waves. While the extent of mats of *P. compressa* on the reefs off of Kahuku Villages is much reduced compared to other areas of West Hawaii only slight damage was observed indicating that the area is not heavily stressed by longperiod swells as other areas (e.g., Dollar 1982). Below the lower limit of extensive coral growth, bottom cover consists of expanses of white sand and rubble.

The major taxa of benthic organisms, other than corals occurring on the reef terrace off the Kahuku Village are sea urchins (Echinoidea) and sea cucumbers (Holothuroidea). By far the most abundant urchins are the two species that bore into limestone surfaces, *Echinometra matheai* and *Echinostrephus aciculatus*. In the shallow reef terrace zones, densities of these urchins are often on the order of 10 individuals per square meter. Less abundant, but ubiquitous across the entire reef are the larger species of urchins, *Tripneustes gratilla*, *Echinothrix diadema* and *Heterocentrotus mammilatus*. The most common of the sea cucumbers are the species *Holothuria atra* and *H. mauritiana*, which occur mainly on the outer reef terrace. Sea stars, predominantly *Linckia* spp. were observed sporadically over the

entire nearshore region. No crown-of-thorns starfish (*Acanthaster planci*) were observed during the course of the present survey.

Marine flora encountered was dominated by encrusting calcareous algae which covers bared basalt and limestone surfaces and the non-living parts of coral skeletons. The most

common forms of encrusting algae were *Porolithon* spp. and *Peysonellia rubra* which grows on the bases of *Porites compressa* branches. Frondose benthic algae are generally rare on the reefs of west Hawaii' and there were no areas of dense algal growth observed on the outer reefs off Kahuku Villages.

The design of the reef survey was such that no cryptic organisms or species living within interstitial spaces of the reef surface were enumerated. Since this is the habitat of the

majority of mollusks and crustacea (at least during the day), detailed species counts were

not included in the transecting scheme. However, no dominant communities of these classes of biota were observed during surveys at any of the study stations.

As a whole, the benthic communities offshore of the proposed Kahuku Village development represent an essentially pristine assemblage of typical Hawaiian reef organisms. With the exception of the occurrence of several extremely large colonies of *Porites lobata* on the reef bench, none of the communities represented what could be considered rare or unique ecosystem components.

3. Reef Fish Community Structure

A rich and diverse fish community, typical of West Hawaii was found in all reef areas off the proposed development. This community has been described in detail by Hobson (1974). The highest concentration of fish occurred at or near transects containing areas of greater bathymetric relief, especially along drop-offs, ledges, and large coral colonies.

A total of 66 species of fish were observed on transects; on a single transect species number ranged from 13 to 27, while individual fish encountered on transects ranged from 55 to 176 (Table 5). Inshore transects (15 feet) tended to have greater number of species but fewer individuals than deeper transects. The lower number of inshore fishes is probably a result of less habitat complexity compared to the outer reef area.

Several representative groups of reef fish were especially abundant on the Kahuku Villages reefs. Algal-feeding Acanthurids were the most numerous single group of fishes observed (284 individuals). At depths greater than 30 feet, the species *Zebrasoma flavescens* (yellow tangs), and *Ctenochaetus strigosus* (orange-eye) were particularly abundant. At shallower sites, *Acanthurus nigrofuscus* (brown surgeonfish) were the most common species.

Planktivorous damselfishes, principally of the genus Chromis, were also abundant (484 individuals). The species *Chromis hanui* and *C. verator* predominated at the outer edge of the reef shelf and into deeper water over the reef slope, whereas *C. vanderbilti* was the dominant species in shallow water. The triggerfishes *Melanichthys* spp. were commonly seen congregating in the water column. Juvenile reef fishes were most abundant at the deeper reef habitats within the matrix created by branching stands of *Porites compressa*. The lattice structure formed by this coral provides a sheltered refuge for small fish. Juveniles belonged mostly to the family Acanthuridae (surgeonfishes), with representatives from the families Labridae (wrasses), Mullidae (goat fishes), and Chaetodontidae (butterfly fishes). In areas where coral rubble was abundant, common fishes included the angelfish (*Centropyge potteri*), and several wrasses, notably *Pseudochilius tetrataenia* and *P. octotaenia*. A few large kahala (*Seriola dumerillii*) were also noted in the deeper regions of the reef.

Although the coastline along the project area harbors an abundant and diverse fish fauna, it is also apparent that the area is subjected to a surprising degree of fishing pressure considering the remote location of the site. Although individuals of the introduced blue-spotted grouper (*Cephalopholus argus*) were seen, size and abundances of fishes considered good "food fish" clearly indicated heavy fishing pressure. Relatively few carangids (i.e. jacks, papio) were sighted, although several small omilu (*Caranx melamphygus*) were sighted in inshore areas where water turbulence was high. Similarly, the scarcity of larger goatfishes and parrotfishes suggests that these species are impacted by fishing pressure. Inspection of rocky ledges and coral heads revealed fair numbers of squirrelfish, but less than would be expected in an unfished area. Few spiny lobsters were observed. Although limpets were large and abundant along particularly rugged parts of the coastline, substantial harvesting of this commercially valuable species had clearly occurred in areas which were accessible by land.

Fishing pressure is exerted in several forms. Carangids (Jacks) are a preferred target species of fisherman casting from shoreline cliffs. Several parties of shore fisherman camped on the cliffs south of Pohue Bay were observed during the course of the present survey. Significant spearfishing activity almost certainly occurs at reef sites easily accessible from the shoreline, such as Pohue Bay, and the beach fronting the "waterhole." Parrotfishes and larger surgeonfishes in these areas were especially wary of divers. Commercial fishermen are also known to work this area of coastline by setting gill nets in shallow areas and traps in deeper areas. Small boat fishermen are also reported to work the area at night during periods of calm weather using small feather lures to catch squirrelfish (mempachi). It also appears that the development area has been subjected to collection of reef fishes for sale to aquarium hobbyists, as several groups of target species were relatively rare (e.g., yellow tangs [Zebrasoma flavescens], and long-nosed butterflyfish [Forcipiger longirostris].

4. Threatened or Endangered Species

Three species of marine animals that occur in Hawaiian waters and have been declared threatened or endangered by Federal jurisdiction may be present in the vicinity of the project site. The threatened green sea turtle (*Chelonia mydas*) occurs commonly throughout Hawaiian waters including the Ka'u and Puna districts, and is known to feed on selected species of macroalgae. Surprisingly, no green sea turtles were observed at any point during the 2009 fieldwork. The endangered hawksbill turtle (*Eretmochelys imbricata*) is found infrequently in waters off West Hawaii. However, Hawksbills are known to nest in the area, and Pohue Bay is one of the study sites for the Hawaii Island Hawksbill Turtle Recovery Project. The annual report for the Hawksbill Recovery Project states that during the 2009 nesting season nine nests from two returning hawksbills were protected, and about 1,258 hatchlings

reached the ocean at Pohue Bay. The Pohue area has also been one of the subject areas for implementation of management strategies (Nesting Habitat Management and non-native plant control) under the Hawaii Island Hawksbill Turtle Nesting Habitat Management Agreement established by the US Fish and Wildlife Service. A stated goal of all planning for the Kahuku Villages project focuses on maintaining the long-term stewardship and preservation of natural resources such as Hawksbill turtles with the continuation of these management programs.

Populations of the endangered humpback whale (*Megaptera novaeangliae*) spend the winter months in the Hawaiian Islands. In general, however, it is not common for whales to occupy the very shallow nearshore areas that are the focus of this survey.

5. Anchialine Pools

Anchialine pools (or ponds) are shoreline depressions without surface connection to the ocean that contain water of measurable salinity. Salinity oscillates with tidal rhythm owing to inland excursion of the oceanic water table. Such ponds are known to occur around the world in lavas and elevated fossil reefs. In the Hawaiian archipelago, anchialine pools exist almost exclusively along the shorelines of West Hawaii and Southwest Maui. The term "anchialine" originates from the Greek "anchialos" meaning near the sea (Holthuis 1973).

Pond basins are related to structural and depositional features in shorelines formed from relatively young lava flows. Basalts formed from cooled lava are too porous to support ponded water above sea level; as a result all anchialine pools are located close to the shoreline in low lying areas where surface depressions intersect the water table. Such depressions are usually simple depositional features in a'a' and fractures or collapsed bubbles in pahoehoe. In areas with elevations greater than several meters above sea level, ponded water is found only in deep fissures or uncommon voids in lava structures.

Comparison of anchialine pools along the coast of west Hawaii reveals a definite successional process related in large part to rates of sediment deposition. Young pools are usually simply depressions in lava with no sediment cover and no associated plant life. Because pool waters are naturally high in dissolved nutrients owing to the composition of naturally occurring groundwater, aquatic and riparian plants are often found growing in older pools. In particular, blue-green algae (*Schizothrix* sp.) often form distinctive mineral crusts that line many ponds. Plant detritus, as well as wind-transported particulate material, gradually cause sediment layers to accumulate on the pond floors. Deposited sediment fills voids in the bottom of the pools, thereby restricting circulation and tidal flushing. The longer residence time of water in the depression promotes further organic production and increased sediment deposition. As sediments deepen, emergent plants such as sedges, rushes, and grasses take root and succulents and vines encroach from the

edges, eventually enveloping the original boundaries of the pools. Thus, the process of sediment deposition drives a feedback loop that accelerates increased rates of particulate production leading to increased residence time, and increased sedimentation rates. In the final stages of senescence, deposition of organic material completely fills the basin, transforming the anchialine pool into a marshy region generally covered with vegetation.

While anchialine pools represent a relatively unique Hawaiian ecosystem, it is only in the last several decades that comprehensive inventories of ponds have been assembled. Resort development along the coast of West Hawaii has raised concerns over the continued existence of the anchialine pool environments. A survey conducted by Maciolek and Brock (1974) described the location, environmental characteristics, and biota of 318 pools on the west coast of the Island of Hawaii. While many individual anchialine pool systems have been investigated, the work of Maciolek and Brock (1974) remains the most comprehensive investigation of Hawaiian ponds and serves as a principal reference for the present survey.

Figure 1 shows the locations of all 17 anchialine pools along the Kahuku Village coastline. The complex of pools numbered I-9 comprise the area known as the "waterhole," and represents the most substantial pond ecosystem on the property. Pools 10 through 17 are located near the central-southern end of the property, and constitute a complex of relatively young ponds in recent lava flows. All pools identified in the present survey were also identified by Maciolek and Brock (1974).

In the present survey, anchialine pools are classified by type according to overall structure and composition of the bottom (Table 6). Cracks or fissures that extend deep enough into the water table to retain brackish water are considered "A'a" pools. This category is characterized as depressions in lava rock with no significant growth of benthic macroalgae or vascular pond sediment accumulation. These pools represent the youngest phase of pond development. Seven of the pools identified within the Kahuku Villages project site are classed as A'a pools (8, 9, 10, 13, 14, 15 and 17).

"Orange crust" pools are similar to A'a ponds except that the rock bottom is covered, at least in part, by orange-brown mineralized crusts of the blue-green algae *Schizothrix* sp. This pond type was by a small majority the most abundant type in the Kahuku Villages complex; 8 of the 17 ponds contained "orange crusts" (2, 3, 4, 5, 6, 11, 12, and 16). "Sediment" pools contain bottom layers of unconsolidated mushy sediment up to 2 feet deep. The sediment appears to consist mainly of the calcareous and organic residue of *Schizothrix*, other pond plants, and debris from shoreline vegetation. While several of the pools had small accumulations of sediment, Pond 1 was the only "true" sediment pond encountered within the Kahuku Villages project site. One pond (7) contained a surface mat of slimy green algae that may be an alternate growth form of *Schizothrix* and probably contained a thick

bottom sediment layer.

Using the same criteria for size that was employed by Maciolek and Brock (L974), 3 ponds on the Kahuku Village site can be classed as "small" in size (less than 105 square feet), 6 as

"medium" (105-1056 square feet) and 8 as "large'" (greater than 1056 square feet)(see Table 6).

In general, the pools at Kahuku span the range of the pond "life cycle" with some appearing to be newly created consisting of bare rock surfaces, while others lined with sediments and in more advanced stages of senescence. It is somewhat perplexing why one pond contains a substantial sediment layer, while another pond, only several feet away, is completely devoid of sediment. As described above, the best hypothesis is that shallow ponds are flushed so effectively by tidal action that detrital material resulting from algae and other organic material does not accumulate as sedimentary material. Deeper ponds, will likely have a somewhat longer residence time are not as effectively flushed, and preferentially retain more algal detritus as sediment. Once initial sediment deposition takes place, porosity of the bottom rock is reduced and residence time is increased further, allowing sediment accumulation to progressively increase in the fashion of a positive feedback loop.

Anchialine pond biotic communities are characterized by a rather unique assemblage of organisms of relatively low species diversity. Maciolek and Brock (1974) listed 55 species of anchialine pool organisms, and considered 27 species "common" in Kona coast pools. Table 6 lists the species found in each of anchialine pools located on the Kahuku Villages property during surveys in 2009.

Many of the ponds were surrounded by dense vegetation consisting of grasses, trees, shrubs and vines. Specific identification of these plants is not included in the report. The most ubiquitous aquatic plant groups in Hawaiian anchialine pools are the orange mineralized algal crusts (*Schizothrix* sp.) that occur in shallow, low salinity ponds. Schizothrix crusts were observed in varying degree in all of Kahuku Village ponds. Ponds with at least some accumulated sediment (Nos. 2, 3 and 11) contained the vascular plant *Ruppia maritima*, commonly known as widgeon grass. Ruppia roots in the sediment, and forms clusters that may be exposed to air at low tide. The plant-like algae *Charra* spp. (commonly called Stonewort) occurred only in pool No. 3.

Of the species that Maciolek and Brock (1974) identified inhabiting anchialine pools, nine are considered "representative species" that comprise the major pond community components. Typically, the most abundant fauna of anchialine pools are mollusks (snails), crustaceans (shrimp) and fish. Maciolek and Brock (1974) classify four shrimp, three snails, and two native fish as being "representative" pond

organisms. Two of the shrimp species, *Halocaridina rubra* and *Metabetaeus lohena* are considered rare, found only in anchialine settings, but are normally the most common shrimp found in ponds. *Halocaridina rubra* is a small red shrimp, commonly called "opae'ula" that is herbivorous and is especially common in pools with at least some plant growth. *Metabetaeus lohena* is also a small red shrimp, but is larger than, and predaceous on *H. rubra*. The other two shrimp species, *Palaemon debilis*, a medium-sized transparent species commonly called "opae' huna" or "glass shrimp", and *Macrobrachium grandimanus*, a native prawn called "opae' oehaa" are found in estuaries and streams as well as in anchialine pools.

At least one of the four species of shrimp were present in each of the Kahuku Villages anchialine pools. *Halocaridina rubra* occurred either commonly or abundantly in all by two ponds (No's 1 and 7). *Metabetaeus lohena* was observed in twelve of the pools, but at lower levels of abundance than *H. rubra* (Table 6). *Palaemon debilis* was the least common shrimp and was observed in only four pools. However, *Palaemon debilis* was the only species of shrimp observed in Pool No. 1, which is the largest pool at the "waterhole" and is likely to be the pond affected most by human influence (i.e. campers, fishermen, etc.). However, there is no obvious reason why the pool should not be inhabited by the other common species of shrimp.

The three representative snails, *Assiminea nitida*, *Melanoides* sp. and *Theodolus cariosa*, typically found in tide pools and anchialine ponds throughout Hawaii were ubiquitous throughout the Kahuku Villages pond system. The only other invertebrates observed were several genera of Amphipods, which were distinguishable only as "gray" and "white" forms.

Fish inhabiting the anchialine pools were rare with the exception of Pool 1. Representative pond fish, *Eleotris sandwicensis*, a predaceous goby and *Kuhlia sandvicensis*, a silvery carnivorous fish commonly called "aholehole", as well as several damselfish (*Abudefduf* spp.) and a surgeonfish (*Acanthurus triostegus*) were observed in Pool No. 1. *Kuhlia sandvicensis* was the only typical anchialine pool fish that occurred elsewhere in the Kahuku Villages anchialine environment (No. 3 and 7) (Table 6).

It is noteworthy that exotic fish species (topminnows, tilapia and guppies) were not observed in any of the Kahuku Villages ponds. These introduced species, which can complete their life cycle within the pools, appear to be much more effective predators of shrimp than native fish. Pool complexes which contain these exotic fish species often are devoid of shrimp owing to intense predation by alien fish.

There has been, however, some subtle effects to native shrimp populations in the Kahuku Villages anchialine pools resulting from predation and competition by the non-native prawn *Macrobrachium lar*, which was found in 11 of the 19 pools (Table 6). There was no occurrence of the typical pond prawn *Macrobrachium*

grandimanus, and Palaemon debilis was observed only in pool complex 1-7, which exhibited the greatest marine influence. Pool No. 1 contained a relatively diverse group of fish compared to any other pond. Most of these fish are marine species that have probably been transported to the pool from large storm waves and have the ability to survive in the low salinity water of the anchialine pools. The complete absence of hypogean shrimp in pools 1 and 7 may be explained by the numerous predatory gobies observed. Of particular note was the presence of an unidentified eel found in pools 11 and 18 which has been observed by others in the past but not definitively identified.

Comparison of the present faunal inventory of the Kahuku Villages anchialine pools with the inventory compiled by Maciolek and Brock (1974) shows very similar species assemblages. *Schizothrix* was more abundant in the present survey compared to 1974, as were *Theodoxus* and *Assiminea*. Both surveys found *Halocaridina* ubiquitous, while native fish species were rare, and exotic fish were absent.

The observed abundance of all known shrimp species (although there is likely predatory effects from a non-native prawn), lack of exotic fish, and the relative absence of signs of modification by humans indicate that the Kahuku Villages pond complex remains essentially pristine and have not yet been noticeably affected by the activities of man.

IV. DISCUSSION and CONCLUSIONS

The purpose of this assessment is to assemble the information to make valid evaluations of the potential for impact to the marine environments from the proposed Kahuku Villages project. The information collected in this study provides the basis to understand the processes that are operating in the nearshore ocean, so as to be able to address any concerns that might be raised in the planning process.

The proposed Kahuku Villages project does not include any plans for any direct alteration of the shoreline or offshore areas. Therefore, potential impacts to the marine environment can only be considered from activities on land that may result in delivery of materials (primarily fresh water and nutrients) to the ocean through surface runoff or infiltration to groundwater on land with subsequent discharge to the ocean, and surface runoff. To evaluate the possible magnitude of these processes, a report has been prepared by Tom Nance Water Resource Engineering (TNWRE) entitled "Assessment of the Potential Impact on Water Resources of the Proposed Kahuku Villages Project in the Ka'u District of the Island of Hawaii" (dated May 2011). Below is a summary of the information provided in the TNWRE report, along with conclusions regarding the potential effects of the project on the marine environment.

The entire Kahuku Villages project site consists of unweathered a'a and pahoehoe lava flows which are devoid of any significant ash, soil, or vegetative cover. The predominance of porous lavas and lack of soil results in topography of extremely high permeability. Surface runoff as a continuous flow over any significant distance, even in the most extreme rainfall events, does not occur. Rainfall either evaporates or becomes groundwater recharge. Development of the project will create impervious surfaces from which localized runoff will occur. However, all such runoff would be directed into undeveloped open space or conveyed to subsurface disposal in dry wells or seepage pits, ultimately becoming groundwater recharge. As a result, there would be no surface runoff discharging directly into the ocean at the shoreline from the project site after it is developed. For this reason, there will be no effects to the marine environment as a result of direct surface runoff.

Thus, the assessment of the project's potential impacts on water resources focuses exclusively on groundwater. These potential impacts include: 1) withdrawal of groundwater from wells for various uses; 2) returns to groundwater in disposal wells; 3) returns to groundwater resulting from irrigation in excess of what is taken up by landscaping; and 4) the change in composition of rainfall that recharges the aquifer.

Water for the project would be supplied by three different systems: 1) a potable system for use within buildings and limited irrigation use; 2) a brackish system for all other landscape irrigation; and 3) a golf course irrigation system supplied by R-1 treated wastewater and supplemented, as needed, with water from the brackish irrigation system.

As a result of the relatively dry and limited area extent of the upgradient watershed, the flow of groundwater beneath the site is quite modest. Potable quality groundwater in limited quantities is only available near to and above Mamalahoa Highway from wells that would be about 2,000 feet deep and five miles from the project site. As a result of such limited availability of fresh groundwater, the potable system will be supplied by saline groundwater pumped from wells and treated for potable use by reverse osmosis (RO) high pressure filtration. Supply wells would be designed to draw water exclusively from beneath the brackish basal lens, so their salinity is expected to be in the range of 30-34‰. Product recovery through the RO process is anticipated to be about 40 percent, meaning the remaining 60 percent would be RO concentrate with a salinity of about 50-60‰ (for comparison, seawater is 34.8‰). The RO brine would be disposed of in wells designed to deliver the concentrate deeper into the saline groundwater zone than the raw water supply wells would draw from, thereby eliminating the possibility of recirculation of the concentrate back to the supply wells.

The brackish irrigation system would consist of a linear array of wells along the 1,000-foot elevation contour which would draw water from the top of the brackish basal lens. At full build-out of the project, six such wells would be required (one as standby) for landscape irrigation and to supplement the R-1 supply for golf course

irrigation. The golf course would be irrigated with R-1 treated wastewater and brackish well water, the latter as needed to supplement the R-1 supply. To approximate the required brackish water supplement, it is conservatively assumed that the quantity of R-1 that will be available for golf course irrigation reuse will be 60 percent of the projected within-building potable water use.

Based on the analysis of water from wells that have already been drilled in the region, and on geophysical studies conducted for the project, groundwater beneath the project site and extending inland above Mamalahoa Highway occurs as a basal lens in hydraulic contact with saline water at depth, and seawater at the shoreline. At inland locations just above and below Mamalahoa Highway groundwater is fresh (chlorides of 50 to 100 MG/L). Moving makai, the salinity of the basal groundwater increases. It is about 300 MG/L at the 1,000-foot elevation, and about 750 MG/L at the 600-foot elevation. Based on groundwater levels and temperatures in the existing wells, underlying groundwater is not a homogenous water body with a gradual, mauka-to-makai increase in salinity (See the 2011 TNWRE report for complete discussion of groundwater composition).

Based on what is known or can plausibly be presumed, the southwest rift zone of Mauna Kea is a barrier to groundwater flow. As such, it delineates the upper end of the watershed which contributes rainfall-recharge to basal groundwater that would be utilized and impacted by the Kahuku Villages project. For the purposes of this assessment, calculations of groundwater recharge have been made for a 4.25-mile wide, mauka-makai corridor which encompasses the entire width of the project site. Inland of the 1,000-foot elevation contour, along which the irrigation wells would be developed, the area of this corridor is 30 square miles. At the shoreline, the total upgradient watershed in this corridor is 45 square miles. Rainfall-recharge calculations approximate the recharge at 3.2 MGD per mile of width at the 1,000-foot elevation, and 3.7 MGD per mile of width as discharge into the ocean along the shoreline. These figures were used as the pre-development flowrates in the assessments of the project's potential impacts on groundwater.

A basic assumption is that groundwater in the inland portion of the watershed moves toward and ultimately discharges at the shoreline. During transit through the aquifer to the shoreline, dissolved nutrients (nitrogen and phosphorus) may be supplemented by natural or anthropogenic inputs, or may be consumed by natural processes (not considering removal by pumping). The project will utilize and alter the quantity and composition of the groundwater which resides at and below sea level, referred to herein as basal groundwater or the basal lens. The project will also use and change, with its RO feedwater supply and concentrate disposal, the body of saline groundwater which exists below the basal lens. With proper well design, impacts on these two groundwater bodies will be separate and distinct and are treated as such in the calculations of impacts which follow.

Estimates of the anticipated changes to the flow of basal groundwater discharging at the shoreline incorporate the following assumptions:

- The pre-development quantity of basal groundwater discharging along the 4.25-mile wide shoreline segment encompassing the project site is 3.7 MGD per coastal mile or 15.7 MGD.
- Withdrawals of basal groundwater from wells arrayed along the 1,000-foot elevation contour will range from 0.166 MGD in Phase 1 to 1.289 MGD at full build-out. These withdrawals will be for landscape irrigation, as well as a supplement to the R-1 treated wastewater for golf course irrigation.
- An allowance of 12% for leakage and unmetered use has been incorporated into the potable and irrigation system supply amounts. It has been assumed that all 12% of this allowance returns to groundwater.
- Irrigation return flow will amount to 10% of the amount of applied irrigation for: potable water used for landscape irrigation; brackish water used for landscape irrigation; and R-1 effluent and brackish well water applied on the golf course.

For this set of assumptions, the reduction in basal flowrate discharging along the project's shoreline would only be around 0.7% in Phase 1 but would increase to 5.2% in Phases 3 and 4.

The net consumptive use of saline groundwater would be about 0.18 MGD in Phase 1 and increase to about 1.1 MGD at full build-out. Unlike the limited supply of basal groundwater, the supply of saline groundwater is essentially unlimited and, with proper well design, the amount of its consumptive use will have no impact on the overlying basal groundwater.

As a result, the estimated changes to the nutrient levels discharging in groundwater along the project's shoreline incorporate the following set of assumptions:

- Nitrogen and phosphorus in fertilization of all landscaped areas, including the golf course, will be applied at 3 lbs/year/1000 ft² and 0.5 lbs/year/1000 ft², respectively. In reality, the use of R-1 effluent on the golf course could reduce the amount of applied fertilizer.
- About 10% of the applied nitrogen and 2% of the applied phosphorus in the fertilizer and in the irrigation water will pass below the plant root zone. The balance will be taken up and incorporated into vegetative matter. These percentages have been established for other golf courses in West Hawaii (Dollar and Atkinson 1992).
- RO-treated potable water will contain 10 μ M nitrogen and 0.15 μ M phosphorus.
- R-1 treated wastewater effluent will contain 2,000 μ M nitrogen and 150 μ M phosphorus. These concentrations are representative of existing R-1 treatment plants in the State of Hawaii.
- For both direct leakage and irrigation return, nutrients are naturally removed during the downward travel through the vadose zone (unsaturated lavas) and

movement with the basal groundwater to discharge along the shoreline. Removal of nitrogen and phosphorus by natural processes will be 80% and 95%, respectively. These percentages have been determined from empirical studies in other areas of West Hawaii.

• One-third of the 25 inches of annual rainfall over the 1,975-acre project site presently becomes groundwater recharge (that is equivalent to 1.22 MGD). As development occurs, the quantity of groundwater recharge will remain essentially the same but the nutrient levels in this post-development recharge will be increased by 70 μM nitrogen and 2 μM phosphorus. In reality, the limited data on the quality of surface runoff from developed areas in areas of Hawaii with similar ground composition as the project site indicates that increases in nutrient concentrations from runoff coming off the developed site will probably be less.

Based on these assumptions, the amount of nitrogen and phosphorus in groundwater withdrawn by the brackish wells will be greater than the amounts returned to groundwater by leakage from the three water systems, by irrigation return from landscaped areas, and by locally generated surface runoff that becomes groundwater recharge. Thus, it is important to note that the result of project buildout will be a reduction, rather than an addition of nutrients to the nearshore ocean. The projected reductions in discharges of nitrogen and phosphorus at the shoreline at full project buildout is about 4.2% and 5.6%, respectively. These projected net reductions of nitrogen and phosphorus are generally of the same magnitude as the projected reductions in groundwater flow discharging at the shoreline, resulting in very little, if any detectable change over the pre-construction scenario.

These results indicate that there will be little change over existing (pristine) conditions in the concentrations of nitrogen and phosphorus in groundwater discharging at the shoreline. The results of the analyses of nutrient concentrations in the nearshore regions presented in this report indicate that at present nutrient concentrations only show effects from input from land in the sub-tidal zone very close to the shoreline at selected locations. The offshore extent of these effects do not reach the area that constitutes viable "reef" habitats with accompanying biotic communities. In addition, nutrient subsidies from land are contained within a thin surface layer that does not come into contact with the reef surface. Hence, because there are no anticipated changes over the existing conditions, and existing conditions (communities) have been shown to not be affected by inputs from land, there is no potential for development of the project to cause changes to water chemistry in the offshore zones where biotic communities do presently exist.

Anchialine pools have been shown to be essentially de-coupled from the concentrations of nutrient in groundwater. Evaluation of anchialine pool water during this survey as well as numerous others along the coast of West Hawaii reveal extremely high levels of dissolved nutrients in pristine pond waters. Short residence times, as well as grazing by native pool organisms establishes a balance resulting in

high clarity of pond water and control of plant growth. The small projected changes in nutrient concentrations and loading from the proposed project will by themselves have no effect on anchialine pool physical and biotic composition. Rather, the factor relating to development that could result in alteration of the presently pristine nature of the anchialine pools is introduction of non-native species that disrupt the natural pool cycle by predative removal of native species.

During the construction phases, it is likely that permit regulations will limit the area of excavation at any one time, and require dust control measures. In addition, the predominant direction of wind (long-shore tradewinds) will not produce offshore winds that would carry construction-generated dust predominantly toward the ocean. As a result, there should be little potential for any significant input of sediment to the marine environment resulting from the proposed project.

In summary, results of the baseline assessment of the marine and anchialine pool environments off the proposed Kahuku Villages project site in the Ka`u District of the Island of Hawaii reveal an essentially pristine setting with little influences from the activities of humans. Groundwater flow to the ocean is restricted in both magnitude and area extent (both in terms of horizontal gradients from the shoreline and vertical gradients within the water column). Offshore coral reef communities consist of the assemblages typical of the west coast of Hawaii, although there is evidence of high fishing pressure. Anchialine pools on the property contain representative native organisms, with no evidence of alien fish. An engineering evaluation of all water supply and use for the project reveals that even at full buildout there will be no substantial changes in either groundwater flow rate to the ocean, or composition of groundwater. As groundwater presently has essentially no effect on existing marine communities, the small changes to groundwater fluxes associated with the project will have no negative impacts to the ocean. The major focus of the Kahuku Villages project centers on recognition, appreciation and long-term stewardship and preservation of the natural and cultural resources of the land. Thus, all activities associated with the project, from establishment of a Shoreline Conservation Management Area and Hawaiian Heritage Center will concentrate on maintenance of the existing pristine conditions. All of these considerations indicate that the proposed Kahuku Villages project will not have any significant negative effects on the anchialine pools or the coastal ocean offshore of the property.

IV. SUMMARY

1. Evaluation of the nearshore marine and anchialine pool environments off of the Kahuku Villages Project site in the Ka`u District of the Island of Hawaii was carried out in April 2009 and March 2011. As there is presently no substantial shoreline or upslope development in the area, the evaluation characterizes essentially the pristine condition of the area.

- 2. Assessment of water nearshore marine water chemistry was carried out by evaluating data from 92 water samples that were collected at six ocean transect sites and in anchialine pools along the shoreline. Water samples were collected on transects perpendicular to shore, extending from the shoreline to a distances of approximately100-200 m offshore. Analysis of fourteen water chemistry constituents included all specific constituents in DOH water quality standards.
- 2. Several dissolved nutrients (Si, NO_3 , PO_4 , TN and TP) displayed strong horizontal gradients at several ocean transect sites with highest values closest to shore and lowest values at the most seaward sampling locations. Correspondingly, salinity was lowest closest to the shoreline, and increased with distance from shore. These gradients were most pronounced at the northern boundary of the project site off the Kanonone Pond area and Pohue Bay, and weakest on the transects off the central-southern region of the project where the shoreline is composed of basalt cliffs. These patterns are indicative of groundwater efflux at the shoreline, producing a zone of mixing where nearshore waters are a combination of ocean water and groundwater.
- 3. Water chemistry constituents that are not major components of groundwater (TON, TOP) did not display as distinct gradients with respect to distance from the shoreline, or depth in the water column. Chl a was elevated in nearshore samples only on transects off of Kanonone Pond and Pohue Bay with decreasing values moving seaward. Turbidity did not vary throughout the sampling regime, and was essentially constant at low values from the shoreline to the stations farthest from shore.
- 4. Water chemistry constituents that displayed distinct horizontal gradients also showed distinct variation between surface and near-bottom (deep) samples, with higher nutrient values and lower salinity in surface water relative to bottom water. Nearshore mixing of groundwater and ocean water creates a buoyant surface lens of low salinity, high nutrient water that is evident throughout the nearshore region fronting the project site.
- 5. The coastal area of Kahuku Villages contains a series of anchialine ponds. These ponds have no surface connection to the ocean, and are essentially an atmospheric exposure of the water table. Water within the ponds consists of a mixture of seaward flowing groundwater and landward flowing seawater, and as such the composition of water within the ponds responds to tidal changes. Measured salinities of 4-5‰ indicate pond water consisted of about 10-15% ocean water and 85-90% with corresponding nutrient concentrations with respect to mixing of groundwater and open coastal waters. For unknown reasons, water samples collected in 2011 had consistently lower values of PO₄3- and NH₄+ than samples collected from the same pools in 2009. Water clarity in all anchialine pools was exceptionally good, indicating that even though nutrient concentrations are

elevated, plankton blooms are not occurring in anchialine pools. The lack of plankton growth in the presence of high nutrients is a result of short residence time of water in the pools, and grazing by native pond biota.

- 6. Application of a hydrographic mixing model to the water chemistry data was used to indicate if increased nutrient concentrations in nearshore waters are the result of mixing of natural groundwater with oceanic water, or are the result of inputs from activities on land. The model indicates that at the time of sampling there were no external subsidies of NO₃- nitrogen to the ocean at any of the ocean transect sites, indicating that the observed horizontal gradients are the result of natural processes of mixing of groundwater and ocean water.
- 7. Evaluating water chemistry from the single sampling in 2009 using DOH specific criteria for Open Coastal Waters indicates many of the measurements in the nearshore areas off the Kanonone Pond and Pohue Bay areas exceed standards, particularly for NO₃-. As these standards do not take into consideration of mixing of high nutrient groundwater with ocean water in the nearshore zone, such exceedances are expected. Area specific DOH water quality standards for West Hawaii do not presently extend to the Ka`u District. If the West Hawaii specific criteria are applied to the data collected off of the Kahuku Villages site, there would be no exceedance of the standards.
- 8. Characterization of the existing marine communities was carried out traditional photo-transect and visual censusing methods. The physical structure of the nearshore marine habitat consists of a narrow reef bench or terrace that terminates in a slope that extends to abyssal depths. Coral communities in the area are typical of the assemblages found throughout West Hawaii, with the reef bench populated predominantly by two major species (*Pocillopora meandrina* and *Porites lobata*). Overall coral cover in the area was about 50% of bottom cover, with all areas of hard bottom beyond the surf zone occupied with healthy coral. A distinguishing feature of the reef was the occurrence of several exceptionally large colonies of *P. lobata* on the order of several centuries old. Overall, coral communities in the area are flourishing, with little indication of any reduction from any stress conditions, including catastrophic storms. Populations of reef fish in the area also appeared typical of West Hawaii reefs, although there was evidence of high fishing pressure. The nearshore habitats of the Kahuku Villages site also represents an important area for nesting of Hawksbill turtles.
- 9. Observations of anchialine pool biota indicated the presence of all representative native species (particularly shrimp), and importantly, a lack of exotic fish species. Invasive exotic species have been shown to be a major factor in degradation of anchialine pools in other areas of West Hawaii.
- 10. Engineering analysis indicate that there will be only small reductions in both groundwater discharge and nutrient discharge to the nearshore ocean over present

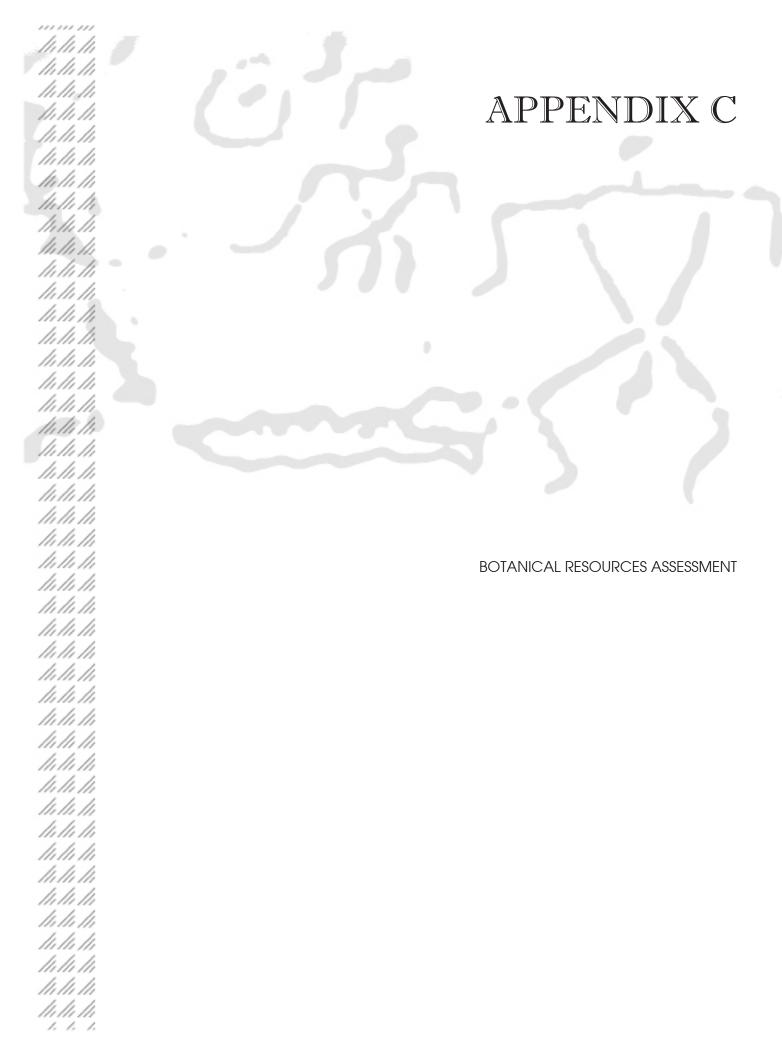
conditions with full build-out of the planned project. As the results of the assessment of existing marine environment indicates that at present groundwater has essentially no effect on marine community structure, the small changes in groundwater dynamics associated with the project do not present a mechanism for future negative effects.

- 11. Overall, results of the water chemistry analysis and characterization of marine and anchialine pool biotic communities indicates that the Kahuku Villages area probably represents as close as possible to a pristine coastal area unaffected by most activities of man. Planning of the Kahuku Villages project focuses on continued maintenance and stewardship of these natural resources to preserve them in the present pristine condition. As a result, as long as best management practices are utilized to avoid any unforeseen impacts during the construction and operational phases of the project, there is no rationale to indicate the potential for negative impacts to the marine and anchialine pool environments.
- 11. The studies conducted for this report, particularly the water quality analyses, can serve as an initial baseline for any monitoring programs that may be required for the project.

V. REFERENCES CITED

- Dollar, S. J. 1982. *Wave stress and coral community structure in Hawaii.* Coral Reefs 1:71-81.
- Dollar, S. J. and M. J. Atkinson. 1992. Effects of nutrient subsidies from groundwater to nearshore marine ecosystems off the Island of Hawaii. Est. Coast. Shelf Sci. 35:409-424.
- Dollar, S. J. and G. W. Tribble. 1993. *Recurrent storm disturbance and recovery: a long-term study of coral communities in Hawaii.* Coral Reefs. 12:223-233.
- Grasshoff, K. 1983. Methods of seawater analysis. Verlag Chemie, Weinheim, 419 pp.
- Holthuis, L.B. 1973. Caridean shrimps found in land-locked salt water pools at four Indo-west Pacific localities (Sinai Peninsula, Funafuti Atoll, Maui and Hawaii Islands), with the description of one new genus and four new species. Zool. Verh. No. 128.
- Maciolek, J.A. and R. E. Brock. 1974. Aquatic survey of the Kona Coast Ponds, Hawaii Island. Sea Grant Advisory Report UHIHI-SEAGRANT-AR-74-04.

- Officer, C. B. 1979. Discussion of the behavior of nonconservative dissolved constituents in estuaries. Est. Coast. Mar. Sci. 9:569-576.
- Smith, S. V. and M. J. Atkinson 1993. Mass balance analysis of C, N, and P fluxes in coastal water bodies, including lagoons. Coastal Lagoon Processes. (ed) B. Kjerfve, Elsevier Oceanography Series, 60. pp. 123-145.
- Strickland J. D. H. and T. R. Parsons. 1968. A practical handbook of sea-water analysis. Fisheries Research Bd. of Canada, Bull. 167. 311 p.



BOTANICAL RESOURCE ASSESSMENT FOR THE PROPOSED KAHUKU VILLAGE PROJECT KAHUKU, HAWAII

Prepared by:

Maya LeGrande LeGrande Biological Surveys Inc 68-310 Kikou Street Waialua HI 96791

> Prepared for: Nani Kahuku Aina, LLC 99-880 Iwaena Street Aiea Hawaii 96701

TABLE OF CONTENTS

INTRODUCTION	3
GENERAL SITE DESCRIPTION	3
DESCRIPTION OF VEGETATION	3
Methods	3
Vegetation	4
Makai Portion	4
Mauka Portion	6
DISCUSSION & RECOMMENDATIONS	7
FIGURES	
Fig 1. Rare plant data from HBMP	9
Fig 2. Makai Vegetation Zones	10
Fig 3. Mauka Vegetation Zones	11
LITERATURE CITED	12
TABLES	
Table 1. Plant Species List	13
Appendix	
Site photographs	
7 1	19

INTRODUCTION

This report includes the findings of a plant inventory conducted in Kahuku on the island of Hawaii including portions of a parcel owned by Nani Kahuku Aina LLC (NKA) [TMK (3) 9-2-001:072]. LeGrande Biological Surveys Inc. carried out a botanical field survey of the above location on the 8th, 9th, and 10th of December 2010 and 3rd, 4th, and 5th of January 2011. The primary objectives of the field studies were to:

- 1) inventory the flora and;
- 2) provide a general description of the vegetation on the project site;
- 3) search for threatened and endangered species as well as species of concern; and
- 4) provide recommendations regarding potential impacts to the biological resources of the area in regards to the proposed development of the survey area.

Federal and State of Hawaii listed species status follows U.S. Fish and Wildlife Listed and Candidate Species (USFWS 2008and Federal Register (2002).

GENERAL SITE DESCRIPTION

The survey area is located in Kahuku, Ka'u District near South Point on the island of Hawaii. The subject property extends from an elevation of approximately 2000 feet at Mamalahoa Highway makai to the coast. To the northwest the property borders Ocean View Rancho Estates and a parcel owned by Kamehameha Schools borders the NKA property to the southeast. The property is composed of pahoehoe and a'a lava without much soil substrate, therefore, much of the property is barren and plants are concentrated near coastal areas with brackish ponds and the mauka areas near the highway that support a pioneer 'ohi'a forest. The survey area consisted of an approximately 2,500 acres.

METHODS

Topographic maps were examined to determine terrain characteristics, access, boundaries, and reference points. Prior to undertaking the field studies, a search was made of the pertinent literature to familiarize the principal investigator with other botanical studies conducted in the general area. Historical plant locations were reviewed from data provided by Hawaii Biodiversity & Mapping Program. Historical locations of two rare plant species are mapped and include *Pleomele hawaiiensis* and *Ophioglossum concinnum*. A flora survey conducted by Char & Associates in 1987 (Char, 1987) for the previous owners of the subject property was reviewed for possible plant taxa that might be encountered during this survey. The main differences between the 1987 survey and the present one is the survey area for the 1987 study was larger (3,200 acres) than the one conducted for this report (2,500 acres). Also, the "Mauka" location was relocated and the "Makai" survey area included an additional TMK to the north that was not included in the present survey.

A walk-through survey method was used. The field survey included 2 separate portions of the TMK parcel, the "Mauka" section consisting of about 100 acres and a "Makai" section consisting of about 1,500 acres. The survey concentrated on areas where plants were locally abundant, i.e. around coastal ponds and pockets of soil found within the lava fields. Transects through the mostly barren lava fields were walked roughly north-south at an average of 20 meters apart within the project boundary as occasional plants were observed scattered throughout

the lava fields. Although a road alignment was proposed on the project map, surveying for the alignment during the present survey was not undertaken as no stakes or GPS points were available. Pinpointing the exact location of the roadway in the rugged terrain would be difficult and an accurate survey of the route would not be ensured. Notes were made on plant associations and distribution, disturbances, topography, substrate types, exposure, drainage, etc. Plant identifications were made in the field; plants that could not be positively identified were collected for later determination in the BISH herbarium, and for comparison with the recent taxonomic literature.

VEGETATION

The two survey areas differ in vegetation type due to several factors including substrate type, elevation, and rainfall amounts. The entire survey area is characterized by barren a'a and pahoehoe lava, composed of prehistoric lava flows, an 1887 and 1907 lava flow. Pockets of thin topsoil or ash and cinder and some sandy beach areas support most of the plant life. The Makai portion encompasses a rugged five mile coastline which includes several anchialine and tidal pools, and a few sandy beaches. Elevations range from sea level to 200 feet. The Mean Annual Rainfall is reported to be 20-30 inches per year. The NRCS Soil Survey shows the Makai site as being composed of either Lava Flows a'a (rLV) or pahoehoe (rLW) with pockets of Cinder land (rCL) and sandy Beaches (BH) (NRCS, 2010).

The Mauka portion is located on a prehistoric lava flow bordered by a section of the 1907 flow to the east. The dominant vegetation type is a Pioneer 'Ohi'a Forest with a small pocket of Lama Forest located in the northwestern corner of the survey area. Elevations range from 1660 feet to 1870 feet. The annual rainfall for the Mauka portion is 40-60 inches per year. The NRCS Soil Survey describes the substrate at the Mauka site as Lava Flows, a'a (rLV). (NRCS, 2010).

There are a total of 83 plant species observed within the survey sites. 48 are alien (introduced), 22 are indigenous (native to the Hawaiian Islands and elsewhere), and 13 are endemic (native ONLY to the Hawaiian Islands). Therefore, 58% of the plant species observed are alien and 42% are native. An inventory of all the plants observed within the survey area is presented in the species list (Table 1) at the end of the report.

MAKAI PORTION (Proposed Makai Village and Hawaiian Heritage Center)

Coastal Vegetation

The coastal vegetation can be found clustered around the anchialine and tidal pools and at the few sandy beaches along the mostly rocky coastal cliffs that dominate the five miles of ocean front within the survey area. Vegetation scattered along the rocky coastal areas is scant and includes plants such as pigweed (*Portulaca oleracea*), akulikuli (*P. pilosa*), fountain grass (*Pennisetum setaceum*), and uhaloa (*Waltheria indica*). The highest densities of vegetation by far are found at the unnamed 'northern pond', Kanonone pool complex, Haliipalala ponds, and Pohue Bay. Tree species at these areas include, coconut (*Cocos nucifera*), milo (*Thespesia populnea*), kou (*Cordia subcordata*), and hala (*Pandanus tectorius*). One tropical almond (*Terminalia catappa*) tree is located at the Haliipalala pond. Several shrubs including Christmas Berry (*Schinus terebinthifolius*) and sourbush (*Pluchea carolinensis*) form thick masses around sections of some of the ponds.

An introduced morning glory (*Ipomoea violacea*) can be found growing over much of the low growing shrubs at both the northern and Kanonone ponds. Other Weedy species mixed in amongst the pond and beach vegetation include natal redtop (*Melinis repens*), love-in-a-mist (*Passiflora foetida*), buffelgrass (*Cenchrus ciliaris*), common sandbur (*C. echinatus*), and *Boerhavia coccinea*.

Several native sedges, mau'u 'aki'aki (Fimbristylis cymosa subsp. umbellato-capitata), makaloa (Cyperus laevigatus), and 'uki (Cladium jamaicense) are dominant along with the hala at the edges of the brackish ponds. The mau'u 'aki'aki can also be found scattered along the rocks between the ponds. Several of the ponds have submerged masses of the native widgeon grass (Ruppia maritima), a native aquatic flowering plant. A native morning glory, pohuehue (Ipomoea pes-caprae subsp. brasiliensis) is the dominant groundcover at the ponds as well at the sandy beaches of Pohue Bay, Haliipalala, Kahakahakea, and Kahiola. A few pua kala or native poppies (Argemone glauca) were located at Pohue Bay.

Cinderland Vegetation

Sections of the coastline are characterized by cinderland; formed when hot lava reached the sea and the explosive reaction threw debri up into the air and formed littoral cones composed of fine ash and cinder material (Macdonald & Abbott, 1970). Plant densities rise in the cinderland areas compared with the a'a and pahoehoe dominated regions as the plants have better substrate for growing. The areas around Pu'u Ki and Pu'u Kahakahakea are composed of cinderland. The dominant species observed within these areas include introduced grass species such as lovegrass (*Eragrostis amabilis*), fountain grass, natal redtop, and barbwire grass (*Cymbopogon refractus*). The native uhaloa was by far the most abundant plant observed in this vegetation type. Other native plants observed in the cinderland, but rarely seen, include pua kala and kakonakona grass (*Panicum torridum*).

A large depression just inland of Pu'u Ki greened after the Decmeber 2010 rains, sprouting with an introduced sedge Bulbostylis capillaries. The sedge was observed throughout the property during the follow-up January 2011 survey in areas that pooled water and had sufficient ash.

Lava

Large portions of the makai survey area are covered with pahoehoe and a'a lava fields. Much of this substrate type is devoid of vegetation, but several hardy plant species such as sourbush, natal redtop, and uhaloa are scattered sparsely throughout. Several large ground cracks were found during the survey in the lava fields most with water in the bottoms. Several were large enough to be investigated by lowering oneself down into the crack and then following for a ways until it closed up or became to narrow to navigate. Individuals of the introduced sword fern (*Nephrolepis brownii*) were scattered along the internal walls of the cracks along with lovegrass.

A depression of pahoehoe and a'a at an interface between the 1887 lava flow and Kahakahakea was dominated by sourbush. During the January survey a population of nohu (*Tribulus cistoides*) was discovered to have sprouted after the rains. Other plant species observed growing in the lava fields include tobacco (*Nicotiana tabacum*) and silverfern (*Pityrogramma calomelanos*).

MAUKA PORTION (Proposed Civic Uses)

Pioneer 'Ohi'a Forest

The survey area for the proposed civic uses is located at the northwestern corner of the subject property with the northern boundary bordered by Mamalahoa Highway. A prehistoric lava flow of a a dominates the survey area. Unstable, sharp blocks of a a and sometimes steep terrain make hiking across the lava slow and difficult. The dominant tree, 'ohi'a lehua (*Metrosideros polymorpha* var. *incana*) is sparsely scattered throughout the survey area. Two other native tree species were encountered in the open lava. One mature maua (*Xylosma hawaiiense*) and one mature kolea (*Mysine lanaiensis*) with several smaller trees clustered around it were growing together at the southeastern corner of the survey area. They were both about 25 to 30 feet tall and multibranched. Plant associated with the maua and kolea are Christmas berry, broomsedge (*Andropogon virginicus*), buffelgrass, 'ohi'a lehua, and 'a'ali'i (Dodonaea viscosa).

Other plants encountered in the open lava include molasses grass (*Melinis minutiflora*), sourbush, lantana (*Lantana camara*), huehue (*Cocculus orbiculatus*), pukiawe (*Leptecophylla tameiameiae*), 'ala'alawainuiwahine (*Plectranthus parviflorus*), and 'ena'ena (*Pseudognaphalium sandwicensium* var. *sandwicensium*). Native ferns and fern allies observed were *Nephrolepis cordifolia*, kalamoho (*Pallaea ternifolia*), kumuniu (*Doryopteris decipiens*), and moa (*Psilotum nudum*).

Along the highway several additional weedy species were prevalent including flora's paintbrush (*Emilia sonchifolia* var. *sonchifolia*), *Sida rhombifolia*, smutgrass (*Sporobolus indicus*), and knotweed (*Persicaria latifolia*). Native plant species along the roadways were ilima (*Sida fallax*), 'a'ali'i and pawale (*Rumex skottsbergii*).

Lama Forest

The richest area in terms of native plant species and density occurs at the northwestern corner of the mauka survey area. In a relatively small area, roughly 30 by 50 feet, is a small natural ravine that has been isolated by roadway building. Mamalahoa Highway borders the ravine to the north, the main gravel road to the coast borders it to the west, and areas of flattened a`a are to the south and east. The pocket of vegetation is dominated by natives such as lama (*Diospyros sandwicensis*), `ohi`a lehua, mamane (*Sophora chrysophylla*), `ulei (*Osteomeles anthyllidifola*), kolomona (*Senna gaudichaudii*), and kulu`i (*Nototrichium sandwicense*). A dozen or so lama trees up to 15 feet in height are scattered around the edges of the forest. Nearly every lama tree has a kulu`i shrub growing at the base or very near the base of the tree. Kolomona, an increasingly uncommon native, is relatively abundant and healthy in the area. The kolomona were in flower and fruit and the seed appeared to be viable.

One mature individual of halapepe (*Pleomele hawaiiensis*) is growing in the Lama forest. The tree is about 25 feet tall and has multiple branches about half way up the trunk. The base of the trunk is split and appears that only half of it is alive. The individual looks to be in fairly good health and had recently flowered and fruited. No fruit were left on the inflorescences, and a ground search was made to locate any fruit or seed, none were found. *Pleomele hawaiiensis* is listed as <u>Endangered</u> by the U.S. Fish and Wildlife Service (USFWS, 2008). 'Endangered' is defined by the USFWS as an animal or plant in danger of extinction within the foreseeable future throughout all or a significant portion of its range. Listing a species can provide it with additional

protection and funding opportunities for preservation. An overview of what listing a species entails can be found here: http://www.fws.gov/endangered/what-we-do/listing-overview.html.

DISCUSSION & RECOMMENDATIONS

The survey area is dominated by large expanses of lava that are nearly devoid of vegetation. Most of the vegetation is concentrated around the coastal ponds, sandy beaches, and in the Lama Forest at the northwestern corner of the Mauka portion. Although, a little over half of the plant species observed within the subject property are introduced (58%), the density of native vegetation near the coastal pools and in the Mauka Lama Forest is still significant. Threats to the native plant components include drought and feral goats. The present survey was conducted after a prolonged drought for the entire state. The average rainfall ranges from 20 to 30 inches for the Makai portion of the survey area, but only 8.5 inches had been recorded for the year in December, only 26% of the average rainfall. The follow up survey in January was conducted after two heavy rainfall events and many plants that had not been observed during the December survey had sprouted and/or flushed so additional identifications could be made. No doubt after further precipitation in the area, more species would be located that were not found during the present survey.

An extreme number of feral goats were observed during the present survey. Goats eat just about any type of greenery and can eat plants down to the roots. Several of the plant species that Winona Char described as being abundant in the coastal area during her 1987 survey were not located during this survey. The length of time that has gone by since Char's survey coupled with the drought and goat pressure could explain some of the extirpations. Additionally, Char's survey area was larger and included a large section of land to the west that was not included in this survey.

The Makai portion of the property slated for the resort development has significant natural resources at the coastal ponds, tidal pools and sandy beaches. Although no rare or endangered plant species were located near these locations, the habitats are essential to the animals and invertebrates that utilize them. Pohue Bay is an important turtle nesting site and the vegetation helps to stabilize the sandy strand which the turtles bury their eggs in. The anchialine and tidal ponds found at northern pond, Kanonone, Haliipalala, and Kahakahakea are exceptional ponds that deserve protection from impacts such as increased use by humans, further invasive plant introductions, runoff into pools that could effect the current state that supports native biota such as the 'opae 'ula, damselflies, and sedges. These ponds have been rated by Maciolek and Brock (1974) as having exceptional natural value based on physical structure, diversity, representative aquatic communities, and unusual endemic species.

The plant communities expected to be impacted by a development in the Makai and Mauka portions of the property include the coastal pond vegetation, the cinderland vegetation, portions of the Pioneer 'ohi'a forest and the Lama Forest. Mitigation measures for these areas would include:

 Creating a buffer or conservation zone around the coastal ponds and sandy beaches and limiting access from the resort areas. The anchialine ponds and the sandy beaches of Pohue Bay and Haliipalala where turtles nest will be impacted depending on the amount and intensity of human disturbance. In order to maintain the current natural resources of the project area, the least amount of human disturbance would be desirable. The buffer zones around these areas should include the ponds and beaches with visitors able to view these areas from designated walkways.

- Several invasive plant species have become established in and around the pond and beach areas. Active management to eradicate these species should be undertaken at the earliest convenience. The plant species to be targeted for eradication include; sourbush (*Pluchea carolinensis*), love-in-a-mist (*Passiflora foetida*), and fountain grass (*Pennisetum setaceum*).
- Landscaping around the Makai Village should include, or be limited to, native plant species including species that are already present and common native coastal species such as naupaka (*Scaevola sericea*), ilima (*Sida fallax*), and maiapilo (*Capparis sandwichiana*).
- The Lama Forest in the Mauka Portion should be excluded from development to protect the native elements found there. The density of native plants within this small area would make it worthwhile and manageable to implement a management plan. At minimum, the removal of weedy plant species including the large sisal plants, lantana, fountain grass, and Christmas berry should be carried out. Care should be taken while plant removal is ongoing as many of the native plant species in the area are small and mixed in with the tangle of weeds. Fencing the area would keep the goats from grazing and trampling smaller plants and seedlings. The Endangered halapepe individual would benefit from management of the Lama Forest. Interested state and federal parties could participate in collecting propagules of the rare plant elements to be used in outplantings either on site or at appropriate satellite areas.
- Implementing an ongoing hunting program for extant feral goats that are abundant on the property. Focusing eradication efforts at the coastal sites where plant grazing was most evident.

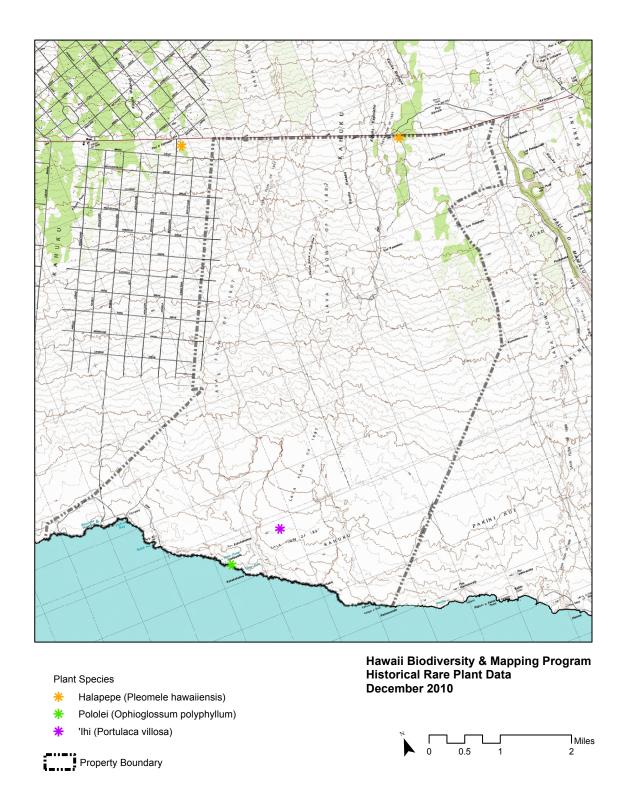
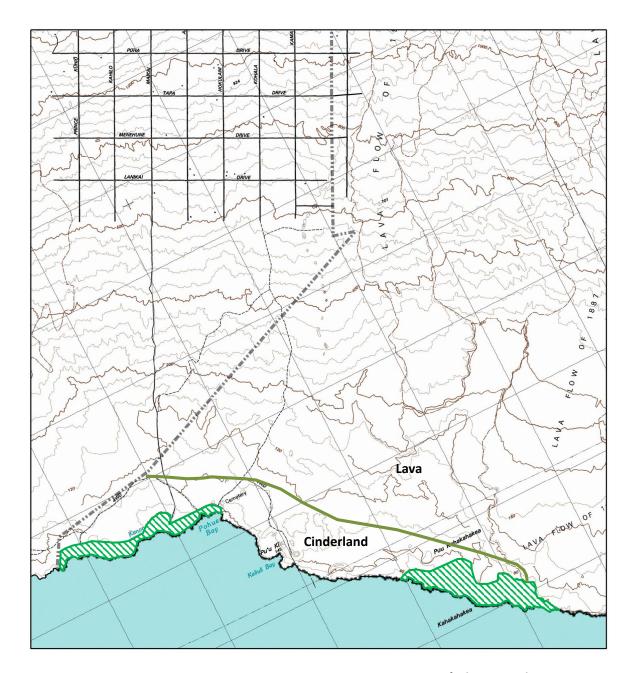


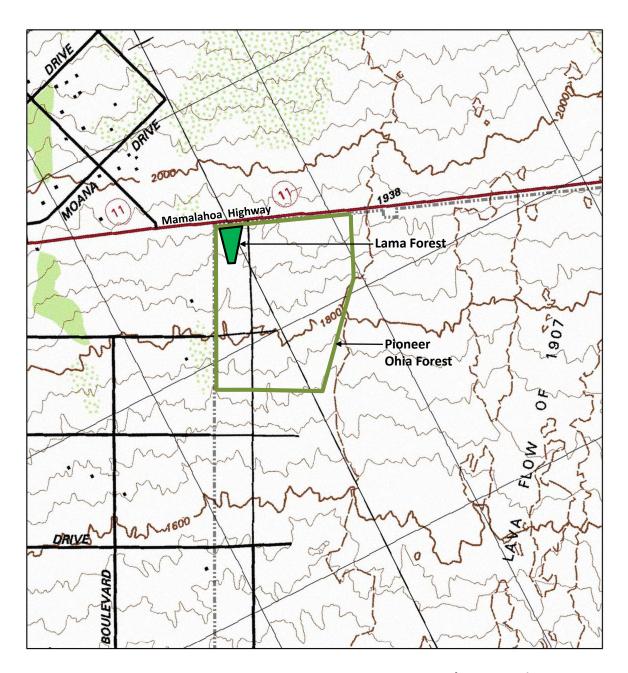
Fig 1. Historical data points of rare plant species within the Kahuku Village survey areas. (Source: Hawaii Biodiversity & Mapping Program)



Makai Vegetation Zones



Fig 2. Makai vegetation Zones



Mauka Vegetation Zones



Fig 3. Mauka Vegetation Zones

LITERATURE CITED

- Char, W.P. 1987. Flora survey, Proposed Hawaiian Riviera Resort, Kahuku, District of Ka'u, Island of Hawaii. Prepared for Belt Collins & Associates, May 1987.
- Evehuis, N.L. and L.G. Eldredge, editors. 1999-2002. Records of the Hawaii Biological Survey. Bishop Museum Occasional Papers Nos. 58-70.
- Federal Register. 2002. Department of the Interior, Fish and Wildlife Service, 50 CFR 17. Endangered and Threatened Wildlife and Plants. Review of Species That Are Candidate or Proposed for Listing as Endangered or Threatened; Annual Notice of Findings on Recycled Petition; Annual Description of Progress on Listing Actions. *Federal Register*, **67** No. 14 (Thursday, June 13, 2002): 40657-40679.
- Foote, D.E., E.L. hill, S. Nakamura, and F. Stephens. 1972. Soil Survey of the Islands of Kauai, Oahu, Maui, Molokai, and Lanai, State of Hawaii. U.S. Department of Agriculture, Soil Conservation Service, Washington, D.C.
- Macdonald, G.A. and A.T. Abbott. 1970. Volcanoes in the sea, the geology of Hawaii. 5th printing. University of Hawaii Press.
- Maciolek, J.A. and R.E. Brock. 1974. Aquatic survey of the Kona coast ponds, Hawaii Island. Sea Grant Advisory Report. April 1974.
- Natural Resource Conservation Service. 2010. Accessed November 19, 2010. http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx
- Staples G. W. and D. R. Herbst. 2005. A Tropical Garden Flora: Plants cultivated in the Hawaiian Islands and other tropical places. Bishop Museum Press.
- U.S. Fish and Wildlife Service. 2008. Hawaiian Islands Plants: Updated April 14, 2008 Listed and Candidate Species, as Designated under the U.S. Endangered Species Act. 21pp.
- Wagner, W.L. and D.R. Herbst. 1999. Supplement to the Manual of the flowering plants of Hawaii, pp. 1855-1918. In: Wagner, W.L., D.R. Herbst, and S.H. Sohmer. 1990. Manual of the flowering plants of Hawaii. <u>Revised Edition</u>. 2 vols. University of Hawaii Press and Bishop Museum Press, Honolulu.

TABLE 1. PLANT SPECIES LIST

The following checklist is an inventory of all the plant species observed within the survey areas of the proposed Kahuku Village Project during two site visits (December 8-10, 2010 and January 3-5, 2011). The plant names are arranged alphabetically by family and then by species into three groups: Pteridophytes, Monocots, and Dicots. The taxonomy and nomenclature of the Ferns and Fern Allies follow Palmer (2002), flowering plants (Monocots and Dicots) are in accordance with Wagner *et al.* (1990), Wagner and Herbst (1999) and Staples and Herbst (2005). Recent name changes are those recorded in the Hawaii Biological Survey series (Evehuis and Eldredge, eds., 1999-2002) and the BISH native-naturalized checklist March 2010.

For each species, the following name is provided:

- 1. Scientific name with author citation.
- 2. Common English and/or Hawaiian name(s), when known.
- 3. Where the plant was observed; marked as in either the coastal or mauka sections of the project area or both.
- 4. Biogeographic status. The following symbols are used:

A = Alien species introduced to the Hawaiian Islands by humans, intentionally or accidentally.

I = Indigenous species native to the Hawaiian Islands and also found elsewhere in the world.

E = Endemic species found only in the Hawaiian Islands.

SCIENTIFIC NAME	COMMON NAME	STATUS	Makai	Mauka
PTERIDOPHYTES (Ferns and Fern Allies)				
NEPHROLEPIDACEAE				
Nephrolepis brownii (Desv.) Hovenkamp & Miyam.	sword fern	A	X	X
Nephrolepis cordifolia (L.) C.Presl		I		X
PSILOTACEAE				
Psilotum nudum (L.) P.Beauv.	moa, upright wiskfern	I	X	X
PTERIDACEAE				
Doryopteris decipiens (Hook.) J.Sm.	kumuniu, `iwa`iwa	Е		X
Pellaea ternifolia (Cav.) Link	kalamoho, laukahi	I		X
Pityrogramma calomelanos (L.) Link	Silverfern	A	X	
MONOCOTS				
AGAVACEAE				
Agave sisalana Perrine	sisal, century plant	A		X

SCIENTIFIC NAME	COMMON NAME	STATUS	Makai	Mauka
Pleomele hawaiiensis O.Deg. & I.Deg.	hala pepe	Е		X
ARECACEAE				
Cocos nucifera L.	niu, coconut	A	X	
CYPERACEAE				
Bulbostylis capillaris (L.) C.B. Clarke		A	X	
Cladium jamaicense Crantz	`uki, sawgrass	I	X	
Cyperus laevigatus L.	makaloa	I	X	
Fimbristylis cymosa subsp. umbellato-capitata (Hillebr.) T.Koyama	mau`u `aki`aki	I	X	
PANDANACEAE				
Pandanus tectorius Parkinson ex Z	hala, screwpine	I?	X	
POACEAE				
Andropogon virginicus var. virginicus L.	broomsedge	A	X	X
Cenchrus ciliaris L.	buffelgrass	A	X	X
Cenchrus echinatus L.	common sandbur	A	X	
Chloris barbata (L.) Sw.	Swollen fingergrass	A	X	
Cymbopogon refractus (R.Br.) A.Camus	barbwire grass	A	X	X
Cynodon dactylon (L.) Pers	manienie	A	X	
Eragrostis amabilis (L.) Wight&Arn. Ex Nees	lovegrass	A	X	X
Melinis minutiflora P.Beauv.	molasses grass	A		X
Melinis repens (Willd.) Zizka	Natal redtop	A		X
Panicum maximum L.	Guinea grass	A		X
Panicum torridum Gaudich.	kakonakona	Е	X	
Pennisetum setaceum (Forssk.) Chiov.	fountain grass	A	X	X
Sporobolus indicus (L.) R.Br.	West Indian dropseed, smutgrass	A		X
RUPPIACEAE				
Ruppia maritima L.	ditchgrass, widgeon grass	I	X	

SCIENTIFIC NAME	COMMON NAME	STATUS	Makai	Mauka
DICOTS				
AMARANTHACEAE				
Nototrichium sandwicense (A.Gray) Hillebr.	kulu`i	Е		X
ANACARDIACEAE				
Schinus terebinthifolius Raddi	Christmas berry	A	X	X
ASCLEPIADACEAE				
Asclepias physocarpus (E.Mey.) Schltr.	balloon plant	A		X
ASTERACEAE				
Conyza bonariensis (L.) Cronq.	Hairy horseweed	A		
Emilia sonchifolia var. sonchifolia (L.) DC.	Flora's paintbrush	A		X
Picris hieracioides L.	hawkweed	A		X
Pluchea carolinensis (Jacq.) G.Don	sourbush, marsh fleabane	A	X	X
Pseudognaphalium sandwicensium var. sandwicensium Gaud.	`ena `ena	Е		X
Sonchus oleraceus L.	sow thistle, pualele	A	X	X
Tridax procumbens L.	coat buttons	A		X
BORAGINACEAE				
Cordia subcordata Lam.	kou	I	X	
CACTACEAE				
Opuntia ficus-indica (L.) Mill.	panini, prickly pear	A		X
COMBRETACEAE				
Terminalia catappa L.	tropical almond	A	X	
CONVOLVULACEAE				
Ipomoea pes-caprae subsp. brasiliensis (L.) Ooststr.	pohuehue, beach morning glory	I	X	
Ipomoea violacea L.	morning glory	A	X	

SCIENTIFIC NAME	COMMON NAME	STATUS	Makai	Mauka
CRASSULACEAE				
Bryophyllum pinnatum (Lam.)	air plant	A		X
CUCURBITACEAE				
Cucumis dispaceus Ehrenb.ex Spach	hedgehog gourd	A	X	
Momordica charantia L.	bitter melon	A		X
EBENACEAE				
Diospyros sandwicensis (A.DC.) Fosberg	lama	Е		X
EPACRIDACEAE				
Leptecophylla tameiameiae (Cham. & Schltdl.) C.M.Weiller	pukiawe	I		X
EUPHORBIACEAE				
Chamaesyce hirta (L.) Millsp.	hairy spurge, garden spurge	A	X	
Chamaesyce prostrata (Aiton) Small		A	X	
FABACEAE				
Chamaecrista nictitans subsp. patellaria var. glabrata (Vogel) H.S.Irwin & Barneby	Partridge pea	A		
Crotalaria incana L.	fuzzy rattlepod	A		X
Crotalaria pallida Aiton	smooth rattlepod	A	X	
Desmanthus pernambucanus (L.) Thell.	Slender or virgate mimosa	A		X
Indigofera suffruticosa Mill.	indigo	A		X
Senna gaudichaudii (Hook. & Arn.) H.S. Irwin & Barneby	kolomona	I		X
Sophora chrysophylla (Salisb.) Seem.	mamane	Е		X
FLACOURTIACEAE				
Xylosma hawaiiense Seem.	maua	Е		X

SCIENTIFIC NAME	COMMON NAME	STATUS	Makai	Mauka
LAMIACEAE				
Ocimum gratissimum L.	wild basil	A	X	X
Plectranthus parviflorus Willd.	`ala`alawai nui wahine	I		X
MALVACEAE				
Sida fallax Walp.	ilima	I		X
Sida rhombifolia L.		A		X
Thespesia populnea (L.) Sol. Ex Correa	milo	I?	X	
MENISPERMACEAE				
Cocculus orbiculatus (L.) DC.	huehue	I		X
MYRSINACEAE				
Myrsine lanaiensis Hillebr.	kolea	Е		X
MYRTACEAE				
Metrosideros polymorpha var. incana (H.Lev.) H. St.John	ohi`a lehua	Е		X
NYCTAGINACEAE				
Boerhavia acutifolia (Choisy) J.W.Moore	alena	Ι	X	
Boerhavia coccinea L.		A	X	
PAPAVERACEAE				
Argemone glauca var. glauca (Nutt. Ex Prain) Pope	Pua kala	Е	X	
PASSIFLORACEAE				
Passiflora foetida L.	love-in-a-mist	A	X	
PIPERACEAE				
Peperomia latifolia Miq.	`ala`ala wai nui	Е		X

SCIENTIFIC NAME	COMMON NAME	STATUS	Makai	Mauka
POLYGONACEAE				
Persicaria capitata (BuchHam. Ex D.Don) Masam.	knotweed, smartweed	A		X
Rumex skottsbergii O.Deg. & I. Deg. (cf.)	pawale	Е		X
PORTULACACEAE				
Portulaca oleracea L.	pigweed	A	X	
Portulaca pilosa L.	akulikuli	A	X	
ROSACEAE				
Osteomeles anthyllidifolia (Sm.) Lindl.	ulei	I		X
RUBIACEAE				
Psydrax odorata (G.Forst.) A.C.Sm. & S.P.Darwin	alahe`e	I		X
SAPINDACEAE				
Dodonaea viscosa Jacq.	`a`ali`i	I		X
SOLANACEAE				
Nicotiana tabacum L.	tobacco	A	X	
Solanum lycopersicum var. cerasiforme (Dunal) D.M.Spooner, G.J. Anderson & R.K.Jansen	tomato, cherry tomato	A		X
STERCULIACEAE				
Waltheria indica L.	uhaloa	I	X	X
VERBENACEAE				
Lantana camara L.	lantana	A		X
ZYGOPHYLLACEAE				
Tribulus cistoides L.	nohu	I	X	

Appendix: Site Photographs



Figure 2. Looking southeast along the coast to Kanonone Ponds, Pohue Bay, and littoral cones of Pu`u Ki.



Figure 3. Expanse of Lava mauka of Pu`u Kahakahakea.



Figure 4. View of Kanonone ponds. Invasive shrubs of Pluchea (in foreground) should be controlled from spreading.



Figure 5. Native sedge `uki and hala trees growing at the margins of water at Kanonone Pond.



Figure 6. Black sand and rubble beach at the base of Pu'u Ki.



Figure 7. Large ground cracks in lava near Kahakahakea. Few plants inhabit this microhabitat including the introduced swordfern *Nephroplepis brownii*.



Figure 8. Northern pond is a pristine example of anchialine ponds.

Massive mats of the native widgeon grass inhabit this pond.

Management should include removal of the weedy Pluchea population.



Figure 9. Pohue Bay with sandy shore. Coconut trees and pohuehue vine dominate the vegetation.



Figure 10. The native kakonakona (Panicum torridum) grass sprouting after rains.



Figure 11. The native Hawaiian poppy, puakala (*Argemone glauca*) seedlings sprouting at the base of old plant.



Figure 12. Lama Forest at Mauka Portion of survey area.



Figure 13. Understory of lama forest showing kulu`i (*Nototrichium sandwicense*) individual (growing to the left of lama tree base).



Figure 14. The sole halapepe (*Pleomele hawaiiensis*) found on the Mauka project site. This species of halapepe is listed as Endangered with the USFWS (2008).



Figure 15. Kolomona (Senna gaudichaudiana) in flower.



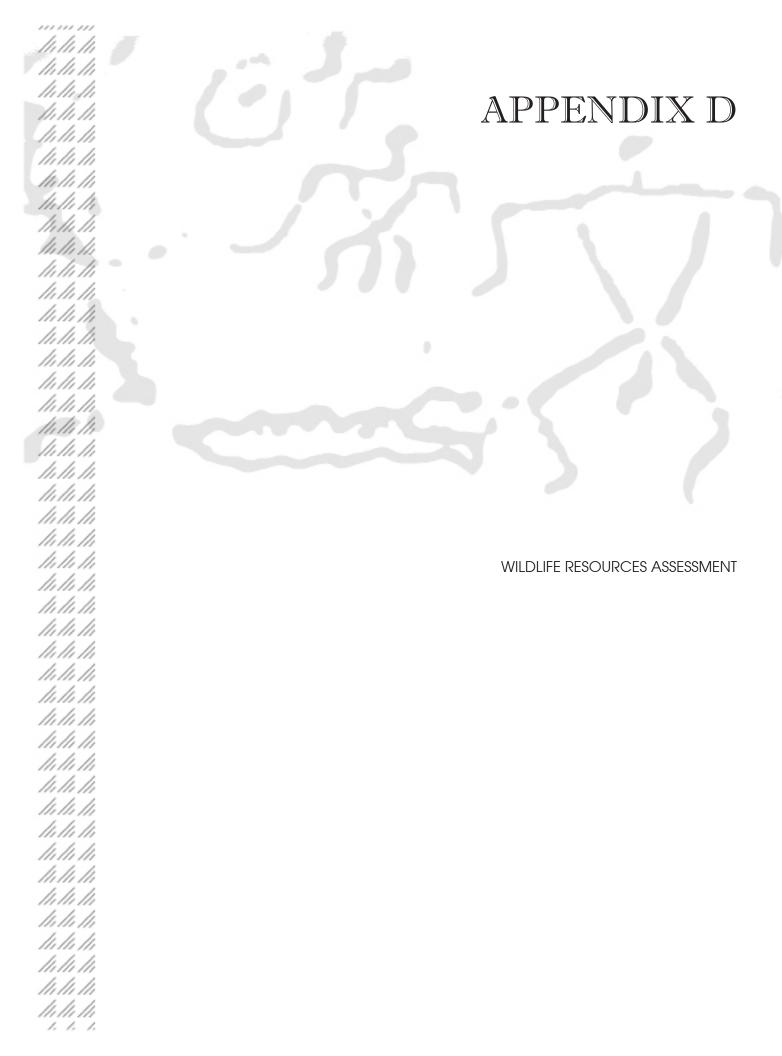
Figure 16. Mamane (Sophora chrysophylla) in full flower during the January 2011 survey.



Figure 17. Large plants of the invasive sisal (Agave sisalana) are recommended for removal at the Lama Forest site.



Figure 18. Maua (*Xylosma hawaiiensis*) in foreground and kolea (*Myrsine lanaiensis*) located in the Pioneer Ohia Forest of the Mauka Portion.



Survey of Terrestrial Wildlife Resources at Kahuku, Ka'ū, Hawai'i Island

FINAL



Prepared by: Steven Lee Montgomery, Ph. D., Waipahu, Hawai'i

Submitted to: PBR Hawai'i & Associates, Inc.

For: Nani Kahuku 'Āina, LLC

REVISED June 2, 2011

Table of Contents

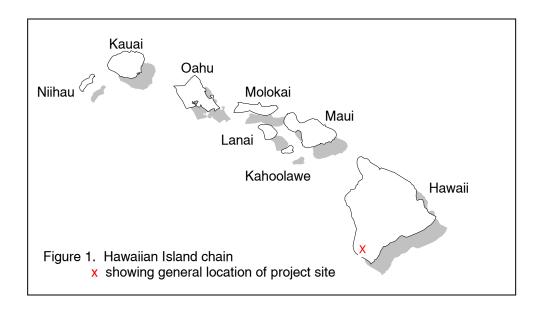
Summary	1
Introduction	1
General site description	4
Survey methods	7
Previous surveys and literature search	7
Fieldwork schedule	9
Methods	9
Survey limitations	14
Results of Survey	18
Native species	
Invertebrates	20
Vertebrates	29
Alien species	
Invertebrates	33
Vertebrates	39
Species not observed	
Lava tube ecosystem	51
Invertebrates	54
Vertebrates	56
Medically important species	
Invertebrates	58
Vertebrates	59
Potential impacts to protected species	59
Recommendations	60
Acknowledgments	63
Nomenclature; Abbreviations	64
Glossary	65
Literature cited	67
Tables	
Table 1 List of Arthropode: Kabuku Village project site	42
Table 1. List of Arthropods: Kahuku Village project site	
Table 2. List of Vertebrates: Kahuku Village project site	48
Figures	
Figures	
Anchialine pond at Kahuku Village	cove
Figure 1. Map showing general location of project site on island of Hawai'i	1
Figure 2. Map showing location of project site, Ka'ū, Hawai'i	2
Figure 3. Survey area within larger property	3
Figure 4. Example of pāhoehoe lava field	5
Figure 5. Example of 'a'ā lava fields	5
Figure 6. Typical strand vegetation	6
Figure 7. Biological diversity supported by the anchialine ponds	6
Figure 8. Baiting to census lava crickets	9
-	

Table of Contents, Figures continued

Figure 9.	Light census seemed unaffected by wind	10
Figure 10.	Map Kahuku Village area showing light monitoring sites	11
Figure 11.	Sweeping with net for flying insects	12
Figure 12.	Kahuku Village project areas maps showing avian count sites	13
Figure 13.	Light rains did not affect the census of invertebrates	15
Figure 14.	Wind was consistent	15
Figure 15.	New vegetation is visible after December and January rains	16
Figure 16.	Native shrimp in anchialine pond	19
Figure 17.	Congregations of shrimp are common	19
Figure 18.	Native wolf spider	20
Figure 19.	Endemic Maua hosts endemic 'true bug' Orthotylus daphne	21
Figure 20.	Hylaeus male bee with yellow face	22
Figure 21.	Hyposmocoma case bearer moth	23
Figure 22.	Eudonia moth	23
Figure 23.	Tamsica moth	24
Figure 24.	Lama showing damage by leaf miner	24
Figure 25.	Adult Hyles calida hawaiiensis showing markings	25
Figure 26.	Anchialine ponds dragonfly and damselfly habitat	26
Figure 27.	Orangeblack Hawaiian Damselfly	26
Figure 28.	Globe skimmer (Pantala flavescens)	27
Figure 29.	Open lava fields, home to lava crickets	28
Figure 30.	Rocky beach splash zone, home to beach crickets	28
Figure 31.	Frigatebirds head inland in advance of storm	30
Figure 32.	Cracked snail shells, evidence of Auku'u feeding	32
Figure 33.	Jumping spider	33
Figure 34.	Alien geometrid attacking native Kolomona	33
Figure 35.	Black witch moths	34
Figure 36.	Black witch moths are present in large numbers	34
Figure 37.	Noctuid caterpillar changes color and habits as it grows	35
Figure 38.	Kou trees damaged by Ethmia nigroapicella.	36
Figure 39.	Sweetpotato hornworm (Agrius cingulata) pink markings	37
Figure 40.	Whitelined sphinx wings closed, wings open	38
Figure 41.	Snake-eyed skink	39
Figure 42.	Goat bones in lava tube	40
Figure 43.	Healthy cavern ecosystem requires long and healthy roots	52
Figure 44.	Typical slime showing characteristic trails of crane fly larvae	52
Figure 45.	Skylights are common in the Kahuku Village tube system	53
•	Typical view of interior Kahuku Village lava tubes	53
-	Big-headed ants attack other invertebrates	54
•	Manduca blackburni's distinguishing orange markings	55
-	Paper wasp (Polistes exclamans)	58

SUMMARY

The Kahuku Village project site sampled in this survey yielded native invertebrates and birds, and adventive arthropods, birds, and mammals. No invertebrate currently listed as endangered or threatened under either federal or state statutes was observed within the survey area. One candidate species, *Megalagrion xanthomelas* or the Orangeblack Hawaiian Damselfly, was observed near anchialine ponds. No vertebrate currently listed as endangered or threatened under either federal or state statutes was observed within the survey area.

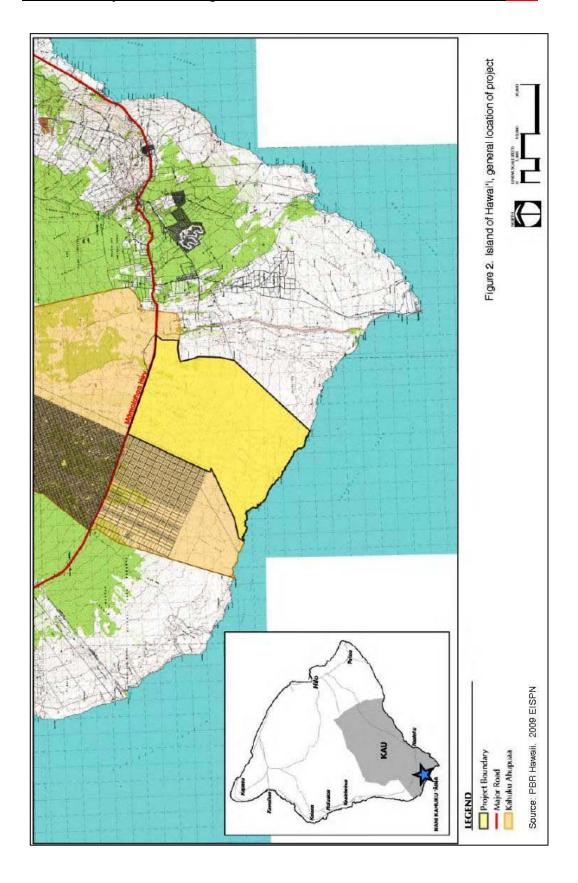


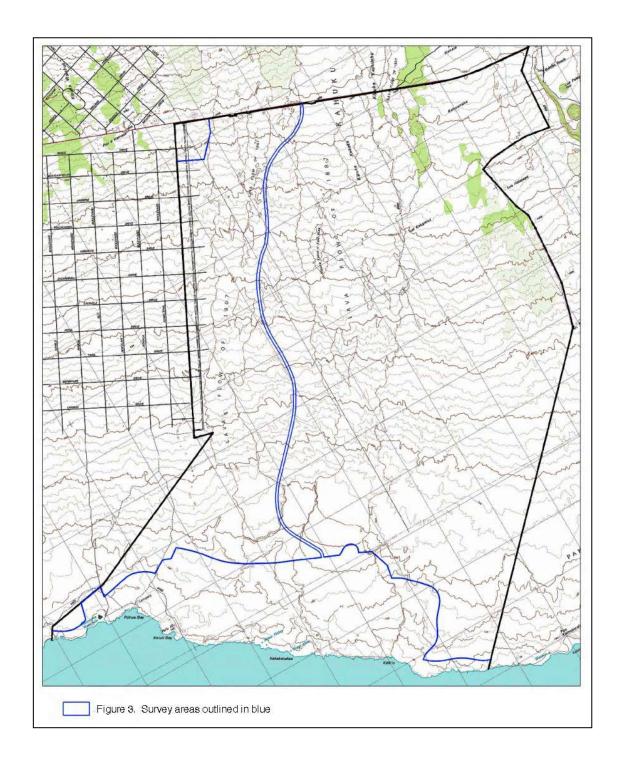
INTRODUCTION

This report summarizes the findings of a survey conducted by Steven L. Montgomery, Ph. D., in support of an environmental impact statement to be prepared by the planning firm PBR Hawai'i & Associates, Inc. The project proposes to create a variety of endeavors with supporting infrastructure in Kahuku, Ka'ū, Hawai'i Island (Figure 1). Nani Kahuku 'Āina, LLC, requested surveys on parts of TMK 9-2-001:072 in Ka'ū, Island of Hawai'i (Figure 2). The survey inventoried terrestrial invertebrates¹ and vertebrates².

¹ Animals without backbones: insects, shrimp, snails, spiders, etc.

² Animals with backbones: birds, mammals, reptiles





Note: the mauka-makai roadway is a conceptual route, not marked by surveyors and could not be specifically reviewed for this report. However, most of the conclusions regarding the lands mauka of the beach area would also apply to the road corridor lava fields.

The goal of this survey was to provide an accurate review of the terrestrial fauna present on the property at Kahuku, Ka'ū. The primary emphasis of the invertebrate survey was on terrestrial arthropods, particularly endemic or indigenous species. The vertebrate survey concentrated on searching for evidence of native birds and the Hawaiian hoary bat. Species having legal status under federal and / or state endangered - threatened species statutes (DLNR 1996, 1997, USFWS 2005a, 2007, 2010a, 2010b) were of special interest.

Native Hawaiian plant, vertebrate, and invertebrate populations are interdependent. Certain insects are obligatorily attached to host plants and use only that plant as their food and / or provide pollination for native plants. Invertebrates such as insects and snails, as well as the fruit and seeds of native plants, are the natural food of native birds. The health of native Hawaiian ecosystems depends on habitat quality and absence or low levels of continental predators and herbivores. Sufficient food sources, host plant availability, and the absence of continental dominants comprise a classic native, healthy ecosystem. Consequently, where appropriate in the survey discussion, host plants, and introduced arthropods, birds, and mammals, are noted.

GENERAL SITE DESCRIPTION

The project area is on the southern portion of the Island of Hawai'i (Figure 1, 2) in the Ka'ū district. Elevation within the survey area rises from sea level to approximately 1900 feet (ft.) above sea level / 580 meters (m.) where the access road would meet Māmalahoa Highway. (Figure 3)

The area to be surveyed included:

approximately 1,937 acres running from the coast inland, starting northwest of Pōhue Bay southeast to Kākio, including 500 acres for a proposed Hawaiian Heritage Village and conservation management area near the shoreline;

approximately 125 acres of mauka land located just below Māmalahoa Highway (190-Hawaii Belt Road) and running along the South Point side of Hawaiian Ocean View Ranchos.

Geologically, the site is mostly pāhoehoe and 'a'ā lavas (Figure 4 and 5) with soil in selected locations and lava tubes present throughout the area. Much of the surface is uneven and irregular. Kīpuka of vegetation are scattered across the property with a denser strand community.



Figure 4. Pāhoehoe lava with only scattered vegetation.



Figure 5. 'A'ā lava fields provide rare pockets of ashy soil.



Figure 6. Typical strand vegetation on the site.



Figure 7. The anchialine ponds supported the most diversity of plant and animal life.

The site incorporates several vegetation communities. The strand vegetation (Figure 6) is unusually simple, with several plants typical of dryland strand communities missing. Biologically, the most diverse areas are the areas surrounding the anchialine ponds (Figure 7). The ponds provide a year-round source of surface brackish water that supports some water-dependent invertebrates and creates food for birds.

There are no flowing perennial fresh water streams present. One nearly fresh water pool was noted inland in cracks in the pāhoehoe lava. Brackish and near-fresh water is present in shallow wells.

The larger site has been through a variety of changes as first Polynesians then Europeans adapted the area to their needs. Early Hawaiian use of the marine resources and establishment of dwellings, including use of lava tubes for shelter and storage, began the process of change. Modern grazing of domesticated and now feral animals combined to remove large portions of the native vegetation and native invertebrate populations. Undoubtedly, the dominant change factor in the last century and a half has been Mauna Loa lava flows in the area. The current surveys and the 1987 bird and mammal survey found evidence of damage to plants by goats (Bruner 1987; LeGrande 2011).

SURVEY METHODS

Since 1970, I have taken part in field projects in other dryland locations on the Island of Hawai'i and throughout the island chain. I have participated in a wide range of biological surveys and field experiences giving me visual and auditory identification knowledge of Hawaii's birds. My study design and my analysis of results utilize those experiences and the results of other surveys. Surveys of other dryland areas have created a sizeable body of information on native invertebrate, vertebrate, and related botanical resources found in areas similar to Kahuku Village (Bridwell 1920, Swezey 1935).

Previous Surveys and Literature Search

A 1987 Environmental Impact Statement (Belt Collins), which included this site within a much larger area, included botanical, avian/mammalian, and anchialine pond surveys of the project area (Bruner 1987; Char 1987; MRC 1987). Those surveys were helpful in preparing for this survey, however, terrestrial and lava tube invertebrates were not included in those surveys. Previous archaeological studies (Haun and Walker 1987) showed evidence of lava tubes in the project area, but no mention of cave-adapted invertebrate species.

A search at the State's Office of Environmental Quality Control (2010) web site for surveys done in adjacent areas returned very few results for invertebrates. Creation of the nearby Hawaiian Ocean View Estates and Ocean View Ranchos predates the 1970s EIS process and no reports are on file for those projects (OEQC 1973; Alakai pers. com. 2010; Elwell 2009). Invertebrates were not surveyed by either a 1994 Environmental Assessment for a proposed park in Hawaiian Ocean View Estates (Terry), or a 2008 Environmental Impact Statement for a proposed Recycling Point and Convenience Center (Geometrician Associates). Vertebrates were surveyed in both cases.

A search was made for independent biological studies associated with this site or with nearby sites. Searches were made in the Bishop Museum and University of Hawai'i libraries (2010). Online proprietary data bases of such as Academic Search Premier, AGRIS, and Ingenta Connect were searched. Searches were made for publicly available articles mounted on the web (Google Scholar, University of Hawaii's Scholar Space). Searches were made in regional and national databases which provide geographic access, such as the Pacific Basin Information Node (2010) and Hawaii Natural Heritage Program (2010). Data base searches were made in Bishop Museum's Arthropod and Mollusk checklists, and the University of Hawaii, Hamilton Library's Hawaii-Pacific Journal Index.

Access to the project area was limited prior to construction of Mamalahoa Highway. After the 1940s, a 4-wheel drive road gave access to Pōhue Bay, but access has always been limited. Fishermen have been the most frequent visitors to the coastline. A search for field notes by botanist and fisherman E. Y. Hosaka, a known visitor to Pōhue Bay until his death in 1961, did not return results. The area lacked the commercial agriculture which generated much of Hawaii's formal entomological surveys since the 1900s. The combination of these factors makes it unremarkable that this review showed no previous independent invertebrate surveys of the specific site. The Hawaii Natural Heritage Program (2010) database did return some records; all associated with the anchialine ponds.

It should be remembered that the place name <u>Kahuku</u> applies to a huge geographic area, the state's largest ahupua'a, including land that is higher and wetter than the survey area. Kahuku and Ka'ū are mentioned as the source of invertebrates which clearly belong to those higher, wetter elevations and those species have been excluded from our comparison and baseline data. For example, in 1916 Bishop Museum botanist C. N. Forbes collected in "Kahuku, between flows of 1887 and 1868." (Forbes 1917) Examination of his notes and published information, descriptions of his means of travel and arrival at the flows, makes it apparent that, although the two flows mentioned may come near each other on the east edge of this property, Forbes was at a much higher elevation above 1700 ft. (Forbes n.d., 1909-17; PBIN).

Fieldwork

Field surveys were conducted between December 3 -12, 2010, and January 3 – 5, 2011. I conducted a general assessment of terrain and habitats at the start of the survey. Surveying efforts were conducted at various times of day and night, vital for a thorough survey. Native botanical resources identified by Char (1987) (see "Previous Surveys and Literature Search" above), and field collaboration with botany surveyors M. LeGrande (pers. com. 2010) were helpful to my invertebrate searches. Incidental vertebrate records were made throughout the Dec. 3-12, 2010, survey.

Fieldwork schedule:

December 3, 2010 December 4-6 2010	Orientation, general invertebrate collecting; light survey General invertebrate collecting; light survey each night
December 7, 2010	Lava tube search and inspection
December 8-9, 2010	General invertebrate collecting, coordination botanical team lava tube inspection; light survey
December 10, 2010	General collecting; lava tube inspection; light survey
December 12, 2010	General collecting; lava tube inspection
January 3, 2011	Vertebrate survey; light survey; lava tube searches
January 4, 2011	Vertebrate survey; light survey; lava tube searches
January 5, 2011	Vertebrate survey; lava tube searches

Survey Methods: Invertebrates

The following survey methods for terrestrial invertebrates were used as appropriate to the terrain, botanical resources, and target species.

Baiting: Baits are used to attract insect species to specific tastes or smells. For example, both native beach and lava crickets respond to a strong odor of decaying flesh. Baits can mimic that smell and taste and so attract those insects. Insects are enticed by the bait's 'advertisement.' Baits are placed at likely locations in bottle traps (Figure 8) and checked periodically. Any insects at the bait are then observed and censused. This is much more efficient than roaming the research area seeking

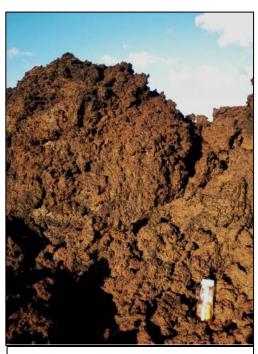


Figure 8. Lava crickets hide by day and can be best censused by baiting with favorite tastes and smells.

cryptic or night feeding insects. Baiting is a recognized method of censusing lava tubes for cave adapted fauna and for censusing beach and lava crickets.

Host plant searches: Potential host plants, both native and introduced, were searched for arthropods that feed or rest on plants. Wandering transects were followed throughout the coastal and inland area with emphasis on reaching native host plants.

Light survey: A survey of insects active at night is vital to a complete record of the fauna. Many insects are only active at night to evade birds, avoid desiccation and high temperatures, or to use night food sources, such as night opening flowers. Light sampling uses a bright light source in front of a white cloth sheet (Figure 9). Night active insects seem to mistake the collecting light for the light of the moon, which they use to orient themselves. In attempting to navigate by the collecting light, disoriented insects are drawn toward the light and land on the cloth in confusion. This type of collecting is most successful during the dark phase of the moon or under clouds blocking starlight.



Figure 9. Despite near-constant winds, night active invertebrate fauna did respond to the light census.

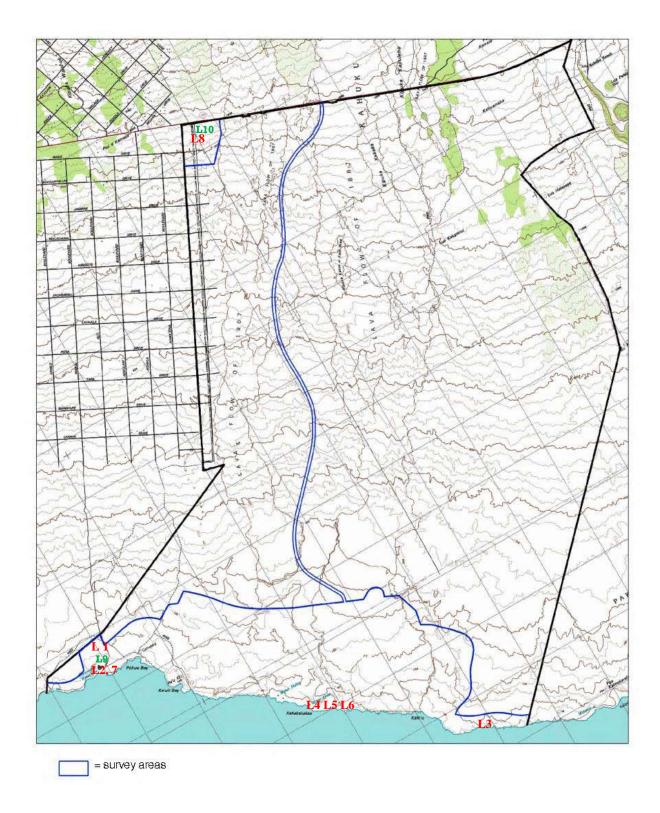


Figure 10. Map of Kahuku Village project area showing light monitoring sites.

- L = December light monitoring
- **L** = January light monitoring

(Methods continued)

Sampling was conducted for approximately 7-8 hours on each night of surveying. The light source was a mercury vapor (MV) bulb. An additional, ultraviolet (UV) light source was used at all sites. Due to the remote location, competing light from housing, street lights and other artificial sources was not a factor.

Locations were chosen based on experience, host plant proximity, and terrain. As the interconnection of arthropods and host plants is strong, light sampling was concentrated in areas with more host plants. The sample locations, marked on Figure 10, are therefore near the coastal ponds and strand vegetation.

Sweep nets: Sweeping is a common method of general collecting for most flying and perching insects. A fine mesh net was swept across plants, leaf litter, rocks, pond surfaces, etc. to collect any flying, perching, or crawling insects. Transfer from the net was either by aspiration, or by placing the net contents directly into а holding container.

Visual observation: At all times, I was vigilant for any visual evidence of arthropod presence or activity. Visual observations provide valuable evidence and are a cross check that extends the reach



Figure 11. The borders and shallows of anchialine ponds were swept for flying insects attracted to the water.

of sampling techniques. Visual observation also included turning over rocks, examining dead wood, and other debris.

Survey Methods: Vertebrates

Avian point counts:

Eight-minute counts were conducted at 10 stations, January 3-5, 2011. Only one station, Kanonone Pond, was counted twice in an effort to provide as wide a geographic sampling as possible. Many of the same locations were the source of incidental sightings during the December fieldwork. Incidental sightings from the December 2010 fieldwork are included in Table 2.

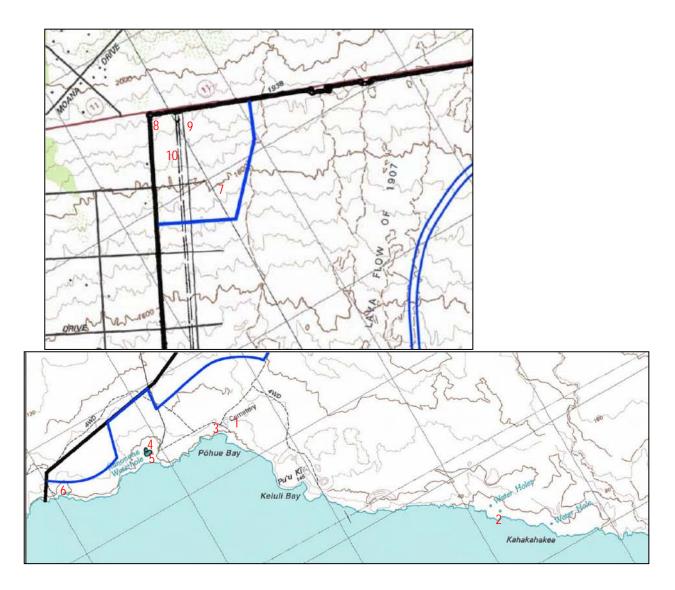


Figure 12. Kahuku Village project areas maps showing avian count sites.

Survey methods: Vertebrates (continued)

Observations were made using binoculars, and by listening for vocalizations. Counts took place between sunrise and 10 a.m. and 4 p.m. and sunset, the peak periods of bird activity. Given the large area, habitat types, and low potential for seeing birds in open lava, straight line transects were not used. Rather, counts were focused along the coast, at the anchialine ponds (Jan. 3-4), and in the mauka portion (Jan. 5, 2011).

Auditory observations: At all times, the team was alert for vocalizations giving evidence of birds or mammals.

Visual observation: At all times, the team was vigilant for any visual evidence of birds or mammals within the survey area. Visual observation also includes notation of scat, tracks, teeth marks on seeds or shells (rats) or browsing on vegetation (goats).

Survey Limitations / Conditions

My ability to form advisory opinions is influenced in the following ways:

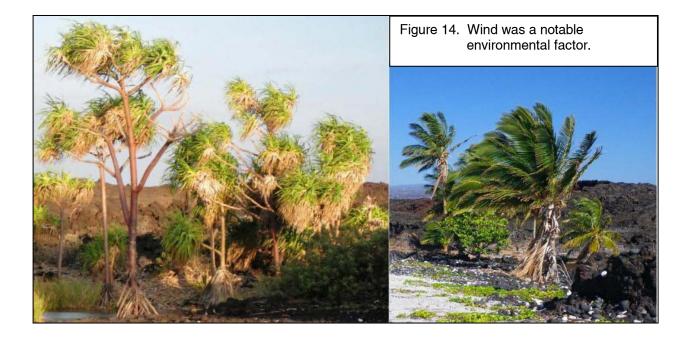
Collecting conditions:

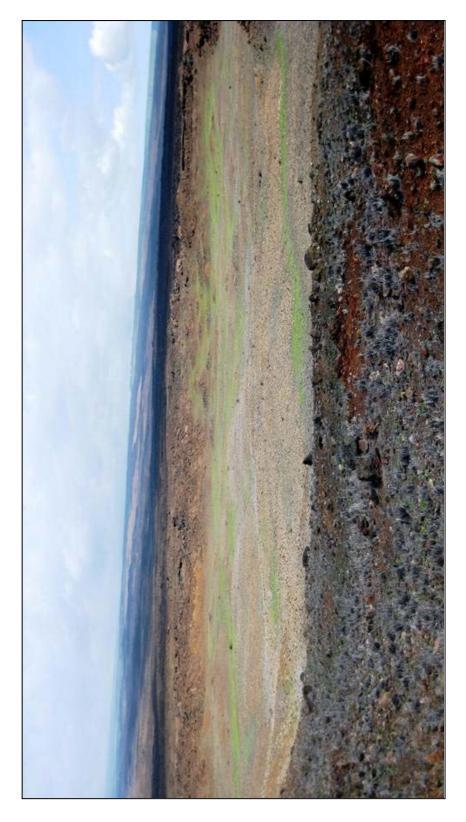
Weather: Weather was favorable for surveying Dec. 3-8, 2010, and Jan. 3-5, 2011. Intermittent rains Dec. 9 -12, 2010, were not heavy and did not greatly disrupt collecting efforts. The atmospheric vog did not appear to alter the behavior of invertebrates and cleared skies after the rains did not make measurable differences in survey results. Vigorous winds seem to represent a 'normal' environment for the location, and wind also was reported by Bruner in his 1987 survey.

Seasons: Weather and seasonal vegetation play an especially important role in any biological survey. Some birds visit the Hawaiian Islands only in winter during their non-breeding season, while others visit Hawaii only in summer to breed. Host plant presence/absence, and seasonal changes, especially plant growth after heavy rains, affect the species collected. Many arthropods time their emergence and breeding to overlap or follow seasonal weather, or to coincide with growth spurts of an important food plant. Monitoring at a different time of the year might produce a longer / shorter / different list of species.



Figure 13. Light rains in the last few December 2010 field days did not affect the insect survey.





(L) Figure 15. Rains in late December and early January brought typical seasonal growth of vegetation. Many invertebrates time their emergence or reproduction to such flushes of growth.

Although there were some small rains in the weeks prior to the December survey, major winter rains and vegetation revitalization had not taken place. If vegetation had developed after winter rains, a different insect list might have resulted. The January 2011 visit mitigated this question as additional rains fell in late December 2010. Nevertheless, the low level of native plants, in part due to consistent browsing by goats, was a stronger factor in determining the invertebrates encountered than the seasonal condition of vegetation. As the botanical survey will show, some native plants noted during the survey in 1987 (Char) were absent and evidence of goat depredations were seen by this surveyor and others (LeGrande pers. com. 2010).

Moon: The moon was 'dark' and presented no competition to the collecting light on the evenings of December 3 - 8, 2010, or January 3-4, 2011. After Dec. 9 the moon was a waxing crescent with increasing portions visible, but did not reach first quarter until after the survey, Dec. 13, 2010. Dec. light surveying was concentrated during the early part of the survey. Dec. 9-12, most days the moon set between 10pm and midnight leaving some hours of no-moon monitoring or rose during daylight hours and set close to or before the end of twilight each night³. The near complete lack of artificial light sources at the chosen sites compensated for the little competition offered by the small moon late in the survey. (USNO)

Limited duration: I believe the survey provides a fair review of the zoological resources present. The vertebrate survey results compare well to those achieved in 1987. More bird species were seen, for example, in this survey. Although the systematic survey of vertebrates took place Jan. 3-5, 2011, incidental sightings were recorded by both the botanical and invertebrate survey teams in Dec. 3-12, 2010 and those records contributed to this report.

Difficulties in sampling a large area for a diversity of species assure that some will elude even the most experienced collector. The overall study strategy and site selections were designed to mitigate this recognized handicap to the extent possible. Given the size of the property, it is probable surveying for a longer period of time would enlarge the list of invertebrate species. It is less likely that many additions would be made to the vertebrate list. A few species reasonably expected to occur on the property were not found (see Species Not Observed).

³ Times given are for Nā'ālehu as closest location tracked by U. S. Naval Observatory

Selectivity: The invertebrate survey was focused on finding any endemic and indigenous Hawaiian land species. No attempt was made to completely document the common alien arthropod species present.

Other factors: All vertebrate species noted were reported, however, no attempt was made to trap or otherwise systematically obtain data on the density or distribution of alien mammals.

All lava tubes located and examined were short sections and in the lower elevations. The results for longer lava tubes at higher elevations, with strong vegetation cover might be different.

RESULTS OF SURVEY:

Incidental records:

In addition to the results noted below, the following species were noted in passing during the survey:

Anchialine Ponds:

Another surveyor is responsible for identification of species in the anchialine ponds. The ponds, as the most reliable source of water for invertebrates such as dragonflies and damselflies, were a focus of my own invertebrate survey. These observations are incidental to that work.

Gymnothorax pictus, a small moray eel [previously *hilonis* (Böhlke and Randall 2000)] was seen in the southeast anchialine pond. It does not appear to be mentioned in the 1987 survey (Marine Research Consultants), but is known from anchialine ponds on Hawai'i Island (Böhlke and Randall 2000).

The shrimp populations (largely *Halocaridina rubra* Holthuis, 1963) appear healthy and utilizing a variety of pond habitats. Noted as a positive is the absence of alien fish in the anchialine ponds. Predatory alien fish in ponds are a major cause in the extirpation of native shrimp. Care should be taken to keep the ponds fish-free. (See "Recommendations")

.

Incidental records: continued



Figure 16. Native shrimp populations appear to be in good condition.



Figure 17. Congregations of grazing shrimp or 'ōpae ula are common.

DISCUSSION

Native terrestrial invertebrate and vertebrate species of note are discussed. Also, information is provided on adventive species often misidentified or confused with native species by the public. Non-native species that constitute a danger to native species (e.g., ants; goats) or human beings (e.g., paper wasp) are discussed.

RESOURCES: NATIVE SPECIES PRESENT ON SITE INVERTEBRATES MOLLUSCA

GASTROPODA (Snails) Pulmonata

Succineidae: Succinea sp.

The only native snail recovered was one empty *Succinea* shell found in litter under a lama tree in the mauka portion of the survey. No live native snails were seen. Although the area surveyed provided generally poor habitat for native snails, it is likely a longer search would have found live *Succinea*. *Succinea* are generalist surface feeders and persistent in even degraded habitat.

ARTHROPODS

ARANEAE (spiders)

Lycosidae: Lycosa hawaiiensis Simon, 1899 (wolf spider)



Figure 18. Native wolf spider

This endemic spider came to my light survey, hunting the concentration of prey species attracted to the light. Wolf spiders will prey on non-native invertebrates allowing it to adapt to a changed prey menu. These are quick, strong predators which give maternal care to their young. They hide alone by day and hunt by night in established individual territories. (Manning/Montgomery in Liittschwager & Middleton 2001)

INSECTA

HETEROPTERA (True bugs)

Lygaeidae: Nysius sp.

This native seed bug, commonly found in dryland locations, uses many alien and native host plants. It is known from most islands in the Hawaiian chain.

Miridae: Orthotylus daphne Kirkaldy, 1902

This endemic 'true bug' is found on O'ahu and Lāna'i as well as Hawai'i Island. It sucks sap from plant leaves, is tied to a specific host plant, Maua (*Xylosma hawaiiense*), and is often the food of native birds.



(L) Figure 19. Maua (*Xylosma hawaiiense*), an endemic plant, found only in the Hawaiian Islands, is the host to the endemic *Orthotylus daphne*.

HYMENOPTERA (Bees, wasps, and ants) Colletidae: *Hylaeus flavipes* (F. Smith) vellow-faced bee

The yellow faced bee was observed on flowering 'ōhi'a lehua in the mauka portion of the property. This native bee is widespread in island coastal zones. Yellow-faced bees comprise over 60 species of native pollinators important to the native flora, more than 25 on Hawai'i Island. It is often seen pollinating 'ilima flowers. The females of this native, ground nesting bee are larger than males



© Figure 20. Hylaeus male with yellow face

and lack the yellow heart-shaped face spot of males (Figure 19). Males and females live in individual tunnels in soft ground. *H. flavipes* is known from Maui (not seen recently), Lāna'i, possibly O'ahu, in addition to Hawai'i. The yellow-faced bee species have been thoroughly studied by Daly & Magnacca (2003) and specific species proposed for endangered status. This species is not among those which may be named as endangered. (USFWS 2010a).

These bees are important native pollinators and may become more important in pollinating crops due to a reduction in honey bee populations. The parasitic *Varroa* mite, recently introduced to O'ahu from North America is now spreading through Hawai'i Island honey bee hives. As the *Varroa* mite kills individual honey bees, colonies die. In the future, the unaffected yellow-faced bee may fill some pollinating needs.

Yellow-faced bees do not sting and are not a danger to humans.

LEPIDOPTERA (butterflies, moths)

Cosmopterigidae: *Hyposmocoma* sp.

Several species of *Hyposmocoma*, as adults, came to light. As the wet season advances it could be expected that a higher number of individuals and more species would be recovered. *Hyposmocoma* are called "case bearers" because after an early beginning inside a leaf curl or similar hiding place, the caterpillars create protection in an intricately constructed portable "cave" woven of their own silk. For camouflage, they add bits of their surroundings to the case using silk: snips of dry grass or leaves, flakes of bark, a little dirt. The case is then easily mistaken by a predator as another part of the inedible landscape. These bunkers are fitted with a hinged lid (operculum),

pulled shut by tiny mandibles to defend them from enemies. Their relationship to the case is similar to that of a hermit crab to his shell. They are dependent on their case, and die if removed – even if protected from predators and given food. They don't move far, but feed while partly emerged from the case, dragging along protective armor by their six true legs. Cases are sometimes attached to rocks or tree trunks and foliage. (Manning/Montgomery in Liittschwager & Middleton 2001)

With over 500 kinds, *Hyposmocoma* micromoths are the greatest assemblage of Hawaiian Island moths, showing astonishing diversity. After writing 630 pages on them, Dr. Elwood Zimmerman lamented the inadequacy of his study. He noted an enormous cluster of species with explosive speciation and diverging radiation (Zimmerman 1978). Much remains to be learned about the life ways of this interesting group of insects now under study by University of Hawaii's Dr. Daniel Rubinoff and his students (Rubinoff 2011).



© Figure 21. *Hyposmocoma* sp. Photo# starr-030724-0089 credit: "Forest & Kim Starr" (HEAR)



© Figure 22. *Eudonia* are found in a wide variety of habitats.

Crambidae: *Eudonia* sp. (moss moth)

This endemic, narrow winged, speckled moth is represented on Hawai'i Island by more than 30 of the 60 species known in the island chain. None are considered rare, endangered, or threatened.

Some species have been reared from moss where they build silken tunnels of protection in which to feed (Swezey 1910), but for many species the host plant is not recorded yet. (HBS 2002a, HOSTS, Zimmerman 1958b)

Tamsica hyacinthina (Meyrick 1899)



© Figure 23. Tamsica at light

Gracillariidae: Philodoria basalis Walsingham, 1907 or

Caloptilia mabaella (Swezey), 1910 or Caloptilia azaleella (Brants), 1913

The young and terminal leaves of lama trees (Diospyros sandwicensis or Hawaiian persimmon) in the mauka dryland forest area show distinctive feeding damage associated with leaf miner caterpillars (Figure 23). Leaf miners burrow or "mine" inside a leaf, creating scars or lines on the leaf surface where they have eaten out the inner flesh. As the caterpillar was identification absent. is difficult. Philodoria basalis is the likely endemic species. The most likely adventive pest is Caloptilia sp. C. mabaella, which has been known in the islands since 1910 (Swezey 1910, 1954), is previously recorded only from O'ahu. Caloptilia azaleella is known from



Figure 24. Feeding by leaf miners.

O'ahu and Hawai'i Island, but not previously associated with *Diospyros sandwicensis*. (HBS 2002a; HOSTS 2010; Nishida 2002)

Noctuidae: Agrotis sp. nr. microreas Meyrick, 1899

Agrotis moths are found from the barren, high elevations of Mauna Kea and Mauna Loa to these lava coasts where adults came to the light survey. These interesting moths are found only on what appear to humans as barren, open lava flows and cinder areas. Their life history and diet of caterpillars are little known.



Sphingidae: *Hyles calida hawaiiensis* (Rothschild & Jordan, 1915)

Hyles adults (Figure 24), endemic subspecies found only on Hawai'i Island, came to the light survey. The adult feeds on nectar in flowers and in the process provides pollination by transferring pollen on its head from flower to flower. The caterpillar probably alahe'e (*Psydrax* eats native odoratum) present on the property. It can be easily confused with the alien Hyles lineata, also found in this survey (see Figure 38).

In form it may be confused with *Manduca blackburni* (see Figure 47) if seen at rest or only glimpsed, but it is only one-third the size of *Manduca*, making it distinguishable.



Figure 25. Adult *Hyles calida hawaiiensis* at light survey, showing markings and underwing coloration.

ODONATA (Dragonflies and Damselflies)

Coenagrionidae: Megalagrion xanthomelas Orangeblack Hawaiian Damselfly



Figure 26. The anchialine ponds give native dragonflies and damselflies year-round water free of predatory alien fish and clear of plants that choke off open water.



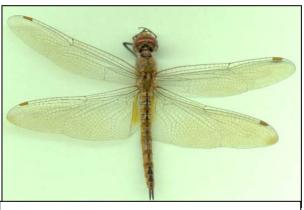
(L) Figure 27. An Orangeblack Hawaiian Damselfly rests between flights

Damselflies, magnificent in flight, would be easily seen by residents or visitors walking near the ponds. The species was previously reported from the property in ponds near Pōhue Bay in the 1990s (Haw. Nat. Heritage Prog. 2010). This native dragonfly is a candidate for Endangered Species Act protection because of threats to habitat and predation by non-native species. M. xanthomelas, however, is rated priority level 8 for U.S. Fish & Wildlife Service protective action, meaning they are not likely to receive action soon (USFW 2010a).

Libellulidae: Pantala flavescens Globe skimmer

An indigenous dragonfly (Pantala flavescens) (Figure 27) was observed on the

property. Among the most easily observed native insects, they are large, easily approached by people, and graceful in flight. Any small amount of fresh water will attract them and they often colonize human maintained water sources such as golf-course water hazards and stock tanks. Globe skimmers are widely distributed throughout the Hawaiian Islands, from Kure to Hawai'i Island (HBS 2002a, Nishida 2002) and have even been found flying at sea (Howarth & Mull 1992).



© Figure 28. Globe skimmers use a wide variety of water sources.

ORTHOPTERA (Praying Mantis, Grasshoppers, Crickets)

Gryllidae: Caconemobius anahulu Lava cricket

This species was first discovered by Dr. D. Otte on open lava 1 km from 'Anaeho'omalu Bay, Hawai'i Island. In his major revision of Hawaiian crickets Otte writes this species "may be widespread along the western slopes of Hawaii Island." (Otte 1994) It is not known as an agricultural or household pest. Rather, the crickets are part of the system that removes dead insects. In the original native Hawaiian environment they took the place of ants in cleaning up. They are attracted to the baits with strong smells as this mimics the smell of decaying moths, flies, or other invertebrates which die on the open lava. The strong winds bring in large numbers of flying insects (e.g., black witch moths) supporting a healthy population of crickets, as well as spiders.

Caconemobius sandwichensis Beach cricket

Caconemobius sandwichensis are specialists feeding on marine detritus in the splash zone among boulders statewide. Being nocturnal, they were seen only by baiting - luring them into bottles and similar traps with baits of fermented shrimp paste, blue cheese, and ripe fish skin. They were widespread in the littoral zone.



Figure 29. Lava crickets inhabit cracks in lava fields.



Figure 30. Beach crickets live in the splash zone among boulders, emerging at night to feed marine debris – a night shift beach cleanup crew.

NATIVE SPECIES PRESENT ON SITE

VERTEBRATES

AVES

A total of 33 individual native birds, representing 5 species were recorded during the December and January surveys. This survey recorded several winter visiting birds and some native residents. The Kolea was seen in the most locations on the most occasions. The largest number of native birds seen in one instance were the Noddies. The large number of Frigatebirds seen was undoubtedly an uncommon occurrence resulting from a storm at sea. The anchialine ponds and seashore were the favored habitat for resident birds. The apparent lack of feral dogs and mongoose, (see "Not observed on the site: Vertebrates") and low level of feral cats and rats, may contribute to the survival of birds on site. Care must be taken to keep numbers of introduced predators low (see *Recommendations: Best Practices Management Plan*).

PELECANIFORMES

Fregatidae: Fregata minor palmerstoni 'Iwa or Great Frigatebird

Two groups totaling 7 Frigatebirds, identifiable by a distinctive wing outline, were observed heading inland in advance of a storm Dec. 9, 2010 (Figure 31). They usually are at sea, but may shelter on the wing along the coast in circumstances such as a strong storm. The species, widespread in the Pacific, nests mostly on off-shore islets and in the Northwest Hawaiian Islands. (Harrison 1990).



Phaethontidae: *Phaethon lepturus* White-tailed Tropicbird or Koa'e kea Jan. 3, 2011, one juvenile bird was observed flying from sea cliffs south of Pōhue Bay at approximately 5:45 p.m. It was seen from above and the mostly white body displayed a checker board like white / black back. It flew out to sea for a short distance, then tumbled a bit in flight and fell into the water in a clumsy manner. It struggled a while to take off again but did succeed, flying away from the observer. The feather pattern and inexperienced flying, led to the identification. This species nests along the rocky coastline and also inland on cliffs of the Big Island, so its presence is not unusual. However, young birds usually leave the natal area and go out to sea after fledging.

CHARADRIIFORMES

Charadriidae: Pluvialis fulva Kolea or Pacific Golden Plover

Kōlea were seen Dec 6, 2010 (1 at ponds); Dec 8, 2010 (2 – 1 at Pōhue Bay; 1 south of the Bay); Dec 9, 2010 (1 near Kākio); Jan 3, 2011 (3 in one location; 1 alone). Perhaps the most commonly seen winter visitor in the island chain, the Kolea adapts to human spaces such as lawns, school and park yards, and even median strips on road ways as well as the wilder areas afforded at this property. They are territorial with most birds returning to the same piece of ground each year. They leave for winter breeding after changing plumage in later April to early May, and return to Hawai'i again in August. A few non-breeding birds may remain through the summer. (Berger 1972)

Sternidae: Anous stolidus or Anous minutus Brown or Black Noddy Noddies were seen along sea cliffs and at Kāki'o as incidental sighting invertebrate survey. Nine birds were seen Dec. 5, 2010, flying toward South Point at twilight. A single bird was seen flying at sea near cliffs on mid-morning on Dec 9, 2010. Although both observers identified the bird as the Brown Noddy, the two species are not easily distinguished at a distance. This resident native nests on off-shore islets and cliffs. They forage at sea and may travel long distances for food. (Harrison 1990).

Scolopacidae: Heteroscelus incanus 'Ūlili or Wandering Tattler 'Ūlili were seen Dec 6, 2010 (1 at shoreline); Jan 3, 2011 (1 at Pōhue Bay); Jan 4 (1 bird each at Kanonone Pond and at western most pond); Jan 5 (1 at Kanonone Pond).

The 'Ūlili is a winter visitor, returning to the islands in August after a spring and summer nesting and raising young in Alaska and northwestern Canada. They are seen throughout the island chain along coastlines, in mud flats and sometimes along streams. They can appear in twos or in small groupings, even associating with other species. A few non-breeding birds may remain through the summer. (Berger 1972)

CICONIIFORMES

Ardeidae: *Nycticorax nycticorax* 'Auku'u or Black-crowned Night-Heron

The 'Auku'u is known from all major Hawaiian islands wherever water offers prey (Berger 1972). Bruner listed this bird among those he had not observed, but believed "could potentially occur on the property." (1987) Although the bird was not observed, its presence is inferred. A pile of approximately 30 shells of *Theodoxus cariosus* (a brackish water neritid snail) were noted beside a pond at Kanonone. The shells were cracked – rather than gnawed as a rat opens shells. The Auku'u is the only bird in Hawaii with a beak design and strength to accomplish this task. The shells mostly retained their color and distinctive spots meaning their collection was recent, not part of older, Hawaiian food gathering. Other food remains were not found with the snails as is common in human created middens.



Figure 32. Cracked snail shells from adjacent anchialine pond, typical of Auku'u feeding.

ALIEN SPECIES PRESENT ON SITE INVERTEBRATES: ARTHROPODS

ARANEAE (spiders)

Salticidae: Unidentified species

A jumping spider was noted on *Pandanus* leaves near the ponds. There are 10 genera of Salticidae spiders reported from Hawai'i Island. Only *Sandalodes* is endemic and has a very different body form. (HBS 2002a, Nishida 2002)



Figure 33. Jumping spider hunting on Hala plants near the anchialine ponds.

INSECTA: LEPIDOPTERA

Geometridae: Macaria abydata Guenee, 1857

Kolomona (*Senna gaudichaudii*), an indigenous plant, growing in the mauka portion of the property is under attack from this alien caterpillar which is stripping leaves from the plants. This appears to be a new host record for this species (HOSTS).



Figure 34. Kolomona (*Senna gaudichaudii*) **(L).** Inset images from lab rearings: top left - caterpillar, lower left - moth.

Noctuidae: Ascalapha odorata (Linnaeus, 1758)

The black witch moth has been widely distributed in the island chain since the first sightings at Honaunau in 1928 (Bryan 1929). This large moth is occasionally mistaken for a bat, especially as it is most frequently seen at dawn or dusk. In cities it rests under the eaves of roofs during the day. At this site it was noted sheltering in lava tube entrances. The caterpillars eat the young leaves of Monkeypod trees (Samanea saman) making the response of a large number of moths to my shoreside light unexpected. It is probable they were carried onto the site by the strong winds blowing from the Nā'ālehu side of the island. The large number of moths, which eventually die, are likely the food source for the high population of crickets on the property.

Black witch moth



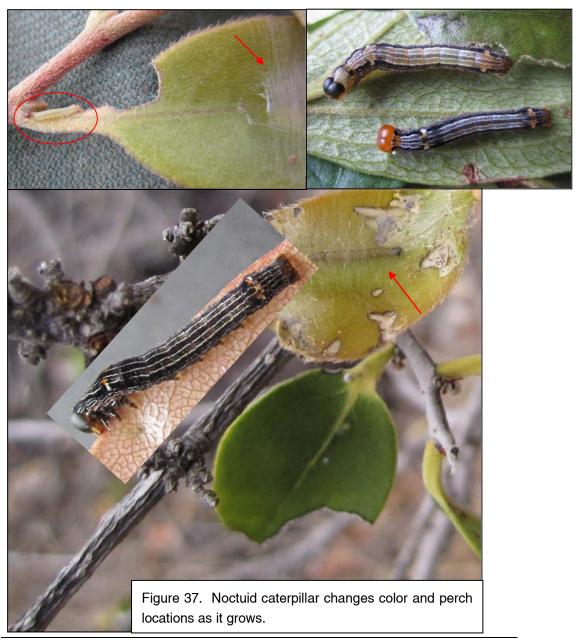
Figure 35. Black witch moths, eyes glowing in the camera flash, dining on a banana slice.



Figure 36. Large numbers of black witch moths may account for large cricket population.

Noctuidae: *Hypocala deflorata* (Fabricius, 1793)

In the mauka portion of the property, native lama (*Diospyros sandwicensis*) foliage is being eaten by this alien caterpillar. The very young (red circle) hide with pale colorings to match the leaf and under silken awnings (red arrow). As their size increases, the caterpillars change color and markings, eventually coming to mimic the dry stems of the plant, complete with simulated stem joints behind the head and just before the posterior. Lama is a recorded food plant. The species was first taken in Honolulu by early entomology collector, Rev. Blackburn between 1877-1883. It is known on all major Hawaiian islands and in the Pacific, Africa, Australia, and may originate in India. (Zimmerman 1958a)



Oecophoridae: Ethmia nigroapicella (Saalmueller, 1880)

Kou leafworm or Cordia defoliator

Kou trees on the property show chewing damage by the caterpillar of *Ethmia nigroapicella*, erroneously, but officially, named the Kou leafworm (caterpillars are not worms). The moth responded to my light survey. Dr. Hillebrand, Honolulu physician / botanist, remarked on their damage in his 1888 *Flora of the Hawaiian Islands* (1888, in Hardy 1978) indicating their relatively recent introduction to the islands. As late as 1944, O. H. Swezey remarked on their destruction of trees. Today their numbers appear reduced, but the caterpillars can reach large numbers and do great damage to the trees.



Figure 38. Kou trees at the makai portion of the property show damage by caterpillars of *Ethmia nigroapicella*.

Sphingidae: *Agrius cingulata* Sweet potato hornworm

The sweet potato hornworm moth (Figure 37) responded to my light survey. It feeds on all sweet potato, morning glory, and related plants, and is widely distributed around the Hawaiian Islands where host plants are present. (HBS 2002a, Nishida 2002). This large moth is most easily confused by the public with the Blackburn's sphinx moth (*Manduca blackburni*) described below (see Species Not Present). Adult *A. cingulata* moths have PINK <u>horizontal</u> body markings on both sides and pink on underwings (Figure 37). *Manduca* (Figure 47) has orange body markings. When the moths are resting with wings folded, the color is hidden, can lead to misidentifications of *Manduca* when *A. cingulata* was actually seen.



Figure 39. Sweetpotato hornworm moth at light showing pink markings.

Hyles lineata Whitelined sphinx

This introduced sphinx moth responded to my light survey. It could be misidentified as Blackburn's sphinx moth (Manduca blackburni) (Figure 47) or Hyles calida hawaiiensis (Figure 24) if seen at rest or only glimpsed. It is distinguished by PINK vertical lines along the body and pink under wings. Note in calida the color is more cream than white and there are no vertical stripes across the horizontal. When resting it can be



distinguished from other Sphingids by the white line along each outer wing. Sometimes it is reported by the public as а hummingbird due to the way it hovers at the mouth of flowers sucking nectar.

Figure 40. Whitelined sphinx wings closed, wings open

ORTHOPTERA (Praying Mantis, Grasshoppers, Crickets)

Gryllidae: Gryllodes sigillatus (Walker), 1869 Flightless field cricket

This world-wide traveler was first recorded in the Hawaiian Islands in 1895 (Zimmerman 1948). In the years since, it spread up and down the island chain.

Although superficially similar in appearance, *Gryllodes sigillatus* males 'sing' by rubbing vestigial wings together, while the native species *C. anahulu* is wingless and mute.

ALIEN SPECIES PRESENT ON SITE VERTEBRATES REPTILIA

Squamata

Gekkonidae: Phelsuma madagascariensis (Gray)

This relatively new alien is spreading across the island chain. First taken in Mānoa, O'ahu, in 1996 this colorful gecko is a growing threat to native species. Although seen in Kona over 5 years ago, this is the furthest south on Hawai'i Island I have observed this species.

Scincidae: Cryptoblepharus poecilopleurus (Wiegmann) 1834

Snake-eyed skink

This skink was sighted at Kanonone pond and other locations. All reptiles in Hawai'i are adventive (not native). This skink has been in the islands for many years and is widely reported on all major islands, Ni'ihau and Laysan. (HBS 2002c)



Figure 41. The coloring of the snake-eyed skink makes it especially cryptic on pāhoehoe lava flows.

Alien species present on site: Vertebrates (continued)

AVES

A total of 69 individual non-native birds, representing 9 species from 7 separate families were recorded during the December and January surveys. As with native birds, the anchialine ponds and sea shore were favored habitats. See Table 2 for a complete listing. None were exceptional and have wide ranges throughout the island chain. Avian diversity was low, with Doves and Cardinals being the commonest. A low level of food resources is the most likely reason for low numbers of birds.

MAMMALIA:

Artiodactyla: Bovidae: Capra hircus Linnaeus

Feral goats were present and browsing on plant resources in several locations in the property. They were observed repeatedly by both botanical and invertebrate surveyors in December 2010 and again during the vertebrate survey, January 2011. They were observed near Pōhue Bay as well as inland. Abundant droppings were noted around the littoral cones at the coast, at and mauka of Pu'u Kī, and surrounding areas. Bruner (1987) also reported goats present on the site. Browsing by goats is the most likely cause of the low diversity in strand plants.





Figure 42. Goat bones in lava tube on the site.

Alien goat browsing does double damage to native species:

- most native vegetation, unlike most continental plants which evolved with browsers, does not sprout back after the growing tip is nipped off;
- *Pluchea carolinensis*, an alien present on site, is not eaten by goats due to a bitter taste in the leaves. The *Pluchea* thrives to displace native species.

Damage to native plants means damage to native invertebrate host plants. *Pluchea* is not known to host native invertebrates.

Alien species present on site: Vertebrates (continued)

Carnivora: Felidae: Felis catus Feral house cat

Feral house cats were not directly observed, but scat, containing bones, was collected along the footpath trail from Kanonone Ponds to the 'western pond'. The scat was too large to be from mongoose. Analysis of the contents showed a diet of insects (cockroaches, praying mantis), mice and rats (fur, teeth), as most plentiful. No bones easily identified as bird bones were seen, but all bone was fragmentary and small so that it was not possible to exclude birds from the cat's diet.

Rodentia: Muridae: Rattus sp. Rat

Rats were evidenced by an isolated instance gnawed hala (*Pandanus* sp.) seeds at Kanonone Ponds and one of chewing on coconuts. *Rattus norvegicus* (Norway rat), *Rattus rattus* (Roof rat), and *Rattus exulans* (Polynesian rat) are present on Hawai'i Island (HBS 2002d). Any of these species could occur on the property. Due to the low level of damage / feeding and lack of visual sightings, the rat population is probably low.

Mus musculus Linnaeus, 1758 House Mouse

Mice were evidenced by small teeth and fur in the Kanonone Ponds cat scat. They are ubiquitous in Hawai'i and their absence here would be surprising. They are likely in the mauka portion of the property as well.

Table 1: List of Invertebrates: Kahuku Village, Ka'ū, Hawai'i

Species	Common Name	Location	Status Fr	equency	Notes
MOLLUSCA					
GASTROPODA					
PULMONATA	snails and slugs				
Succineidae					
Succinea sp.		M	End	R	shell only; in leaf litter
ARTHROPODA					
ARACHNIDA					
ARANEAE	spiders				
Lycosidae					
Lycosa sp.	wolf spider	С	End	R	hunting at light survey
Salticidae	jumping spider				
undetermined spider 1		M	?	U	
INSECTA					
BLATTODEA					
Blattidae	cockroaches				
Periplaneta americana (Linnaeus), 1758:	American cockroach	LT	Adv	0	in cat scat; in lava tubes
COLEOPTERA	beetles				
Anobiidae					
Holcobius sp.		M	End	R	in dry lama stem
Bostrichidae					
undetermined beetle 1		М	Adv	R	ID by dry tunnels in dead <i>Diospyros</i> (lama)

Species	Common Name	Location	Status	Frequency	Notes
COLLEMBOLA	springtails				
Entomobryidae					
undetermined sp. 1		M	?	0	under stones
DIPTERA					
Canacidae					
Canaceoides hawaiiensis Wirth, 1969	beach fly	С	End	0	
Ceratopogonidae					
Forcipomyia hardyi Wirth & Howarth, 1982		C, M	End	Α	at light
Chironomidae	bloodworm midges				
Chironomus hawaiiensis Grimshaw, 1901		AP	End?	0	at light
Culicidae	Mosquitoes				
Aedes albopictus(Skuse, 1894)	forest day mosquito	M	Adv	R	breeding in trash
Culex quinquefasciatus Say, 1823	Southern house mosquito	С	Adv	R	breeding in trash
Dolichopodidae					
Hydrophorus williamsi Parent, 1938	tidal long-legged fly	AP	End	0	
Drosophilidae					
Drosophila sp.		С	?	0	in <i>Ipomoea</i> flowers adults and larvae
Ephydridae					
Scatella sp.	shore flies	С	End	0	

Species	Common Name	Location	Status	Frequency	Notes
HETEROPTERA	true bugs				
Lygaeidae	seed bugs				
Nysius sp.		M	End	R	at light
Miridae					
Orthotylus daphne Kirkaldy, 1902		М	End	U	
HOMOPTERA	planthoppers				
Cicadellidae	leafhoppers				
Nesophrosyne sp. 1		С	End	U	
Nesophrosyne sp. 2		С	End	U	
Psyllidae					
Trioza hawaiiensis Crawford 1918		M	End	Α	in 'ōhi'a leaf gall
Cixiidae					
Oliarus sp. 1		M	End	R	2 on <i>Pleomele</i>
Oliarus sp. 2		M	End	U	6 at light
Oliarus sp. 3, nr. discrepans		С	End	U	at light, possible n. sp.
HYMENOPTERA	wasps, bees, ants				
Anthophoridae	·				
Xylocopa sonorina F. Smith, 1874	carpenter bee	С	Adv	U	
Formicidae	ants				
Camponotus variegatus	carpenter ant	AP, M	Adv	0	to light
Anoplolepis gracilipes (F. Smith, 1857)	longlegged ant	М	Adv	С	many on maua, lama, 'ōhi'a
Pheidole megacephala (Fabricius, 1793)	big-headed ant	AP, M	Adv	A	on soil by lama; many on kou

Species	Common Name	Location	Status	Frequency	y Notes
Hymenoptera continued					
Colletidae					
Hylaeus flavipes (F. Smith)	yellow-faced bee	M	End	R	by 'ōhi'a lehua flowers 11 ♂, 1 ♀
Vespidae	wasps				
Polistes exclamans Viereck, 1906	common paper wasp	C, AP, LT, M	Adv	0	widely distributed
LEPIDOPTERA	butterflies & moths				
Anatrachyntis incertulella (Walker, 1864)		С	Adv	R	larvae feed on <i>Pandanus</i> male inflorescence
Hyposmocoma sp. 1	black adult	M	End	0	at light
Hyposmocoma sp. 2	white thorax, adult	M	End	U	at light
Hyposmocoma sp. 3		M	End	R	at light
<i>Trissodoris honorariella</i> (Walsingham 1907)		С	Adv	R	cocoon in leaf
Crambidae (Pyralidae)	micro-moths				
Eudonia sp. 1	moss moth	M	End	U	at light
Eudonia sp. 2	moss moth	C, M	End	U	at light
Mestolobes sp.		M	End	R	at light
Omiodes blackburni (Butler, 1877)	coconut leafroller	С	End	U	larval evidence
Omiodes continuatalis (Wallengren, 1860)		AP	End	R	at light
Orthomecyna sp. nr. chrysophanes		М	End	R	at light
Orthomecyna exigua exigua (Butler, 1879)		М	End		at light
Tamsica hyacinthina (Meyrick 1899)			End	С	at light
Udea sp. 1		М	End	R	at light
Udea sp. 2		M	End	R	at light

Species	Common Name	Location	Status	Frequency	/ Notes
Lepidoptera continued					
Geometridae					
Macaria abydata Guenee, 1857		М	Adv	0	at light & reared ex. Senna
Gracillariidae					
Caloptilia sp.		M	Adv	R	
<i>Philodoria basalis</i> Walsingham, 1907	leaf miner	M	End	R	at light
Noctuidae					
Agrotis sp. nr. microreas Meyrick, 1899		С	End	R	at light
Ascalapha odorata (Linnaeus, 1758)	black witch moth	C, LT, M	Adv	Α	at light; in lava tube openings
Hypocala deflorata (Fabricius, 1793)		M	Adv	U	on lama
Oecophoridae					
Ethmia nigroapicella (Saalmueller, 1880)	Kou leafworm	M	Adv	Α	leaf damage, widespread
Sphingidae					
Agrius cingulata (Fabricus, 1775)	sweet potato hornworm	С	Adv	R	at light
Hyles calida hawaiiensis (Rothschild & Jordan, 1915)	Hawaiian sphinx	C, M	End	U	at light
Hyles lineata (Fabricus, 1775)	white-lined sphinx	С	Adv	U	at light

Species	Common Name	Name Location Status Frequence		requency	Notes
ODONATA	dragonflies; damselflies				
Aeshnidae					
Anax junius (Drury, 1770)	common green darner	AP	Adv	U	at pond
Coenagrionidae					
Megalagrion xanthomelas (Selys-Longchamps, 1876)	Orangeblack Hawaiian Damselfly	AP	End	0	candidate species for protection End Sp Act
Libellulidae	skimmers				
Pantala flavescens (Fabricius, 1798)	globe skimmer	AP	Ind	R	in flight
ORTHOPTERA	praying mantis, grasshoppers, crickets				
Gryllidae	crickets				
Caconemobius anahulu Otte,1994	lava cricket	C, M	End	0	identification under review, possible n. sp.
Caconemobius sandwichensis Otte,1994	beach cricket	С	End	0	
Gryllodes sigillatus (Walker)1869	flightless field cricket	C, M	Adv	0	on lava

LOCATION:

Anchialine Ponds ΑP

С Coastline

LT Lava Tube

Mauka (northwest corner of property) М

STATUS:

End endemic to Hawaiian Islands indigenous to Hawaiian Islands Ind

Adv adventive

purposefully introduced Pur

unknown

FREQUENCY = occurrence ratings:

seen in only one or perhaps two locations. seen in several locations R Rare

U Uncommon-

seen with regularity observed numerous times Occasional 0 С

Common found in large numbers Abundant Α

Very abundant abundant and dominant AA

Table 2: List of Vertebrates: Kahuku Village, Ka'ū, Hawai'i

	1987	
се	survey	1

					1987	
Species	Common Name	Location	Status	Abundance	survey	Notes
REPTILIA						
Squamata						
Gekkonidae						
Phelsuma madagascariensis	Madagascar day gecko	М	Α	R		near lama, on agave
Scincidae	Skinks					
Cryptoblepharus poecilopleurus (Wiegmann) 1834		AP	Α	Α		
AVES						
PELECANIFORMES						
Fregatidae						
Fregata minor palmerstoni	'Iwa or Great Frigatebird	С	R	R		coming inland, advancing storm
Phaethontidae						
Phaethon lepturus	Koa'e kea White-tailed Tropicbird	С	R	R		immature
CHARADRIIFORMES						
Charadriidae						
Pluvialis fulva	Kōlea Pacific Golden-Plover	C, M	V	U	Х	
Sternidae						
Anous sp.	Black or Brown Noddy	С	R	R		
Scolopacidae						
Heteroscelus incanus	ʻŪlili Wandering Tattler	AP, C	V	U	Х	

1987

					1987	
Species	Common Name	Location	Status	Abundance	survey	Notes
(Aves continued)						
CICONIIFORMES						
Ardeidae						
Nycticorax nycticorax	'Auku'u; Black- crowned Night-Heron	AP	R	?		based on cracked pond snail shells; theorized by Bruner
COLUMBIFORMES						
Columbidae						
Geopelia striata	Zebra Dove	AP, M	Α	С	Х	
Streptopelia chinensis	Spotted Dove	AP, M	Α	С	Х	
GALLIFORMES						
Phasianidae						
Francolinus pondicerianus	Gray Francolin	AP	Α	U	X	
PASSERIFORMES						
Cardinalidae						
Cardinalis cardinalis	Northern Cardinal	M	Α	U	Χ	
Paroaria capitata	Yellow-billed Cardinal	AP	Α	U		
Estrildidae						
Lonchura cantans	African Silverbill	AP	Α	U		theorized by Bruner
Fringillidae						
Carpodacus mexicanus	House Finch	M	Α	U	Χ	

Species	Common Name	Location	Status	Abundance	1987 survey	Notes
(Aves Passeriformes continued)						
Sturnidae						
Acridotheres tristis	Common Myna	AP	Α	U	Χ	
Zosteropidae						
Zosterops japonicus	Japanese White-eye	M	Α	U	Χ	
MAMMALIA						
RODENTIA						
Muridae						
Rattus sp.	rat	AP	A	R		based on gnawed seeds and teeth in cat scat; theorized by Bruner
Mus musculus Linnaeus, 1758	house mouse	С	А	R		based on teeth, fur in cat scat; theorized by Bruner
Carnivora						
Felidae						
Felis catus Linnaeus, 1758	domestic cat, feral	С	Α	R		based on presence of scat
ARTIODACTYLA						
Bovidae						
Capra hircus Linnaeus, 1758	domestic goat, feral	C, M	Α	С	Χ	visual, bones, scat, browsing

LOCATION:	STATUS:	ABUNDANCE *
AP Anchialine Ponds C Coastline M Mauka (northwest corner of property)	R Resident native speciesA Alien introduced speciesV Visitor, breeds elsewhere	R Rare seen only once during survey. U Uncommon- less than 5 seen on average daily C Common between 5-10 seen on average daily A Abundant more than 10 seen on average daily
* to allow comparison to Bruner's survey,	nis abundance ratings have been used	X Seen in 1987 by Bruner

SPECIAL HABITATS

Lava Tubes on the site

The survey examined a sampling of the lava tubes present within the project area. Representative tubes were sought from among tubes located in my own work and in previous archaeological surveys (Haun 1987; Dye pers. com. 2010).

Native lava tube specialist species require a cave long enough to have a dark zone, moisture, and a food source. Long roots can support herbivorous members of the ecosystem (Figure 42), which in turn are hunted by the carnivores. In wetter lava tube communities, the herbivores, the larvae of crane flies (*Limonia* sp.), may eat slime covering large portions of the wall surface and leave characteristic trails (Figure 43). (Howarth 1973)

At Kahuku Village I found tubes had both low moisture and no overhead plants with roots descending to reach into the lava tubes. These lava tubes generally have multiple skylights and a very short dark zone or none at all (Figure 44). The surveyed tubes showed no evidence of slime (Figure 45). These results are similar to those observed by recent archaeological surveyors (Komori pers. com. 2010), and by cave mappers (Bosted pers. com.). None of the lava tubes located proved suitable for baiting.

No cave-adapted invertebrate species were seen. The most common arthropod encountered in the sample of lava tubes surveyed was the adventive American cockroach (*Periplaneta americana*). The Black witch moth (*Ascalapha odorata*) (see pg. 33), uses the lava tubes for daytime shelter, just as they shelter under roof eaves in the city. Goat droppings were frequently seen in the tubes with larger entrances.



Figure 43. To support a thriving lava tube ecosystem a cavern needs a long dark zone and a large number of long and healthy roots penetrating from overhead vegetation (example above).



Figure 44. In wetter lava tubes that support healthy ecosystems, large portions of the surface may be covered with a slime, on which the larvae of crane flies (*Limonia* sp.) leave characteristic trails. © near volcano Feb 2008



Figure 45. Frequent skylights or openings to the outside in the Nani Kahuku lave tube system, make the tubes too dry and too bright for a healthy dark-adapted cave ecosystem.



Figure 46. Typical view inside a Nani Kahuku lava tube. Inhospitable to cave adapted invertebrates, with no roots penetrating, and no slime coating.

SPECIES NOT OBSERVED ON THE SITE INVERTEBRATES

Alien predatory ants are a major cause of low numbers of native arthropods. The bigheaded ant (*Pheidole megacephala*), longlegged ant (*Anoplolepis gracilipes*), and carpenter ant (*Camponotus variegatus*), which prey on other insects (Zimmerman 1948-80), are present on the property. They were often noted patrolling native plants such as 'ōhi'a lehua, documented as host to a long list of native invertebrates. Ants are well documented as a primary cause of low levels of native arthropods at elevations up to 2000 ft. (Perkins 1913). On all nights, during light censusing, ants quickly appeared and began attacking the resting moths and smaller insects at my light⁴. Ant populations often do not overlap. Rather they have separate territories, effectively apportioning the hunting grounds between themselves, offering few, if any, ant-free zones where native arthropods can thrive.



Figure 47. Big-headed ants appeared each night attracted to my light survey. Their hunting technique is to overpower prey in large numbers, dismember the insect, carrying off parts to the nest. The group on the right is guarded by a soldier (larger, far left).

⁴ Native insects were quickly rescued. The two aliens in Figure were used to illustrate what happens in nature.

Not observed on the site: Invertebrates (continued)

ARTHROPODA INSECTA

Diptera: Drosophilidae: Drosophila Picture-winged flies

The location does not provide appropriate habitat for any of the 12 native *Drosophila* species recently listed as endangered or threatened and none were observed. (USFWS 2006a, b).

Lepidoptera: Sphingidae

Manduca blackburni Blackburn's sphinx moth Blackburn's sphinx moth (Manduca blackburni). (Figure 47) an endangered species (Fed Reg 1999-2000) which favors leeward slopes, was not found in this survey. The moth's solanaceous native host plant, ʻaiea (Nothocestrum sp.), and best alien host, tree tobacco (Nicotiana glauca), were not observed on the property in my own survey, or on a prior botanical survey (Char 1987), nor the most recent botanical survey (LeGrande 2010 pers. com.). Intact, uneaten Nicotiana tabacum was seen once in my survey. Although Capparis sandwichiana, a nectar plant favored by the adult moth, was reported by Char (1987), the plant was not encountered in my surveying.

Although the original *Recovery Plan* (USFWS 2005b) for this large sphinx moth proposed two



© Figure 48. Blackburn's sphinx moth is distinguished from other hawk moths by orange markings.

small management areas in North Kona, Hawai'i, the *Final Rule* (USFWS 2003) designated habitat only at the more inland location, Pu'uwa'awa'a. Neither originally proposed location was near the survey site.

Not observed on the Site: (continued)

VERTEBRATES AVES

Bruner's 1987 survey observed 5 species of note not seen by this survey:

- 'lo, Hawaiian Hawk (Buteo solitarius), native
- Barn Owl (Tyto alba), alien
- Pueo, Short-eared Owl (Asio flammeus sandwichensis), native
- Hawai'i 'Amakihi (Hemignathus virens), native
- 'Apapane (Himatione sanguinea), native

'Amakihi and 'Apapane require extensive upland forest habitat not included in the current project footprint. Bruner reported these birds in the uplands, near the Kahuku Ranch property. It is possible individual birds might rarely visit the mauka area of this survey when 'ōhi'a flowers are in bloom and providing nectar. Although some flowers were blooming, and a careful watch was kept, no birds were seen.

'lo can use forested and open habitats, but require more extensive vegetation to support a higher abundance of prey than the project area presents. Pueo and Barn owls also use open habitats, but are more often associated with agricultural or forested habitat and a prey density not observed in this survey. Additionally, this survey did not observe any owl pellets in locations where pellets have been seen in other surveys (e.g., lava tubes entrances).

Both 'lo and the owls were reported by Bruner (1987) from upland areas and closer to the Kahuku Ranch and from reports of the Ranch manager.

Birds not seen by Bruner or this survey, but which may use the property:

- 'Ua'u or Hawaiian or Dark-Rumped Petrel (*Pterodroma sandwichensis*)
- 'Ake'ake or Band-rumped Storm-Petrel (*Oceanodroma castro*)

'Ua'u, a federally endangered seabird, nests inland to breed on the upper slopes of Mauna Loa inside Hawaii Volcanoes National Park, far above the project area. Less is known about the nesting of 'Ake'ake, listed as endangered by the state and a candidate for federal endangered status (USFW 2010a). Both birds only would be present on Hawai'i Island during an April to November nesting season. Neither bird was observed by Bruner (1987) whose survey did take place in April, nor were they among the birds he believed "could potentially occur on the property." Petrels can be detected by calls in flight, but some birds may not call and presence is best detected by radar (Swift & Burt-Toland 2009), which Bruner did not use. Nevertheless, adults and young, whose flights take place at night,

Not observed on the Site: (continued)

may transit over the property on their way to the sea. It is prudent to act as if they might be present occasionally in small numbers over the project area. (See Recommendations)

'Ae'o or Hawaiian Stilt (*Himantopus mexicanus knudseni*) is known to use anchialine pond habitat in other areas of Hawai'i Island. Although not seen by this survey, the pond habitat is suitable for them. Bruner listed this bird among those he had not observed, but believed "could potentially occur on the property." (1987) It is prudent to act as if stilts, listed as endangered by the state, might be present occasionally in small numbers at the ponds. (See Recommendations)

MAMMALIA

Carnivora: Canidae: Canis familiaris Feral Dog

Neither Bruner (1987) nor this survey noted any feral dogs on the property.

Chiroptera: Vespertilionidae: Lasiurus cinereus semotus (H. Allen, 1890)

Hawaiian Hoary Bat

1-hour bat searches were conducted at dusk January 3 and 4, and at dawn on January 4 and 5, 2011. Additionally, although both the botanical and invertebrate teams were alert for bat sightings in December 3-12, 2010 field work, neither team sighted the animal. Previously, both teams often have observed bats in flight elsewhere.

Bruner (1987) did not see the bat, but states it "has been reported in the area." It should be noted Bruner's survey covered a much larger acreage, including a large forested kīpuka in the mauka section of the property closer to the Kahuku Ranch entrance. Tracking Bruner's statement shows one source is the Kahuku Ranch manager reporting on ranch lands. Also cited is a letter by E. Kosaka, Office of Environmental Services USFWS. Kosaka quotes S. Gon, III: "Hawaiian bats have been observed within this coastal region." Dr. Gon (2011 pers. com.) recalls no specific viewing of the bat on the Kahuku Village property and believes his comment referred to the entire Ka'u coastline.

Although the native bat may overfly the property or occasionally feed there, the portions of the site now considered for development do not provide appropriate habitat for roosting. Bruner notes strong winds (encountered during this survey as well) may make foraging for prey impractical for bats at this location. However, this survey shows a high number of insects blown onto the property (e.g., black witch moths) making a large potential bat food supply. (See Recommendations)

Not observed on the Site: Vertebrates

Carnivora: Viverridae: *Herpestes auropunctatus auropunctatus* (Hodgson, 1836) Small Indian mongoose

Although surveyors were alert for their presence in both December 2010, and January 2011, mongoose were not observed. They were reported by Bruner (1987) in the upper portions of the property. Together with a lack of continuous human generated food sources, this may be a reason for their absence from my survey.

Artiodactyla: Suidae: Sus scrofa scrofa Linnaeus, 1758 Feral Pig Feral pigs, common in the Hawaiian Islands, were not observed during the survey. The area may be too dry and the lava fields do not provide sufficient food sources (e.g., earth worms, soft fruits). Bruner (1987) reported seeing no individuals, but did see remains. Again, Bruner's survey covered a wider area than this survey and may have been conducted during a wetter year when food sources were more plentiful. A freshly butchered pig carcass was found dumped in the upper portion of the property along a roadside during the January 2011 survey. It is possible the remains noted by Bruner (1987) were the result of a similar, but aged dump.

MEDICALLY IMPORTANT SPECIES ON THE SITE

Invertebrates:

Although not seen during the survey, the larger Kahuku Village project area includes some classic habitat for centipedes, scorpions, and widow spiders. Common paper wasps (*Polistes exclamans*) (Figure 48) were seen on the property.

Those entering the property should be alert for these species as they may pose a serious risk to some individuals, and supervisors should be aware of any employee allergies. Some individuals can



© Figure 49. Paper wasp

experience anaphylactic reactions to venom. Before entering lava tubes, inspect overhangs for wasp nests. Never put hands where eyes cannot see. When moving stones or piled brush workers can greatly reduce the risk of accidental contact and bites or stings with all species noted here with clothing. Recommended are the use of gloves and wearing long sleeved shirt, long pants, boots with socks pulled up over pant cuffs.

Medically Important: (continued)

Two types of mosquitoes, *Aedes albopictus* and *Culex quinquefasciatus*, were seen in small amounts of water created in trash. Both species are widespread in the islands and known to be vectors of disease for humans (*A. albopictus*, dengue) and birds (*C. quinquefasciatus*, bird malaria) (Goff & vanRiper 1980). Care should be taken during construction and in design of new facilities not to create standing water without control agents. In the anchialine ponds the many native creatures control any mosquito eggs laid there.

Please see What Bit Me? (Nishida & Tenorio 1993) and What's Bugging Me? (Tenorio & Nishida 1995).

Vertebrates:

Evidence of rats was observed on the property. Rats have a long history as a danger to human health. They are documented as attacking nesting birds (Tomich 1986) and damage the seeds of native plants reducing natural replacement of mature plants. Care should be taken during the construction phase not to provide conditions that will lead to an increase in rat populations. (see "Recommendations")

POTENTIAL IMPACTS

Potential Impacts on Native, Rare, Federally or State Listed Species

No federally or state listed endangered or threatened invertebrate species were noted in this survey (USFWS 2010b).

Actions related to the anchialine ponds should be specifically assessed as project plans are finalized. The ponds support and affect all other wildlife within the project area and are extremely fragile.

It should be remembered that the Endangered Species Act is not the only law affecting wildlife. All birds, native and introduced, are protected by state law to varying degrees (HAR). All native birds and most introduced birds are protected by the federal Migratory Bird Treaty Act (USC), for example. Any action affecting birds or their habitat should involve consultation with state and federal wildlife officials.

RECOMMENDATIONS

Prevent habitat degradation:

Fulfillment of the plan to preserve some archaeological sites and parts of the beach habitat should assist native birds and invertebrate species, including any cave adapted species which may be present in lava tubes not seen in this survey.

We concur with LeGrande's recommendations (2011) for removal of selected alien plants in and around the pond and beach areas. Fountain grass especially is known to assist in the spread of fire and can crowd out other species quickly. Removal of aliens can assist native plants – hosts to invertebrates, food source for native birds - in filling their natural habitat niches. Additionally, it is important to prevent establishment of new competitive plant or predatory alien invertebrate species during any building activities (see below).

We concur with LeGrande's recommendation (2011) to fence out goats in the Lama forest in the mauka portion to allow recovery of gnawed flora. In coordination with alien plant removal, the exclusion of goats can be very helpful in encouraging native plants and the zoological resources which depend on them. Goats contribute to plant deaths, resulting in open soil. In areas such as Ka'ū, where rains come only very sporadically, erosion from flash run-off can seriously affect off-shore water quality or despoil anchialine ponds with silt. We also agree with LeGrande's recommendation (2011) to implement a goat hunting program to greatly reduce numbers, with special concentration on those in the area around the ponds.

A **Best Practices Management Plan** for construction should be written and implemented specifying methods and controls for the entire construction zone to prevent or minimize runoff, spills, and impact on the makai coastal habitats and anchialine ponds as well as archaeological sites. Establish construction staging areas and storage of materials well away from the most fragile sites.

Invasive species, alien to a Hawaiian ecosystem, can do terrible damage to native invertebrates and reduce native plant pollinators, and food resources for native birds (see Figure 46 above). Two factors influence establishment of alien species which prey on and compete with native species: access and regular food sources. Soil packed in tires, on helicopter runners, or workers' boots can transport seeds and insect or snail eggs. Ants, snails and slugs, and many other invertebrates can hide in boxes or equipment resting at one location and later be carried to Kahuku Village.

Recommendations: (continued)

To prevent establishment of alien species:

Inspect construction materials for hitchhiking seeds or animals. When establishing landscape plantings after construction, care should be taken to prevent alien plant or animal species from being introduced on the plantings, associated soil, or pots.

Clean tools, boots, and equipment used at other projects to minimize the chance of transporting new pest plants or animals to the area.

Remove trash regularly. Predatory invertebrate species such as ants easily establish in areas where food trash is consistently available. Food trash during construction can attract and / or increase mongoose, cat, and rat populations as well, resulting in predation on birds and native seeds. Provide trash cans at construction areas where food is consumed, keep cans covered, and empty them frequently. Importantly, construction supervisors need to establish a culture of using the receptacles.

Restrict food sources: Do not allow employees or others to feed cats or encourage cat colonies. In addition to attracting cats, this will feed rats and mice.

Restrict animal access: Do not allow employees or others to bring pet dogs or cats to the work site. Even well behaved animals can escape a leash and fail to return on command. Dogs will harass and kill birds and turtles.

Shield external lighting:

During construction and in the finished project and roadways, it will be important to plan to shield outdoor lighting. Unshielded lighting is well-known for confusing, exhausting, and stranding sea birds and turtles making them vulnerable to predators. Additionally, artificial lighting is attractive and confusing to many arthropods (see *Methods* page 7), concentrating them as easy prey for feeding bats at night. Insects attracted to lights at night often remain in place at dawn and are easily seen and consumed by birds. Additionally, the Hawaii County Code § 14 – 50 et seq. requires shielding exterior lights, to reduce glare interference for the astronomical observatories located on Mauna Kea.

Landscape with native dryland plants for lower cost maintenance:

We concur with the advice of Char (1987) and LeGrande (2011) to revegetate public and common areas with native dryland adapted plants. The plantings will provide educational, visual, and aesthetic benefits to residents while conserving water. Native plants would provide habitat for native arthropods, while creating interesting areas for walking, cultural learning, nature study, and bird watching.

Recommendations: (continued)

Given the project area climate, native plants are both practical and appropriate. Using dryland plants to landscape can lower long-term watering costs and water draws. Planted in a mix of ground cover, shrub, and tree heights, native plants will slow run off and retain moisture when rains do come. Native plants will remain green and more fire resistant throughout dry periods. Most native plantings have lower maintenance costs as well. Native species need less hedge trimming, weed whacking, and usually grow well without fertilizers, reducing cost and the potential for non-point pollution potential for the ocean and anchialine ponds. Native invertebrates will find this refuge over time. Native birds will obtain food from fruits and seeds.

Home buyers could be given guidance on xeriscaping with restrictions being considered as part of covenants or homeowner association rules. Several southwestern U. S. continental cities have long enforced water / yard planting restrictions due to water concerns. Their experiences may prove helpful in planning.

Resources helpful in understanding Hawaiian plants in an urban setting include *Native Hawaiian Plants for Landscaping, Conservation, and Reforestation* (Bornhorst & Rauch 1994) and *Growing Native Hawaiian Plants* (Bornhorst 2005). By prior arrangement with growers, native Hawaiian plants can be as convenient to mass plant as the introduced plants commonly used to re-vegetate after new construction. Plants grown from seeds gathered from Kahuku plants would be especially well adapted to local conditions.

Community Education:

The best defense any fragile ecosystem can have is an informed public. Providing defined pathways would reduce trampling of plants and disturbance of wildlife. Providing signage and partnering with community environmental groups to provide information and guidance about enjoying preserved beach side areas, archaeological, and natural features, would make preservation more effective. A good start has been made with the Turtle sightings program.

ACKNOWLEDGMENTS

Thanks are extended to Nicholas Mitchell and Maya LeGrande for assistance in the field. Special thanks are due to T.S. Dye & Colleagues, Archaeologists, Inc., and P. Bosted for providing guidance to locate lava tubes. The Dept of Land and Natural Resources provided permits to collect voucher specimens to validate identification of native invertebrates. Dr. F. G. Howarth and Dr. F. Stone are thanked for consultation on the native crickets.

Steven Lee Montgomery directed all surveys and is responsible for all conclusions. Nicholas Mitchell (veteran organizer of Hawaii Audubon Society annual bird counts on Hawai'i Island) and Maya LeGrande participated in the vertebrate census. Anita Manning contributed to preparation of this report. Thanks are extended to Dr. Eric VanderWerf for comments on the Vertebrate sections of the report.

Some images used in this report were not taken in the course of this project. These photos, marked by © symbol were made by Anita Manning and/or S. L. Montgomery prior to this contract and were chosen because they best illustrate the subject. Images marked by (L) were made by Maya LeGrande during this project.

STANDARD NOMENCLATURE

Bird names

English and scientific follow *Checklist of the Birds of Hawaii.* (Hawaii Audubon Society 2002, 2005)

Hawaiian names follow Pukui & Elbert (1986).

Invertebrate names follow

Freshwater & Terrestrial Mollusk Checklist (HBS 2002b)

Common Names of Insects & Related Organisms (HES 1990)

Hawaiian Terrestrial Arthropod Checklist (HBS2002a; Nishida 2002)

Mammal names follow *Mammals in Hawai'i* (Tomich 1986) and *Hawaiian Mammal Checklist* (HBS 2002d)

Place name spelling follows *Place Names of Hawai'i* (Pukui et al. 1976) and *Hawai'i Place Names: Shores, Beaches, and Surf Sites* (Clark 2002)

Plant names follow

Manual of the Flowering Plants of Hawai'i (Wagner et al. 1999)

A Tropical Garden Flora (Staples and Herbst 2005)

Reptile and Amphibian names follow *Hawaiian Reptile & Amphibian Checklist* (HBS 2002c)

ABBREVIATIONS

DLNR Department of Land and Natural Resources, State of Hawai'i

DOFAW Division of Forestry and Wildlife, State of Hawai'i **EISPN** Environmental Impact Statement Preparation Notice

ft feet

HBS Hawai'i Biological Survey

m meter

MV Mercury Vapor

n. newsp. species

spp. more than one species

TMK Tax Map Key

UH University of Hawai'i

USFWS United States Fish and Wildlife Service

UV Ultraviolet

GLOSSARY⁵

Adventive: organisms introduced to an area but not purposefully.

Alien: occurring in the locality it occupies ONLY with human assistance, accidental or purposeful; not native. Both Polynesian introductions (e.g., coconut) and post-1778 introductions (e.g., guava, goats, and sheep) are aliens.

Arthropod: insects and related invertebrates (e.g., spiders) having an external skeleton and jointed legs.

Aspiration: invertebrates are transferred from the original location (leaf, net, etc.) into a large vial. Two tubes are lodged in one stopper in the vial. Air drawn in on one tube, creates suction at the end of the second tube; the target insect is drawn into the vial by the pulling air.

Endemic: naturally occurring, without human transport, ONLY in the locality occupied. Hawaii has a high percentage of endemic plants and animals, some in very small microenvironments.

Indigenous: naturally occurring without human assistance in the locality it occupies; may also occur elsewhere, including outside the Hawaiian Islands. (e.g., Naupaka kahakai (*Scaevola sericea*) is the same plant in Hawai'i and throughout the Pacific).

Insects: arthropods with six legs, and bodies in 3 sections

Invertebrates: animals without backbones (insects, spiders, snails / slugs, shrimp)

Kīpuka: an area of vegetation surrounded by younger lava flows

Larva/larval: an immature stage of development in offspring of many types of animals.

Makai: toward the ocean

Mauka: toward the mountains

Midden: human food refuse in an archaeological setting, often in a heap or pile

Mollusk: invertebrates in the phylum Mollusca. Common representatives are snails, slugs, mussels, clams, oysters, squids, and octopuses.

Native: organism that originated in area where it lives without human assistance. May be indigenous or endemic.

Naturalized: an alien organism that, with time, yet without further human assisted releases or plantings, has become established in an area to which it is not native.

Nocturnal: active or most apparent at night.

⁵ Glossary based largely on definitions in *Biological Science: An Ecological Approach*, 7th ed., Kendall/Hunt Publishing Co., Dubuque, a high school text; on the glossary in *Manual of Flowering Plants of Hawai'i*, Vol.2, Wagner, et al., 1999, Bishop Museum Press, and other sources.

Glossary: cont.

Pupa: the stage between larva and adult in insects with complete metamorphosis, a non-feeding and inactive stage often inside a case

Purposefully introduced: an organism brought into an area for a specific purpose, for example, as a biological control agent.

Rare: threatened by environmental factors and in low numbers.

Species: all individuals and populations of a particular type of organism, maintained by biological mechanisms that result in their breeding mostly with their kind.

Vertebrates: animals with backbones (birds, mammals, reptiles)

Waxing: describes a gradual increase in the amount of the moon's disk that is visible

LITERATURE CITED

- Academic Search Premier. Accessed November 2010. http://web.ebscohost.com/
- AGRIS on-line index. Accessed November 2010. www.fao.org/agris/Centre
- Alakai, R. 2010. Office of Environmental Quality Control, Honolulu, HI. Personal communication, November 10, 2010.
- Belt, Collins & Associates. 1987. Hawaiian Riviera Resort, Kahuku, Ka'u, Hawaii: Draft Environmental Impact Statement. Prepared for Palace Development Corporation. Honolulu, HI. 897 pp.
- Berger, A. J. 1972. *Hawaiian Birdlife*. University Press of Hawaii, Honolulu, Hawai'i', 270 pp.
- Böhlke, E. B and J. E. Randall. 2000. "A review of the moray eels (Angulliformes: Muraenidae) of the Hawaiian Islands, with descriptions of two new species," *Proceedings of the Academy of Natural Sciences of Philadelphia*, 150:203-278. Philadelphia, PA
- Bornhorst, H. L. 2005. *Growing native Hawaiian plants: a how-to guide for the gardener*. Bess Press, Honolulu, 104 pp.
- and F. D. Rauch. 1994. *Native Hawaiian plants for landscaping, conservation, and reforestation*. HITAHR, College of Tropical Agriculture and Human Resources, University of Hawaii, Honolulu. 17 pp.
- Bosted, P. 2011. Personal communication. Cave survey team.
- Bridwell, J. C. 1920, "A New Lowland Plagithmysine Cerambycid from Oahu with Notes on its Habits. [Ewa Dryland Insect survey]," *Proceedings of the Hawaiian Entomological Society*, 4 (2): 314-327.
- Bruner, P. L. 1987. Avifaunal and Feral Mammal Survey of Hawaiian Riviera Resort Property at Ka'u, Hawaii. Prepared for Belt Collins and Associates, Honolulu, HI. 21 pp.
- Bryan, Jr., E. H. 1929. Notes and Exhibitions, *Proceedings of the Hawaiian Entomological Society*, 7(2):237.
- Char, W. P. 1987. Flora Survey: Proposed Hawaiian Riviera Resort, Kahuku, District of Ka'u, Island of Hawai'i. Prepared by Char & Associates for Belt, Collins, & Associates, Honolulu, HI. 31 pp.
- Clark, J. R. K. 2002. *Hawai'i Place Names: Shores, Beaches, and Surf Sites*. University of Hawai'i Press, Honolulu, 412 pp.

- Daly, H. V. and K. N. Magnacca. 2003. *Insects of Hawaii*. Volume 17: *Hawaiian Hylaeus*. University of Hawaii Press, Honolulu, Hawaii. 234 pp.
- Department of Land and Natural Resources (DLNR). 1996, 1997. Indigenous Wildlife, Endangered and Threatened Wildlife and Plants, and Introduced Wild Birds. Department of Land and Natural Resources. State of Hawaii. Administrative Rule §13-124-2 -§13-124-3, June 13, 1996. Exhibit 1. Feb. 1, 1997. www.state.hi.us/dlnr/dofaw/rules/Chap124exhib.pdf
- Dye, T. S. & Colleagues, Archaeologists, Inc. 2010. Personal communication.
- Elwell, M. and D. 2009. History of Kahuku Ranch: A historical guide to the ahupua'a of Kahuku... Elwell Associates, Naalehu, HI. 71 pp.
- Federal Register. 1999-2000. Title 50, Volume 1, Parts 1 to 199. [Revised as of October 1, 2000] U.S. Government Printing Office via GPO Access [CITE: 50CFR17.11, pp. 102-143]
- Forbes, C. N. No date. "Characters of Hawaiian Lava Flows." Ms. SC Forbes 4.19, in B. P. Bishop Museum Archives, Honolulu, HI.
- _____. 1909-1917. "Notes on Bishop Museum Herbarium." Ms. SC Forbes 4.11, in B. P. Bishop Museum Archives, Honolulu, HI.
- ______. 1917. "Report of the Curator of Botany," in *Report of the Director for 1916*, p 201-203. *Bishop Museum Occasional Papers*, Vol. 6, No. 4, Honolulu, HI.
- Geometrician Associates. 2008. Final Environmental Impact Statement, Ocean View Recycling Point and Convenience Center, Ka'u district, Hawai'i Island, State of Hawai'i. Prepared for County of Hawai'i, Department of Environmental Management. 531 pp. 2008-04-23-FEIS-Ocean-View-Recycling-Point-and-Convenience-Center
- Goff, M. L. and C. van Riper III. 1980. "Distribution of Mosquitoes (Diptera: Culicidae) on the East Flank of Mauna Loa Volcano, Hawaii", *Pacific Insects* Vol. 22, no. 1-2: 178-188
- Harrison, C. S. 1990. *Seabirds of Hawaii: Natural History and Conservation*. Cornell University Press, NY. 249 pp.
- Haun, A. E., and A. T. Walker. 1987. Final Report: Archaeological Reconnaissance Survey Hawaiian Riviera Resort Project Area, Land of Kahuku, Kau District, Island of Hawaii. Prepared for Belt, Collin and Associates, for Palace Development Corporation and Hawaii Ka'u aina Partnership, Honolulu, HI. 140 pp.

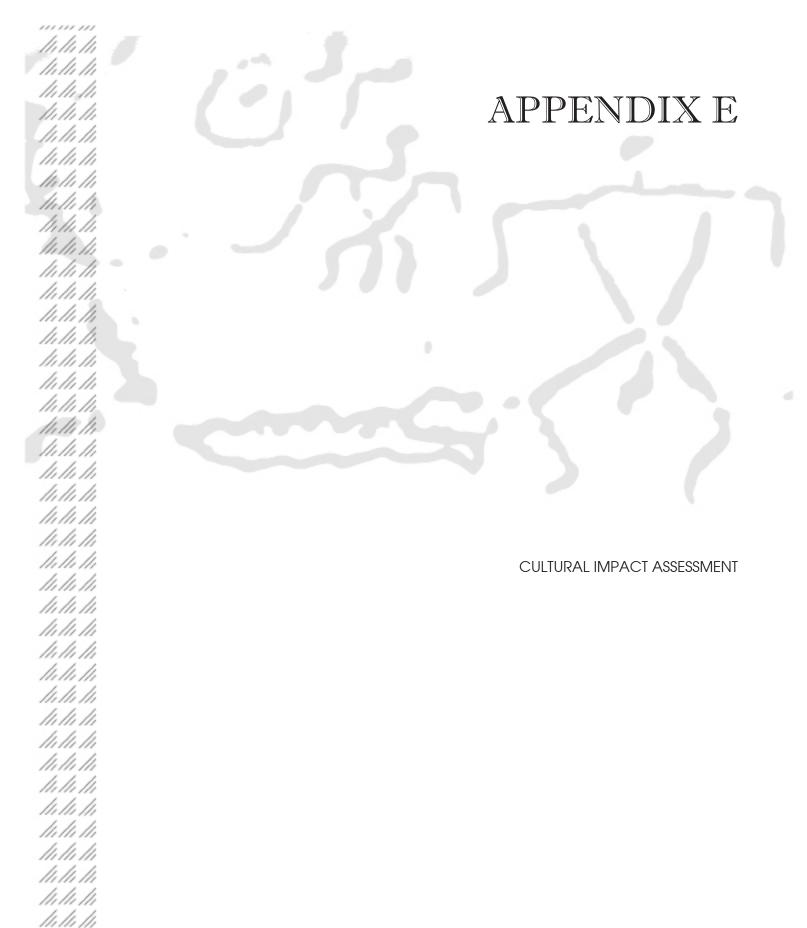
- Hawaii Administrative Rules (HAR). *Indigenous Wildlife, Endangered and Threatened Wildlife, and Introduced Wild Birds.* Title 13, Sub 5, Part 2, Chapter 124. http://www.state.hi.us/dlnr/dofaw/rules/Chap124.pdf
- Hawaii Audubon Society. 2002; 2005 updates. *Checklist of the Birds of Hawaii*. Hawaii Audubon Society, Honolulu, Hawai'i. http://www.hawaiiaudubon.com/checklist/checklist2002.pdf
- Hawai'i Biological Survey (HBS). 2002a update. *Hawaiian Arthropod Checklist*. B. P. Bishop Museum, Honolulu, Hawai'i. Accessed November 2010. http://www2.bishopmuseum.org/HBS/checklist/
- ______. 2002b. Hawaiian Freshwater & Terrestrial Mollusk
 Checklist. B. P. Bishop Museum, Honolulu, Hawai'i. Accessed
 November 2010. http://www2.bishopmuseum.org/HBS/checklist/
- P. Bishop Museum, Honolulu, Hawai'i. Accessed January 2011. http://www2.bishopmuseum.org/HBS/checklist/query.asp?grp=Herp
- ______. 2002d. *Hawaiian Mammal Checklist*. B. P. Bishop Museum, Honolulu, Hawai'i. Accessed January 2011. http://www2.bishopmuseum.org/HBS/checklist/query.asp?grp=Mammal
- Hawaii Natural Heritage Program (HNHP). Undated. *Hawaii Natural Heritage Program*, Center for Conservation Research and Training, University of Hawaii at Manoa. Data provided by Roy Kam, Database Manager, accessed November 16, 2010.
- Hawaii-Pacific Journal Index. University of Hawaii, Honolulu, Hawai'i. Accessed November 2010. http://uhmanoa.lib.hawaii.edu/cgi-bin/Pwebrecon.cgi
- Hawaiian Entomological Society (HES). 1990. Common Names of Insects & Related Organisms. Committee on Common Names of Insects. 87 pp.
- Hillebrand, W. 1888. Flora of the Hawaiian Islands. quoted in E. Hardy, 1978, Insects of Hawaii, Vol. 9: Microlepidoptera, Part II, University Press of Hawaii, Honolulu, 1903 pp.
- HOSTS a Database of the World's Lepidopteran Hostplants, Natural History Museum London. Accessed January 2011 . www.nhm.ac.uk/research-curation/projects/hostplants/
- Howarth, F. G. 1973. "The Cavernicolous Fauna of Hawaiian Lava Tubes," *Pacific Insects*, 15(1): 139-151.

- Howarth, F. G. and W. P. Mull. 1992. *Hawaiian Insects and Their Kin.* University of Hawai'i Press, Honolulu. 160pp.
- Ingenta Connect search service / online abstracts. Accessed November 2010. http://www.ingentaconnect.com/
- Komori, E. K. 2010. Personal communication. Dye, T. S. & Colleagues, Archaeologists, Inc
- LeGrande, Maya. 2010. Personal communication. LeGrande Biological Surveys, Inc., Waialua, HI
- resources. LeGrande Biological Surveys, Inc., Waialua, HI
- Liittschwager, D. and S. Middleton, photographers. 2001. *Remains of a Rainbow*, National Geographic / Environmental Defense Fund. Accompanying zoological captions by Manning, Montgomery, *et al.*
- Marine Research Consultants (MRC). 1987. Baseline Assessment of the marine and Anchialine Pond Environments in the Vicinity of the Hawaiian Riviera Resort. Prepared for Belt, Collins & Associates, Honolulu, HI. 78pp.
- Nishida, G. M. (ed.). 2002. *Hawaiian Terrestrial Arthropod Checklist*. Fourth edition. *Bishop Museum Technical Report* 22, Honolulu, HI. 313 pp.
- Nishida, G. M. and J. M. Tenorio. 1993. *What Bit Me?* Univ. of Hawaii Press. 72 pp.
- Office of Environmental Quality Control. 1973. *EIS Newsletter*, 1:1 (April 1973). 26pp.
- Office of Environmental Quality Control. Online library. Accessed November 2010. http://oegc.doh.hawaii.gov/Shared Documents/
- Otte, D. 1994. *The Crickets of Hawaii*. The Orthopterists' Society, Philadelphia, PA. 396 pp.
- Pacific Basin Information Node (PBIN). Data base / geographic search accessed November 2010. http://pbin.nbii.gov/otherinverts/index.asp
- PBR Hawaii. 2009. EIS Preparation Notice: Kahuku Villages, Kahuku, Ka'ū, Island and County of Hawai'i. Prepared for Nani Kahuku 'Āina, LLC. Honolulu, HI. 92pp.

- Perkins, R. C. L. 1913. "Introduction. Being a review of the land-fauna of Hawaiia," and "Vertebrates." *In*: Sharp, D., ed., *Fauna Hawaiiensis. Vol.*1. Cambridge University Press, Cambridge, and Bishop Museum Special Pub. 6.
- Pukui, M. K. and S. H. Elbert. 1986. *Hawaiian Dictionary, Revised and Enlarged Edition*. University of Hawaii Press, Honolulu, Hawaii. 572 pp.
- Pukui, M. K., S. H. Elbert, and E. T. Mookini. 1976. *Place Names of Hawaii*. University of Hawaii Press, Honolulu, Hawaii. 289 pp.
- Rubinoff, D. et al.. accessed Jan 2011 . "Molecular systematics and adaptive radiation of the Hawaiian endemic moth genus *Hyposmocoma* (Lepidoptera: Cosmopterigidae)" http://www.ctahr.hawaii.edu/rubinoffd/rubinoff_lab/projects/Hyposmocoma/hyposmocoma.htm
- Staples, G. W. and D. R. Herbst. 2005. *A tropical garden flora*. Bishop Museum Press, Honolulu, 908 pp.
- Swezey, O. H. 1910. "The Ebony Leaf-miner (*Gracilaria mabaella*) [Lep., n. sp.]," *Proceedings of the Hawaiian Entomological Society*, 2: 88-90.
- _____. 1935. "Winter Revival of Insect Life in the Arid Region at Koko Head, O'ahu," *Proceedings of the Hawaiian Entomological Society*, 9: 95-96.
- _____. 1944. "The Kou Moth, Ethmia colonella Wlsm., in Hawaii," Proceedings of the Hawaiian Entomological Society, 12(1):133-135
- _____. 1954. *Forest Entomology in Hawai'i*. Special Publication 44, Bishop Museum Press, Honolulu, 266 pp.
- Swift, R. and E. Burt-Toland. 2009. Surveys of Procellariiform Seabirds at Hawai'i Volcanoes National Park, 2001 2005. Pacific Cooperative Studies Unit Technical Report 163, University of Hawai'i at Mänoa, Department of Botany, Honolulu, HI.
- Tenorio, J. M. and G. M. Nishida. 1995. What's Bugging Me? University of Hawaii Press, Honolulu, HI, 184 pp.
- Terry, R. 1994. Final Environmental Assessment Kahuku Community Park. Prepared for County of Hawaii Dept of Parks and Recreation and Hawaiian Ocean View Estates Community Association. Submitted to Office of the Mayor, County of Hawaii. 25 pp.
- Tomich, P. Q. 1986. *Mammals in Hawaii*. Bishop Museum Press, Honolulu, Hawaii. 375 pp.

- U.S. Code (USC). *Migratory Bird Treaty Act.* 1918 ff. 16 U. S. C. §§ 703-712. http://www.fws.gov/pacific/migratorybirds/mbta.htm
- U.S. Fish & Wildlife Service (USFWS). 2003. Endangered and Threatened Wildlife and Plants; Designation of Critical Habitat for the Blackburn's Sphinx Moth; Final Rule. 50 CFR Part 17.In Federal Register, June 10, 2003, Volume 68, Number 111, pp. 34709-34766.
- _____. 2005a. Endangered and Threatened Wildlife and Plants. 50CFR 17:11 and 17:12 (Tuesday, November 1, 2005).
- _____. 2005b. Recovery Plan for the Blackburn's Sphinx Moth (Manduca blackburni). Portland, Oregon. 125 pp.
- U.S. Fish & Wildlife Service (USFWS). 2006a May 9. Endangered and Threatened Wildlife and Plants; Determination of Status for 12 Species of Picture-Wing Flies From the Hawaiian Islands. 50 CFR Part 17, Federal Register, Vol. 71, No. 89, pp. 26835 -26852.
- ______. 2006b August 15. Proposed Designation of Critical Habitat for 11 Species of Picture-Wing Flies From the Hawaiian Islands. 50 CFR Part 17, Federal Register, Vol. 71, No. 157, pp. 46994 47054.
- ______. 2007 December 6. Endangered and Threatened Wildlife and Plants; Review of Native Species That Are Candidates for Listing as Endangered or Threatened; Annual Notice of Findings on Resubmitted Petitions; Annual Description of Progress on Listing Actions; Proposed Rule. 50 CFR Part 17, Federal Register, Vol. 72, No. 234, pp. 69033-69106.
- _______. 2010a November 10. Endangered and Threatened Wildlife and Plants; Review of Native Species That Are Candidates for Listing as Endangered or Threatened; Annual Notice of Findings on Resubmitted Petitions; Annual Description of Progress on Listing Actions; Proposed Rule. 50 CFR Part 17, Federal Register, Vol. 75, No. 217, pp. 69221-69294.
- ______. 2010b. USFWS Threatened and Endangered Species System (TESS), accessed online at http://ecos.fws.gov/tess_public/StartTESS.do
- U.S. Naval Observatory (USNO), Astronomical Applications Department. *Sun and Moon Data for One Day*. http://aa.usno.navy.mil/
- Wagner, W. L., D. R. Herbst, and S. H. Sohmer. 1999. *Manual of the flowering plants of Hawai'i*, Rev. ed. University of Hawaii Press and Bishop Museum Press, Honolulu, 1919 pp.

Zimmerman, E. C. 1948- 80. <i>Insects of Hawaii</i> . University of Hawaii Press Honolulu.
1948. <i>Insects of Hawaii. Volume 2: Apterygota to Thysanoptera</i> University of Hawaii Press, Honolulu. 475 pp.
1958a. <i>Insects of Hawaii. Volume 7: Macrolepidoptera.</i> University o Hawaii Press, Honolulu. 542 pp,
1958b. <i>Insects of Hawaii. Volume 8: Lepidoptera: Pyraloidea</i> University of Hawaii Press, Honolulu. 456 pp.
1978. Insects of Hawaii. Volume 9: Microlepidoptera Part II University of Hawaii Press, Honolulu, pp. 1029-1699.



11.11.11

Ki'eki'e Ka'ū, kua makani, He umauma pā'ia e ke 'Aēloa

Majestic Ka'ū, of the windswept back, Whose chest is raised to meet the 'Aēloa wind

CULTURAL IMPACT ASSESSMENT FOR KAHUKU, KA'Ū PREPARED FOR NANI KAHUKU 'ĀINA, LLC

BY HELEN WONG SMITH, MLIS, CA

ARCHIVAL & HISTORICAL CONSULTANT

May 2011

Contents

Introduction	4
Scope of Work	6
Methodology	6
Documentary Resources	6
Literature	6
Interview Methodology	7
Overview of the Cultural Historical Landscape	8
Natural and Cultural Resources	8
Hawaiian Land Use and Resource Management Practices	9
Native Traditions and Historic Accounts of Kahuku and Ka`ū	11
Traditions of Ka`ū	11
Historic Events of Kahuku and Vicinity	16
Kahuku and Vicinity described 18 and 19 th century Journals	17
Captain James Cook and Crew, 1779	17
Archibald Menzies, 1794	19
The Journal of William Ellis, 1823	21
Rev. Elisha Loomis, 1824	22
Additional 19 th century visitors	22
Transitions in Land Tenure and Land Use Practices	23
Mahele	24
Kuleana Claims	27
Transportation	37
Boundary Commission Testimonies	38

Land Grants	40
Kahuku Ranch	43
Place Names	48
Site Documentation – 20 th century	51
Archaeological Surveys	51
Petroglyphs at Pōhue	64
Interviews	67
Virginia Goldstein	74
Cultural Impacts	78
Summary and Recommendations	79
Appendix A	82
Appendix B	97
Testimony	99
Journal of trip to Ohialele	119
Description of rocks and places on the boundary omitted in the Journal	120
Notes from a Journal – October 21, 1873	126
References	127

Introduction

At the request of Tom Witten, President PBR Hawaii & Associates, Inc., Helen Wong Smith, MLIS, CA, conducted a detailed study of documentary literature and oral history interviews for lands of Kahuku, Ka'ū for their client Nani Kahuku 'Āina, LLC. While the primary lands of interest to the present study are the ma kai section of the ahupua'a of Kahuku, its unique configuration of reaching the summit of Moku'āweoweo prompted the inclusion of adjoining ahupua'a. This report is intended to accompany an Environmental Impact Statement compliant with Chapter 343 HRS, as well as fulfilling the requirements of the County of Hawai'i Planning Department and the Department of Land and Natural Resources (DLNR) with respect to permit approvals for land-altering and development activities. This study has been prepared pursuant to Act 50, approved by the Governor on April 26, 2000; and in accordance with the Office of Environmental Quality Control (OEQC) Guidelines for Assessing Cultural Impact, adopted by the Environmental Council, State of Hawai'i on November 19, 1997.

The archival-historical research and oral-historical interviews that were conducted were performed in a manner consistent with Federal and state laws and guidelines for such studies. Among the pertinent laws and guidelines are the National Historic Preservation Act of 1966, as amended (36 CRF Part 800); the Advisory Council on Historic Preservation's (ACHP) "Guidelines for Consideration of Traditional Cultural Values in Historic Preservation Review" (ACHP 1985); National Register Bulletin 38, "Guidelines for Evaluation and Documenting Traditional Cultural Properties" (Parker and King 1990); the Hawai'i State Historic Preservation Statue (Chapter 6E), which affords protection to historic sites, including traditional cultural properties of on-going cultural significance; the criteria, standards, and guidelines currently utilized by the Department of Land and Natural Resources - State Historic Preservation Division (DLNR-SHPD) for the evaluation and documentation of cultural sites (cf. 13§13-275-8; 276-5); and the November 1997 guidelines for cultural impact assessment studies, adopted by the Office of Environmental Quality Control.

In Section 1 of Act 50, enacted by the Legislature of the State of Hawai'i (2000) with House Bill 2895, it is stated:

...there is a need to clarify that the preparation of environmental assessments or environmental impact statements should identify and address effects of Hawaii's culture, and traditional and customary rights...¹

Act 50 also requires state agencies and other developers to assess the effects of proposed land use or shoreline developments on the "cultural practices of the community and State" as part of the HRS Chapter 343 environmental review process (2001).

¹ H.B. NO. 2895

The purpose of a Cultural Impact Assessment (CIA) is to identify the possibility of cultural activities and resources within a project area, or its vicinity, and then assessing the potential for impacts on these cultural resources. The CIA is not intended to be a document of in depth archival-historical land research or a record of oral family histories unless these records contain information about specific cultural resources that might be impacted by a proposed project.

According to the guidelines for the above cited Guidelines for Assessing Cultural Impacts established by the Hawai'i State Office of Environmental Quality Control:

The types of cultural practices and beliefs subject to assessment may include subsistence, commercial, residential, agricultural, access-related, recreational, and religions and spiritual customs. The types of cultural resources subject to assessment may include traditional cultural properties or other types of historic sites, both manmade and natural, which support such cultural beliefs."

The meaning of "traditional" was explained in *National Register Bulletin*:

Traditional in this context refers to those beliefs, customs, and practices of a living community of people that have been passed down through the generations, usually orally or through practice. The traditional cultural significance of a historic property then is significance derived from the role the property plays in a community's historical rooted beliefs, customs, and practices...²

While the subject parcel is limited *ma kai* of the Māmalahoa Highway extending to the shoreline, in an effort to provide a comprehensive and holistic understanding of the current study area, this report examines the entire *ahupua'a* and its relationship to neighboring lands within this portion of the Ka'ū district aligning with the ACHP Guidelines advocacy to study the cultural resources and practices on a broader geographic area such as a region or district. Archival-historical literature from both Hawaiian and English language sources were reviewed, including an examination of Hawaiian Land Commission Award records from the *Mahele* (Land Division) of 1848; survey records of the Kingdom and Territory of Hawai'i; and historical texts authored by David Malo, Samuel Kamakau, Rev. William Ellis, Stokes, Marion Kelly, Dorothy Barrere, and Handy and Handy with Puku`i. The current study includes historical narratives authored by eighteenth and nineteenth century visitors to the region who viewed firsthand the impact of lava flows and earthquakes.

Over the last twenty-five years, the author had researched and prepared several land-based studies, first as an assistant to Marion Kelly, anthropologist at the Bernice Pauahi Bishop Museum in the 1980s, and later for Historical Documentary Research include in archaeological reports, commencing with her employ with Paul H. Rosendahl, Inc. the archaeologist who surveyed the subject parcel in 1987. The author's work has included the review Hawaiian language newspapers, historical accounts recorded by Hawaiian and non-Hawaiian residents, and government land use records, with a focus on unpublished manuscript collections. Currently the archivist at the Hawai'i Volcanoes National Park, the owners of the

-

² Parker and King 1990:1

remainder of Kahuku ahupua'a, the author was privy to documents pertinent and people familiar with Kahuku. Great care was made to assure only public documents were sought and included in this report.

Scope of Work

The scope for the cultural impact assessment includes:

- 1. Examination of historical documents, Land Commission Awards, and historic maps with specific purpose of identifying Hawaiian activities including gathering of plant, animal and other resources or agricultural pursuits as may be indicated in the historic record.
- 2. A review of the existing archaeological information pertaining to the sites on the property as they may allow reconstruction of traditional land use activities and identify and describe the cultural resources, practices and beliefs associated with the parcel and identify present uses, if appropriate.
- 3. Conduct oral interview with persons knowledgeable about the historic and traditional practices in the project area and region.
- 4. Preparation of a report on items 1-3 summarizing the information gathered related to traditional practices and land use. The report will assess the impact of the proposed project on the cultural practices and features identified.

Methodology

This Cultural Impact Assessment was prepared in accordance with the suggested methodology and content protocol in the Guidelines for Assessing Cultural Impacts (OEQC 1997). In outlining the "Cultural Impact Assessment Methodology," the OEQC states that:

..Information may be obtained through scoping, community meetings, ethnographic interviews and oral histories... (1997)

Documentary Resources

While historical documentary research and oral history interviews have been conducted for the subject area, this report sought to uncover previously unexamined resources to supplement the existing knowledge base. As a result the documentation herein brings a wide range of historical references (though not exhaustive) into one manuscript, with written accounts dating from the 1779 and oral historical accounts dating from the 1950s. This study offer readers a detailed overview of native traditions of the land, traditional and historic residency, travel and use of resources in the Kahuku-Manukā region.

Literature

The documentation from historical literature, was researched in the collections of the Hawai'i State Archives; State Survey Division; Bureau of Conveyances; Bernice Pauahi Bishop Museum; the Hawaiian Mission Children's Society Library; the University of Hawai'i-Mānoa, Hamilton Library, University of

Hawai'i-Hilo, Mookini³ Library; the Hawai'i Volcanoes National Park Library and Archives, and the private collection of Frank "Sandy" Sinclair, a descendant of Captain Robert Brown.

While not claiming to be an exhaustive study this document includes references previously not cited. Among the historical resources cited, are – land documents recorded by native residents from the Mahele (Land Division of 1848-1850; records of the Bureau of Conveyances; testimonies and records of the Boundary Commission (1861 to 1918); and writings of several Hawaiian scholars and non-native historians. Unpublished surveys and notes by Bernice Pauahi Bishop Museum archaeological staff were reviewed with excerpts presented in this report.

These include legendary accounts of native and early foreign writers; early historical journals and narratives; historic maps and land records such as Land Commission Awards, Royal Patent Grants, and Boundary Commission records; historic accounts; and previous archaeological project notes and reports. Historical documents, maps, and existing archaeological information pertaining to the sites in the vicinity of this project were researched at the library of the Hilo Office of the State Historic Preservation Division, and the previously cited repositories.

When quoting directly from text, i.e. translations of land commission award testimonies, Hawaiian didactical marks were not imposed reflecting the absence or partial diacritics of the supplied by the original author.

Interview Methodology

Interviews were conducted in accordance with Federal and State laws, and guidelines, when knowledgeable individuals are able to identify cultural practices in, or in close proximity to the project area. The Office of Hawaiian Affairs, Ka'ū Hawaiian Civic Club, and the Hawai'i Volcanoes National Park were contacted and visited to identify potentially knowledgeable individuals with cultural expertise and/or knowledge of the study area and the surrounding vicinity. The names for potential community contacts were also provided by Vern Yamanaka, property manager for over twenty years and Virginia Goldstein, former Hawai'i County Planning Director, and Alan Walker, Supervisory Archaeologist of the 1987 archaeological reconnaissance survey of the project area. Ross Cordy, PhD who reviewed the 1987 said survey in his position of Archaeologist of the State Historic Preservation Division was contacted but did not respond. Due to the Environmental Impact Statement submitted by Belt Collins and Associates in 1987 and the oral history interviews conducted in 2006, individuals not previously interviewed were sought for this study. It should be stressed that this process does not include ethnographic interviews or oral histories as described in the OEQC's Guidelines for Assessing Cultural Impacts (1997). The assessments are intended to identify potential impacts to ongoing cultural practices or resources within the project area or in its close vicinity.

The oral history interviews compiled for this report reflect the recollections and thought of several native families with generational ties to Ka'ū and former employees of Kahuku Ranch, the longest

³ Respecting the wishes of Edwin Mookini's widow Esther an 'okina is not written in his name.

historical land use. The interviews demonstrate a loss of continuity of traditional Hawaiian practices by the larger Hawaiian community, then say, Miloi'i in South Kona due to the continued private ownership of the project area which limited public access. An interview with a descendant of Captain John Brown, Frank "Sandy" Sinclair, of Olympia Washington was conducted on behalf of the Hawai'i Volcanoes National Park, the owners of the remainder of Kahuku in 2010.

Overview of the Cultural Historical Landscape

Natural and Cultural Resources

While ahupua'a are predominately characterized as long narrow strips of land extending from the mountain (customarily a mile or two into the forest zone) to the sea, there are exceptions. Kahuku also includes the southern portion of Moku'āweoweo crater at the top of Mauna Loa and the mountain's entire southern flank down to an irregular boundary at an elevation between 5,000 and 6,000 feet, which defines the inland boundary for most of the ahupua'a in Ka'ū. Lyons explains these inland extensions of territory are geographic reflections of rights possessed by the residents of that land to particular resources⁴.

Land use in Kahuku prior to the devastation of the successive lava flows of 1868, 1887, 1907 and 1950 is found in Native Planters in Old Hawaii: their life, lore, and environment:

KAHUKU

Kahuku, a very large ahupua'a which for many years has been a ranch, is just beyond the southwest shoulder of Mauna Loa. Over these heights the moisture-laden trade winds, having traversed the wet uplands and forested interior of eastern Ka'u, Hilo, and Hamakua Districts, spread a great roll of cool clouds. These masses of cool water vapor expand and precipitate as rain when they meet the air that rises morning to evening from the ocean, warmed in its passage over the dry lower plains of Kahuku, Manuka, and neighboring Kona. Warmed trade winds also blow in over the southeast coast and Ka Lae, crossing the high rolling plains of Kama'oa and Pakini, there precipitating much moisture as dew where it meets the cooled air blanketing the uplands. Actually, during the months of March through November, the blanket of cool moist air moving over the upland flank of Mauna Loa, and the warm damp flood of wind diverted inland and overland by the high plains of Kama'oa and Pakini, are nothing more nor less than vast eddies of the great southeastward flow of arctic air, which is warmed as it passes over the ocean in these latitudes. These we term the "trades" — the winds so named because the "traders" (sailing vessels) utilized their regular flow from March through November in their voyages. In the season of southerly (kona) cyclonic storms, the wind and rain [page 560] came in upon western Ka'u from oceanward in more violent gusts, sometimes sweeping in with great force. These kona storms originate in the equatorial regions, hence their warm winds are heavily laden with moisture. Coming upon the cool uplands their heavy black clouds produce electric storms, with thunder and lightning, and downpours starting with light gentle rain (hilina), which gradually

⁴ Kelly 1969:44

increase into deluges, at times veritable cloudbursts. These winter storms drench the whole land, which, whether dry lava, grassland, or forest, soaks it up greedily, and in the uplands stores it beneath the forests⁵.

Continuing our journey into Ka`u, going southeastward, the next ahupua`a after Manuka is Kahuku. Until the land was covered by lava through much of the verdant lower forest area in the last century, this must have been a far more favorable area for human occupation than was Manuka. The evidence of such occupation have, however, been obliterated. Where lava has not covered the land, the pastures of Kahuku Ranch have done so. The seacoast of Kahuku is a barren as any on this side of Hawaii.

Standing on top of a hillock named Pu`u Lohena on the east of Pakini and looking north across the 1868 flow, one can see beyond lava-covered land to where there was an open sandy area of Ka'iliki'i between two sections of the 1868 flows. Ka'iliki'i was in 1823 described by Ellis as "a populous shore village." The open ground led directly north toward Kahuku from the beach at Ka'iliki'i, where travelers from Kona often landed. We could see how their path would have crossed an older flow that was there before the 1868 flow, as they headed for a break in the pali. This is a low dip in the ridge called Lua Puali.

In its lower reaches Kahuku is said formerly to have had flourishing gardens of sweet potato and sugar cane on the land now covered with lava. If so, and we have no reason to doubt the veracity of informants, there must have been underground water here. Surface verdure, also, may have drawn more cloud and dew. There probably was more rain coming across from Pakini when the plains east of the Pali-Mamalu and Pali Kulani (the great cliff that borders Kahuku on the east) were more verdant and covered with brush. The bare lava of the recent flows, and the now dry plains of Pakini, Kama'oa, and Ka'alu'alu must desiccate the winds which, sweeping along the coast line, normally throw up a cloud of cooled air that is moisture laden when the trade winds blow.

There is no similar drift of moisture over the naked shores of Kahuku and Manuka. Yet these coasts, barren as they are today, must have sufficed as good fishing grounds for the population settled in the two western ahupua'a of Ka'ū. Wai-o-'Ahu-kini close by, with its spring, pond, and canoe haven, and the best fishing ground in all Hawaii, was awarded in the ancient land allotment to Pakini, then one of the most verdant of the plains areas of cultivation. Doubtless it was Pakini's numerous population, which gave its ali'i power, that was responsible for this award.6.

Hawaiian Land Use and Resource Management Practices

Over generations, the ancient Hawaiians developed a sophisticated system of land and resources management. By the time `Umi-a-Līloa ruled the island, ca. 1525 the island (moku-puni) was divided into six districts (moku-o-loko)⁷. The moku-o-loko was further divided into political regions and manageable units of land. These smaller divisions or units of land were tended to by the maka'āinana (people of the

⁵ Handy et al., 1972:561

⁶ Handy 1972:571-572

⁷ Fornander 1973-Vol. II:100-102

land)⁸. Of all the land divisions, perhaps the most significant management unit throughout the islands was the ahupua'a. Ahupua'a are subdivisions of land that were usually marked by altars with images or representations of a pig placed upon them, thus the name ahu-pua'a or pig altar. In their configuration, the ahupua'a may be compared to wedge-shaped pieces of land that generally radiate out from the center of the island, extending to the ocean fisheries fronting the land units. Their boundaries are generally defined by topographic and geological features such as pu'u (hills), ridges, gullies, valleys, craters, or areas of a particular vegetation growth⁹.

Under the Hawaiian system of land-use rights the people living within each ahupua'a had access to all the necessities for subsistence life-style. The system guaranteed its tenants a degree of economic independence, their needs being supplied by products of the forest, cultivated crops, and marine resources. As Lyons wrote: Hawaiian life vibrated from uka, mountain, whence wood, kapa for clothing, $olon\bar{a}$ for fish line, ti-leaf for wrapping paper, `ie for rattan lashing, wild birds for food, to the kai, sea, whence i'a, fish, and all came connected therewith.

Maly explains the sub-divisions within the *ahupua'a* and the political structure of the activities within:

The ahupua'a were also divided into smaller manageable parcels of land—such as the 'ili, kō'ele, mahina 'ai, māla, and kīhāpai—that generally run in a mauka-makai orientation, and are often marked by stone wall (boundary) alignments. In these smaller land parcels the maka'āinana cultivated crops necessary to sustain their families, and supplied the needs of the chiefly communities they were associated with. As long as sufficient tribute was offered and kapu (restrictions) were observed, the common people who lived in a given ahupua'a had access to most of the resources from mountain slopes to the ocean. These access rights were almost uniformly tied to residency on a particular land, and earned as a result of taking responsibility for stewardship of the natural environment and supplying the needs of ones' ali'i (see Malo 1951:63-67 and Kamakau 1961:372-377).

Entire ahupua'a, or portions of the land were generally under the jurisdiction of appointed konohiki or subordinate chief-landlords, who answered to an ali'i-'ai-ahupua'a (chief who controlled the ahupua'a resources). The ali'i-'ai-ahupua'a in turn answered to an ali'i 'ai moku (chief who claimed the abundance of the entire district). Thus, ahupua'a resources supported not only the maka'āinana and 'ohana (families) who lived on the land, but also contributed to the support of the royal community of regional and/or island kingdoms. This form of district subdividing was integral to Hawaiian life and was the product of strictly adhered to resource management planning. In this system, the land provided fruits, vegetables and some meat in the diet, and the ocean provided a wealth of protein resources¹¹.

⁸ Malo 1951:63-67

⁹ Maly 2004:5

¹⁰ Lyons 1875:111 IN Kelly 1980:i

¹¹ Maly 2004:5

Native Traditions and Historic Accounts of Kahuku and Ka'ū

Ka`ū Mākaha (Fierce Ka`ū)

The 18th century Native Hawaiian historian Samuel Mānaiakalani Kamakau states "Before the time of Wākea and his wife Papa, all people were of one class; they were not divided into chiefs, priests, and commoners; they were all mixed together¹²." After the time of this couple considered the ancestor of all Hawaiian people, "people were divided into chiefs, priests, commoners, outcasts..." While attributing *ali`i* to specific islands, Kamakau provides the first mention of a district connected to a chief, "As for Pohukaina, the chief of Ka`ū, his remains are at Mahiki in Waimea, Hawai`i¹³. Pohukaina's father was Kamea-a-Lu`anu`u who was born at Kahakaha-kea at `Opuhue, *ma kai* of Kahuku in Ka`ū, Hawai`i. His corpse too was laid at Mahiki in Waimea¹⁴.

Kelly writes:

In ancient times the people of Ka'u, while they labored willingly for their chiefs (ali`i), nevertheless took pride in their independence and dignity and never permitted themselves to be abused for long. There are several stories about oppressive chiefs against whom the Ka`ū people rebelled. Three chiefs were named by Malo, who said that they died violent deaths because they abused their people.

Kohala was put to death in Kau, for which reason the district was called The Weir (Makaha)

Koha-i-ka-lani was an ali`i who was violently put to death in Kau.

Halaea was a kina who was killed in Kau¹⁵

Kelly appropriates the types of abuse by the *ali'i* toward their servants, fishermen, and those who labored for them ¹⁶.

Traditions of Ka'ū

"The story of a famous chief of the District of Kau: of Koha (Koha-i-ka-lani)" written by Z.P. Kalokuokamaile

Hilea, in Kau was the birthplace of Koha. As it was the custom in the olden days to worship fishes, birds, stones or wood, Koha wishes to have a wooden god to worship. Koha was living in the upland of Hilea. There were many houses in this place and life there, in olden times, was pleasant.

The houses stood on ground composed only of earth. The chief desired much to have (his god) made of a big log and have it erected on Makanau hill, close to the village of upper Hilea. He

¹² Kamakau 1991:33

¹³ Kamakau 1991:37

¹⁴ Kamakau 1991:147

¹⁵ Malo 1951:195

¹⁶ Kelly 1980:6

ordered his kahunas to ascend with the men to cut wood and the size of log that he desired was four fathoms in length and girded by three men. Because the kahunas heard his words, they replied, "O chief, if that is your wish here is a large, tree nearby that only requires cutting. It has a hardwood like the kauuila which would not rot when buried in the earth." Koha asked, "What kind of tree is it?"

"Here is a breadfruit tree with the size desired by the chief." The chief approved of this, "Yes, that is good." The a large breadfruit tree, five fathoms long and could be girded by three men, was cut down, a tree the size desired by the chief.

The breadfruit log was hauled up to the foot of Makanau hill and there it was left. There was one thing that needed doing and that was to carve one end of the breadfruit into an image of a man. Orders were given to the wood carvers and they made it look like a man. After the carvers had finished their work then it was ready to pull up to the top of Makanau hill where it was to be erected. Many men climbed to the top of the hill to pull it upward.

Many of the men struggled to lift up the lower end of the log, the chief was among them. This they did all day long and all day long and all week. It took a very long time but it did not budge to move upward. The people were tired and bored with the needless task of the chief's. They had no time to do their own work for they were occupied with this wearisome useless work. Therefore the men who worked below at lifting the log and some of those on the hill met and plotted to put an end to this wearisome task. "Tomorrow we shall tell the chief to go directly below the log so that he could plead with his image." This was agreed to by those at the foot and at the top of the hill. "When you pull the image upward it gets above the head of those who are lifting, just as it does every day as we work, then you let go. We will tell the chief to get directly under the leg." In the morning the men gathered where the wooden image was. Those at the top of the hill assembled there and those at the bottom of the hill went there. Then the man who gave the orders to pull, called out to pull the log upward.

The men on the hill pull and those below lifted but it did not rise any higher, it was just as before. Some of the men at the foot of the hill said, "O Chief, today you go directly under the other end of your god and lift it up. It is strange that it would not move. What do you think of this idea?" "It is good." The chief went under the end of the log. The people above pulled and those below lifted. Every person below was eager to have the log higher than their heads. Then the call came, "Mokua ke kaula." This was the signal to pull the log up and let it go. The log was pulled up and then it was released. So it was that Koha met his death. This deed of the men of Kau earned them the name of Makaha (Destroyers). This district, Kau, became renowned as Kau Makaha 1 .

Kamakau writes of Imaikalani retaining Ka`ū despite overtures from 'Umi-a-Līloa until Pi'imaiwa'a's intervention:

I-mai-ka-lani was the chief of Ka-'u. He was blind, but noted for his strength and skill in battle. Many chiefs who had fought against him were destroyed. He was skilled in striking left or striking right, and when he thrust his spear (pololu) to the right or to the left it roared like thunder, flashed like lightning, and rumbled like an earthquake. When he struck behind him, a cloud of

¹⁷ Hawaiian Ethnographic Notes vol. 3:147-148, Bernice Pauahi Bishop Museum Archives

dust rose skyward as though in a whirlwind. 'Umi-a-Liloa feared I-mai-ka-lani. Although he was blind and unable to see, his hearing was keen. He had pet ducks that told him in which direction a person approached, whether from in front, at the back, or on either side. All depended on the cries of the birds. In former days I-mai-ka-lani was not blind, and 'Umi was never able to take Ka-'u. The war lasted a long time. 'Umi went by way of the mountains to stir up a fight with I-mai-ka-lani and the chiefs of Kona. He became famous as a chief who travelled through the mountains of Hawaii, and [its trails] became the routes by which he went to war. After I-mai-ka-lani became blind the fight between him and 'Umi continued.

I-mai-ka-lani was never taken captive by 'Umi, but Pi'i-mai-wa'a was crafty and studied the reason for his great strength and skill with the spear. Not a single thrust failed its mark, and with one blow [the victim] was torn from head to buttocks. Pi'i-mai-wa'a discovered the reason for the skill and fearlessness of this blind man. Ducks flew overhead and cried, and when he heard them, before, behind, or on either side, he declared, "A man approaches from the rear." The man who quided him about answered, "Yes, there is a man." "Where is his club (la'au)?" "In front of him." He recognized it as a club (la'au hahau). "Is he near?" "Yes." The blind man smote with his club (la'au palau), and the other was torn from head (puniu) to buttocks (olemu). Whenever a bird cried, there was a man. "Where is his club?" I-mai-ka-lani asked. "On the right side." "A left stroke will get him." When the other smote he missed, but when the blind man smote, [his opponent] was struck from head to abdomen. As Pi'i-mai-wa'a studied and knew every angle of I-mai-kalani's strength and marvelous skill, he said to himself, "I shall kill you yet." He went to kill the bird quards, the two men who led I-mai-ka-lani on each side, and the forty men who carried his weapons, long and short spears. I-mai-ka-lani thrust ten spears at a time, five with the right [hand] and five with the left. The spears flashed forth like lightning, and no man was able to dodge the spears when he faced I-mai-ka-lani.

Kona chief 'Ehu-nui-ka-malino is credited with trails constructed "from the uplands of Kona into Kau which is called the way of Ehu¹⁸." Both 'Ehu and the blind Ka'ū chief Imaikalani were conquered by 'Umi who used these hidden uplands paths to easily view ocean approaches.

The natural resources of Kahuku are cited in this passage regarding control of Maui between the brothers Kihapi'ilani and Lonoapi'ilani:

Lono-a-Pi'i-lani heard that Kiha-a-Pi'i-lani was on Hawaii, and that war canoes were being built there in great numbers. The kauila wood of Napu'u and Kahuku, the o'a and koai'e were being made into dubs to be used against Maui. When the news of impending war reached him and his warrior chiefs, they trembled with fear.

A whole year of the making of canoes and war implements went by, and all of the warriors were well supplied. There was no war prior to that time to compare with this one, in which there were so many canoes. The first ones reached Hana, Maui while the last ones were still on Hawaii.¹⁹.

¹⁸ Ibid. 429

¹⁹ Kamakau 1961:23-29

'Umi's kingdom was divided between his sons Keawenuia'umi and Keli'iokaloā'aumi. When the former learned of the latter's mistreatment of the *mak"āinana* (commoners) of Kona he led "his chiefs, war lords, war leaders, and warriors from Hilo, Puna and Ka`ū to make war on Kona."

The war parties [met?] at the volcano (pit of Pele) before going on to battle along the southern side of Mauna Kea and the northern side of Mauna Loa. The mountain road lay stretched on the level. At the north flank of Hualalai, before the highway, was a very wide, rough bed of lava—barren, waterless, and a desert of rocks. It was a mountain place familiar to `Umi-a-Liloa when he battled against the chiefs of Hilo, Ka-`u, and Kona. There on that extensive stretch of lava stood the mound (ahu), the road, the house, and heiau of `Umi.* It was through there that Keawe-nui-a-'Umi's army went to do battle against his older brother, Ke-li'i-o-kaloa.

When the chiefs of Kona heard that those of Hilo were coming by way of the mountain to do battle, Ke-li'i-o-kaloa sent his armies, but they were defeated by the armies from Hilo. The armies of Kona were put to flight. When the armies of Hilo reached the shore of Kona the war canoes arrived from Ka-'u and from Hilo. The battle was [both] from the upland and from the sea. Ke-li`i-o-kaloa fled and was killed on a lava bed. The spot where he was killed was called Pu`u-o-Kaloa (Kaloa's hill), situated between Kailua and Honokohau.²⁰.

Historian Carol Silva points out these sites – waterholes, shelter caves, the mound, road, house and heiau fall within the ancient upland boundaries of Kahuku and frequently referred to by native informants testifying before the Boundary Commission and their connection to 'Umi and 'Ehu²¹.

The legend regarding Pu'u a Pele at Keawaiki is connected with Kahuku, as relayed by Clark:

...the lava flows from the southwest rift zone of Mauna Loa entering the ocean have formed a series of littoral cones. The largest concentrated group of these cones is situated at the end of the Road to the Sea, a cinder road that leads from the Hawai'i Belt Road to the shore. The highest of the cones are the two known as Nā Pu'u a Pele ("The hills of Pele") at Keawaiki. According to the Hawaiian legend, these hills were once two young men, chiefs of Kahuku, who excelled in all sports, especially hōlua ("sled")-riding. Pele also loved this sport. One day she appeared as a beautiful young chiefess to join in the competition. The chiefs, however, suspected her identity and refused to race with her. Angered, Pele came after them with a lava flow that devastated the once fertile lands of Kahuku as she chased them toward the beach. She overtook the chiefs just inland of Keawaiki and turned them into hills that bear her name, Nā Pu'u a Pele²².

In the Hawaiian language newspaper *Ka Makaainana* this account of a rain storm published December 24, 1894 provides insight to cultural beliefs maintained in the late 19th century:

²⁰ Kamakau 1961:35-36

²¹ Silva IN Haun and Walker 1987:D2

²² Clark 1985:80

On the 21st of November, Kulanihakoi²³ let down its drenching rain drops and the rain drops and the rain spread over the land from end to end, damaging some parts of the land and the dwellings of the people. The sugar plantation also suffered loss.

The residence of John Cooper, manager of the plantation, at Hina-kukui in Hilea was filled with large rocks. It was a beautiful yard, a pleasant sight to see before it was damaged but now it is unsightly. There is an interesting tale about this white man whose name is mentioned above. One day he went with his companions to the mountain, at Kaiholena where a supernatural rock, called Ku-mauna stands. This stone was worshipped in the olden days. Such were the gods in the period of Little-Wa`awa`a-the ignorant and so also to the present generation. It is much visited by visitors. This is the tale of this white man. When he arrived at the place where the stone is, he hammered on its head and broke a piece. This stone John Cooper carried with him to ridicule the Hawaiians for praying to a stone god. When trouble came, the swelling of a stream where Kumuna stands to Mr. Cooper's dwelling place Hina-kukui, it filled the place with a great number of stones; great heaps and loads of them, with mud too. HE quickly said, "This trouble is due to my mistreatment of Kumauna. Such is the result of my abusive act." (A few) he was told by Komaka, "You did mischief to Ku-mauna and now your yard is filled these days with his ammunition of war." He had no answer.

That being over, the place of Aki, a Chinese, was also filled with rocks, for his house was close to the stream. His wife said, "Let us gather up our belonging and move to the other house." "You shut up. Why would the water carry away our goods?" When the water came it did carry off some. The Chinese opened his mouth then and lamented to the wind. It rained on just that one day. In these few days there are winds, ran and sunshine...

P.K. Puaikeao – Pa`ula [Kaunamano ahupua`a], Ka`u²⁴.

²³ The god Ku, represented in rain and storm IN Parker 1922:333

²⁴ Hawaiian Ethnographic Notes vol. 1:2812, Bernice Pauahi Bishop Museum Archives

Historic Events of Kahuku and Vicinity

When Captain Cook visited Kealakekua Bay in 1779 the high chief of the island was Kalaniōpuʻu, a prominent chief from Kaʻū who died at Waiʻahukini in 1782. It was at the *heiau* of Pākini where Kamehameha symbolically usurped the right of Kalaniōpuʻuʻs designated heir Kiwalaʻō, when he placed the body of the rebel chief, Imakakoloa, on the altar, leaving Kiwalaʻō a hog to offer²⁵. During Kamehameha's struggle against Keōua, a high-ranking chief of Ka`ū, Keōua and his supporters were on their way from Hilo to Kāʻilikiʻi in 1789, after having defeated his uncle Keawe-ma`u-hili, when explosive eruptions from Kīlauea volcano killed some of his men. Continuing on their way, the remainder met Kamehameha's group under the leadership of Kaiana. Keōua was defeated at Kaʻilikiʻi and retreated to Hilo while "Kaiana and his warriors returned to Waiohinu to remain there till the place of his [Keōua's] retreat should be discovered²⁶."

Kamehameha received the war god Kūkailimoku from Kalaniōpu'u, constructing several *heiau* to honor the god. Upon the completion of one such *heiau*, Pu'ukōhola at Kawaihae, Kamehameha sought Keōua in Ka'ū once more:

As soon as the heiau was completed, just before it was declared free, Kamehameha's two counselors, Keawe-a-heulu and Ka-manawa, were sent to fetch Keoua, ruling chief of the eastern end of the island of Hawaii. These two men were skilled in preparing a dose of the slippery hau sap and the uhi root; they knew well how to use cunning and deceitful speech. Keoua was living in Ka-`u mauka in Kahuku with his chiefs and the warriors of his quard. Keawe-a-heulu and his companion landed at Ka`iliki`i and began the ascent of Kahehawahawa along the plains of Ke`eke`ekai. Close to the extreme edge of the tabu enclosure of Keoua's place the two got down and rolled in the dirt and began to weave their nets of speech. Keoua's people nodded at each other, and Ka`ie`iea said to Keoua, "It will be a good thing to kill these counselors of Kamehameha." Keoua answered, "They must not be killed for they are younger brothers of my father." Ka`ie`iea went on, "If these are killed he will have but two counselors left, and the government will become yours." "I cannot kill my uncles." The two messengers rolled along in the dirt until they came to the place where Keoua was sitting, when they grasped his feet and wept. When the weeping was over Keoua asked, "What is your errand?" Keawe-a-heulu answered, "We have come to fetch you, the son of our lord's older brother, and to take you with us to Kona to meet your younger cousin, and you two to be our chiefs and we to be your uncles. So then let war cease between you." "I consent to go with you to Kona," answered Keoua²⁷.

Keōua was then sacrificed at Pu'ukōhola, despite the entreaties of his counselors to kill the messengers and to "return by the mountain" to his sacred residence of Kahuku, Ka' \bar{u}^{28} . Keōua's residence within Kahuku was situated above the *pali* on the fertile ash lands²⁹.

_

²⁵ Kamakau 1961:155

²⁶ Ellis 1825:110-112

²⁷ Kamakau 1961:155

²⁸ Silva IN Haun and Walker 1987:D-4

²⁹ Cordy 2000:340

After his conquest of the islands Kamehameha retired at Kailua, Kona to farm and fish. Kamakau lists Pōhue in Kahuku among Kamehameha's favorite spots for 'ahi fishing:

Fishing was the occupation of Kamehameha's old age at Kailua. He would often go out with his fishermen to Kekaha off Ka`elehuluhulu and when there had been a great catch of aku or `ahi fish he would give it away to the chiefs and people, the cultivators and canoe makers. If word was brought that `ahi were plentiful at Kalae, off went the chief to the `ahi fishing, and he fished also at Kaulana, Ka`iliki`i, Pohue, Na-pu'u-o-Pele, Kapalilua, and at other places along the coast. During the season for flying fish he would sail to Kohala where the big schools ran and dispose of his catch to the cultivators of Kohala, Waimanu, and Waipi'o. Kamehameha made a crafty bargain with the cultivators to give a single fish for a single bundle of pounded taro (pa`i`ai) or a calabash of poi, and so on. The cultivators lost on this, so they sought a way to get even with him, and wrapped up a single taro in a bundle.

This incident is commemorated by the saying explained here by Kawena Puku'i:

Kahuku kau 'ao'ao

One-sided Kahuku

One-sided Kahuku refers to Kahuku, Ka'ū. At one time, Kamehameha I made a bargain with some farmers to exchange poi for fish. A konohiki of Kahuku named Kaholowalo took huge calabashes of poi to the chief, who gave him one small fish in return. Kaholowalo tied the fish to one end of a carrying stick to show his neighbors what the chief had done. After several such exchanges, Kaholowalo brought Kamehameha a small taro in a big container. When the chief saw the taro he laughed, and from then on he played fair. The fish tied to the side of the carrying stick produced the saying, "One sided Kahuku³¹."

Kahuku and Vicinity described 18 and 19th century Journals

Captain James Cook and Crew, 1779

In late December 1778 Captain Cook sailing around the easternmost point of the island toward Ka Lae (South Point) in search of protected anchorage recorded in his journal the natives came out in canoes as far as "five leagues" from land to trade. "But whether from a fear of lossing [sic] their goods in the Sea or the certainty of a Market, they never brought much with them, the Chief [sic] article we got was salt which was extremely good³²."

After rounding the south point of the island Cook's entry for January 5, 1779:

On this point stands a pritty [sic] large village, the inhabitants of which thronged off to the Ship with hogs and women...As we had now got a quantity of salt I purchased no hogs but what were fit for salting, refuseing [sic] all that were under size, in general they being no other at first, but when they found we took none but the large ones, several went ashore and returned with some, however we could seldom get one about 50 or 60 lb weight. As to fruit and roots we did not want

³⁰ Kamakau 1961:203

³¹ Pukui 1983:144 #1320

³² Cook/Beaglehole 1967:486

and it was well we did not for it was very little of either they brought with them, indeed the Country did not seem capable of producing many of either having been destroyed by a Volcano...³³

Kelly postulates the canoes with traders may have been from the villages of Wai'ahukini and Kā'iliki`i to the west and Keana and Ka'alu'alu to the east³⁴.

The next morning Captain Cook sent the master Mr. Bligh in a boat to sound the coast. Bligh reported he had "found no fresh water, but rain water lying in holes in the rocks and that brackish with the spray of the sea, and that the surface of the Country was wholy [sic] composed of large slags and ashes here and there partly covered with plants³⁵."

Another member of Cook's expedition Captain James King provides his similar impressions of Ka'ū and its inhabitants:

It is not only by far the worst part of the Island, but as barren waste looking a country as can be conceived to exist...we could discern black Streaks coming from the Mountain even down to the Seaside. But the s[outhern] neck seems to have undergone a total change from the Effect of Volcanoes, Earthquakes, etc...By the SE side were black honey comd rockds, near the s extremity were hummocks of a Conical Shape which appeared of a reddish brown rusty Colour, & we judged them tot consist of Ashes. The s extremit, which projects out, has upon it rocks of the most Craggy appearance, lying very irregularly, & of most curious shapes, terminating in Sharp points; horrid & dismal as this part of the Isalnd appears, yet there are many Villages interspersed, & it Struck us as being more populous than the part of Opoona [Puna] which joins Koa [Ka'ū]. There are houses built even on the ruins lava flows we have describ'd. Fishing is a principal occupation with the Inhabitants, which they sold to us, & we also had a very plentiful supply of other food when off this end...³⁶

...those we saw off Kao [Ka \dot{u}], are very tawny, thin, & smallmean looking people, which doubtless arises from their constant exposure to the heat of the Sun, their being mostly employed in fishing or other hard labor on shore, & to their spare diet.³⁷

Captain Charles Clerke confirmed King's view of this district writing:

...On the Southern side the scene is quire alterned, the land from the hills breaks off with a gentle descent quite to the Sea, and instead of the verdure which on the other side was most beautiful, you are hre presented with a Country whose face is entirely covered with Cindars [sic]; this part of the Isle is merely the dregs of a volcano, the heart of the Country is fairly town to pieces with it.³⁸

³³ Ibid:486

³⁴ Kelly 1969:10

³⁵ Cook/Beaglehole 1967:487

³⁶ Ibid:606-607

³⁷ Ibid:611

³⁸ Ibid:591

Archibald Menzies, 1794

The next European observation was made by Archibald Menzies, the botanist on Captain Vancouver's expedition (1790-1795). Menzies' observations from the ship of the coastline is closer to Kahuku:

January 11 [1794]...Being then near the shore, Mr. Whidbey was sent in the cutter to examine a bay [Waiahukini Bay in Pakini Nui] on the west side of the South point, but such was the rough sea and rolling swell into it that we was unable to accomplish his object.

We met a fishing party off this point jin a few single canoes. With these Kamehameha sent his orders on shore for some hogs to be brought off to us, which was instantly obeyed.

January 12. Our distance from the land on the morning of the 12th was pretty considerable and as we stood in for it in the forenoon, some canoes came off to us. From these we understood that it was a taboo day on shore, on which account we could expext no refreshments...³⁹

The ship anchored in Kealakekua Bay and after successfully scaling Hualālai, Menizes left Kealakekua Bay by canoe on February 5, 1794 toward Ka'ū with the intent of scaling Mauna Loa. The first coastal village encountered in Ka'ū was in Manukā for which he provides environmental aspects of life in an eighteenth century fishing village:

About noon we came to a small village named Manu-ka where we found our chief Luhea's residence, and where we landed before his house at a small gap between rugged precipices against which the surges dashed and broke with such violence and agitation and with such horrific appearance, that even the idea of attempting chilled us with the utmost dread. We however quietly submitted ourselves to their guidance and were highly pleased to see the extraordinary dexterity with which they managed this lands. Having placed their canoe in readiness before the gap, they watched attentively for a particular surge which they knew would spend itself or be overcome in the recoil of preceding surges before it could reach the rocks, and with this surge they dashed in, landed us up on a rock from which we scrambled up the precipice, and in an instant about 50 or 60 of the natives at the word of command shouldered the canoe with everything in her and clambering up the rugged steep, lodged her safely in a large canoe house upon the brink of the precipice, to our utmost astonishment. The other canoe was landed in the same manner, and as the chief had some arrangements to make, we were obliged in compliance with his request, to remain at this dreary-looking place all night. A situation more barren and rugged can scarcely be imagined. The kind civilities and good treatment received from the natives were, however, unremitting. Here, as if to make amends for the dreariness of the situation, they particularly exerted themselves by every means in their power to amuse and entertain us The chief and his people were equally eager and attentive in doing little acts of kindness and thereby assiduously displaying t heir unbounded hospitality.

On seeing near the village a large pile of stones, built regularly up in a square form on the brink of the shore, curiosity prompted us to enquire what was the intent of it. When they informed us that

³⁹ Menzies 1920:142-143

it was erected to mark out the limited between the two districts of Kona and Ka-u, by which we found out that we had reached the southern limits of Kona 40 .

Menzies description of what is mostly likely Kahuku:

...a dreary rugged tract composed of black porous rock of lava forming here and there grotesque arches, vaults and deep caverns into which the sea pushes in by the violence and agitation of the waves with great force, and frequently gushes up again several yards inland through chinks and crevices with a hissing noise in the form of fountains... ⁴¹

Menzies' second landing in Ka'ū was at Pākini village:

Early in the afternoon we landed at a small village called Pakini.⁴², near the south point of the island. We took up our abode in a hosue belognig to Keawe-a-heulu, and they told us that the village, which consisted of only a few fishermen's huts, belonged to Namahana, Keeaumoku's wife. The country between this and Manu-ka, the place we left this morning, is one continued tract of loose, rough and peaked lava, the most dreary and barren tract that can possiblity be conceived, so that it would be a tedious and fatiguing journey to come from thence by land, and such as even the natives themselves seldom attempt. For when they wish to visit the south side of the island, they generally come thus far in canoes from the west side and leave them here till they return again, so that this forms a common port at which there were several arrivals to and fro in the course of the evening ⁴³.

Menzies discovered the shoreline environment was drastically different from the uplands in this area when upon ascending Pali-o-Kūlani at the boundary between the Pākini Nui and Pākini Iki he viewed, "an extensive tract of the most luxuriant pasture we had yet seen amongst thes island rushed at once upon our sight, extending from the south point to a considerable distance inland...⁴⁴" His guides pointed out the location of "battles and skirmishes were fought in the late civil wars between the adherents of the present king and the party of Keoua, the son of the late Kalaniopuu, who was king the island in Captain Cook's time⁴⁵." After arriving in the uplands Menzies mentions a plantation named Kahuku:

Close by us was a fine plantation belonging to Kamehameha, called Kahuku, where our purveyor was particularly ordered to demand suplies for our journey, which he did and only received one small hog. This however, did not come to our knowledge till after we passed it, and when the chief told me of it, I made a show of noting it down in my little memorandum book in order to make it known to the king. This had the desired effect, for it instantly spread through the crowd, and from them to the steward of the plantation, whom we found extremely assiuous in supplying our wants on our return. In the afternoon we resumed our journey and soon after reached the

⁴⁰ Menzies 1920:178-180

⁴¹ Ibid.180

⁴² Kelly notes the village is within the *ahupua* `a of Pākini but the name of the village area is Wai-o-Ahukini or Waiahukini.

⁴³ Menzies 1920:181

⁴⁴ Ibid.

⁴⁵ Ibid:183

upper plantations, when instead of ascending directly up the mountain as we expected, they led us across these plantations to the north-eastward at a distance of five or six miles from the shore by a narrow winding path which in some places was very rugged and seldom admitted more than one person at a time, so that we followed one another in a string, and occupied a considerable space in length from the number ofour party and the crowds that followed us from village to village through curiosity and flocked to see us from far and near. This path we found to be the public road leading to the east end of the island, and at small eminences here and there, we met cleared spots for resting on, where the wearied travellers generally sit down to chew sugar cane and admire the surrounding prospect.⁴⁶.

The Journal of William Ellis, 1823

Rev. William Ellis toured the island in 1823 for the purpose of surveying appropriate locations for mission stations. Ellis excelled in notating place names and traditions during his tour and provides us with some of the earliest documentation of places, practices, and traditions. Just before daybreak on July 27, 1823 Ellis arrived by canoe at the small fishing village and landing of Kā'iliki'i in Pākini Nui later destroyed by the 1868 lava flow where his companion Mr. Thurston preached to 60 to 70 residents. Kelly believes residents were supplemented by residents from the villages of Kā'iliki'i and Wai'ahukini and the plains of Kamā'oa⁴⁷.

Ellis' shares Menzies' amazement of the difference of the terrain below and above Pali-o-Kūlani:

After traveling about a mile we reached the foot of a steep precipce. A winding path led to its top, up which we pursued our way, occasinally resting beneath the shade of huge overhanding rocks. In half an hour, we reached the summit, which we supposed to be about 300 feet from the plain below.

A beautiful country now appeared before us, and we seemed all at once transported to some happier island...The rough and desolate trace of lava, with all its disotrted forms, was exchanged for the verndant plain, diversified with gentle rising hills and sloping dales, ornamented with shrubs, and gay with blooming flowers. We saw, however, no streams of water during the whole of the day; but from the luxuriance of the herbage in every direction, the rains must be frequent, or the dews heavy ⁴⁸.

Between three and four o'clock in the afternoon, we reached Kauru, a small village, environed with plantations, and pleasantly situated on the side of a wide valley, extending from the mountains to the south point of the island.⁴⁹.

Kelly proposes Ellis may have spent the night among the well-populated gardens of inland Kahuku refered to as "Kauru⁵⁰."

47 Kelly 1969:18

⁴⁶ Ibid:184

⁴⁸ Ellis 1825:101

⁴⁹ Ibid:102

⁵⁰ Kelly 1969:20

Silva declares these observations establish the population resided in the interior of Kahuku with the shoreline relatively devoid of permanent residents, save fishermen. The cultivated area traveled by Ellis was further documented by testimonies for land claims during the Mahele in the 1840s and 1850s.

Rev. Elisha Loomis, 1824

A year after Ellis, Elisha Loomis, a member of the First Company of American missionaries to Hawai'i set out by canoe from Ka'awaloa, Kona to approach Mauna Loa from Ka'ū. Landing at a village he identified as Kaulanamauna, the last ahupua'a in Kona abutting Ka'ū, he walked twenty miles to the village of "Haperoa."

The whole of the intervening country along the shore exhibits the most barren and rugged appearance conceivable. Streams of lava descending from the mountain have covered the whole of this part of the country rendering it impossible to be cultivated except at a considerable elevation some distance from the sea where the frequent rains have in some measure decomposed the lava and thus produced a soil. The inhabitants reside mostly on the seashore, subsisting in a great measure upon fish. The place where I have put up contains only a few houses, but these are well filled with inhabitants. The one which I am to sleep in is less than ten feet square, yet it has a fireplace in the center and accommodates eleven inhabitants⁵¹.

From there the Loomis party took in inland trail and up the pali:

I was delighted to find myself in a new region, where a thin but rich soil and luxuriant foliage concealed the lava from our view....Continuing our journey over a beautiful tract of country (but thinly inhabited)...⁵²

Additional 19th century visitors

Subsequent visitors and foreign born residents made comments of Ka'ū, including James Dana of the U.S. Exploring Expedition, 1840; Rev. John D. Paris, 1841; and Chester Lyman, 1846. Lyman's trip from Wai'ōhinu to Kona which led him across the uplands of Kahuku and Manukā and then down to the coast at Kapua in Kona, is the first account of the upland trail. Lyman remarked "the country west of Waiohinu is delightful—the soil appears to be good and vegetation abundant⁵³." In 1849 Samuel Hill sailed in a small boat from Kealakekua Bay to Kā'iliki'i and took shelter at a tiny harbor near Pōhue Bay and explored the rough lava fields in the area:

...we hauled into the cove in which Kailili [Kailikii] is situated, and landed...near the hut of the government agent...

...the village of Kailili consisted of but three or four huts...The country immediate to the village was also of the rudest description...They gave us...fish, very good sweet potatoes, and dry taro...they seemed to be plentifully supplied⁵⁴

⁵¹ Loomis ms.:7 IN Kelly 1969:22

⁵² Ibid:12 IN Kelly 1969:22

⁵³ Kelly 1969:31

⁵⁴ Hill 1856:239-240 IN Kelly 1969:32

In 1861 Sophia Cracroft and her friends arrived in Wai'ōhinu and departed on May 1 toward Pali-o-Kūlani. Unlike earlier visitors, she hiked down to the coast where they reached the solitary house on the shore:

...It proved to be a very excellent native one, of grass as usual, belonging to one of the lower Chiefs, by whom it was a matter of course given up to one of Mr. Kalakaua's rank— the family of the owner moving into a small one usually occupied by the servants, adjoining which was the cooking place—a mere sloping thatch upon poles. Besides these buildings of grass, there was a large canoe house. This made up the little homestead, distant from the nearest village by about two miles⁵⁵.

Kelly reports the land route was not popular at first, but eventually came to replace the sea route, at least for much of the missionary traffic between Ka'ū and Kona⁵⁶.

Transitions in Land Tenure and Land Use Practices

Foreign influences impacting Ka'ū in the 1840s were reflected in missionary station reports. (A tangential indicator was the adoption of Western style clothing from traditional *kapa māmaki* as the decade progressed.) Lebo writes, "Faced with few external markets for their produce, high taxes, little property, and periods of epidemics, drought, famine, and fire, ever more families left Ka'ū for the growing ports of Lahaina, and Honolulu. While some parents returned, estimates suggest that two-thirds to nine out of ten children did not⁵⁷." Henry Kinney's 1851 station report stated:

...a year after the ravages of measles (!), there has been a scarcity of the common food of the natives – Many were Compelled (!) to resort to wild food; but not food is pleanty [sic] (!) again – for a few months past, the people have been unusually active in planting talo [taro], potatoes & onions, having been encouraged that vessels will come bye & bye for their produce (Station Report 1851).

Goat production became the principle export commodity by 1850 followed by *pulu* (Cibotium spp)⁵⁸. W. C. Shipman reported in 1860 the *pulu* trade:

started in the last twelve months has put an end to all agricultural pursuits; even the cultivation of taro; the "staff of life" to Hawaiians; is greatly neglected. The greater part of our people are now engaged in gathering pulu (Station Report 1860).

The abandonment of their crops in favor of a tradable commodity accompanied by droughts and freeranging livestock of foreign residents contributed to the exodus of residents for more populated centers.

⁵⁵ Korn:1958:61-62 IN Kelly 1969:32

⁵⁶ Kelly 1969:33

⁵⁷ Lebo IN Dye 2010:8

⁵⁸ n. A soft, glossy, yellow wool on the base of tree-fern leaf stalks

Mahele

The Mahele of 1848 radically changed the Hawaiian system of land ownership and tenure dividing the `āina among 245 chiefs and Kamehameha III. The king then divided his lands between the government and himself. Nine of the ten *ali'i nui* including the king were awarded land in Ka'ū,

...the bulk of the 'Āina Kauikeaouli gave to the government came from his holdings on Hawai'i island, the center of his father's birthright. It was as if having decided that government 'Āina should be set aside for the maka'āinana, Kauikeaouli decided that the gift should represent his father, Kamehameha, the makua of the Lāhui⁵⁹.

Kauikeaouli, (Kamehameha III) received and relinquished the great number of *ahupua'a* in Ka`ū, 43 and 40 respectively.

Six landlord chiefs (*konohiki*) received twenty *ahupua'a* within Ka'ū and several of these were turned over to the king in lieu of commutation fees. *Konohiki* ownership and rights did not include *kuleana* lands awarded to commoners within the *ahupua'a*. Boat landing areas were retained by the government⁶⁰.

Kahuku was claimed by William Pitt Leleiōhoku (1819-1848) and then relinquished to the king in lieu of commutation fees due on the lands awarded him. The son of Kalanimōkū and Kiliwehi. Leleiōhoku held 93 'āina prior the Mahele, relinquishing 57 of them. He received a significant amount of land from his "sister-cousin" Kekau'ōnohi, a granddaughter of Kamehameha 53. Leleiōhoku's claim to Kahuku may have derived from his first wife, Nāhi'ena`ena, a daughter of Kamehameha and his sacred wife Keōpuolani and sister of Kamehameha III, or through Kuakini, a son of Namāhana and governor of the Hawai'i Island from 1820 to 1848 who named Leleiōhoku one of his heirs 64 or Kekau'ōnohi. Although it cannot be ascertained for certain from whom Leleiōhoku received Kahuku, Kame'elihiwa provides an insightful discourse of how Kalanimōkū broke from tradition by leaving his 'āina to Leleiōhoku and Kekau`ōnohi instead of the king and of Leleiōhoku's temperament and behavior:

In early 1827, Kalanimōkū, feeling that death was near, left Oʻahu saying that he was afraid that if he died there his brother Boki, the Kiaʻāina (Governor), might desecrate his body. He may also have been afraid that Boki would gain his `āina....As Kalanimōkū lay dying in the circle of his Chiefs, the idea arose within him to hoʻihoʻi all his ʻĀina to the Mōʻī- as was the traditional custom and, no doubt he felt was pono behavior. Haihā Nāihe and Hoapili, sons of the Kona Uncles, objected, declaring, "He mau keiki o kā mākou," that is, "We all have children of our own,"

⁵⁹ Kame`eilihiwa 1990: 238

⁶⁰ Kelly 1980:ix

⁶¹ Barrere notes Fornander cites Kuwahine as Leleiōhoku's mother as Kuwahine but four different Hawaiian sources cite Kiliwehi as his mother 1994:410

⁶² Kame`elihiwa 1992:229

⁶³ Ibid.:243

⁶⁴ Kamakau 1961:395

meaning that they had heirs to whom they wanted to pass their ` \bar{A} ina and felt that Kalanim \bar{o} k \bar{u} 's suggestion to ho'iho'i might threaten the newly acquired Land inheritance right⁶⁵.

Feeble as he was and finding himself of two minds over the matter, Kalanimōkū acquiesced. Kalanimōkū had only two keiki at this time, his young son Leleiōhoku (about ten years old) and his niece Kekau`ōnohi, who was a grown woman.

Leleiōhoku was his son by Kiliwehi, a daughter of Kamehameha, and was considered a very high Ali'i Nui because of the intermingling of the high Māui and Hawai'i lineages. Not only was he a grandson of Kamehameha, but on one side he was a descendant of the great Kekaulike of Māui, while on the other, a descendant of the equally famous Keawe of Hawai'i island. He had been named Leleiōhoku in commemoration of the death of Kamehameha, which occurred on the night of Hoku⁶⁶.

Kekauʻōnohi was the daughter of Wahinepio, Kalanimōkūʻs sister, and Kahōʻanokū Kīnaʻu, a son of Kamehameha. Actually Leleiōhokuʻs mother, Kiliwehi, and Kekau`ōnohi's father, Kaho`ānokū Kīna`u, were full brother and sister, their parents being Kamehameha and Peleluli (she was a daughter of Kamanawa, one of Kamehameha's Kona Uncles). Thus, the relationship between Kekauʻōnohi and Leleiōhoku was doubly close, and they were as brother and sister.

Kalanimōkū therefore left all if his 'Āina to his "daughter" Kekau'ōnohi as his keiki ho'oilina and made his son Leleiōhoku her kanaka.

One might argue that Kalanimōkū sensibly bequeathed his 'Āina to Kekau'ōnohi because Leleiōhoku was only ten years old, and Kekau'ōnohi, an adult, would be better able to control the 'Āina. However, the responsibility which fell to Leleiōhoku as konohiki-to administer the 'Āina and collect the rents and taxes-was in and of itself an arduous duty.

In addition, other Ali'i Nui who had died before Kalanimōkū had also given their 'Āina to Kekau'ōnohi, with Leleiōhoku as kanaka. It seems to have been the custom with sister and brother heirs to leave the property to one and designate the other as kanaka. Therefore, if Kekau'ōnohi should die, all the property would go to Leleiōhoku as "there was no other person it could descend to."

The relationship between keiki hoʻoilina and kanaka worked in the following manner. A kanaka could eat with the owner of the 'Āina, and use the 'Āina, but not alienate it. In ancient times, the "owner" could not turn the kanaka out because he was kolohe (mischievous) and "so Leleiōhoku could not have been turned away and made destitute from his bad conduct" (referring to Leleiōhoku's frequent and infamous bouts of drunkenness and fighting, even with maka'āinana).

Thus, Kekau'ōnohi would give instructions to Leleiōhoku, who would pass them on to Malo and Ha'alelea, both of whom were kahu of Leleiōhoku. Sometime, however, she would speak directly to his kahu and they would have to obey her orders. Likewise, they had to follow Leleiōhoku's orders, even though he was only ten years of age. Leleiōhoku was free to parcel out the usufruct

⁶⁵ Kame`eilihia 1992:112

⁶⁶ Ibid:113

rights without consulting Kekau`ōnohi, but she had the right to approve or repudiate the decision. At the time of the 1848 Mahele, Leleiōhoku went to see Kakau'ōnohi about the 'Āina, and she divided them equally, whereupon she went immediately to the Mō'ī to obtain his approval of their division, and he gave it.

Despite Kalanimōkū's kauoha, it seems that of the eighty-odd parcels of 'Āina he held in 1827, not all went to these two heirs, for at one point Leleiōhoku complained to Judd that some of his father's 'Āina were being held by his cousin Kekāuluohi. By the same token, Kekāuluohi also complained to Judd that some of the 'Āina she should have inherited had gone to Kekau'ōnohi⁶⁷.

When William P. Leleiōhuku died at age 29 in 1848 of measles, his second wife, Ruth Ke'elikōlani and son, John Pitt Kīna'u, were required to cede twelve more of his 'āina in government commutation. When his lands were divided in May 1850, Kahuku was ceded to the government as part of their one-third interest and valued at \$20,400⁶⁸. Kingdom minutes and correspondence reflect his ownership and this transfer:

Privy Council vol. 3:662

Re. land laid off as the Government. One-third of the above land [Kahuku] of the Leleiōhoku Estate.

Interior Department Document No. 372

List showing...set aside to William P. Leleihōhoku.

Interior Department, Lands - 1847

Lands of King as reported by C[harles] Kanaina same as reported by Namauu.

Interior Department, Lands – December 15, 1847

Lands of King as reported by M. Kekuanaona [and] J. Kaeo [on December 16].

Interior Department, Lands – May 27, 1850

Regarding division of lands between Government and the heirs of W.P. Leleiōhoku; showing that the above land was granted to the Government, which was sanctioned by the Privy Council on May 27, 1850.

Interior Department Letter Book 3:7 - September 12, 1850

Minister of Interior (by Kalama) to E. Bond. Above land ceded by W.P. Leleiohoku to the Government.

⁶⁷ Kame`elehiwa 1992:114-115

⁶⁸ Interior Dept, Land, Letters (incoming) 1850, May

Kuleana Claims

The native tenants of the lands could file *kuleana* claims regardless of the owner of the *ahupua'a*. *Kuleana* claims were permitted only for house lots (not to exceed ¼ acre) and garden lands the claimant had under cultivation to feed his own family. Commoners were not permitted to claim *kula* land they utilized for grazing cattle, horses, or goats, nor were they permitted to claim any lands they cultivated for the purpose of selling the crop. Such claims were permitted only to the *konohiki* and foreigners⁶⁹.

Within Kahuku, twenty-five separate claims were filed fourteen of which were awarded and eleven denied. Numerous *kalo* (taro, *Colocasia esculenta*) patches, upland banana fields, plots for *māmaki* (*Pipturus*) were described. Claims appear to be mainly inland in areas favorable for gardens (see Figure 1 of planting zones). None of these claims have been determined to fall within the project area as the first five are described on the tax map as "unlocated⁷⁰." These awards fringed the upland boundary of TMK 3-9-2-01:72 in an area known as Keopuka. Here, both taro and banana were cultivated. Several claimants mentioned their parcels adjoined Samuela, the school teacher of Kahuku district. Samuela's taro patch in Keopuka was situated adjacent to his school house; a road also ran along another boundary of his patch⁷¹.

Table 1 – Awarded kuleana claims

Awardee	LCA ⁷²	Acres	# Pieces	Register	Testimony
Kaaua	9229	7.40	1	N. ⁷³ . 8:628	N 8:482
Kepola	8769	15.20	1	N 8:167	N 8:474
Kila	8771	9.25	1	N 8:167	N 8:472
Naohe	10514	13.60	1	N 8:657	N 8:475
Ku	9248	9.40	1	N 8:629	N 8:475
Samuela Kuula	11028-B	6.20	1		
Pau	10842	6.55	1	N 8:664	N 8:472

Testimonies for these and non-awarded claims provide insight to cultivation and residency.

⁶⁹ Kelly 1980:ix

⁷⁰ Silva IN Haun and Walker 1987:D-12

⁷¹ Ihid

⁷² Land Commission Award Number

⁷³ Native. Registers and testimonies are categorized as either as Native, in Hawiian or Foreign, usually in English.

LCA 9229 Kaau Kahuku, Kau, Hawaii

Native Register vol. 8:628

He ye, ye Land Commissioners meeting at Honolulu: I am a claimant of land. I have an ili of land. In another ili in this ahupua'a I have 5 kihapai.

Native Testimony (Spelled Kaana) vol. 8:482

Kumauna sworn he has seen Kaana's land.

Section 1 – ili in Kekeekai ahupuaa, Wahine had given in 1840.

Section 2 – 5 taro kihapai in Puukoae ili of Kahuku, from Kumauna in 1840, no objections. Both sections are bounded by Konohiki's land.

LCA 9248 Ku Kahuku, Kau, Hawaii

Native Register vol. 8:629

He ye, ye Land Commissioners at Honolulu: I have a claim for an ili of land in the ahupua'a of Kahuku. I have 5 other kihapai in another ili in this ahupua'a.

Native Testimony vol. 8:475

Kumauna and Samuela sworn they have seen Ku's land.

Section 1 – 3 taro kihapais and banana at Keopuka, ili of Kahuku

Section 2 – 2 taro kihapai at Puukae ili of Kahuku ahupuaa, Kumauna had given in 1840. No one had objected to him. the boundaries are:

Section 1 – bounded by the land of the konohiki

Section 2 – bounded by the land of the konohiki

LCA 10514 Naohe Kahuku, Kau, Hawaii

Native Register vol. 8:657

I am a claimant of land. I have an ili, a kihapai of taro and a mountain banana patch. This is my claim, for your information.

Native Testimony vol. 8:475

Pau and Samuela sworn they have seen Naohe's land.

Section 1 – Aukahua ili in Kahuku ahupuaa, from Haumea in 1839

Section 2 – Taro kihapai at Keopuka, ili of Kahuku

Section 3 – Banana field, no objections. The boundaries are:

Section 1 - 3 – bounded by the land of the konohiki.

LCA 10842 Pau Kahuku, Kau, Hawaii

Native Register vol. 8:664

I have an ili and 2 kihapai in another place; a kihapai of taro and a mountain banana patch. That is my claim for your information.

Native Testimony vol. 8:472 November 12, 1849

Wahine and Samuela sworn they have seen Pau's land.

Section 1 – Kukuinui ili of Kahuku, from Haumea in 1839.

Section 2 – Taro kihapai, ili of Keopuka from Kaumea in 1840, no one had objected.

The boundaries are:

Section 1 Mauka - Kaopuana

Puna - Konohiki Makai – Manae Kona – Konohiki

Section 2 Mauka – Konohiki

Puna - Keawe Makai - Naohe Kona - Konohiki

LCA 8771 Kila

Native Testimony vol. 8:472

Kumauna and Samuela worn they have seen * Kila's section at Keopuka ili in the Kahuku ahupua'a that Kamailiilii had given in 1819, no objections. Life has always been peaceful. The konohiki's land surrounds this lot.

LCA 8769 Kepola (Debora)

Native Testimony vol. 8:474

Samuela and Kumauna sworn they have seen Kepola's ili section of Puukoae in Kahuku, Mailiilii had given in 1819, no objections. It is bounded by the land of the konohiki.

LCA 11028 Samuela

Native Testimony vol. 8:473

Wahine and Kaaloa sworn they have seen:

Section 1-3 taro kihapais at Haleolono, ili of Kiao from Samuela's parents in 1819.

Section 2 – house lot at Haleolno ili of Kiao ahupuaa

Section 3 – Taro kihapai in Keopuka ili of Kahuku.

Section 4 – banana kihapai, Debra had given in 1847, no objections. The boundaries are:

Section 3 – Mauka and Puna – Debora

Makai – Kamanuwai

Kona - Namanele

LCA 9175 Kauwila

Native Testimony vol. 8:471

Kuwaha and Wahine sworn they have seen Kauwila's land.

Section 1 – Poopueo ili of Kekeekai ahupuaa, Kamoku had given in 1819.

Section 2 – taro kihapais at Hakepala, ili of Pakini, from Lapuwale in 1840.

Section 3 - taro kihapai in Keokuka, an ili for Kahuku ahupuaa, Haumea had given in 1840, no objections.

Boundaries 3:

mauka - Manae

Puna - Samuela

Makai – Konohiki

Kona - Kaleo

LCA 8772 Kaaloa

Native Testimony vol. 8:472

Wahine and Samuela sworn they have seen Kaaloa's land.

Section 1 – Haleokane ili of Kiko ahupuaa from his parents in 1819.

Section 2 – banana field at Keopuka ili of Kahuku ahupuaa. No objection and from Haumea in 1839. The boundaries are:

Section 2:

Mauka - Paele

Puna - Namanele

Makai - Namale

Kona - Hanuhanu

LCA 9058 Kuoha

Native Testimony vol. 8:473

Wahine and Samuela sworn they have seen Kuoha's land.

Section 1 – Wehhiwahale ili of Kekeekai ahupuaa, Namoku had given in 1819.

Section 2 - Kaoma ili

Section 3 – Kihapai in Nohoiki ahupuaa, Ihupuu had given in 1819.

Section 4 – Banana kihapai at Keopuka ili of Kahuku ahupuaa, Debora had given in 1840, no objections.

[all bounded by konohiki lands]

LCA 9156 Kualaula November 12, 1849

Native Testimony vol. 8:474

Wahine and Samuela sworn they have seen:

Section 1 – Haleolono ili of Kiao ahupuaa that Poka had given in 1840.

Section 2 – Taro kihapai at Kaoma ili in Kekeekai ahupuaa, from Kuwaha in 1840.

Section 3 – Taro kihapai at Keopuka ili in Kahuku, from Haumea in 1840.

Section 4 – banana field, no objections to him. The boundaries are:

Section 3:

Mauka – Waipa

Puna- Kaleo

Makai – Konohiki

LCA 9209 Kemu (deceased)

Native Testimony vol. 8:475

Kaaloa and Kauwila sworn they have seen Kimuu's land.

Section 1 – Kukuinui ahupuaa, Poka had given in 1839.

Section 2 – Taro kihapai at Keopuka ili, of Kahuku ahupuaa, from Haumea in 1840. Life has been peaceful, no objections. The boundaries are: bounded by the land of the konohiki.

Table 2 – Silva's Synopsis of Mahele claims

LCA Awardee	Term of Residence	Land Uses	Comments/Descriptions
8769 Kepola	Received in 1819 from Mailiilii	An 'ili in Puukoae; probably banana patch	Surrounded by land of konohiki; upland 15.2 acres
8770 Kanoe			Not awarded
8771 Kila	Received in 1819 from Mailiilii	<i>ʻili</i> in Keopuka	Surrounded by land of konohiki; bound on a side by Samuela; 9.25 acres
8772 Kaaloa	Apana 2 from Mauna in 1839	Banana patch	Surrounded by Paele, Namanele, Namale, Hanuhanu (not described in deed)
8773B Haumea	Land from Kapulikoliko in 1830; may have been a konohiki	Claims <i>opelu</i> fishing rights and <i>mamaki</i> trees	Not awarded
8775 Kaopuana	Land from Haumea in 1833	Tli	Surrounded by land of konohiki; Not Awarded
9058 Kuoha	Apana 4 from Debora in 1840	Banana patch	Surrounded by land of konohiki
9156	Apana 3 & 4 from Haumea in 1840	Taro garden and banana patch	Surrounded by claimants on 3 sides; (not described in

Kualaula			deed)
9175 Kauwila	Apana 3 from Haumea in 1840	Taro garden and bananas	Surrounded by claimants on 3 sides
9209 Kemu	Apana 2 from Haumea in 1840	Taro, bananas, and mamaki for tapa making	Surrounded by land of konohiki; claimant deceased
	Ili from Wahine in 1840; taro land from Kumauna in 1840	`ili in Kekeekai and 5 taro plots in Puukoae	Both surrounded by the land of the <i>konohiki</i> ; in 1867 sold to A.E. Spencer of Waiohinu for \$12; 7.4 acres
9247 Kaleo	From Haumea in 1833	lands for taro, bananas, mamaki for tapa	Surrounded by land of konohiki; Not awarded
9248 Ku	From Kumauna in 1840	`ili of taro and 3 banana patches in Keopuka and 2 taro plots in Puukoae	Nearly surrounded by konohiki lands, 9.4 acres
9995 Lamaikahiki	`ili from Haumea in 1833	`ili	Surrounded by land of konohiki; Not awarded
9997 Luamano	From Haumea in 1833	`ili	Surrounded by land of konohiki; Not awarded
10508 Namanele	From Haumea in 1843	6 taro lands and 1 banana land	Surrounded by land of konohiki; Not awarded
10509 Nuhi	From Haumea in 1846	Taro lands and <i>mamaki</i> for tapa	Surrounded by land of konohiki; Not awarded
10511 Namale	From Haumea in 1833	4 taro lands and 1 banana land	Surrounded by land of konohiki; Not awarded
10113 Manae		`ili	Surrounded by land of konohiki; Not awarded
10514 Naohe	From Haumea in 1839	`ili in Aikahua, taro land in Keopuka and banana land in the uplands	3 sections, one with a road through it; 13.6 acres

10842 Pau	From Haumea in 1839 & 1840	`ili in Kukuinui, taro land and banana land upland; also a houselot	Cultivated land surrounded on 3 sides by <i>konohiki</i> land; houselot surrounded by <i>konohiki</i> land
10842 Paele	From Haumea in 1833	`ili	Surrounded by land of konohiki; Not awarded
11007 Wahine	From Kumauna in 1840	taro land	Surrounded by land of konohiki; not described in deed
11028 Samuela	From Debra in 1847	A taro land and a banana land	Samuela was listed as the school teacher and konohiki
11026B Samuela Kuula	Apana 1 from parents in 1819; Apana 4 from Kepola (Debora) in 1847	3 taro lands in Kiao and a houselot there; taro lands in Keopuka and a banana land probably upland	Keopuka taro land is bound on the side by the school house and on other side by road

These records provide evidence to the general settlement patterns for upland Kahuku. The inland *ala nui*, main trail, rose up through the Kahuku escarpment from the western lava lands of Kahuku, then descended gradually seaward through the rich, high-rainfall, ash lands above *pali*, passing through houselots and farms. At Pu'u Po'o Pūeo the road turned east and headed across the upper fields of Pākini and Kamā'ao towards Wai'ōhinu and the eastern lands of Ka'ū⁷⁴.

Claims are predominately inland from the *ko kula uka*, the upland slopes favorable for dryland taro, sweet potatoes and sugar cane. Beyond these open slopes *kīhāpai* (cultivated patch) were claimed in the *ko wao*, the forested areas. Lebo concludes, "The likely resided and farmed within *ko wao `ilima*, where the lower altitudes provided good agricultural land, resided for temporary periods in the more inland *ko wao kanaka*, farming and gathering wild resources. No records or accounts provide any indication of activities other than exploitation of marine resources occurred within the project area. Shorter gathering trips were likely made to *ko wao nahele*, the drier plains and deserts⁷⁵. Resources and crops in relation to their zones are shown here in a graphic from *Native Planters of Old Hawaii*.

⁷⁵ Lebo IN Dye 2010:12

⁷⁴ Cordy 2000:351

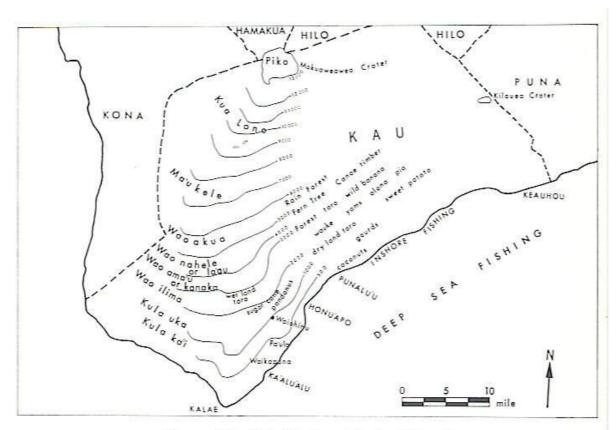


FIGURE 39.-Ka'u District, Island of Hawaii.

Figure 1 – Handy and Handy's (1972) graphic showing traditional zones in Ka`ū

The government subsequently set apart and designated Kahuku as School Lands for the use and income of the Department of Public Instruction. (Unconnected to this designation a Protestant school was established in 1857 in Kahuku with 55 students in 1847 and 31 students⁷⁶.) Records of the Privy Council and correspondence to the Minister of Interior provide further insights to land use and transactions in Kahuku:

Interior Department, Lands – September 25, 1851

Minister of Interior to Rev. D. B. Lyman. Enclosing list...showing the above land does not belong to the Government.

Public Instruction, Lands – August 20, 1855

None of the above school land in Kau had been sold.

Public Instruction, Lands – July 2, 1856

S. Laanui to Minister of Public Instruction. That Kamakana and Kaua, have brought \$10 for the school land is the above tract which they desire to purchase.

⁷⁶ Kelly 1969:41

Public Instruction – March 6, 1858

R.K. Chamberlain to Minister of Public Instruction. Applying to purchase the above land.

Public Instruction - December 3, 1858

Kupa to Minister of Public Instruction. Receipt for \$116, amount paid by him for land, now refunded.

Public Instruction, Lands - December 23, 1859

Kalaamaikahiki to Minister of Public Instruction. Receipt for \$103, amount paid by himself, now refunded.

Public Instruction, Lands – June 16, 1860

A/C sales of above land, sold for \$3100.

Interior Department Letter Box 10.304 - October 10, 1870

Minister of Interior to F.S. Lyman. Enclosing Royal Patent No. 6083 for Pau for land in the above place.

Interior Department, Lands – November 6, 1871

W. T. Martin to C. T. Gulick. Stating the owners of the land of Kapua at Kahuku desires to have boundaries of said lands defined. That they are living at this time, certain Hawaiians who know the boundaries of said lands. Desires that the boundaries be settled at once, for if delayed, these old native may die &c.

Interior Department, Lands - April 26, 1872

R.A. Lyman to Commissioner of Crown Lands

Stating that G.W.C. Jones & Co. have applied to have the boundaries of the above settled.

Interior Department, Lands – 1873

Report by the Commissioner of Boundaries (Hoapili) showing that moneys have been paid to the witnesses who testified at the hearing on the settlement of the boundaries of a piece of land in the above place belonging to G.W.C. Jones & Co.

Interior Dept, Land Letters (Incoming) January 1873

"Lands in Kau settled before the Commissioner of Boundaries, 1873"

(Mar. 11/12/14/17) (Mar. 18/19/21) Owner: G.W.C.Jones & Co. Kahuku No.Days worked 7 No. of Witnesses 2 Amount paid witnesses \$2.00

Interior Department, Lands – February 1, 1873

R.A. Lyman to Commissioner of Crown Lands

Informing that he had advertised the hearing for the settlement of the boundaries of the above land to take place on March 11th at the Waiohinu Court House. States that the Crown Lands in Kona adjoining Kahuku are Honomalino in Kona and Waiohinu and Kapapala in Kau. That the lands of Keauhou and Hilea 1 & 2 belong to the Kekuanaoa Estate. That the Governess of Hawaii won the lands of Kappua, Kawela and Mohokea adjoining Kahuku. Desires him to appoint a person to look after his interests. Would like to be informed of his decision about leasing the land of Waiakea, &c.

Interior Department, Lands – March 10, 1873

F.S. Lyman to Minister of Interior

Acknowledging the receipt of his two favors of the 3rd instant and stating that they had designated J. Kauhane to look after the interests of the Government in the settlement of the boundaries of the above land.

Same - March 17, 1873

J.G. Hoapili to J.O. Dominis

Reporting on the matter pertaining to the settlement of boundaries of the above land, adjoining the land of Keauhou, &c.

Interior Department Letter Book 12, p. 254 – May 26, 1873

Minister of Interior to R. A. Lyman

Forwarding the following Royal Patent for land in the above tract, &c. No. 6083 Pau \$5.00

Interior Department, Lands - January 6, 1874

R.A. Lyman to Minister of Interior

Statement reporting that Royal Patent No. 6083 for a piece of land in the above place had been delivered to Pau.

Interior Department, Lands - January 18, 1876

W.T. Martin to Minister of Interior

Informing that the boundaries of the above land has encroached on the boundaries of the land of Manuka, &c.

Interior Department, Letter Book 13 p.282 - March 22, 1876

Enclosing letters from Rev. J. Kauhane to the Minister and from R.A. Lyman, Commissioner of Boundaries for the Island of Hawaii, to J. Kauhane, informing him of his decision of the boundaries between the above land and Manuka in Kau, Hawaii. Notes of survey defining the boundaries between said lands and a Memorandum from W. T. Martin.

Interior Department, Book 14 p.138 – February 19, 1877

Desiring him [Captain Brown] to furnish Brewer & Co. with a buoy of the necessary size and shape for mooring at Punaluu.

Interior Department, Book 14, p214 - May 3, 1877

Authorizing Captain Brown to construct the necessary stand, house &c. for the tide-gauge in accordance with the instructions of Professor W.D. Alexander, &c.

Interior Department, Lands - January 31, 1891

Samuel Norris to Minister of Interior. Applying to lease several pieces of land lying below the Government road between Kahuku and Waiohinu for 25 years at \$75 a year. Sketch and report of Government Survey Office relating thereto attached.

Interior Department, Lands – February 16, 1893

Samuel Norris to Minister of Interior. To purchase for cash Government lands lying on the east and south side of the above land, &c. Documents and report of Government Survey Office relating thereto attached.

Executive (Commissioner of Public Lands) – June 24, 1921

Commissioner of Public Lands to Governor. Submitting for approval, deed from Territory of Hawaii to the United States of America, covering 5,962 acres of land at the above tract, Kau, for National Park purposes, &c.

Transportation

Marine transportation to and out of Kahuku was subsidized by the government. References to a Captain J. Brown's operations of running the steamer *Pele* during the 1860s are found in the Interior Department's records and correspondence:

Interior Department Book 7:437 – September 20, 1862

Minister of Interior to Captain J. Brown. Informs him that his salary has been reduced to \$120 per month on account of the small amount appropriated by the last Legislature for the steamer under his charge.

Interior Department Book 7:637 - February 6, 1866

Minister of Interior to Captain J. Brown Instructing him to take the necessary steps for rigging the Steamer Pele under the estimate which he furnished.

Interior Department Book 8:66 - February 7, 1867

Minister of Interior to Captain J. Brown. Requesting him that separate accounts be kept for the new wharf, the dredge & any other Government work and also keep a correct note of all the men's time every day &c.

Interior Department Book 8:80 – February 22, 1867

In letter from Minister of Interior to Captains McIntyre & Berril informing them that from & after the last of this month no commissions will be allowed from the earnings of the Steamer *Pele*. Also states that Captain J. Brown will be instructed to collect all amounts due for towards that date.

Interior Department Book 8:81 – February 22, 1867

Minister of Interior to Captain J. Brown. Requesting him to collect all earning of the Steamer Pele from and after the first of next month.

As a result of Act 65, 1893-4 Laws, the Superintendent of Public Works replaced the Minister of Interior as the authority who appointed a road supervisor for Honolulu and supervisors across the islands. During his reign Kalākaua was allowed "to amend the law concerning Road Supervisor(s) and the disposition of the Road Tax and to establish local road boards which were to build and maintain all roads, bridges, and public highways within their respective districts. Road development in Kahuku fell under the responsibilities of the Ka'ū Road Board. These Road Boards functioned until their duties were assumed by the County governments.

Under certain specific conditions, roads could be constructed without involving the Road Boards. Act 82 Laws stated that any new roads or bridges, the construction of which were funded by appropriations outside of the road taxes, could be constructed by the Minister of Interior without reference to the district road boards. Few references could be found regarding Kahuku in these records at the Hawai'i State Archives:

⁷⁷ Roads - November 25, 1887

Naalehu October 31, 1900 to J. A. McCandless, Superintendent of Public Works

I am nominated by the people of this island to be one of the Sanators [sic] from this island; and I write to inform you that I resign from my office as Chairman of the Road Board of Kau - S. Kauhane [on Hutchinson Sugar Planation Co. letterhead, Naalehu]

To McCandless Naalehu January 21, 1901

- ...report from the Kau Road Board year ending December 31, 1900. During the year aforementioned new roads have been constructed...viz.
- 2. From Waiohinu to Kahuku 6 ¼ miles at a cost of \$4350 turned over to and accepted by this Board July 1900.
- 3. From Kahuku to Kona 10 miles at a cost of \$7777 turned over to and accepted by this Board July 1900.

Superintendent C.S. Holloway Kailua-Kona, January 21, 1905

[Chair of Kau Board] telephoned me to write you that he considers the most crying need of Kau are...and the top-dressing of the road from Kahuku to Kona over the aa flows. This latter work must necessarily be expensive owing to the nature of the country and the difficulty of providing water and feed for stock etc. He figures it may take \$35000 to properly crush and apply dressing to the same – G.G. Kinney, Secretary Kau Road Board

Jeep roads and foot trails in the area are highlighted in John Clark's description of the coastline:

The beach at Humuhumu Point and the beach at ' \bar{A} wili Point are collectively known to most area residents as Road to the Sea. Road to the Sea, a 7-mile-long cinder road, begins at the western edge of Hawaiian Ocean View Estates and ends on the shoreline of Humuhumu Point. It is one of the few mauka-makai access routes in Ka' \bar{u} to the ocean... ' \bar{A} wili Point is said to be one of the better ulua grounds when these fish are running in Ka' \bar{u} ⁷⁸.

Behind 'Āwili Point, a trail leads from the jeep road across the 'a'ā to Nā Pu'u a Pele and climbs directly over the summits of these massive hills....A series of brackish-water ponds lines the backshore, and a number of habitation sites that comprised portions of the former Keawaiki village also occupies the area. The trail from Nā Pu'u a Pele leads down to Keawaiki, where it crossed the shoreline trail heading back to the beach at 'Āwili....Beyond Keawaiki and the remnants of an old bombing target-range marker, a jeep road follows the rocky shoreline toward Kaunā Point...⁷⁹

Boundary Commission Testimonies

In 1862, a law was enacted establishing the Commission of Boundaries (the Boundary Commission). The Commission's goal was to legally set the boundaries of all the *ahupua* 'a that had been awarded as private properties in the *Mahele* 'Āina. R.A. Lyman, Commissioner for the Island of Hawai'i between the 1860s to early 1900s, noted a commissioner's responsibility to "determine certain geographical lines,

⁷⁸ Clark 1985:80-81

⁷⁹ Clark 1985:82

that is, he is to ascertain what, in fact, were the ancient boundaries of lands, which have been awarded by name only⁸⁰." Furthermore, the Commissioners were, whenever possible, to determine and "assign whatever was included in such land according to the boundaries as known and used from ancient times⁸¹". This charged the commissioners with addressing not only land matters, but also those of fisheries, and a wide range of resources and practices as known from ancient times⁸².

In order to accomplish their mandate, the commissioners were to identify knowledgeable native residents and *kama* `āina from whom detailed testimonies and descriptions of the lands and rights could be recorded. This process produced thousands of pages of firsthand accounts describing many facets of land use; residency; beliefs and customs; changes in the landscape in the period from ca. 1790 to 1890.

The primary informants for the boundary descriptions were elderly native residents of the *ahupua* a for which boundaries were to be certified, or of neighboring lands. Nearly all of the informants stated they were either born on one of the lands being described, or that they had lived there since their youth. All of the witnesses learned of the boundaries either from their own elders, or from others who resided there in the preceding generation. Nearly all native witnesses described the landscape by the nature of the terrain, resources present, land use, and features which were of significance to the *kama* aina.

Most of the testimonies were taken 1873 between 1893 though some were recorded in the early 1860s. The oldest informants were born around 1785, based on association with events described at the time of their birth, and the youngest around 1830⁸³.

Silva writes of the importance of having an intimate knowledge of Kahuku *ahupua* 'a boundaries, "as they [informants] discovered that whatever they had obtained outside of these boundaries were quickly confiscated and handed over to the *konohiki* of the respective district. Testimonies reflected much activity—bird catching in the uplands for the *uwao* and *nēnē*, collecting of sandalwood, felling of timber for carpentry from the *koa* woods, goat-catching, gathering of fern *pulu*, etc...⁸⁴" She quotes an aged canoe-maker:

...In ancient days the people of Kahuku did not go fishing, but were after birds of all kinds to eat and this is the reason all the land on the mounatin belonged to Kahuku. My Makuaponoi and others always took their weapons with them as they used to have fights, when they found people from other lands catching birds. The sandalwood belonged to Kahuku; there was none in Kona except on Kapua, and when the other Kona people came on Kahuku after it the Kahuku people would take it away...⁸⁵

⁸⁰ Lyman, 1900 Volume D No. 5:35

⁸¹ Lyman 1897 – Volume D No. 5:101; cf. Supreme Court, 4th Hawaiian Reports

⁸² Maly 2003:319

⁸³ Ibid.

⁸⁴ Silva IN Haun and Walker, 1987:D-5

⁸⁵ Ibid.

Another informant stated at one time uhu (parrot fish, Scarus perspicillatus) was the kapu fish and koa (Acacia koa) the kapu wood for the district. Mamo (black Hawaiian honey creeper, Drepanis pacifica) and 'ō'ō (black honey eater, Moho nobilis) birds apparently flouished in the upland woods. Several informants cited Kamehameha III traveled to Kahuku and in 1835 a tribute of mamo feathers was given to him at the boundary between Manukā and Kahuku⁸⁶.

Transcriptions of English testimonies are presented in Appendix B of this report. These boundary commission testimonies are presented here due to their relevance to the project area due to their coastal focus:

Kahuku, Kau District

Kumauna, sworn: ... The sea bounds Kahuku on the makai side and the land had ancient fishing rights. The cave Kanupa is between Puulonolono, Puukeokeo and Pohaha on the aa; a hill called Hapaimamo is on Kahuku and the boundary between Kapuhonu and Puuohia runs makai of this hill. I am an old canoe maker... In ancient days the people of Kahuku did not go fishing, but were after birds of all kinds to eat and this is the reason all the land on the mountain belonged to Kahuku. My makuahonowai and others always took their weapons with them as they used to have fights when they found people from other lands catching birds. The sandalwood belonged to Kahuku... [Volume A No. 1:141-142]

J. Kaulia, sworn: I live at Waiohinu, Kau, and according to my parents' statement, I was born about three years after the missionaries first arrived on the Islands. Am kamaaina of Kahuku and some other lands in Kau. In 1848...Pipi ordered me to inquire about boundaries of land as it was at the time they were setting apart the ia kohu [select fish] and the Laau kohu o na Konohiki [select tree of the Konohiki]. Pipi had lived in Kau a long time, and told me the boundaries. He said Kalaehumuhumu was the boundary between Manuka and Kahuku, and Kaumuuala between Kahuku and Pakini... Haumea was Konohiki of Kahuku at that time. <u>Uhu ia kohu [Uhu was the select fish]</u> and Koa laau kohu [Koa the select tree]... Afterwards I came to live at Kaanaholua (near Pohakuloa) on Kahuku and near the boundary of Manukaa and Kahuku, catching goats... [Volume A No. 1:145]⁸⁷

Land Grants

Under the Kuleana Law, commoners were required to present their land claims to the Board of Commissioners to Quiet Land Titles by February 14, 1848. For those who failed to make application by the closing date, government lands were made available for purchase. After 1855, large grants were sold for as little as 10 or 20 cents per acre. Between 1852 and 1879 148 land grant purchases to 123 individuals were made in Ka'ū⁸⁸. On July 8, 1861 184,298 acres of Kahuku, the entire ahupua'a was assigned by King David Kalākaua to Charles Coffin Harris under Patent 2791 for \$3,000. As with most grants it recognized the "ancient boundaries" and reserved "the rights of native tenants⁸⁹." Harris, a graduate of Harvard learned the Hawaiian language and set up a law practice in Hawai'i. His service to

⁸⁶ Ibid.

⁸⁷ Maly 2003:326

⁸⁸ Index... 1887:900-94

⁸⁹ Microfilm Reel 4, 2013-2937:237, Grant Book 10:431 to 13:530

the kingdom included Minister of Finance, Minister of Foreign Affairs, Hawai`i's first Attorney General, Associate Justice of the Supreme Court, and then Chief Justice, 1877-1881, police magistrate and legislative member. Kalākaua studied law under Harris at the age of 17 making it no surprise Harris became the King's adviser⁹⁰. While no record of Harris' activities in Kahuku could be found the land may not have been used for ranching until the next owner.

	HELU 27.9.1	
	BUTEBUTE SITE	MUI,
	A KE ALII, MAMULI O KA OLELO A KA P	OE HOONA KULEANA.
į	O KA MEA, ua hooholo na Luna Hoona i na kumu kule	ana sina i ka olelo, he kulenna olalo ko
	Vahai	(Sulvana Aldusno
	O Alodio iloko e kahi i oleloia malalo.	
t kona loke	ila, ma keia Palapala Sila Nui, ke hoike nku nci o Ka maikai i hoonoho ai maluna o ko Hawai' Pae Aina, i n	a kanaka a nau i Iraia Ta wana it
no koná m	au hope alii, ua haawii aku ola ma ke Ano Alodio i	a Mahiai
ma ka mok	i kela wahi a pau loa ma <i>Maso</i> upuni a <i>Masu'</i> penei na me	mondu (Hula)
Moune		
ujima i	& hormako ana ku kiki la	Pinu, a e Role ana
	Alema 64° Alik svo franki	
	Aluma 330 Stom 220 "	. Konohiki
	Mian 50° Mon 294	
	Man 26° CHito 153 "	
	hiki i ke kihi mua.	attender
Mana	1 at A beauty 6	1.011.1 1
ujimi	2 Stula, & hvamaka ona ka k	in OWR, URaw, a e Ri
	Alma 50 Nom 470 Kand	anai Ro Mariakarar
	Almabo' Chem 225	
Total Control	Mina 30° Colom 160 "	" "
1 190	Mamokana 194 "	" Alomohita
	Skan 80 Ken 440 "	. " Kanana
	Man 33° Hik 165 "	
	Man 38 Hik 210 "	
	Skan 86 alike 330 "	n Kahawai
	a hiki i ke kihi mua	Able 2 43 Eka
	a nura i rie rina Omica	(WIE 2 The Cerca
4		
	*	
Maloko o	in man apana Stohn 41/100 -	
a oi iki aku, a	emi iki mai paha. Ua koe nac i ke aupuni na mine minerela	Eka
ua aina la i han	Wild ing to ANO ALODIO	
ka auhau a ka I	around I held manawa	Keia manawa.
	A i mea e ikea ai, ua kau wau i ko'u ine	
	Hawaii Pao Aina ma Honolulu i ke	ia la 🌖
When how	and Kamthamsha	
- Deliver and	- Dunning Thank	

Figure 2 – Grant C.C. Harris for Kahuku, Kaʻū

⁹⁰ Ewell 2010:8

BOYAL PATERT.

KAMEHAMEHA IV., By the grace of God, King of the Hawaiian Islands, by this His Royal Patent, makes known unto all men, that he has, for himself and his successors in office, this day granted and given, absolutely, in Fee Simple, unto his faithful and loyally disposed subject, for the consideration of the second paid into the Royal Exchequer, all that piece of Land situated at War Comment and described as follows: O little da Mid Mal He sit tot in the Police to the Man, Kean, and other the de a. H. L. It to the Lear in the treat by Manuta. and when they to the Describaine according to the a civil how changes of the said of the hate. Quetent boundaries Reserved the highes of native time. 102 198 1/10 recording to the ancient bounds no excepting and reserving to the Hawaiian Government, all mineral or metallic Mines of every description. To have and to hold the above granted, Land in Fee Simple, unto the said 6. 6. Harres , /Le U Heirs and Assigns forever, subject to the taxes to be from time to time imposed by the Legislative Council equally, upon all landed Property held in Fee Simple. In Witness Whereof, I have hereunto set my Hand, and caused the Great Seal of the Hawaiian Islands to be affixed, at Honolulu, this Muchancha Na Ka Hori & Hohine tim In Marchancha

Figure 3 – Royal Patent to C.C. Harris for Kahuku, Ka'ū

Kahuku Ranch

Ownership of Kahuku Ranch transferred from Harris to Theopilus Brown of Groton of Connecticut on April 3, 1866 for the price of \$5,250⁹¹. Theopilus' brother Captain Robert Brown (not to be confused with the previously cited Captain J. Brown) operated the Ranch bringing his family with him. Tax records reveal Robert paid taxes on 364,000 acres referred to as Kahuku Ranch, indicating a sizable increase from the acreage purchased from Harris. A visitor to the ranch during these years was Mrs. Alura Brown Cutler wrote the ranch had miles of stone walls enclosing gardens, cattle yards, calf pasture, goat and pig pens. The gardens contained fig and peach trees as well as bananas and mulberries. She reported the house was located seven miles from the sea and five stone houses for families working for the ranch were provided⁹².

Hawaiian Volcano Observatory provides a synopsis of the onslaught of natural disasters that befell Ka`ū in 1868, devastating Kahuku and the Brown family:

On Friday, March 27, 1868, at 5:30 a.m., several whaling ships anchored in Kawaihae Harbor noticed a dense column of fume reflected by a bright light southwest of the summit of Mauna Loa. An eruption near Moku`āweoweo had taken place, lasting several hours before subsiding. Pele's hair had drifted down upon the residents of Ka'ū and South Kona, indicating the presence of lava fountains above.

In near synchrony with its larger neighbor, Kīlauea Volcano began to shake at 10:00 a.m. the next day with a series of earthquakes that increased in intensity for several days. Cracks appeared around the summit of Kīlauea; the level of the lava lake in Halema`uma`u fluctuated rapidly. Stone walls collapsed, houses shook, and trees vibrated.

The largest historic earthquake in the Hawaiian Islands happened at 3:40 p.m. on April 2. The earthquake had an estimated magnitude of 7.9. Clocks stopped on O'ahu. At Kohala, the shock was so strong that it stopped all of the engines at the Kohala Mill, including the 75-horsepower main engine. All over the Island of Hawai'i, the effects were felt as a large portion of the coastline from Honu'apo to Kapoho subsided 1.2 to 2.1 meters (4 to 7 feet).

Coastal villages were inundated by a huge tsunami, at places over 15 meters (50 feet) high. The coastal villages of 'Apua, Keauhou, Punalu'u, Nīnole, Kawa'a, Honu`apo and Ka'alu'alu were destroyed. There were five large waves in succession. The largest came first. A total of 75 people and numerous animals were swept out to sea and drowned.

Along with the coastal subsidence and tsunami, the earth at Kiolaka'a, near Wood Valley, broke loose and slid 300 meters (1,000 feet) down from the summit and southeast side of the hill onto the valley below, covering houses and trees. This event, known as the mud flow, buried people, horses, cattle, goats and sheep under a thick layer of mud. The mud flow was 5 km (3 miles) long, as wide as 1.5 km (1 mile), and varied in thickness from 1 meter (3 feet) to 27 meters (90 feet).

⁹¹ Moulds-Carr & Langlas 2005:56

⁹² Ibid:59

All stone walls and dwellings in Ka'ū were flattened by the earthquake; people and animals were thrown down, and ground cracks appeared throughout Kīlauea and in the district of Ka'ū. Landslides occurred island-wide, and plantation chimneys in the Hilo area fell down. Aftershocks almost as violent as the April 2 event hit at 12:20 a.m. and again at 12.45 a.m. on April 4.

At about 5:00 p.m. on April 7, a great crack opened along Mauna Loa's southwest rift zone above the Captain Robert Brown ranch in Kahuku. Lava gushed from the earth and flowed directly toward the ranch house. Captain Brown, his wife, and nine children ran for their lives as the molten flood engulfed their home. Within three hours, the flow reached the sea, a distance of 17 kilometers (10 miles) from the vent 93

Prior the earthquake and lava flow, daughter Amanda had died and was buried in Kahuku. Saying no child of his should rest in such a grave, Captain Brown, with the help of a couple of laborers, uncovered the grave and removed the body to a regular cemetery.



Figure 4 - Captain Robert Brown at Amanda's gravesite post 1868

H.M. Whitney described the scene of the eruption in Kahuku:

...At the left were these four grand fountains playing with terrific fury, throwing blood-red lava and huge stones, some as large as a house, to a height varying from 500 to 1,000 feet...

[.]http://hvo.wr.usgs.gov/volcanowatch/1999/99 07 22.html

Then there was the rapid, rolling stream, rushing and tumbling like a swollen river, down the hill, over the precipice and down the valley to the sea, surging and roaring like a cataract, with a fury perfectly indescribable...⁹⁴

Kahuku Ranch foreman Swain who would later become a Deputy Sherriff provided this account of the eruption and their escape to a Hawaiian newspaper:

The house had been knocked to pieces by the great shake, so we rigged up a light shelter in the yards. Suddenly, one evening, a few days later, it was as light as day. We knew that the lava had broken through the mountain at last, and also that the break was not far from us, for we could hear the lava pouring out. Captain Brown started off immediately with his family... I saw that they were going towards Kona and started after them. I had gone but a few feet when suddenly the thought came that there was not water that way, and I shouted: "The other way." They turned without a word...We had just reached some high ground when the lava came down past us with a rush like a freshet of water. Had we gone the other way we would surely have been lost 95.

Shortly after the disaster Rev. Titus Coan visited the scene of the lava flows in the uplands of Kahuku, Pākini, and Kāmoa and where Pali-o-Kūlani overlooks Wa'iahukini and Kā'iliki'i recording, "...three houses standing near the shore...at Kailikii.96."

Subsequent lava flows impacted Kahuku Ranch as provided by this synopsis provided by the Hawai'i Volcano Observatory:

The 1868 flow destroyed the house of Capt. Robert Brown, who was managing the ranch for his brother, Theophilus. The flow advanced so quickly on the house that Captain Brown and his family escaped with only the clothes on their backs.

Soon after the eruption, Theophilus sold the ranch to a hui (group) that included George Jones, who bought out his partners' interests to became sole owner in 1877.

Another Mauna Loa eruption in 1887 produced an 'a'ā flow to the west of the 1868 eruption. From vent to ocean, the flow advanced 24 km (15 mi) in about 29 hours and came close – but did not damage – Jones' residential compound.

The real impact of the 1887 eruption on Jones' ranch was the flow of sightseers. George was known as a very hospitable man and, for several weeks, was forced to suspend operations in order to accommodate the hordes of curious visitors.

About a year-and-a-half after the 1887 eruption, Jones sold the ranch to Col. Samuel Norris. Norris, described as eccentric and peculiar, was not hospitable to his fellow Caucasians. Another Mauna Loa eruption in 1907 produced lava flows to the west of the 1887 and 1868 flows, further reducing pasture lands. Tourists flocking to the new flows were not welcomed by the new ranch owner.

⁹⁴ Whitney 1868:113 IN Kelly 1969:35

⁹⁵ Rice, 14 IN Moulds-Carr & Langlas 2005:60

⁹⁶ Coan 1869:95 IN Kelly 1969:36

Norris was 66 when he bought the ranch. In 1910, when he realized he was dying, Norris essentially gave away the ranch, "selling" it to his long-time friend, Charles Macomber, for a dollar, complaining that lava flows had devalued the property. Norris died a few months later.

In 1912, Macomber sold the ranch to A.W. Carter (making a profit of \$89,999) for inclusion in the famed Parker Ranch.

The upper reaches of the ranch were overrun by lava in 1903, 1916, and 1926 but these eruptions did not precipitate a sale as the earlier ones had. After 1947, Kahuku Ranch changed hands two more times before the 2003 acquisition and addition to Hawai'i Volcanoes National Park⁹⁷.

The deed transferring ownership from Brown to William H. Reed and Charles E. Richardson describes the land use and boundaries of Kahuku:

bounded on the East by the Lands of Pakini, on the West by Manuka andextending to the Mountains according to the Ancient boundaries of the said Land of Kahuku . . . together with all the rights privileges appurtenances and improvements to the said Land of Kahuku belong and with rights of fishing and rights in the Sea to the said Land of Kahuku belonging together with all Cattle, Wild Goats, Horses, and other Stock belonging to the said Theophilus Brown on the said Land of Kahuku . . . and reserving the Kuleanas of native tenants . . . [and] It is understood that Lorenzo Marchant holds a Lease of the Goat run on the Land of Kahuku aforesaid West and North of the recent Lava flow for the term of Four Years from the 1st day of January AD 1871 at a yearly rental of \$200 per annum payable half yearly - the rent of which from the 1st day of September AD 1871 is to be paid to the Grantee of this deed 98.

Details of Jones' tenure of the ranch are captured in $N\bar{a}$ wahi pana o Ka \bar{u} an oral history project at Ka \bar{u} High School:

Between 1871-1876 the Volcano House builders, George W. Calhoun Jones, a Hawaiian named Kaina, and Jules and Charles Richardson (of Kapapala) bought Kahuku Ranch from the owner, Captain Robert Brown. At that time Kahuku Ranch consisted of 184,000 acres that stretched from Mauna Loa to the ocean. George W. Calhoun eventually bought out his partners and became sole owner of Kahuku Ranch. Jones and his associates erected two dwellings that housed him and his family for seventeen years. The main home was a story-and-a-half cottage...

Along with the 184,000 acres that Jones owned, he leased 60,000 adjoining acres from the Princess Pauahi Bishop Estate. Many different animals roamed around this vast area, such as white-faced Herefords, red and roan Durhams, speckled neck Ayshires, black and white polled Angus, and herds of horses, mules, oxen, and donkeys. Sheep and angora goats were also raised, mostly for their wool, and pigs and chicken for domestic purposes. They hunted wild turkeys, geese, quail, and chickens that ran free on the lowlands of the ranch. Kahuku had a forest that had many different native trees. There were kukui trees, which supplied them with candle nuts for torches and relishes. There was also koa and kou, which were used to make canoes and some of

_

⁹⁷.http://www.hawaii247.com/2010/10/29/volcano-watch-lava-flows-cow-pastures-coexist-in-kahuku/_

⁹⁸ Deed BK 34:47-8

the furniture; 'ōhi'a trees, which provided firewood for the stove; and sandalwood which they used for bartering.

Kahuku Ranch had many visitors; among them were Charles R. Bishop, Sanford B. Dole, and King Kalākaua's brother Prince Leleiōhoku. Also Princess Kai'ulani and her mother Princess Likelike visited Kahuku for several days before Princess Kai'ulani left for school in England⁹⁹.

Samuel Norris' ownership and sale of Kahuku Ranch reflected his litigious nature:

His litigation experience in Hawaii started in the spring of 1890 with a case entitled G.W.C. Jones v. S. Norris (8 Hawaii 71). Jones had sold Norris the "Kahuku Ranch" by warranty deed dated September 21, 1888, together with buildings, cattle, horses and other livestock, agricultural tools and implements situate thereon. The question involved in this case was as to who should pay taxes which were in lieu but not yet due at the time of the sale. In deciding in Norris' favor on May 5, 1890....¹⁰⁰

Hawaiian Agricultural Company v. S. Norris (12 Hawaii at p.229 in 1899) was a suit for specific performance of an alleged contract to sell the Kahuku Ranch for \$100,000 ¹⁰¹

His ranch was handled in a very slipshod fashion, the livestock running wild and often being stolen. Shortly before he died at the age of 88 he sold his cattle to a man by the name of Samuel Kauhane for \$30,000 of which half was cash and half in promissory notes. After his death the ranch was sold to Alfred W. Carter for the Parker Ranch for \$90,000.

Some years after the settlement of this matter I visited the Kahuku Ranch and saw Norris' residence. It was in the region subject to lava flow from Mauna Loa. In one flow the lava...[kīpuka description] while there was some pasture on his ranch, the lava situation was such as to make the land of no great value in spite of its enormous extend, said to have been 180,000 acres¹⁰²

As cited above A.W. Carter purchased Kahuku Ranch for inclusion to Parker Ranch in 1912. During this ownership 1200 head of cattle were largely run on the land nearest the highway, marginally using the land above the 1,400 foot elevation 103. On February 6, 1947 Parker Ranch sold Kahuku to James W. Glover founder of the general construction firm bearing his name for \$365,000. During his ownership Glover planted koa for logging and continued the installation of smooth wire fencing¹⁰⁴. After Glover's death, the ranch was sold under court order by the Hawaiian Trust company, the executor of his estate to pay estate debts including inheritance taxes amounting to almost a million dollars. The trustees of the Samuel M. Damon Estate made the winning bid in 1958 as reported in this Honolulu Star-Bulletin article:

⁹⁹ MouldsCarr & Langlas 2005:60-61

 $^{^{100}}$ "Samuel Norris: Litigious Pioneer" IN *California Historical Society Quarterly* v. 26, 1946:225

¹⁰¹ ibid:226

¹⁰² ibid:227

¹⁰³ Ewell 2010:10

¹⁰⁴ Ibid.

With an offer of \$1,363,630, trustees of the Samuel M. Damon Estate were the successful bidder for the 158,000-acre Kahuku Ranch in the Kau district on the Big Island today.

The ranch is almost as large as the entire island of Molokai.

The ranch was sold under court order by the Hawaiian Trust Company, executor of the estate of James W. Glover, late owner of the ranch, to pay estate debts, including inheritance taxes amounting to about \$1 million.

Bids were opened by Circuit Judge William Z. Fairbanks. Only the Damon Estate and Dr. Estridge, Wonsik You, and Associates, a Honolulu real estate concern, made offers on the ranch properties.

The You Associates made an initial bid of \$1,203,250, which was later increased to \$1,270,550.

The Damon Estate's offer was about \$93,000 higher. The sale was approved by Judge Fairbanks.

Terms of the successful bid include a \$350,000 cash down payment; \$350,000 cash when trustees receive copies of the order approving the sale, and the balance in cash on delivery of deeds and evidence of title.

The bid included an offer of \$774,130 for the land and \$589,500 for 2,700 head of cattle, a water system, buildings and fences¹⁰⁵.

On July 3, 2003, the National Park Service partnered with the Nature Conservancy to purchase the 116,000-acre Kahuku Ranch from the estate of Samuel Mills Damon as an addition to Hawaii Volcanoes National Park. The \$22 million transaction -- the largest land conservation deal in Hawaii's history -increased the size of the park by 50 percent to 333,086 acres. Now known as the Kahuku Unit of the national park, the property runs along the slopes of Mauna Loa¹⁰⁶.

Place Names

Mary Kawena Pukui noted on a list of place names compiled by J. S. Emerson they were from Ka \tilde{u}^{107} . Those near or within Kahuku are provided here:

Table 3 – Place names compiled by Emerson

Name	Ahupua`a	Notes
Akihi	Kahuku	A peaked mass of rock
Auhuhu	Manukā	A fish poison. Many years ago this vicinity was densely populated the kama`āina raising great quantities of taro, the auhuhu growing wild. The residents used to take loads of pai`ai with quantities of auhuhu to Kamilo at that time the rendezvous of the fishermen from Naalehu to

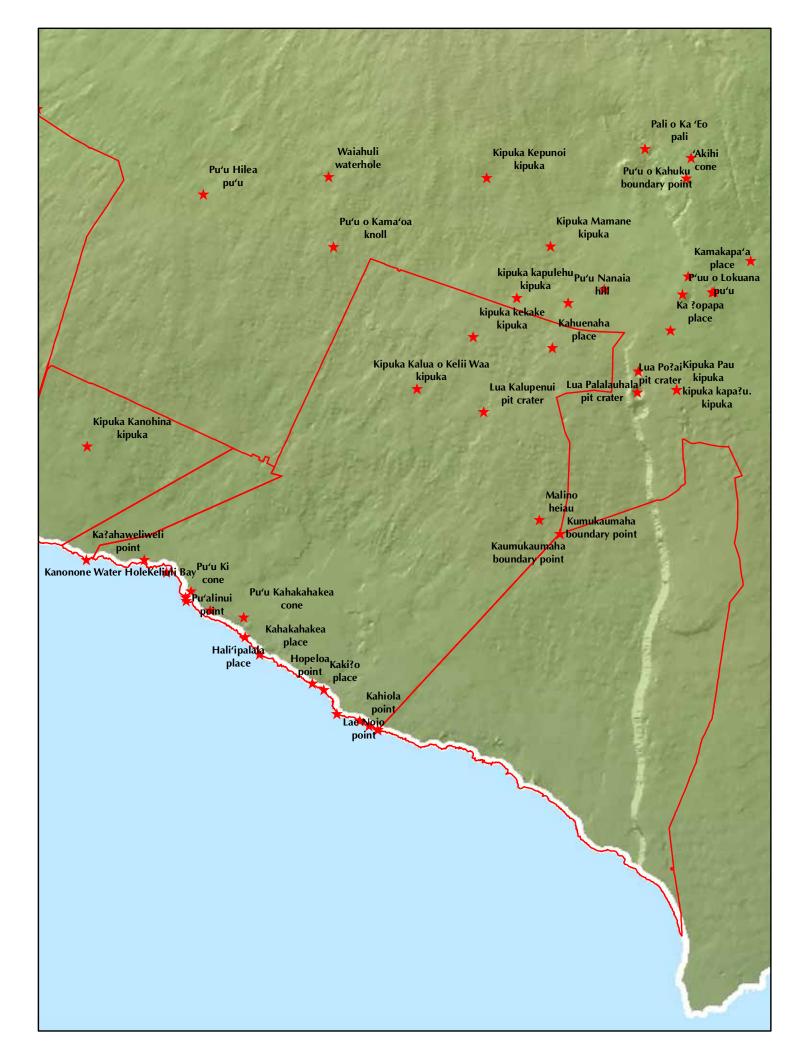
¹⁰⁵ "Damon Estate Bid Buys Big Isle Kahuku Ranch" Honolulu Star-Bulletin September 18, 1958

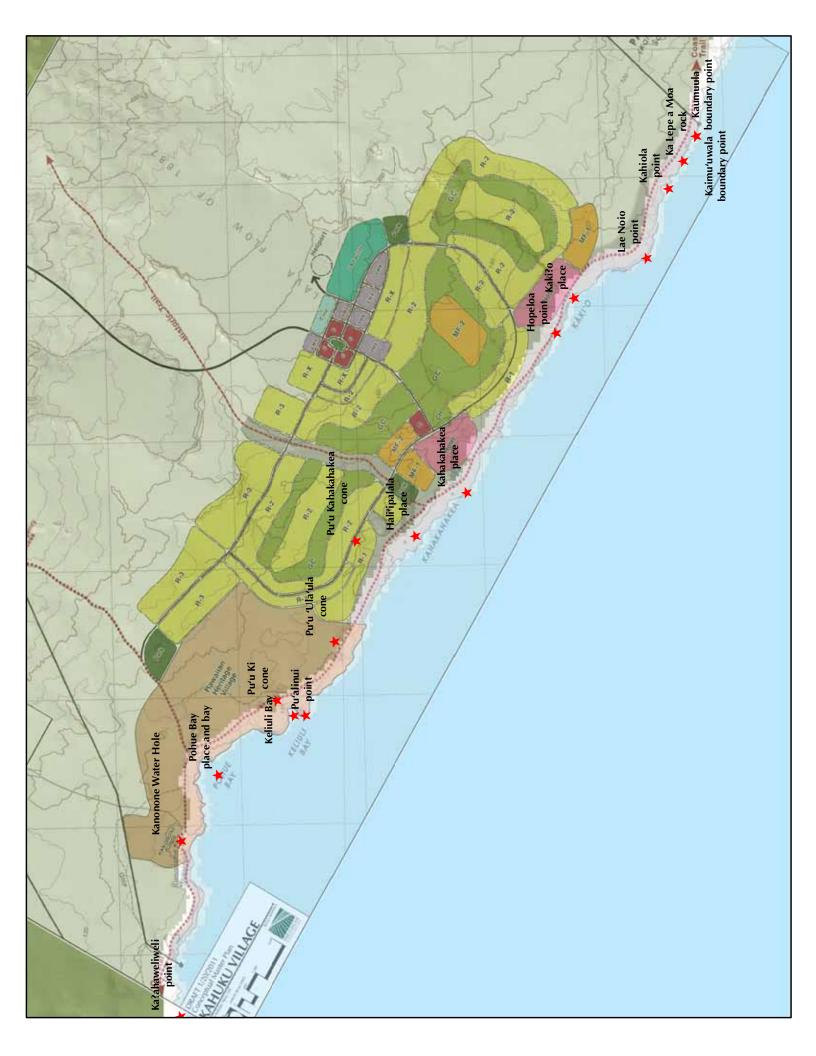
¹⁰⁶ Honolulu Star Advertiser September 19, 2010

¹⁰⁷ Hawaiian Ethnographic Notes vol. 1:723-727, Bernice Pauahi Bishop Museum Archives

		Kahuku. They traded their products for fish. The fishermen would		
		pound up the auhuhu and scatter it on the surface of the water, in a		
		few minutes the fish would float on the surface, dead. They were		
		gathered and taken ashore where the women immediately removed		
		the stomach, this would prevent the poison from injuring the flesh.		
Ka`ai uwiuwi	Kiolaka`a	There was much ti root grown here, when placed in a calabash with		
		water it would ferment and if indulged in caused drunkenness, the		
		eating seems to suggest that they ate the pulp.		
Napalua	Kiolaka`a	So named for two adjoining hills which characterize the place.		
Ka lae koa	Kiolaka`a	A cape of koa trees.		
Kalua olai	Pākini Iki	A deep hole and fissure caused by the disturbance during the flow of		
		'68 [1868]		
Ka punohu	Kiolaka`a	A cloud resting on the surface of the sea.		
Ka puu nui	Kiolaka`a	A big hill.		
Ka wai hou	Kahuku	New found water-hole.		
Kilohana	Kahuku	Beautiful view.		
Lolena nui	Kiolaka`a	A lazy loafer; a man of this character lived here.		
Po oki`a	Kahuku	Robber's den, where the thieves used to cut off the victim's head.		
Pu a A`o	Kiolaka`a	Hill of the A`o bird		
Puu o	Kahuku	Hill of the heavy rains		
Lokuana				

Archaeologist Lloyd Soehren's compilation of place names are culled from land commission and boundary commission testimonies, USGS maps, and other publications are presented in Appendix A. Their locations are georeferenced on this map:





While named more recently the fishing area known as "Hosaka Point" or "Eddie Hosaka" fronting the summit of Pu`u Kī is one of the most productive ulua fishing grounds in Ka`u. John Clark provides a biography of Hosaka and the place's attribution to him:

Edward Y. Hosaka was born and raised in Hawai'i and attended the University of Hawai'i at Manoa in the early 1930s. After earning a master's degree in 1934 he became an agronomist with the University's Extension Services, specializing in pasture management. In time he became recognized throughout the Pacific as an authority on pasture grasses for cattle. His work took him often to the Big Island and into the remotest areas of many of the island's large ranches. In these areas, when his work was completed, he often went shoreline fishing, one of his greatest pleasures. Hosaka, regarded as one of the finest ulua fishermen of his day, often fished at Pu`u Kī, located on the shoreline of Kahuku ranch, and it was there at the age of 55 while doing what he loved best, that he suffered a stroke. Taken immediately by his companions to Hilo Hospital, he died on July 23, 1961. Since that date the point has been known as Eddie Hosaka.

In addition to his work for the University, Hosaka was for many years an honorary associate in Botany at the Bishop Museum – and also an author. Probably his best known and most widely circulated work in "Sport Fishing in Hawaii," first published in 1944 and still considered one of the standard works on fish and fishing in the Hawaiian Islands¹⁰⁸.

Site Documentation – 20th century

Archaeological Surveys

In 1919 John F. G. Stokes conducted a survey of *heiau* on the island identifying two within Kahuku:

Halepõhāhā Heiau

Bishop Museum Catalogue: 50-Ha-B23-100

State of Hawai'i Catalogue: 3657

Heiau of Halepōhāhā, land of Kahuku, Ka`ū. Described as being on the west of the lava flow of 1887, 3 or 4 miles north of the Kona-Ka`ū road. Said to have been used for human sacrifices and to have been built by `Umi.

Malino Heiau

Bishop Museum Catalogue: 50-Ha-B22-4

State of Hawai'i Catalogue: 3657

¹⁰⁸ Clark: 1985:79

Heiau of Malino, land of Kahuku, Ka`ū. Described as located above Kaunakaumaha, near the boundary of Pākini nui ,and south of the Kona-Ka`ū road¹⁰⁹.

The location of these and other *heiau* in Ka`ū are shown here:

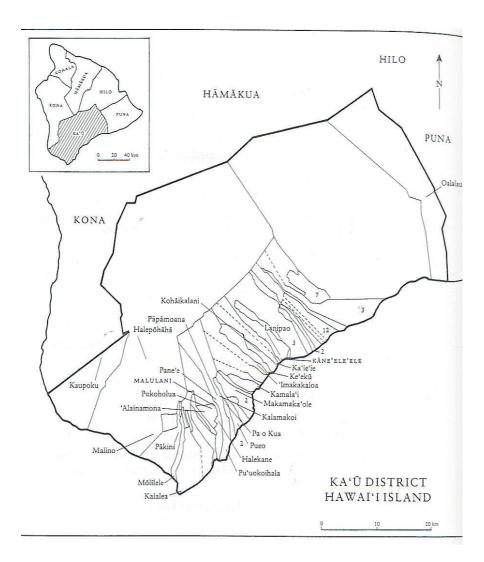


Figure 6 – Location of heiau in Ka'ū as reported by Stokes

The earliest archaeological surveys within the project area appear to be an excavation in July 1958 by William J. Bonk and Yoshiko H. Sinoto. Bonk and Sinoto excavated Site H59 (HRHP Site 3654) at Pōhue Bay, the results which were not published.

¹⁰⁹ Stokes & Dye 1990:113

A 1970 proposal for a formal archaeological survey of an area approximately one mile wide between Lae o Humuhumu and Kalepe a Moa, a distance of some six and half miles, by the Department of Anthropology at the Bernice Pauahi Bishop Museum noted 48 sites in the area: the two *heiau* previously noted by Stokes; one shrine; 18 house sites and platforms; ten lava tube shelters; five burials; and five fields of petroglyphs¹¹⁰. These finding were based on surveys conducted by staff field trips between 1954 and 1965. During one such field trips to the island, J. H. Cox recorded several hundred petroglyph units located in the vicinity of Pōhue Bay¹¹¹. While the images included amorphous figures, dots, circles, abstractions, fans, crabs, ships, rubbing holes, dates, and names were also identified.

Bishop Museum staff field trips included those made by Violet Hansen and Roger Green of the coastal portions of Kahuku. Hansen and Green recorded 33 sites including walled house sites, cave shelters, five burial platforms, trails, anchialine ponds, and petroglyphs in the vicinity of Pōhue Bay and Kahakahakea. The 1962 notes of Violent Hansen for the burials are as follows:

Burial No.: F[eature].2 & B[urial].1 Size of grave: 7 ft. x 12 ft., 1ft. to 5 ft. high

Remarks: Jeep road along the north side, burial situated on a slope, 1 foot high at the north end to 5 feet

high at the south end. Condition good. November 9, 1962

Burial No.: F[eature].6 & B[urial].2 Size of grave: 11 ft x 12 ft, 3 ft. high

Remarks: One of 3 burials measured situated on top of Puu 025° and approximately 500' from the south

corner of leveled area. Coral on top. November 10, 1962

Burial No. F[eature].8 & B[urial].4 Size of grave: 4 ft x 5 ft, 2 ft. high

Remarks: None November 10, 1962

Burial No. F[eature].7 & B[urial].3 Size of grave: 11 ft x 13 ft, 3 ft. high

Remarks: On top of Puu Puu 025°, approximately 500 ft from south corner of leveled area, collapsed

center, coral on top. November 10, 1962

Burial No. F[eature].22 & B[urial]5 Size of grave 7 ft x 10 ft, 3 ft. high

Remarks: Facing of water-worn stones, northwest corner disturbed, coral on top, crack along the south

side. Condition fair. November 15, 1962

¹¹⁰ Bishop Museum Archives: Anthropology manuscripts, Group 7 Box 19.4

¹¹¹ Cox 1970:80, 82

The locations of these burials are indicated on the following sketches. Burials identified as F[eature] 6, 7, and 8 are located within the circle near "Wall" above Pōhue Bay. This sketch also shows the location of a petroglyph field identified as Feature 40 near Pu`u Kī.

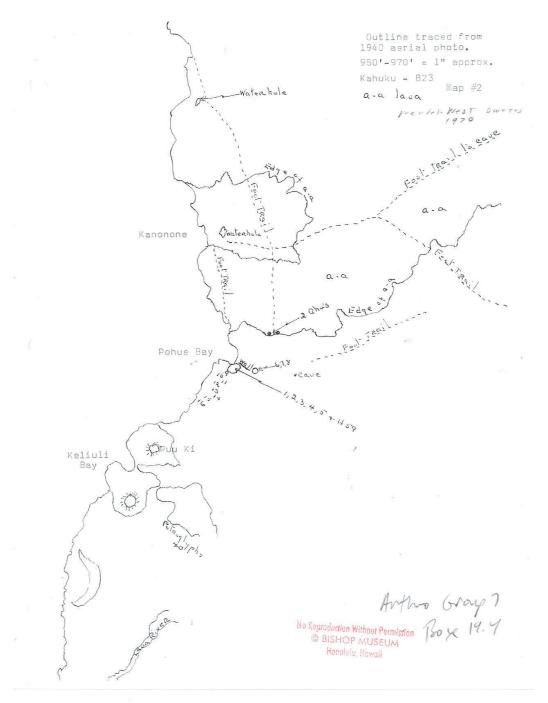


Figure7 - Sketch showing location of burials identified as Features 6-8 above Pohue Bay

Included in this sketch is a foot trail described in detail by Hansen who surveyed it with *kama* `āina William Meinecke in 1957 and 1965. Hansen's notes describe it commencing

"approximately 4200 ft. Kona side of Pu`u Kamaoa triangulation station (19.05n – 155.46w) makai side of high-way...Trail goes south and slightly west over an old aa flow for about 7000 ft. then it begins to fade out as you enter a grassy kipuka....There is a possibility that the trail continues on down to Kanonone also going by or very near to a cave shown on Pohue Bay map at the 800 ft. contour line, 1 ¾ miles west of the present Pohue Bay jeep road.

Returning to the high-way we checked the mauka side. We were unable to pick up any trail on this side though we both felt that the trail could have continued on up in a north-east direction for one mile to Waiahuli, a waterhole. This mauka side of the high-way is now the Hawaiian Ocean View Estates subdivision and a great deal of bull-dozing has taken place.

From this trail, now called the Kanonone Trail, going west and slightly north along the high-way for a little over 2000 ft., mauka side is another waterhole called Ohiawai. Waterhole is shown on map by not named. The name Ohiawai gotten from Mr. Otto Brithaupt and verified by Mr. Meinecke.

Notes from an earlier trip to Kanonone Bay, Kahuku, in 1957.

There is a trail over an lava going mauka from Kanonone. Trail is not shown on Hoopuloa map scale 1:62500 nor the Pohue Bay map scale 1:24000.

The present jeep road going from Pohue Bay north-west then west passes over this trail. You are able to pick up the trail from jeep road 2000 ft. north of Kanonone Bay. About ¾ mile up this trail you come to a fork, one trail bearing Kau side the other Kona side. The Kona side trail appears to go in the direction of the above mentioned cave. Getting yourself into a high place and with binoculars you are able to see the entrance of the cave. This fork in the trail very easily be missed.

We checked the Kau side trail for about an mile then it disappears as you enter a kipuka of pahoehoe lava. Checked two large lava tubes, apparently used only by goat hunters.

It was on our way back that we discovered the fork in the trail and by that time it was too late to check the Kona side trail¹¹².

A tracing of a map with the scale of 1:24000 of the same area provides additional feature locations as well as the name of the water hole, Kanonone. The other features in this area include house site platforms; circular pens; a cave near the coast referred to as "Glover Cave; Malino heiau; the Old Government Road remains in a $k\bar{l}puka$ made by the 1907 flow; and the foot and horse trail leading to Hawaiian Ocean View Estates described above. A contemporary reporting of the 1907 flow from the Hawaii Tribune Herald is presented here.

Yesterday the lava reached the sea. It appears that in its course that stream of fire has done much damage to the Kahuku Ranch, that vast tract owned by Col. Samuel Norris. The flow is described as having split into three rivers and to have gone over the flows of 1887 and 1868¹¹³.

-

¹¹² Bishop Museum Archives: Anthropology manuscripts, Group 7 Box 19.4

¹¹³ January 15, 1907

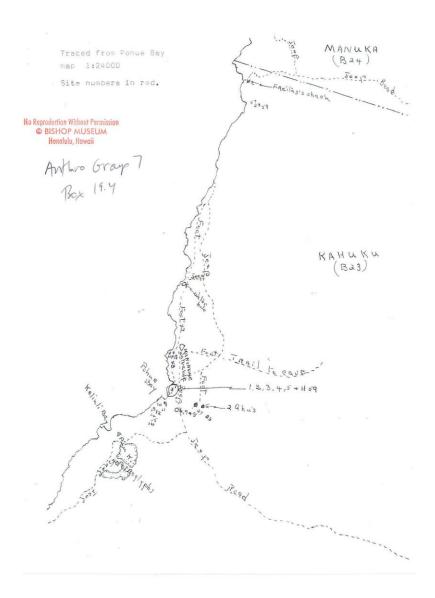


Figure 8 – Sketch depicting trails and road as well as archaeological sites

This sketch is overlaid onto an aerial to show the terrain is presented here as Figure 9

[xxx 006].

Figure 9 – Bishop Museum sketch overlaid onto aerial

A burial identified as Feature 22 is located in the area referred to as Kahakahakea can be seen located at the edge of a "flow older than 1887" in this sketch:

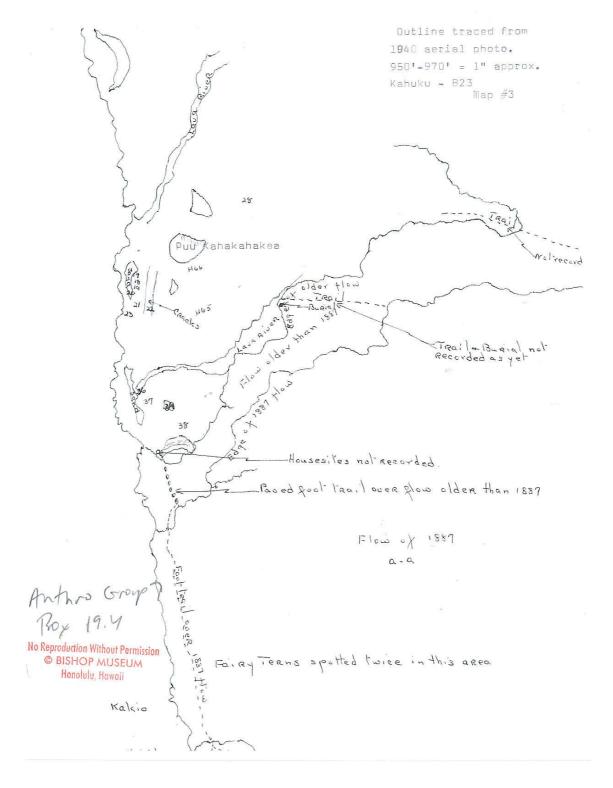
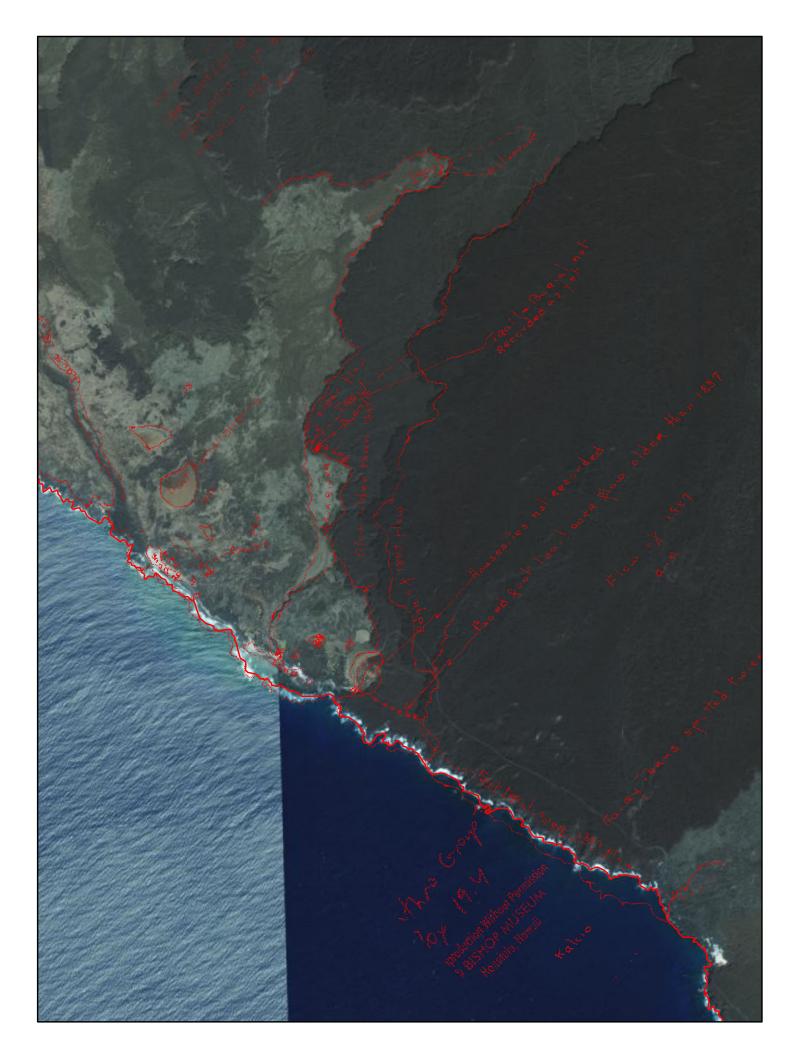


Figure 10 - Sketch of sites near the 1887 lava flow

Also in the Kahakakea area are house sites, shelter caves, a bubble cave and a shrine identified as Pohaku o Kane, as well as a water hole. The preceding sketch is overlaid on an aerial



Continuing south along the coast is an area referred to as Hopeloa containing a kahua (foundation) hale, a cave and wall shelter, and petroglyphs:

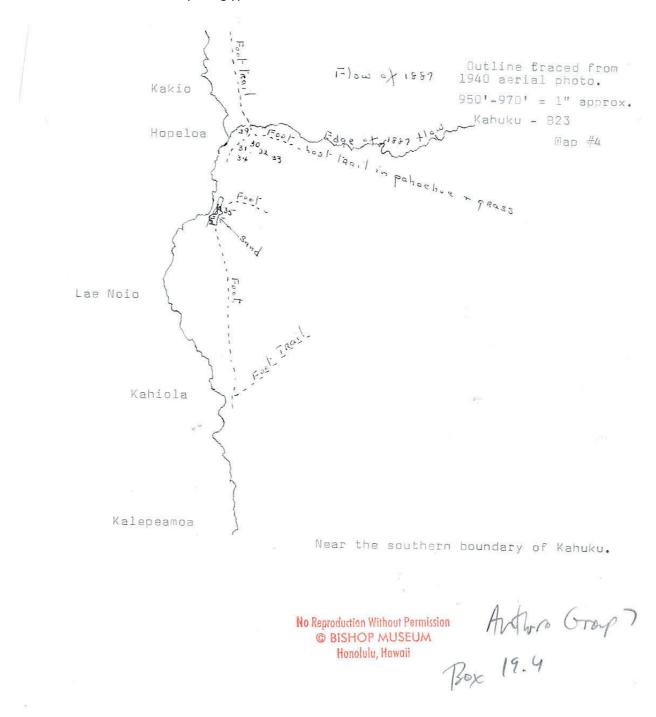


Figure 12 – Sketch of the sites and trails near the southern boundary of Kahuku

This sketch overlaid on a U.S.G.S. quad map shows the relation of the foot trails to the lava flow:

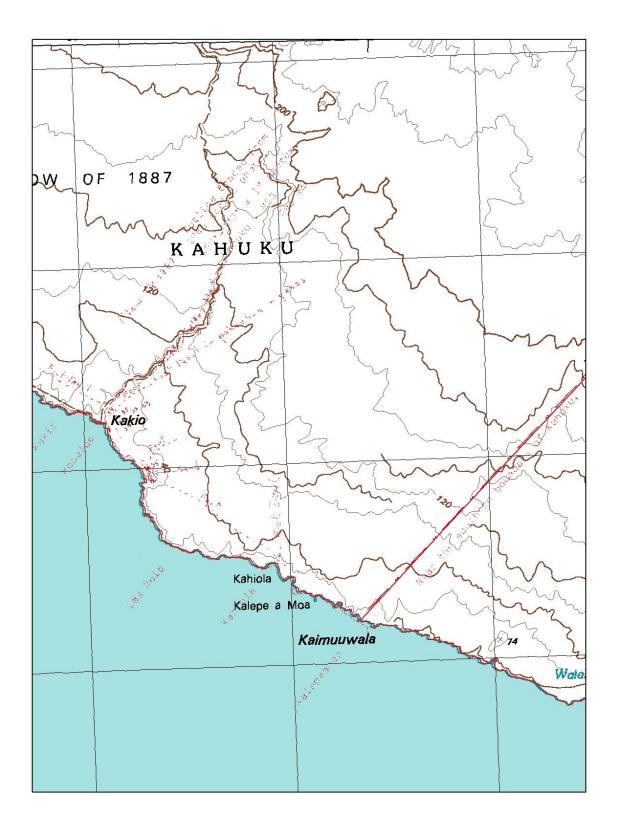


Figure 13 – Bishop Museum sketch overlaid a USGS Quad of the project area

The heigu Halepohāhā identified by Stokes is located near the cinder hill Halepohāhā visited by Violet Hansen in 1964 bounded by the 1887 lava flow on the east and the 1907 flow on the west. At the top the name "KAIAMA" was carved into flat slabs of lava. According to Meinecke a man by this name known as "the strong man of Ka'u" was a police officer stationed at the Waiakea waterfront where he effectively kept law and order. The children of Ka'ū, when playing as strong-man and beating their chests would say "Kaiama" the way children today would say "Tarzan¹¹⁴." This pu'u and heigu are outside of the project area.

In the summer of 1965 Lloyd Soehren also with the Bishop Museum with National Science Foundation support conducted excavations of two cave shelters at Kahakahakea – Sites H65 (3635) and H66 (HRHP Site 3636). Site H65 yielded radiocarbon dating from the 14th and 5th century, the latter Soehren rejected as being too early. However, based on dates recorded for South Point, Kirch believes the 5th century date should not be discounted¹¹⁵. Soehren also explored a large tube in the vicinity of H65 finding in a nearly inaccessible chamber of the tube an upright wooden pole with a gourd on the upper end, and two-piece fishhook and strands of human hair¹¹⁶.

Violet Hansen recorded a "ramp like structure" on September 3, 1966 at Pohue Bay she postulated as used for drying hides due to the large amount of scattered bleached goat bones, horns, wire and fence posts she found at the site in 1957.

In 1970 Dr. Kenneth P. Emory, Director of the Bishop Museum provided an inventory of archaeological and historical sites in Kahuku, recommending "These ruins at Pohue Bay should be treated in a similar way to those at Waiahukini, i.e. surveyed, mapped in detail, evaluated, some excavated for the purpose of reconstructing as much as possible the ancient Hawaiian life in coastal village settlements in this type of environment." His inventory includes:

3646 (B23-35) Hopeloa (Puu Hou Quad, 75)

A shelter cave, located 2000 feet southeast of Hopeloa

3640-45 (B23-29 to 34) Hopeloa

Four shelter caves, one of which is walled, one house platform, and one small cluster of petroglyphs (B23-24, Cox, 1970:82). The sites -p13 are located on the Ka'ū side of the 1887 lava flow.

3648 (B23-41) Kahakahakea

Petroglyphs, consists of a few human figures and letterings (Cox, 1970:82)

3635 (B23-24) (H65) Kahakahakea

¹¹⁴ Field Report August 5, 1964, Bishop Museum Archives: Anthropology manuscripts, Group 7 Box 19.4

¹¹⁵ Kirch 1985:87

¹¹⁶ Kirch 1985:160-161

¹¹⁷ Bishop Museum Archives: Department of Anthropology manuscripts, Group 7 Box 19.9

Shelter cave situated in the entrance of a lava tube, excavated by Lloyd Soehren of the Bishop Museum in the summer of 1965, yielding radio carbon dates of A.D. 420 \pm 100, and A.D. 1355 \pm 80. Report in preparation.

3636 (B23-25) Kahakahakea

Shelter cave situated in a lava blister. Excavated by the Bishop Museum in the summer of 1965. Report in preparation.

3637 (B23-26) Kahakahakea

Shelter cave situated in a lava blister. The floor of this cave has been disrupted by artifact hunters.

B3638 (B23-28) Kahakahakea (Pohue Quad 72)

A small shrine, consists of a single upright water worn stone surrounded by pieces of branch coral. A feature which should be preserved.

3647 (B23-40) Pohue Bay

On pahoehoe, inland and east from sandy beach, and on trail toward east (north of cinder cone) at edge of depression also west of bay. Wide variety of figures, dots, circles, abstractions, fan, crabs, ships, rubbing groves, dates, and names. There are several hundred units (Cox 1970:80, 82). This is one of the important petroglyph areas on the island of Hawaii because of the extent of the area and the variety of figures. It may not only represent of favorite stopping place on the way around the island, but mark the area as of some special significance for the early Hawaiians. The area should be set aside.

3639 (B23-27) Pohue Bay

A shelter cave located 1/3 mile inland from Pohue Bay. Significance; The floor of this shelter holds the possibility of dating the span of occupation of this bay area. If not already vandalized, it should be protected and archaeologically excavated.

3612-27 (B23-1 to 16) Pohue Bay Settlement Complex

This complex is composed of eleven house sites, four burial platforms, and two circular pens. They are grouped around Pohue Bay and along the shore eastward. Petroglyphs are scattered between the sites and include *papamu* as well as some modern writing. –p14

Significance: This cluster of sites indicates a village settlement accommodating more than fifty inhabitants, and their adaptation to the terrain of this bay area. Excavations should reveal the time span of occupancy.

3654 (B23-47) (H59) Pohue Bay

A small shelter cave formed by a break in a lava tube at the head of the bay. A test pit made in July of 1958 yielded midden material and artifacts dating back to the early period of Ka'ū settlement. Significance: This site, if not already vandalized should be reserved for archaeological excavation. In 1958, it offered the best chance of readily obtaining the date of occupancy of this area from the beginning and also artifacts in use during the period of occupation.

3649-53 (B23-42 to 46) Pohue Bay

This group consists of a shelter, a pen, a paved foot trail along the coast from Pohue Bay westward to a waterhole about 2,000 feet away. Significance: This complex illustrated typical activity adjacent to a waterhole, as do the sites at Keawaiki. The shelter is still useful. Both the shelter and the trail should be preserved.

3655-56 (B23-48 to 49) Pohue Bay

About 600 feet directly inland from the shore, a number of walled structures, which could provide shelter, indicate a camp site. A papamu and a scattering of linear human figure petroglyphs further assure their use. Significance: These structures illustrate how the Hawaiian accommodated seasonal visitors or an overflow of guests.

3657 (B23-50) Kahuku

Heiau of Malino, no description.

3697-99 (B23-57 to 59) South of Humuhumu Point

Two clusters of ahu, with seven in each cluster, and also one platform house site paved with water worn slabs and pebbles.

MANUKA (POHUE BAY AND MANUKA BAY QUAD 72 AND 71), KA'U

3670-73 [3686] (B24-12 TO 16 Keawaiki, Pohue Quad, 72)

A paved stepping stone coastal trail, a U-shaped shelter, a platform house site with a sheltering wall, a paved canoe landing ramp, and a group of three platforms which may be house platforms. The site is remarkable because of the ramp. -p15

Petroglyphs at Pohue

The most comprehesive reporting found on the petroglyphs here was written September 1961 by J. Halley Cox, author of Hawaiian Petroglyph Sources, 1825-1967, c1967 and Hawaiian Petroglyphs, c1970. Excerpts from Cox' five page report and a portion of his map showing the location of the petroglyphs:

Within a radius of about a half mile from Pu`u Ki, a cinder cone just south east of Pohue Bay, Ka`u, there is a considerable concentration of petroglyphs. The area is in a pocket surrounded by a`a lava flows and the smooth pahoehoe surfaces here offer the only good spots for petroglyph making for some distance along the coast. There was appartently no large permanent population here. Two house platforms near the beach are the only evidence of continous occupation. The many small natural shelters and caves in the area may have been used on a very temporary basis The petroglyphs were most likely made by transients, fishermen, and visitors to the area....The small circles on the map indicating the location of the petroglyphs in most cases represent a cluster of a half dozen or more figures in close association. In some cases these figures are very concentrated and even overlapping as in some sections of A and K. In other cases the symbol may indicate the location of only one or two isolated figures as at J or E.

The styles of the petroglyphs represented here are of the usual kind found elsewhere in the islands but with a predominance of the simple lineal angular figures and those with triangular bodies. Only one or two are elaborated with muscles or with pecked out surfaces. A great variety of subjects are found other than the human figure, such as: animals, artifacts, abstract symbols and lettering....Some of the petroglyphs appear to be very old, particularly at K where some are very eroded and scarred by later chipping. Some are obviously newer, dated 1864, 1891, and some still fresher, obviously cut with steel tools. One feature that is peculiar to the area is the numerous rubbing or sharpening places. These are oval shaped, about 12" to 18" long, some quite flat or shallow, like adz sharpening surfaces, but many are deeper and bowl-like, four to five inches deep. Scattered in with these grooves made with a round instrument an inch or so in diameter, possiblity the result of sharpening a chisel-shaped tool. The bowl-like despressions could not have been made as mixing or food-grinding areas or as salt pans since many of them are on slanted surfaces and could not function as "containers." At area D there is a small rise about 25 feet long which contains 30 or 40 of these "rubbing" bowls. They also occur in other areas and are often found as a smoot oval surface nearly containig a small petroglyph.

Other forms are found which are not known elsewhere, such as a lineal figure inside of a curving cloak-like shape. Another is a triangular figure with sweeping lines at each side suggesting a flowing cloak. In area K there are two occurences of a curved arc form with a "handle" at the center, very much like the Hawaiian fan 118

[Discussion of eleven areas as well as several papamū.]

¹¹⁸ Bishop Museum Archives, Manuscript Document 457, Anthropology Manuscripts Group 7, Box 19.9

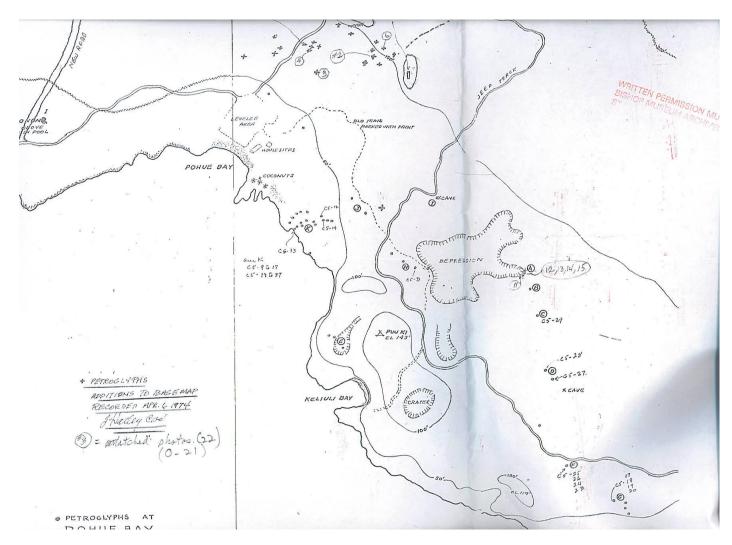


Figure 14- – Sketch from Cox's report on petroglyphs at Pōhue.

In their 1999 book *Spirit of Place: Petroglyphs of Hawai`i* the Stasacks report of the seventy petroglyph sites on the island, "…only the one that apppears to have different motifs is Pohue Bay….This site has some strange amoeba-like forms that might be described as sea creatures of some sort. What they represent is unknown."

¹¹⁹Lee and Stasack, 1999:149

Interviews

In 2005 selected students at Ka`ū High School conducted an oral history project resulting in the publication $N\bar{a}$ wahi pana o Ka`ū: the celebrated places of Ka`ū, sponsored by the Hawai`i Council for the Humanities. Among the interviewees was Thomas Kaniho who grew up on Kahuku Ranch attending Na`alehu School until the ninth grade in the 1930s. At the age of 16 he was employed by Parker Ranch who owned Kahuku at the time which consisted of 165,000 acres at the time. Earning \$1.00 per day he was provided with housing, meat, milk, poi, and medical care. A fourteen to sixteen hour workday was the norm. When not working directly with the cattle, repairing fences and removing lantana and other scrub brushes were addressed.

Kaniho relayed a week-long cattle drive of up to 1,000 calves from Kahuku to Saddle Road where cowboys from Parker Ranch would drive the cattle to Waimea. The first stop from Kahuku was Wai`ōhinu where the calves were corralled and the only night the cowboys could return home, camping with the cattle the rest of the drive. The second stop was Kapāpala Ranch; the third 'Ōhaikea, the fourth Keauhou Ranch and the fifth stop on the Saddle Road where they met the cowboys from Parker Ranch. Provisions were *pa`i`ai* (waterless poi), salted beef, round onions, chili pepper, and crackers. The ride home was usually made within a day¹²⁰.

Parker Ranch sold Kahuku Ranch to James Glover. Glover Construction in Hilo still carries his name although he is deceased and it was sold after he died. Damon Estate purchased Kahuku Ranch at a court auction after Glover's death. Freddy Rice worked for the Damon Estate made many improvements including the installation of a 2 million gallon water reservoir¹²¹.

Working with Kaniho was Carl Bredhoff (b.1934) at C. Brewer's Hawaiian Ranch Co. (Ka'alu'alu, Kapāpala and Keauhou Ranches and Na'alehu Dairy) from '60-'67. Bredhoff then managed Kahuku from 1982 until his retirement in 2000. Bredhoff reported in the 1980s he and seven other workers all resided on the ranch divided into two camps. Two homes in a *ma uka* camp and seven homes at a *ma kai* camp. The employees: Julian Beck, Gilbert Medeiros (cattle foreman), Sam Ka`upu, Nelson Ka`aupu, Dave Ka`awa, "Junior" Molcilio, Joe Velez, and Louise Kainoa. Gilbert "Boone" Medeiros transferred from Palani Ranch. Under Bredhoff's management some 2,000 mother cows were supplemented by bulls and steers.

Dave Ka'awa worked for Kahuku Ranch for thirty-five years from 1970-2005. During his tenure Freddy Rice imported buffalo in 1966. The areas between Highway 11 to South Point are three craters in the area of the ranch headquarters. The first crater is the orchard containing avocado, orange, lemon,

-

¹²⁰ Moulds-Carr 2005:63

¹²¹ Ibid.

lychee, and tangerine trees. The second and third craters contain *kukui* where hunting was conducted. The two beaches the ranch owned were Wai`ahukini and Kahuku (Pōhue). 122.

Ms. Usha Prasad conducted interviews for the preparation of an Environmental Assessment for the project area in 2006. Individuals, their association with Kahuku their comments and recommendations are presented in the table below:

Table 4 - Interviews, 2006

Individual	Role	Interview Date(s)	Comments	Recommendations
Pele Hanoa	Founder of Ka`u Preservation Society	August 27, 2006	Few people lived at Waiohinu at one time (near Pōhue). "They were campinghad a house site. These same people went and planted the trees around the fresh water spring (Kanonone)." Associates Pōhue with Waiahukini. Regarding coastal sites, "this is the area there the royal <i>ali`i</i> once lived. Kamehameha was banned from entering the area but it is where Keoua, Kalaniopu`u came from. Ka`u people didn't allow Kamehameha to come to their lands. But these were strong people of royalty.	"Build a cement 'port' at Pohue that will allow the emergency use of a boat. But not in the area where the turtles hatch. You could go down on either side of the bay proper (to avoid the turtles). But there should be no disturbance to the area where the turtles hatch." Although there are controls on who goes in and out of Pohue Bay area, she feels that coming in from the Oceanside could be done during emergency situations.
Emilio "Junior" Molcilio	Kahuku Ranch cowboy. During his 48 years with the Ranch he was responsible for access and maintenance of the entire coastline from Pohue, Kahekea to Kakio.	August 4, 2006	"When I first came [ca. 1952] it [Pōhue] was completely off-limits to the outside. I used to be at the beach a lot, maintaining the gates. It was very expensive to keep people out. Weren't just fishermen who came to use it. So much trash and stuff [was left behind]. People would get a pass but would give it to others to use.	

¹²² Ibid:66-67

Get guys trespassing all the time. Fishing, hunting, everything...was a hunter's dream. Beach was [early 50s] great....There's a road which runs from the Kona side (Kahakahakea) towards Kakio and South Point. Wai'ahukini, which is just below the pali, is the boundary of Kahuku Ranch. The ranch surrounded Wai`ahukini, and went down close to South Point. "There are many beaches...Pohue, Kahakahakea, Kakio are just a few." Next to Kahakahakea is an area called JR Point after him as this is where he always fished. It is also known as "Icebox" as he left a cooler there near Pu'u Kī. Hosaka Point was named after government worker Eddie Hosaka who regularly fished there. Kanonone was known as "Lauhala" to the ranch hands. "Kanonone water hole and the others already had lauhala growing when I came. A friend came and planted a whole bunch more. He brought down a pile of coconuts and put them there. The Oceanview (construction) guys knocked down some of the coconuts [trees] in order to get the nut. They couldn't climb the tree so they just chopped it down to get the nuts. The ocean waves also thinned out the trees from the area. Kahakahakea also has a water hole. A nearby crack near Kahakahakea supplied fresh water for them. Junior never drank the water from the holes; the water was brackish. "But the ponds were used by some of the

			fishermen as a place to put in little fish. Kind of like a 'holding pond.' Then people came and started stealing the fish that were in the ponds. There was even a barracuda in there, and it grew pretty big. But eventually it too was taken. A lot of people stole and made <i>pilikia</i> at the place." A foot trail with the terminus at Pōhue Bay is part of the Ala Kahakai that runs along the shoreline ending on the north edge of Pōhue Bay. This trail was also used for horse riding.	
Tommy & Chiyoko Ishimura	Bulldozed roads for Kahuku Ranch for over twenty years.	July 17- 18, 2006	Fished in the Pōhue vicinity and saw people camping there. "Not too many Hawaiians in the Kahuku area" and Kahuku essentially uninhabited until Oceanview development took place.	
Gil Kahele	Born and current resident of Miloli'i. Member of Ka'u Coastal Conservation Task Force	July 25, 2006	Not familiar with Pōhue but is aware of the importance fishing is for Ka`ū residents. Petroglyph design used by Na Ala Hele (state trails system) based on petroglyph located at Pōhue	Deferred to Pele Hanoa
Bobby Camara	Naturalist hiked and camped at Pohue Bay ca. 1982	July 2, 2006	See current interview notes below	
Robbie Hind	Former livestock manager of Park Ranch. Family ranch lands include area around Waiohinu.	August 15, 2006	Kahuku area bombed a great deal during World War II.	
Joanne Kahanamoku-	Stayed at Kahuku Ranch with uncle	June 13, 2006		Recommended Blue Coleman.

Sterling	Gilbert Lee			
Vern & Caleb Yamanaka	Caretakers for over twenty years	2006	Area federally funded as Hawksbill grounds May to December. Vern asserts Hoopuloa Village covered by lava. The next neighboring village to Pōhue Bay project area is Milolii. Caleb referred to a second anchaline pond is south of Kahakahakea and north of Kanonone Spring. A segment of the Ala Kahakai leads to it. This pond is 6 to 8 feet deep and up to 15 feet across its water has a ruddy tinge possibly from chemical released from the rocks.	Interview Pua Kanahele who brings her hālau there.
Ruby McDonald	Family ties to Ka`u lands	June 16, 2006		Recommended contacting Tommy Ishimaru.
Billy Bergin	Author of Loyal to the Land	July 24, 2006	Rode <i>ma uka</i> trails of Kahuku Ranch with Sonny Keakealani.	Recommends Sonny Keakealani who worked for Parker Ranch
Keawe Vredenburg	Archivist for Paniolo Preservation Society	August 2, 2006	Visited Hind relations in ma uka portion of Kahuku. Considers Hilea River an 'old' area located near Punalu'u as an important residential and gathering area in the late 1800s and early 1900s.	Recommended: David Kimura, Freddy Rice, Gilbert Medeiros, Palikapu Redman

Upon reviewing the notes taken by Usha Prasad in 2006, Bobby Camara found them inaccurate and requested they not be included in this report. During an interview on March 24, 2011 he stressed his knowledge of the project area is through historical documents i.e. Boundary Commission Testimonies (his transcriptions presented in Appendix B). He emphasized the Boundary Commission Testimonies cite the notable activity in Kahuku was bird catching, not fishing or other marine exploitation. He believes the high olivine composition of the lava produced superior abrader instruments and would be interested if the archaeological survey revealed abrader quarries. Bobby asserts Wai`ahukini and Kā`ili-ki`i where the coastal habitation sites of the area due to the sheltered geography. Bobby's primary concern for the current project is its location on a rift zone. He acquiesced to having the following regarding the naming of Hapaimamo included in this report.

Hapaimamo

Our source of the name "Hapaimamo" is the Boundary Commission Testimony for Kahuku, collected at the courthouse in Waiohinu in 1873.

Please remember that while the BCT can and usually does contain amazingly interesting information, there are also numerous conflicting statements. The testimonies were collected so officials of the Kingdom could determine the boundaries of *ahupua* 'a. Most people lived near and knew the *makai* boundaries. The regions *mauka* were infrequently visited, so old bird catchers were asked to describe the boundaries. Many of the men were in their 70's, feeble and tired (this according to comments in various BCTs). We can imagine that voices were weak, perhaps slurred. The secretary wrote a transcript of the proceedings, dependent, of course, on what he thought he heard.

Then there is the problem of the meaning of the name. While many people like to be definite and quantify things, it's important that we allow ourselves the unknowable. To wonder, be puzzled, think and question. "Maybe...what if...perhaps...." Because we weren't among those who coined the name, perhaps the best we can hope to do is guess, based on sound ideas.

Here are some basic definitions:

- <u>hāpai</u>: to carry, bear, lift, elevate, raise, hoist, hold up; to support, as another's testimony;
- <u>mamo</u>: black Hawaiian honeycreeper (*Drepanis pacifica*), with yellow feathers above and below the tail that were used in choicest featherwork--formerly found only on Hawai'i, but not seen since the 1880's;
- note also, lehua mamo, the yellow lehua, literally "mamo-bird lehua", so called because the mamo has yellow feathers.

"To carry mamo (birds)" would be the literal meaning, referring perhaps to an area where mamo were once caught. There are other possible meanings as well.

We can look to the BCT, and in this case find reference to the colors of various birds. "...Hapaimamo. said place taking its name from the color of the earth and stones being like to the yellow feathers of the 'Ō'ō and the black feathers of the mamo bird, like on amokihi (sic) [and] 'i'iwi." On a field trip to the area one can easily find green tephra (like an 'amakihi). Other pieces of tephra and surrounding areas are 'i'iwi colored, as well as golden or pale yellow. It is truly a remarkable place with stunning features.

One of my ideas: According to Jack Lockwood the Hapaimamo eruption is C^{14} dated to 1710 + /-60 years, or between AD1650 and 1770. It was, he says, one of two eruptions of Mauna Loa that produced an unusually large amount of reticulite. Hapaimamo reticulite is a light colored tephra that was spread over a large field. The winds carried (hāpai) the pale golden (mamo) tephra over a wide area.

"Hapaimamo in Kahuku is a large smooth hill formed of pumice and sand with red spots on it and on the plain around it. It is an old crater with a gap in the South side where a stream of aa has flowed out" (BCT: 1873).

Notes by Bobby Camara, 2004; minor editing by Ed Bonsey

¹ The other being the vents, near the Kulani Prison dump, that produced the Panaÿewa flows 1300 years ago that entered the sea east of Hilo

Interviews were conducted in accordance with Federal and State laws, and guidelines, when knowledgeable individuals are able to identify cultural practices in, or in close proximity to the project area. The Office of Hawaiian Affairs, Ka'ū Hawaiian Civic Club, and the Hawai'i Volcanoes National Park were contacted and visited to identify potentially knowledgeable individuals with cultural expertise and/or knowledge of the study area and the surrounding vicinity. The names for potential community contacts were also provided by Vern Yamanaka, property manager for over twenty years; Virginia Goldstein, former Hawai'i County Planning Director, and Alan Walker, Supervisory Archaeologist of the 1987 archaeological reconnaissance survey of the project area. Ross Cordy, PhD who reviewed the 1987 said survey in his position of Archaeologist of the State Historic Preservation Division was contacted but did not respond. Neither did *Kumu hula* Pua Kanahele. Due to the Environmental Impact Statement submitted by Belt Collins and Associates in 1987 and the oral history interviews conducted in 2006, individuals not previously interviewed were sought for this study. It should be stressed that this process does not include ethnographic interviews or oral histories as described in the OEQC's *Guidelines for Assessing Cultural Impacts* (1997). The assessments are intended to identify potential impacts to ongoing cultural practices or resources within the project area or in its close vicinity.

The oral history interviews compiled for this report reflect the recollections and thought of several native families with generational ties to Ka'ū and former employees of Kahuku Ranch, the longest historical land use. Due to the Environmental Impact Statement submitted by Belt Collins and Associates in 1987 and the oral history interviews conducted in 2006 for same property owners individuals not previously interviewed were sought for this study. Interviewees were provided with a draft of this CIA and/or selected maps prio in-person or telephone interviews. They were asked about their history and familiarity with the project area and of any cultural practices they either engaged in or had first-hand knowledge of. The questions were intended to identify potential impacts to ongoing cultural practices or resources within the project area or in its close vicinity.

Table 5 – Oral History Interviews, 2011

Individual	Role	Interview Date(s)	Comments	Recommendations
Carl Bredhoff	Kahuku Ranch Manager, 1982-2000	January 12, March 28, 2011	Below the Hawaiian Ranchos subdivision was a horse trail which was later bulldozed where remnants of village were discovered. However there were much fewer than those found at Waiahukini. The flat rocks placed by the Māmalahoa Highway were taken from the airstrip area. Did not know when the dry stacked rock walls throughout Kahuku were	None

Virginia Goldstein	Former Hawai`i County Archaeologist & Planning Director	January 14, 2011	constructed (NPS archaeologists are trying to ascertain this) and guess it may go back to the 19 th century. Believes the EIS submitted in 1987 would suffice for this project. Noted the burials above Pōhue Bay may have constituted a historic cemetery.	Suggested contacting Paul H. Rosendahl, Inc. who conducted the archaeological survey and Ross Cordy, PhD the reviewer at the State Historic Preservation Division at the time, specifically
Pele Hanoa	Kama`āina of Punalu`u and community advocate	February 2, 2011	The project area is appropriate because there are sufficient agricultural and conservation lands nearby, i.e. the rest of Kahuku owned and managed by the National Park Service. [Maps of the cultural sites and place names were provided.]	Due to the isolation of the project area recommends the construction at Pōhue to facilitate access for safety issues.
David Ka`awa	Kahuku Ranch Employee, 1970-2005	February 4, 2011	Ka`awa lived in one of the two houses in the <i>ma kai</i> residential area the ranch maintained. Many of the stone walls were constructed in the 1930s and 1940s as animal chutes and pens. The airstrip was used by Murray Air until ca. 1983 for fertilizer crop dusters. Access to the coastline was monitored by the Ranch due to liability concerns. If we people asked for permission to camp or fish, they were usually given access. [Maps showing trails and roads where mailed to Ka`awa for confirmation and comments.]	None
Alan Walker	Supervisory Archaeologist,	January 19, 2011	Walker worked for over two decades with Paul H. Rosendahl,	None

	PHRI		Inc. (PHRI) and was the supervisory archaeologist for the	
			Archaeological Reconnaissance	
			Survey of the Hawaiian Riviera	
			Resort Project Area, comprising of the approximate land of the current	
			project area ¹²³ .	
			The coastal section of Kahuku was a	
			transient area reflected by the	
			temporary habitation structures and few burials.	
			In comparing the findings of	
			Hansen and PHRI, Hansen and	
			Soehren's sites B23-2, 6, 7, 8 were identified as burials. PHRI found	
			only two probable burials in this	
			area (T-169, T-172). T-169 was a	
			platform with no cultural	
			deposits ¹²⁴ . T-172 contained five	
			features consisting of four	
			platforms and an enclosure with a high amount of coral present which	
			were interpreted as either as a	
			possible shrine or burial ¹²⁵	
			Walker entered one lave tube	
			(possibly Site T-361) where at least	
			six burials were found. This tube	
			was part of an extensive system requiring further exploration ¹²⁶ .	
Bob Damate	Long-time	April 12,	Bob Damate moved to Ka`ū in the	Cultural sites and
	resident of	2011	early 1970s when hired by C.	practices remain but
	Kaʻū, Member		Brewer to open the resort at	unwilling to identify
	of Ka'ū Community		Punalu`u. Residing in Hawaiian Ocean View Rancho he is a vocal	them at this time.
	Development		member of the community relaying	
	Steering		the knowledge received from lineal	
			descendants who continue their	

¹²³ Pers. Comm. January 19, 2011 ¹²⁴ Haun and Walker 1987:B-32

¹²⁵ Ibid.

¹²⁶ Haun and Walker 1987:B-113

Committee

cultural practices in Ka`u.
Unfortunately, these descendants
have requested their knowledge
not be shared at this time.

Uncle Bob did relay the last family left Wai`ahukini along the eastern boundary of the project area in 1943 due to bombing by the U.S. He asserts Army and conclusions by Emory and Sinoto following their excavations in the 1960s of the coastal Pakini did not include knowledge of the *kama`aina*.

According to Uncle Bob, in the Kāki'o¹²⁷ portion of Kahuku the walls of a *halemua*¹²⁸ remains from the former *kauhale*¹²⁹. He also asserts Henry 'Opukahai'a's parents were killed in Kahuku¹³⁰. He maintains *wahine and kane* cultural practices, although which, he did not specify, continue today. Asked if ranch access management curtailed these practices which he replied it did not, as people would walk to reach specific sites.

Uncle Bob stated all sand beaches along the coastline are *honu* nesting sites and the root system of coconut trees prevents them from continued nesting.

In the hopes lineal descendants would share their knowledge of cultural sites and practices, copies of the draft CIA were sent to Uncle

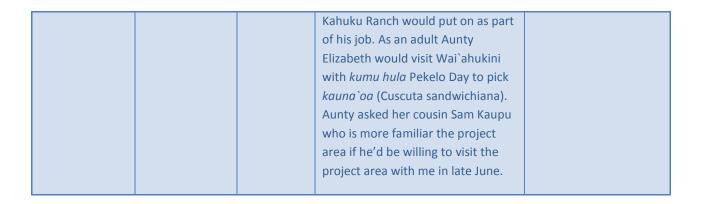
¹²⁷ Beach, fishing site, Kahuku, Hawai`i. Small pocket of calcareous sand in the otherwise rocky shore of the 1887 lava flow. *Lit.*, skin rash or sore.

¹²⁸ The house where males ate their meals

¹²⁹ Group of houses comprising a Hawaiian home

¹³⁰ References to this assertion could not be found in published literature.

			Bob for distribution. Several	
			follow-up calls were made with no	
			comments received.	
Marvin Min	Born and	May 16,	Born in 1965 Min is the third	None
	reared in Ka`ū.	2011	generation residing in Ka`ū growing	
			up in Pahala. His family established	
			a coffee and macadamia farm in	
			Punalu`u and utilized the entire	
			shoreline including the subject area	
			for marine resources including	
			`opihi and `a`ama. In the ma uka	
			areas of Kahuku, pigs and sheep	
			were hunted as the need to	
			eradicate sheep was necessary. He	
			emphasized that while hunting or	
			fishing; they were not focused on	
			historical sites and never learned	
			their names or significance, but	
			rather avoided them with respect.	
			They would receive the key from	
			"Junior" Molcilio who readily	
			allowed access to residents.	
Elizabeth	Kama`āina of	May 29,	Kuluwaimaka is the first of six	None
Kuluwaimaka	Ka'ū	2011	children of Joseph Kauwe and	
			Caroline Pua Kaluahi. Her father	
			worked for Kapapala Ranch	
			transferring to Kahuku Ranch in	
			1965 where he remained for about	
			three years later working for the	
			three years later working for the aforementioned Tommy Ishimura,	
			aforementioned Tommy Ishimura,	
			aforementioned Tommy Ishimura, 1971-1975. Her uncle Sam Pua also	
			aforementioned Tommy Ishimura, 1971-1975. Her uncle Sam Pua also worked at Kahuku Ranch under the	
			aforementioned Tommy Ishimura, 1971-1975. Her uncle Sam Pua also worked at Kahuku Ranch under the management of Freddy Rice	
			aforementioned Tommy Ishimura, 1971-1975. Her uncle Sam Pua also worked at Kahuku Ranch under the management of Freddy Rice residing in the "long house." What	
			aforementioned Tommy Ishimura, 1971-1975. Her uncle Sam Pua also worked at Kahuku Ranch under the management of Freddy Rice residing in the "long house." What Junior and other's refer to as "Molcilio Shack" near Pōhue Beach, her family referred to it as "Manoa	
			aforementioned Tommy Ishimura, 1971-1975. Her uncle Sam Pua also worked at Kahuku Ranch under the management of Freddy Rice residing in the "long house." What Junior and other's refer to as "Molcilio Shack" near Pōhue Beach, her family referred to it as "Manoa Shack" after a foreman of Kahuku	
			aforementioned Tommy Ishimura, 1971-1975. Her uncle Sam Pua also worked at Kahuku Ranch under the management of Freddy Rice residing in the "long house." What Junior and other's refer to as "Molcilio Shack" near Pōhue Beach, her family referred to it as "Manoa Shack" after a foreman of Kahuku Ranch. Her father didn't take his	
			aforementioned Tommy Ishimura, 1971-1975. Her uncle Sam Pua also worked at Kahuku Ranch under the management of Freddy Rice residing in the "long house." What Junior and other's refer to as "Molcilio Shack" near Pōhue Beach, her family referred to it as "Manoa Shack" after a foreman of Kahuku Ranch. Her father didn't take his family to Pōhue Beach as Punalu`u	
			aforementioned Tommy Ishimura, 1971-1975. Her uncle Sam Pua also worked at Kahuku Ranch under the management of Freddy Rice residing in the "long house." What Junior and other's refer to as "Molcilio Shack" near Pōhue Beach, her family referred to it as "Manoa Shack" after a foreman of Kahuku Ranch. Her father didn't take his family to Pōhue Beach as Punalu`u was easier access not requiring a 4	
			aforementioned Tommy Ishimura, 1971-1975. Her uncle Sam Pua also worked at Kahuku Ranch under the management of Freddy Rice residing in the "long house." What Junior and other's refer to as "Molcilio Shack" near Pōhue Beach, her family referred to it as "Manoa Shack" after a foreman of Kahuku Ranch. Her father didn't take his family to Pōhue Beach as Punalu`u was easier access not requiring a 4 wheel-drive. An excellent	
			aforementioned Tommy Ishimura, 1971-1975. Her uncle Sam Pua also worked at Kahuku Ranch under the management of Freddy Rice residing in the "long house." What Junior and other's refer to as "Molcilio Shack" near Pōhue Beach, her family referred to it as "Manoa Shack" after a foreman of Kahuku Ranch. Her father didn't take his family to Pōhue Beach as Punalu`u was easier access not requiring a 4	



The majority of individuals contacted for this project did not express any strong concerns regarding cultural impacts within the project area with the exception of Bob Damate. Copies of this CIA were provided to him to distribute to lineal descendants for their comment. Follow-up calls to Damate did not result in any comments.

Cultural Impacts

The land of Kahuku is largely unoccupied now but clearly was previously occupied at Pōhue as evidenced by the multiple archaeological features remaining there. In previous interviews (c.f. Pele Hanoa, Tommy Ishimaru, Junior Molcilio) a handful of families may have remained in the Pōhue area. The land use of the Kaʻū area dramatically altered when sugar and cattle were introduced in the 1860s. Sugar brought non-Hawaiians (Chinese, Portuguese, Japanese and Filipinos). Cattle ranching, though on a smaller scale, also brought in non-Hawaiians as labor. Kahuku Ranch was one of the largest ranches on the island with over 180,000 acres. The succeeding major land use change beginning in the 1960s was housing developments. These residential subdivisions, Hawaiian Ocean View Estates and Hawaiian Ranchos were developed in close proximity to the project area, primarily with Caucasian residents. The communities bordering Kahuku, including Pahala, Miloliʻi, Punaluʻu, Naʻalehu, Waiohinu, and Ka Lae, all have a significant native Hawaiian population, Miloliʻi has the distinction of being one of the last traditional fishing villages.

The traditional cultural value of the project area is based on its association with historical uses and its continued support of traditional gathering practices, and access to traditional cultural sites, i.e. *heiau* and burials, associated for native Hawaiians or other cultural groups. Ethnographic and historic documents clearly indicate Kahuku supported a permanent population in the *ma uka* portion of the *ahupua'a*. The far upland areas of Kahuku while not habited provided the resources for bird hunting, wood procurement (sandalwood and koa), *pulu* and later goat hunting. The coastline was a noted fishing ground attracting even Kamehameha I although habitation by fishermen was most likely temporary. No agricultural or gathering practices were revealed within the project area. Native informants testifying before the Boundary Commission in the 19th century cited roads and trails, one of which was used for hauling tree trunks to the coast for use in canoe manufacture.

The bulk of archaeological research has been conducted on the coast including the project area. The sites identified at Pōhue Bay included walled house sites, possible burial platforms, cave shelters, some with burials, trails, anchialine ponds, and petroglyphs. In 1965 Lloyd Soehren excavated two caveshelters southeast of Pōhue at Kahakahakea, one of which produced a radiocarbon date ranging from the 1300 to the 1400s¹³¹. The large-scale archaeological reconnaissance survey conducted in 1987 confirmed the relatively intensive use of the coastal region reflected by C, U, and L-shaped walls, enclosures, platforms, terraces, cairns, linear and curved walls, petroglpyhs, lava tubes and blisters, mound alignments, *pāhoehoe* excavations, and other modified areas. This survey concluded the great majority of the sites were temporary habitation sites of pre-contact origin, possibly between the 5th and 14th centuries suggesting a long period of occupation¹³².

Cultural uses of the project area and its immediate surrounding have been limited and/or severely altered in the past 150 years due to cattle ranching. Use of the lands for cattle ranching in the immediate vicinity of the project area may have occurred more recently and not as intensive. Ownership and control of access by Kahuku Ranch the project has resulted in limited access to the project area. While traditional use of the project area still persist in the form of fishing, camping, gathering and likely spiritual practices, pre-contact archaeological features remain along the coastal belt of Kahuku. The present cultural community in closest proximity to the project area reflects modern-day, generally non-traditional Hawaiian setting.

Summary and Recommendations

Reviewing the information presented in this cultural impact assessment – historical documentation, archaeological surveys and research, and oral reminiscences – reveal significant cultural sites and practices but limited contemporary or continuing cultural practices. This is largely due to the privatization of lands that occurred following the Mahele in 1848 and the subsequent decline in cultural practices that occurred throughout Hawaii as access became restricted on many private lands. Relative to the Nani Kahuku Aina property, private ownership and use of the property for cattle ranching restricted the continuation of traditional cultural practices. Today, although access to the site is granted by Nani Kahuku Aina to cultural practitioners, traditional cultural practices have declined compared to pre-Mahele practices and are limited to fishing, camping, gathering, and spiritual practices.

Along with two *heiau* within the *ahupua* `a, previous researchers have located numerous cultural sites including a notable number of petroglyphs in the coastal zone contingent. Further inland, sites and features indicative of dryland agricultural activities substantiated by Mahele and Boundary Commission testimonies of cultivation remain. The traditional practices of bird catching, and forest harvesting have long ceased in the forest zone. Historic use of Kahuku was primarily ranching with limited exploitation of marine resources, primarily recreational.

-

¹³¹ Soehren 1966

Petition of the Palace Development Corp. to amend the Agricultural District Boundary into the Urban District for approximately 900 acres and the amend the Conservation District Bondary into the Urban District for approximately 2,420 acres, at Kahuku, Ka`u, Island, County and State of Hawaii, Hawaii Tax Map Key Nos. 9-2-1: por. 72, por. 75 and por. 76

The area containing a concentration of cultural sites from Kanonone Ponds past Keliuli Bay including Pōhue Bay has been designated as a historic preserve by the project developers which will promote their preservation and interpretation. Care should be taken in the vicinity of Kahakahakea and the 1887 lava flow as ancient foot trails and other cultural sites and features have been identified, some preceding said lava flow.

Native Hawaiian cultural practices still take place in the project area including:

- 1. Fishing
- 2. Gathering of resources at anchialine ponds (e.g. Kanonone)¹³³
- 3. Camping and picnicking
- 4. Possible shoreline ceremonies (visits by halau hula)
- 5. Hiking on the ala kahakai

Non-native Hawaiian activity takes place at Pōhue Bay with the federally funded and managed Hawksbill Turtle protection efforts. Referred to as "Hawksbill grounds" from May to December the bay is the site of turtle counts. Volunteers with the National Park Service reside at the bay during this period and conduct surveys.

Determination of Cultural Impacts

Cultural Resource, Belief or Practice	Potential Impact and Avoidance of said Impact
Fishing	Restriction of this activity would constitute removing a cultural resource and practice. This practice should be allowed to continue with special consideration within the management or restrictions and include consultation with area kūpuna and cultural practitioners ¹³⁴ .
Camping	Camping near anchialine pond is a traditional activity. These water holes can be accessed from paths or jeep trails with existing jeep trails along the shoreline facilitating access through the same management as stated above.

¹³³ Such brakish water ponds provided coconut and pandanus and `ōpae`ula (Hawaiian Shrimp, *Halocaridina rubra*) for cultural gathering.

¹³⁴ The Land Assets Division of Kamehameha Schools has such a procedure in place for such activities within Makalawena, North Kona.

Hiking	The <i>ala kahakai</i> along the shoreline is part of the King's Trail circling the island. While the frequency of use is not available for this section, as the trail in the immediate vicinity of Pōhue is broken, it continues on either side of the bay. The National Park Service established the <i>Ala Kahakai National Historic Trail</i> in 2000 and shares jurisdication with the State's <i>Na Ala Hele</i> Hawai'i Trail & Access System. Collaboration with these two entities is recommended.
Shoreline ceremonies	Continued access to a halau hula ¹³⁵
Access to historic resources	The numerous archaeological sites including multi- feature complexes, petroglyphs, and rock quarries area likely to be visited by both Hawaiians and non-Hawaiians including scientists. Any development should be situated away from these sites.

The Hawaiian Heritage Center will assist in the preservation of Hawaiian cultural resources, beliefs and practices representing the larger project area while improving awareness and access of these resources.

It should be noted, however remnants of Hawaiian practices, be it agricultural, temporary habitation sites, or additional burials may reveal themselves during development. In the event such archaeological resources are encountered during land-altering activities associated with construction, work in the immediate area of the discovery should be halted and DLNR-SHPD contacted as outlined in Hawaii Administrative Rules 13§13-280.

 $^{^{\}rm 135}$ Attempts to contact this kumu by previous and this researcher have been unsuccessful

Appendix A

Kahuku Place Names Compiled by Lloyd Soehren

Name	Feature	Comments	Lexicology	Source
Ahupohaku*	Boundary point	"the mauka corner of Kiolaka`a" on Kahuku/Wai`ōhinu boundary. Elev. about 5125 ft.	ahu-pōhaku. Pukui and Elbert (PE): stone cairn.	Boundary Commission Testimony (BCT) vol. 1:403
Akihi*	Cone	A prehistoric cinder cone in the Ka`ū Volcanic Series. "A peaked mass of rock." (Alexander) "Station is on southeasterly rim of a deep crater." (Mitchell) Elev. 2992 ft. at survey station. TMK 9201:2.	ʻakihi. Pukui, Elbert and Mookini (PEM): petrel.	USGS 1962; Registered Map (RM) 2176; Alexander ms:1; Mitchell 1930:196.
Alanui o Umi 1	Trail	Lower Alanui o Umi now mostly obliterated by historic lava flows. "This is not Umi's road that runs way up on the mountain, but is the road that comes from Kahuku running past Ohialele; not the one from Halepohaha." (2:199) "Kahuku and Keauhou cut Kaapuna off at Nahuaumi [q.v.], at lower Umi's road." (p.200); "Kahukubounds Kaapuna at Alanui o Umi." (p.202).	ala-nui o 'umi. PE: road of `Umi.	BCT 2:199,200,202
Alanui o Umi 2*	Trail	Upper Alanui o Umi. "the one from HalepohahaAt Humuula [q.v.], Kaapuna is cut off by Kahuku and Keauhou, thence makai along Keauhou to Ahu a Umi and the upper Umi Road" Now mostly obliterated by historic lava flows. Perhaps the "Old Hawaiian Trail" shown on quad 10-58 is a portion of `Umi's upper road.	ala-nui o 'umi. PE: road of 'Umi.	BCT 2:199.
Alika Cone*	Pu`u	The source of the 1919 Alika lava flow. El. 7843 ft.	See same for South Kona	USGS 1967.
Ana Halulu	Cave	"Ana Halulu caveis a break 50	ana halulu.	USGS 1925; FB

		ft. long and 25 ft. deep into one of the subterranean caverns of an ancient flow80 skulls and dead bodies of goats are in itIt was an ancient hiding place of natives in war, whence its name" (FB 558). A survey "station is situated 144 ft southeast of the mauka edge of thecave" mauka of Hookena, S. Kona. Elev. 6901 ft.	Thunder cave.	558:46.
Awikahua	`ili `aina	Claim no. 10514:1 by Naohue is for "Awikahua ili ma Kahuku ahupuaa".		Native Testimony (NT) 8:475.
Hale Pohaha*	Heiau	"Described as being on the west of the lava flow of 1887, 3 or 4 miles north of the Kona-Kau road. Said to have been used for human sacrifices and to have been built by `Umi." USGS shows "Hale Pohaha (Ruins)" in Hawaiian Ocean View Estates, bounded by Mahimahi, Lurline, Ohia roads, elev. about 4550 ft. See Alanui o Umi 2.	hale põhāhā. PEM: bursting house.	Stokes 1991:113; USGS 1967. Stokes 1991:113; USGS 1967.
Halelehu	`ili `aina	Claim no. 8775 by Kaopuana for a parcel in "ili o Halelehu ma Kahuku ahupuaa" was not awarded.	hale-lehu.	NT 8:496.
Haleohale	`ili `aina	Claim no. 8770 by Kanae for his "apana Haleohale ili ma Kahuku" was not awarded.		NT 8:495.
Haliipalala*	Place	Several small water holes are nearby.	Hāliʻi-pālala. PEM: spread wide.	USGS 1962; RM 1677.
Hopeloa*	Point	Located north of Kakio, at shore.	hope-loa. PEM: very last.	RM 1677.
Humuula	Boundary point	"a place opposite Puu Keokeo [quad 10-66]I have never been thereAt Humuula Kaapuna is cut off by Kahuku" (p.199) In	Humu'ula. PE: red jasper stone, as used for adzes.	BCT 2:199,201.

		Kahuku today; the boundaries as surveyed often differ from those described in the higher elevations.		
Ihuanu*	Cone	A prehistoric cinder cone in the Kau Volcanic Series in a kīpuka between 1887 and 1907 lava flows. Elev. 5303 ft.	ihuanu. PE: name of an odoriferous tree or shrub.	USGS 1967; Stearns and Macdonald 1946.
Ka Lepe a Moa*	Rock	Located about 800 feet northwest of the Kahuku/Pakininui boundary.	ka-lepe-a- moa. PEM: the comb [acquired] by [a] chicken.	USGS 1962.
Kaahaweliweli*	Point	Located between Humuhumu Point and Pohue Bay.	ka-'aha- weliweli.	RM 1677.
Kahakahakea*	Place	Place at shore near some water holes.	kahakaha-kea.	USGS 1962; RM 1677.
Kahiola*	Point	Perhaps a cove or small point.		USGS 1962.
Kahuenaha*	Place	Elev. about 1840 ft.		USGS 1962.
Kahuku	Ahupua'a	Surrendered by Leleiohoku. Named as School Land in 1850 and sold as RPG 2791.	The projection	Mahele Book (MB) 29; IN 50,76; PCR 1850 Dec. 23; USGS 1962
Kaimuuwala*	Boundary Point	A boundary point at the shore between Kahuku and Pakini-nui. Called "Kaumuula" on RM 1677 and in BC 83. USGS seems to have confused Puu Kaimuuwala with Point Kaumuula, naming the latter after the former.	ka-imu-ʻuwala. PE: the sweet potato oven	USGS 1962.
Kakaiokaaha	Heiau	"on the boundary of Kaalaala and Kahuku is a small heiau on the pahoehoe above the woods." (p.143) "built by a Hilo chief" (p. 141) "heiau o Umi on the road to Kona kaalaoehu a small heiau. There are many stone houses there." (p. 142) Probably about 6400 ft. elev.	kākai-o-ka- ʻaha.	BCT 1:141- 143.
Kakio*	Place	At east edge of the 1887 lava	Kāki`o. PE:	USGS 1962.

		flow, at the shore.	mange, itch, impetigo.	_
Kaluaiki	ʻili ʻāina	Claim no. 10508:1 by Namanele for a parcel in "Kaluaiki ili ma Kahuku" was denied.	ka-lua-iki. PE: the small pit.	NT 8:495.
Kamakapaa*	Place	Perhaps a knoll mauka of Puu o Kahuku. Elev. about 2360 ft.	ka makapa'a. PE:the one- eyed [person].	USGS 1962.
Kamakoa	ʻili ʻāina	Claim no. 8115 by Hinai for a "kihapai ma Kamakoa ili ma Kahuku ahupuaa" was not awarded. Claim no. 6980:2 by Kawaa for a "kihapai maia ma Kamakoa ma Kahuku" was denied. Claim no. 7307 by Kuoi in Kulauala is bounded by "Kamakoa ame Pookia ma ka hikina". Cf. Kumukou.	ka-makoa.	Native Register (NR) 8:133; NT 8:494,497.
Kanakaloloa*	Place	Along the mauka side of Hwy 11. Elev. about 1960 ft. During construction of Manukā State Park long bones of four skeletons were uncovered and reburied at the east side of the park. The name is misplaced by USGS, being about 2.5 miles too far east and in the wrong ahupua`a. Coordinates are those of the "Grave" in Manuka State Park.	kanaka loloa. PEM: tall person.	USGS 1962; PEM 83.
Kanonone Water Hole*	Water hole	Located close to shore, 1/2 mile west of Pohue Bay.		USGS 1962.
Каорара*	Place	Elev. about 2040 ft.	ka 'ōpapa. PEM: the flats	USGS 1962
Kapeleiki	ʻili ʻāina	Claim no. 8115 by Halulu and Hinai extends into "ka nahelehele of Kapeleiki ma ka akau" but was not awarded. Cf. Kapeleoiki.	ka-pele-iki. PE: small Ka-pele.	NR 8:154.
Kapeleoiki*	Boundary point	"koa and aa, Waiohinu on the east side of the flow" at NW corner of Waiohinu on Kahuku boundary. Elev. about 5250 ft. Cf.	Perhaps ka- pele-'ōiki. PE: the narrow	BCT 1:403.

		Kipuka Pele-o-Iki, Ke A Pele-o-Iki, both nearby on Kahuku.		
Kapoalaala*	Cone	A prehistoric cinder cone. Elev. 6778 ft.	ka-pōʻalaʻala.	USGS 1967; Stearns and Macdonald 1946.
Kaumukaumaha*	Boundary point	Located at the corner of Kahuku/Kiao/Pakini-nui. Misspelt "Kumukaumaha" on USGS; also called "Kaulukaumaha" (BCT 1:395). Elev. 875 ft.	ka-umu- kaumaha.	Boundary Commision (BC) 85 (3:186).
Kaumuula*	Boundary point	Place at shore on boundary between Kahuku and Pakini-nui. Called "Kaimuuwala" on USGS.	Perhaps ka- umu-ula. PE: the lobster oven.	RM 1677; BC 83 (3:177).
Kawaihou*	Boundary point	"New found water hole." Located on Kahuku boundary at upper end of Mohowae (TMK 9304:5). Elev. about 2240 ft.	ka-wai-hou. PE: the new water.	Alexander ms:4; RM 2176.
Ke A Pele o Iki*	Lava flow	Lava flow of 1926.	Perhaps ke 'ā pele 'ōiki. PE: the narrow lava flow.	USGS 1967.
Ke A Pohina*	Lava flow	An undated lava flow at about 6400 ft. elev.	ke 'ā pōhina. PEM: the gray lava.	USGS 1967
Keanaoumi	Boundary	"where Kahuku cuts off the lands of Kaalaiki and Waiohinu" above Na-manu-0-Haalou. The northeast corner of Waiohinu at Kahuku. Elev. about 5700 ft. BC witness Kalakalohe gives this account: "The old native story is that the konohiki of Waiohinu went to Ke-ana-o-Umi and asked Umi for the pahoehoe, but he gave the pahoehoe to the land of Kahuku, and the woods from Namanu-o-Haalou to Peleoiki to Waiohinu."	ke-ana-o-'Umi. PE: the cave of 'Umi.	BCT 1:404.
Keanapaakai*	Place	An area named after a cave. Elev.	ka-ana-	USGS 1963.

		about 6200 ft.	pa'akai. PEM: the salt cave.	
Keau*	Pu'u	Elev. about 6520 ft.	ke-au.	USGS 1967.
Keliuli Bay	Bay	Located 1/2 mile southeast of Pohue Bay.		USGS 1962
Keopuka	ʻili ʻāina	Named in claim by Keawe for a kihapai of kalo. Quad uncertain. [The description of Keawe's claim in NT and NR disagrees with LCAw 8776 to Keaweamahi as found in AB and IN.]	ke-ō-puka. PEM: the perforated sand.	NT 8:497.
Kilohana*	Boundary point	"on an aa flow where we used to catch birds and where Kahuku joins KeauhouThe Kona lands reached to the mauka edge of the woods from Kilohana along Kapapala to Pohaku Hanalei a hill on top of the mountain." Elev. 6800 ft.	kilohana. PEM: lookout point.	BCT 1:258; USGS 1967.
Kipuka Aiaka Alala*	Kīpuka	Between fingers of the undated "Alala Lava Flow." Elev. about 8000 ft.	kīpuka 'ai-a- ka-'alalā. PE: food-of-the- crow kīpuka.	USGS 1967
Kipuka Akala*	Kīpuka	In the 1926 lava flow. Elev. about 5300 ft.	kīpuka 'ākala. PEM: raspberry kīpuka.	USGS 1967
Kipuka Kalua o Kelii Waa*	Кīрика	In 1887 lava flow, between 1200 and 1440 ft. elev.		USGS 1962
Kipuka Kanohina*	Kīpuka	Along the west side of the ahupua`a, near the shore on old lava flows.	kīpuka kano- hina.	USGS 1962
Kipuka Kapau*	Kīpuka	A very small kīpuka, elev. 1840 to 1860 ft., "named for a man called Ka-pā`ū who lived here with his wife. A lava flow [in 1868] surrounded their house but left them alive." Misspelt Kipuka Pau on USGS 1962.	kīpuka ka- pā'ū.	PEM 113
Kipuka Kapulehu*	Kīpuka	A large area between fingers of the 1887 lava flow. Elev. about	kīpuka ka- pūlehu.	USGS 1962

		2360 ft.		
Kipuka Kekake*	Kīpuka	In the 1887 lava flow, below Mamalahoa Hwy, 1480 to 1900 ft. elev. "A donkey (kēkake) was saved here from a lava flow." (PEM).	kīpuka kēkake. PEM: donkey kīpuka.	USGS 1962; PEM 113.
Kipuka Kepunoi*	Кīрика	A small kīpuka in the 1887 lava flow. Elev. 2660 to 2800 ft.		USGS 1962
Kipuka Mamane*	Kīpuka	A small area between fingers of the 1887 lava flow. Elev. about 2360 ft.	kīpuka māmane. PE: mamane tree (Sophora chrysophylla) kīpuka.	USGS 1962
Kipuka Nene*	Kīpuka	Shown in two locations above Kaalaiki, one about 5900 ft. elev. and one about 6700 ft. Coordinates are of the upper kipuka. Coordinates of the lower kipuka are: N 141,000, E 453,000	kīpuka nēnē. PEM: goose kipuka.	USGS 1967
Kipuka Noa*	Kīpuka	Elev. about 4000 ft. in Hawaiian Ocean View Estates subdivision.	kīpuka noa. PEM: non- sacred kipuka.	USGS 1967
Kipuka Pahipa*	Kīpuka	Elev. about 5500 ft.	kīpuka pā- hipa. PEM: sheep-pen kipuka.	USGS 1967
Kipuka Pau*	Kīpuka	A very small kīpuka in the 1868 lava flow. Elev. 1840 to 1860 ft. See Kipuka Kapau.		USGS 1962
Kipuka Peehi*	Kīpuka	At the end of the 1916 lava flow. Elev. about 4800 ft.		USGS 1967
Kipuka Pele o Iki*	Kīpuka	Elev. about 5000 ft.	Perhaps kīpuka pele 'ōiki. PE: kīpuka [by the] narrow lava flow.	USGS 1967
Koaekea	ʻili ʻāina	Claim no. 10511 by Namale for his "apana aina ma Koaekea ili ma Kahuku" was not awarded.	Koa'e-kea. PEM: white tropic bird.	NT 8:495.

Komakawai*	Place	Ranch buildings in Kahuku near Komakawai Waterholes (385.19.012) and corner of Kealia, South Kona.		USGS 1960
Kukaeokaoha	ʻili ʻāina	Claim no. 10113 by Manae for his plot in `ili o Kukaeokaoha ma Kahuku ahupuaa" was denied.	NT 8:496.	
Kukuinui	ʻili ʻāina	Claim no. 10842:1 by Pau for a parcel in "ili o Kukuinui ma Kahuku" was not awarded.	kukui-nui. PE: large candlenut tree.	NT 8:472.
Kulauala*	ʻili ʻāina	Claim no. 7307 by Kuoi for a parcel in "ili o Kulauala ma Kahuku ahupuaa" was not awarded. "Where sweet potatoes used to be cultivated." (Alexander) Above the mauka corner of Pakini-nui & Pakini-iki in Kahuku. TMK 9201:2. Elev. about 2300 ft.	kula-'uala. PE: sweet potato field.	NT 8:497; Alexander ms:4.
Kulaula	ʻili ʻāina	Claim no. 8265:2 by Ioane for his "kihapai ma Kulaula ili ma Kahuku" was not awarded. Perhaps a misspelling of Kulauala	kula-'ula. PE: red plain.	NT 8:483.
Kumukaumaha*	Boundary point	Located at the corner of Kahuku/Kiao/Pakini-nui. Correctly called "Kaumukaumaha" (BC 85); also called "Kaulukaumaha" (BCT). Elev. 875 ft.		USGS 1962; BCT 1:395.
Kumukou*	Boundary point	Located at the head of Pakini-iki.	kumu-kou. PE: kou tree [Cordia subcordata] trunk.	BCT 1:391,392.
Lae Noio*	Point	Located between Kakio and Kahiola.	lae noio. PEM: tern point.	RM 1677.
Laula*	Pu'u	Elev. 6348 ft. on USGS 1925 7.5 laulā. PEM: C		Coulter 1935:44.
Lua Hohonu*	Crater	A small crater on the southwest	lua hohonu.	USGS 1966;

		rift of Mauna Loa, near the summit. Elev. 13,000 ft at rim, 12,901 ft on floor. This crater, which was examined by Wilkes in 1841, "is of the kind that I shall hereafter designate as a pitcrater"	PEM: deep pit.	Wilkes 1845(IV):158.
Lua Hou*	Pit crater	A prehistoric pit crater in the Kau Volcanic Series, on the southwest rift of Mauna Loa. Elev. 12,920 ft. at rim, 12,639 ft. on floor.	lua hou. PEM: new pit.	USGS 1966; Stearns & Macdonald 1946.
Lua Kalupenui*	Pit	A small pit near the east edge of the 1887 lava flow. Elev. about 1360 ft.		USGS 1962.
Lua Palalauhala*	Pit crater	The smallest of three pit craters at Kahuku Ranch, only 500 ft across. Elev. about 1920 ft at N rim, 1822 ft at bottom.	lua pala-lau- hala. PE: pit [of] pala-lau- hala [yellow as a pandanus leaf, said of the very old].	USGS 1962.
Lua Poai*	Pit crater	Elev. 1840 ft. at north rim, about 200 ft. deep and 1000 ft across.	lua pōʻai. PE: circular pit.	USGS 1962
Malino*	Heiau	"Described as located above Kaunakaumaha, near the boundary of Pakini-nui, and south of the Kona-Kau road." On USGS quad, elev. about 920 feet, northwest of "Kumukaumaha" boundary pt. at 875 ft. elev. on Kahuku/Kiao/Pakini-nui boundary.	malino. PEM: calm.	Stokes 1991:113; USGS 1962.
Namanuohaalou*	Boundary point	An area at the mauka edge of the woods; the name was given to the northeast corner of Waiohinu at the Kahuku boundary in BC 91 (elev. about 5700 ft.), called Keanaoumi elsewhere. On USGS 1967, "Na Manua Haalou" is the name of a swampy area below Kahuku in Kaalaiki, near the	nā-manu-o- haʻalo`u. The birds of Haʻaloʻu.	BC 91 (3:207); BCT 1:403; USGS 1967.

		Waiohinu corner. Coordinates		
		are of the boundary point.		
Niau	ʻīli ʻāina	Claim no. 10843 by Paele for a parcel in "ili o Niau ma Kahuku ahupuaa" was not awarded.	NT 8:496.	
One Hundred Acre*	Waterhole	One Hundred Acre Waterhole, elev. about 5630 ft.; above Honomalino, South Kona.		USGS 1962
Pahukapu	ʻili ʻāina	Claim no. 8776 by Keawe for "2 kihapai ma Pahukapu ma Kahuku ahupuaa" was not awarded.		NT 8:497
Pali o Ka Eo*	Pali	The source of the 1868 lava flow. Elev. 2600 to 2800 ft.	pali o ka 'eo. PEM: cliff of Ka'eo [a person?].	USGS 1962
Palikapuokahoalii*	Pali	Along the west rim of Mokuaweoweo, between South Pit and "Cone K" near the corner of Keauhou. Interrupted by "1949 Cone".	pali-kapu-o- kahoali'i. PE: sacred cliff of Kahoali'i.	RM 1264.
Papahaiau	ʻili ʻāina	Claim no. 9997 by Luamano for a parcel in "ili o Papahaiau ma Kahuku ahupuaa" was not awarded. Claim no. 9247 by Kaleo in "ili o Papalahaiau [sic] ma Kahuku ahupuaa" was not awarded.	papa-haiau.	NT 8:496.
Pohaku Hanalei*	pit crater	"There are two places on the mountain called Pohaku Hanalei, one is a rock on the northeast slope, the other is a crater on the south slopeabout south of Mokuaweoweo." (p.255) "Keauhou does not reach to Mokuaweoweo. Thence to Pohaku Hanalei a rock on the southern slope of the mountain, thence down to Puu Lonalona [378.40.181], a hill, along Kahuku." (p.449) A small pit crater in the Prehistoric Mauna	pōhaku hanalei. PEM: untranslated. [The story refers to a different location, in Puna.]	BCT 1:437,449, 2:255; Stearns & Macdonald 1946; USGS 1966.

		Loa Volcanic Series west of Lua Hou, elev. about 12760 ft. Formerly a boundary point between Kahuku and Kapapala (p.437,449) but now entirely within Kapapala. Cf. Pohakuohanalei.		
Pohaku-o- hanalei*	Pit crater	"Keaweehu, the bird catcher, who gave us the name of the terminal crater, as Mokuaweoweo, and of that south of it as Pohakuohanalei." (p.150) "The crater is of an oval shape; it is stratified, and seventy layers of basaltic rock were counted which have evidently been deposited by the overflow of the large crater [Mokuaweoweo]" (p.154) [This crater is now called "South PIt." Cf. Pohaku Hanalei, a small cone a mile to the southwest.]	pōhaku-o- hanalei. PE: the rock of Hanalei.	Wilkes 1845(IV):150,1 54
Pohue Bay*	Place and bay	Formerly a village; petroglyphs nearby (see Cox and Stasack, passim).	pōhue. PE: gourd.	USGS 1962; Cox and Stasack 1970.
Polewai*	Waterhole	Elev. about 6400 ft.		USGS 1963
Pookia*	Boundary point	"Robber's den, where the thieves used to cut off the victim's head." (Alexander) A place between Kumukou and Waiamahoe on Pakini-iki/Kahuku boundary, also written "Pookiia". (BCT) A boundary point on RM 2176 located at SW corner of Lot 31 (TMK 9304:por.4), 200 ft. east of NE corner of Pakini-iki. Elev. about 2220 ft.	po['o]-'okia. PE: head cut- off.	Alexander ms:4; RM 2176; BCT 1:391.
Pualinui*	Point	South side of Keliuli Bay.	Pūʻali-nui.	RM 1677
Pualoalo	`ili `āina	Claim no. 9995 by Laamaikahiki for a parcel in "ili o Pualoalo ma Kahuku ahupuaa" was denied.	pualoalo. PE: short for pua aloalo	NT 8:496.

			[Hibiscus	
			flower].	
Punaluu	Place	Ranch buildings above Punaluu,	Punalu'u	USGS 1967
Kahawai*		elev. 6167 ft.	kahawai.	
			Punaluu	
			stream.	
Puu Hilea*	Place	Along the mauka side of Hwy 11.	Pu'u hīlea. PE:	USGS 1962
		Elev. about 1960 ft.	careless hill.	
Puu	Cone	A littoral cone in the Prehistoric	Pu'u	USGS 1962;
Kahakahakea*		Kau Volcanic Series. Elev. 97 ft.	kahakaha-kea.	Stearns and
				Macdonald
				1946.
Puu Ki*	Cone	A littoral cone in the Prehistoric	Puʻu kī. PEM:	USGS 1962;
		Kau Volcanic Series. Elev. 145 ft.	ti plant hill.	Stearns and
		at triangulation station.		Macdonald
				1946.
Puu Kinikini*	Place	Above Punaluu, elev. about 6300	Puʻu kinikini.	USGS 1967
		ft.		
Puu Koae	ʻili ʻāina	Claim no. 8776 by Keawe for	Puʻu koaʻe.	NT
		"two kihapai kalo ma Puu	PEM: tropic	8:474,475,497
		Koaema Kahuku ahupuaa" was	bird hill.	
		not awarded. Claim no. 11007:3		
		by Wahine for "kihapai kalo ma		
		Puukoae ili no Kahuku ahupuaa"		
		was not awarded. Claims no.		
		8769 by Kepola, 9229 by Kaaua,		
		and 9248 by Ku (TMK		
		9201:por.1unlocated) are		
		probably under the 1868 lava		
		flow near Kahuku Ranch		
		headquarters.		
Puu Nanaia*	Hill	hill along Hwy 11 [a section now		USGS 1962
Puu o Kahuku*	Boundary	abandoned]. Elev. 2099 ft.	Puʻu o kahuku.	USGS 1063:
ruu o Nanuku	1	A boundary point at the upper	PE: hill of	USGS 1962;
	point	end of Pakini-nui, on "top of Puu o Kahuku hill" (BC 83) Elev.	Kahuku.	RM 2176; BC
		about 2280 ft.	naiiuku.	83 (3:177).
Puu o Kamaoa*	Knoll	Along makai side Hwy 11, elev.	Puʻu o	USGS 1962
		2005 ft.	kamā'oa. PE:	
			hill of	
			Kamā'oa.	

Puu o Keokeo*	Cone	A prehistoric cinder cone in the	Pu'u-o-	USGS 1967;
		Kau Volcanic Series. Elev. 6875 ft.	keʻokeʻo.	Stearns and
		The USGS quadrangle is named		Macdonald
		after this hill.		1946.
Puu o Lokuana*	Pu'u	"Hill of the heavy rain." A	Puʻu-o-loku-	Alexander
		prominent hill near the head of	ana. PE: hill of	ms:4; RM
		Pakini-nui, elev. about 2280 ft.	pouring rain.	2176; USGS
		Only RM 2176 shows a trig.		1962.
		station here. TMK 9201:2.		
Puu Ohohia*	Boundary	A prominent, prehistoric cone in	Puʻu ohohia.	USGS 1962;
	point	the Kau Volcanic Series with a	PE:	Stearns and
		deep crater. Elev. 5524 ft. at	enthusiastic	Macdonald
		survey station on southwest rim.	hill.	1946.
		The pu□u marks the southeast		
		corner of South Kona district.		
Puu Pohakuloa*	Pu'u	Elev. 6222 ft. Above Honokua,	Pu'u pōhaku-	USGS 1963
		South Kona.	loa. Long	
			stone hill.	
Puu Ulaula*	Cone	A littoral cone in the Prehistoric	Puʻu ʻulaʻula.	RM 1677;
		Kau Volcanic Series. Elev. over	PEM: red hill.	Stearns and
		120 ft. on USGS.		Macdonald
				1946.
Red Cone*	Cone	A prehistoric cinder cone in the		USGS 1966
		Kau Volcanic Series. Elev. 11,400		
		ft. on the southwest rift of		
		Mauna Loa.		
Sleeping Cave*	Cave	Along "Old Hawaiian Trail" on the		USGS 1966
		southwest rift zone of Mauna		
		Loa. Elev. about 9940 ft.		
South Pit*	Crater	A smaller pit crater containing		USGS 1966
		historic lava adjoining		
		Mokuaweoweo on the south.		
		Elev. 13,249 ft. at rim, 13,040 ft.		
		on floor. This crater was called		
		"Pohakuohanalei" (q.v.) by		
		Wilkes' guide, Keaweehu the		
		bird-catcher.		
Sulpher Cone*	Cone	A prehistoric cinder cone in the		USGS 1966
		Kau Volcanic Series. Elev. 11,329		
		ft. on the southwest rift of		
		Mauna Loa.		

Umi Caverns*	Cave	Numerous caves in vicinity of Alika Cone. Elev. between 7800 & 8000 ft. Named for the famous chief, □Umi, who is credited with the trail which passed through this area.		USGS 1967
Wahie	ʻili ʻāina	Claim no. 9750:3 by Kaikamahine wahie. PE: for a "kihapai kalo ma ka ili o firewood. Wahie ma ke ahupuaa o Kahuku" was not awarded.		NT 8:460
Waiahuli*	Waterhole	Elev. about 2430 ft.	wai-a-huli. PE: water of Huli.	USGS 1962
Waiakalou	ʻili ʻāina	Claim no. 10236:3 by Maeha for his "kihapai kalo ma Waiakalou ili ma Kahuku" was not awarded.		NT 8:489.
Waikoloa	Boundary point	"a pond mauka of the woods where Kahuku cuts Hileanui off" (p.420) Hileanui does not reach to Waikoloa, according to another witness (p.424) and BC 113. Quad uncertain.	wai-koloa. PEM: duck water.	BCT 1:420,421,424

Place names noted with an * are georeferenced on this map

Appendix B

Transcription of English Boundary Commission Testimonies for Kahuku, Kaʻū

The Ahupuaa of Kahuku District of Kau

Island of Hawaii 3rd J.C.

On this the Eleventh day of March AD 1873 the Commissioners of Boundaries for the 3rd J.C. Island of Hawaii met at the Court House Waiohinu Kau, pursuant to notice in Hawaiian Gazette of February 5th and Auokoa of February 6th 1873, and notice personally served on owners of adjoining lands as far as known, for the hearing of the application of Kahuku Ranch Co, for the settlement of the boundaries of Ahupuaa of Kahuku situated in the District of Kau, Island of Hawaii. Present G.W. Jones, L. Kaina, W.H. Reed, and C.E. Richardson on part of applicants. JG Hoapili for Crown Commissioners Her Excellency R Keelikolani, for Districts of Kona and Kau and Government Lands in Kona.

J Kauhane for Hawaiian Government WT Martin for self and leased land of Pakininui LR Macomber and others for self and J Kauhane for Kau Lands.

Petition read as follows:

Kahuku April 8th 1872 Hon. RA Lyman Hilo

Sir,

We wish to apply to you as the as the Boundary Commissioner for the Island of Hawaii for a settlement of the boundaries of the lands of Kahuku Kau, recently purchased by us.

As near as we can ascertain, the Lands adjoining Kahuku on the Kona side are:

Manuka		belong	ing to th	ie	Government
Kaulanamauna		"	11	11	II
Kapua		11	11	11	Governor of Hawaii
Okoe		"	11	"	Government
Honomalino		11	11	11	Crown
Omokaa		"	11	"	Government
Kalihi		11	11	11	II
Milolii		11	11	11	II
Wapueloa (?)		11	II	11	11
Anapuka		11	II .	"	II
Papa 1 st	"	11	II .	"	
Papa 2 nd		11	II .	"	Kaopua
Alika		11	II	11	Government
Kipahoehoe		11	11	11	II

Kaapuna belonging to Kahaulelio and the land of Keauhou in Kona, the owners of which are unable to give, but which we understand joins Kahuku on the top of the mountain. On the Kau side the lands adjoining Kahuku are:

Paakini Nui	owned	by	His Majesty			
Kao	"	ıı .	W.I Martin			
Pulena	11	11	WJ Martin and B Naihe			
Na Keaa	11	11	Governmentt			
	11		"			
Waiopaa Mohoai	11	11	П			
	11	11	п			
Pueo	11		Cavaman of Have:			
Kawela "			Governor of Hawaii			
Waiopua			L Macomber			
Kau			Government			
Napapohaku	"		"			
Keolakaa	"					
Waiohinu			Crown			
Hionaaa	"	"	Government			
Kalaiki	"	"	II			
Na Hilea	"	"	His Majesty			
Ninole	11	"	Government			
Wailau	11	"	П			
Punaluu	"	"	His Majesty			
Mohokea	11	11	Governor of Hawaii			
Moaula	11	II	Government			
Makaka 2 nd	"	II .	п			
Paanau	II .	"	Mrs Bishop			
Kauhuuhuola	11	11	JS Lyman			
Wailoa	11	"	"			
Keaiwa	"	11	п			
Kaalaala	II .	"	Government			
Kapapala	11	11	Crown			
Very Respectfully Yours						
(sig) Kahuku Ranch Co						
(318) National Nation Co						

Testimony

WJ Martin Sworn

I live at Waiohinu Kau Island of Hawaii, Have lived here twenty years, and am interested in a number of lands in Kau, they are Kiao owned by me, Manukaa and Kaulanamauna and Pakininui which I lease Keaa owned partly by me and partly by Government and Waiohinu leased from Crown Commissioner and Kiolaku ^{k.} Have leased the pulu privilege on Kaalaiki from the Government Land Agent Kauhane. Know the boundaries of Pakininui as pointed out. Two places were formerly pointed out to me one above the new road where an ohia tree is marked and one place makai same place as now showed me have heard a little about other places being the boundary but do not remember names. Have seen the boundaries of Kiao lately and have owned said land about six or seven years. It is held by Royal Patent to WC Shipmans L know a part of the boundaries but do not know the old names of corners; do not know all of

the boundaries as I was not there when the land was surveyed. I understand I Kupa, Kaanaana and Naihe owned land on Kiao by Royal Patent. Have heard of boundaries of Manukaa having leased and had charge of said land for about ten years, had men catching wild goats there. Have been told that the boundary at the beach is at a point called Kalaehumuhumu between Manukaa and Kahuku thence mauka to a place called Papale o Kamaiwa near the old road. I have not seen the place the boundary on the new road is at a place called Puuhileamakai of the road. Some men that were at work showed it to me. Mauka of said road is a large hole. Have heard the mauka boundary is at a place called Puulonalona have since hear that the boundary at the road is at Kahiawai heard this after the land was sold to Brown. Have since heard that the boundary is between Puuohilea and Kahiawai but do not remember then name of the place did not hear of the last named boundary in old times. Kamuaa k. and Keaka k. pointed out boundaries to me. Kauwaa k told me Manukaa was cut off by Keauhou and Kaalaala at Pahoehoepoha. Have heard within the last few days from Nauka k. about the boundaries of Keauhou. I do not know the boundaries of Manukaa. The only places I have been to on the boundaries are Puuohilea and Papaleokamaewa, Cannot say what part of the point at sea shore is called Kalaehumuhumu I have seen an advertisement by Keaka ma in the paper (I do not know what year it was printed) in which they mentioned a great many names of lands

Puuulaula a red hill, Kalaehumuhumu Pulonalona also a place at the road the name of which I forget Do not remember the names of the other places. I was Government Agent of the lands of Manukaa at the time it was leased to Keaka ma by the year. I have had conversations with Mr Jones about boundaries of lands and have told him the names of lands in Kona adjoining Kahuku. I think it was in the coffee shop at Waiohinu where the conversation took place. I can point out boundaries of Manukaa on the new road. Mess Spencer and Haley had an interest in Kahuku and Manukaa at the time the road was built.

CX^d By JG Hoapilli

Paakini and Kiao run in an Easterly direction.

Puhi ^{k.} pointed out to me the boundaries of Pakininui Kahuku and mauka boundaries of Kiao as surveyed by Alexander. I do not know whether the points he showed me are the ones surveyed or not.

CX^d Kauhane Questioner

When we went after shingles for the church a man now dead told me the mauka boundary of Kiolokaa between Kahuku and Kiolokaa was makai of lae aa makai of the koa woods, Lae aa was called Kapeleoike and was on the land of Kahuku Have heard the natives talking a great deal about the boundaries of lands within the last few days.

LR Macomber Sworn

I live on Kau in the District of Kau, First came into said place in the year 1853. As a witness Mr Jones has not talked to me in reference to the boundaries of Kau. I have lived on Kahuku some length of time and know some of the boundaries am a carpenter by trade and have been in the habit of going into the woods after timber. Went after shingles for the Mission House in 1854 and the natives told me the Koa woods were in Kahuku and the ohia woods were on Waiohinu. Kalakalohe k. was guide and showed me the boundary of Kahuku being School land it was necessary for us to get permission to go on it. I have been told that the lands of Kiolokaa, Napapohaku Puueo, Mohoai, Waiopua

Keaa, Pakininui and Puulena are all cut off in the lower part of the woods by Kahuku,

Waiohinu is the first land that runs clear through Koa woods. Have seen a tree near the lawa stream on a hill which was marked by Mr Alexander and makai of said tree another tree was marked and a bottle buried, There is a water hole at the corner of Keaa. The surveying party went due North to the woods surveying nearly a mile, near to Keaa or

Waiopua their kamaainas said such was the course till they should get out of the woods. Kumauna k. Poaeae Puhi perhaps and others were with Alexander Have seen a hill in the woods which was pointed out to me as the boundary of Puueo and Kahuku but do not know the name of the hill. Have had a water holecalled Waiokalala, situated on the old road pointed out to me as the boundary between Kahuku and Manukaa. I would know the place if I saw it as the natives have shown it to me a great many times.

A large rock at a point on the Kau side at Seashore is boundary of Manukaa. I think the name of the point is Kalaehumuhumu but have not been there. ^X Have always heard Kahuku joined Keauhou in Kona on the mountain and Kapapala on the other side. An old man at Olaa told me Kahuku Kapapala, Keauhou of Puna, and Waiakea all join at Makapana a round hill on the Hilo and Puna slope of Mauna Loa. Kenoi ^{k.} said the same. Have always heard that Kahuku cuts off all Kona lands until it joins Keauhou on the slope of Mauna Loa. I do not know the was said to boundaries, it _v contain over 300,000 acres. I worked for Rev Mr Kinney on Kahuku. he obtained the privilege of cutting timber from Mr Armstrong who was then Minister of Public Instruction.

CXd

Kalakalohe is still living. he pointed out the boundaries between Waiohinu and Kahuku. I know the mauka boundary of Pakininui it is on a hill near Kauluuala

Pakini has no woods. Kumauna k. and Poaeae k. have told me that Kahuku joined Keauhou on the mountain. Pakininui runs into the edge of the ferns and the boundary line from there to a water spring turns makai. Near said spring Keaa joins Waiopua and Kahuku the boundary being still inside of the fern thence it runs North. The lands Mohoai and Waiopua do not go into the woods, Puueo joins Kahuku and runs into the woods to a hill. Paapohaku then runs further in and joins Kahuku. Keolokaa (sic) runs into the woods farther still and is there cut off by Kahuku. Waiohinu runs to the Koa. said koa being in

groves above the ohia trees. Waiohinu is at mauka edge of ohia woods the boundary being a few scattering koa trees, Kalakalohe said Kahuku joined Kapapala, the old man told me of his own accord.

WJ Martin Recalled

I have never heard of any Ili aina in Kahuku at Sea shore but that Kahuku extends from Pakininui to Manukaa

Kumauna k. Sworn

I was born at Kahuku before Kamehameha 1st went to Maui, and before the building of the Peleleu canoes. My parents told me the boundaries of Kahuku, At night we used to go out and catch birds to eat and I asked them the boundaries as I did not wish to trespass on other lands, as we belonged on Kahuku. If people of other lands came onto Kahuku their birds and property were taken away from them and given to our chiefs. I know the land of Manukaa, and the boundary between said land and Kahuku; my Grand father told me; Kalaehumuhumu a ridge of stones at a point at the Sea shore is the boundary between Manukaa and Kahuku thence the boundary runs mauka to Pohakuloa, a large stone, thence mauka to Puainako, a resting place on the old road, thence mauka to Kaheawai

A swail runs from the beach up to this place and belongs to Manukaa. The boundary of Kahuku being on the upper edge towards Waiohinu, said boundary not reaching the swail until you get onto the new road, thence from Kaheawai to Kahonopu (a large rock) thence to a large hole or crater, with trees growing in it, called Puuohia, thence runs along the pali to a cave called Kumualii ^{1st} thence the boundary between Manukaa and Kahuku runs toward Kona to ana Ohialele (a cave where natives used to live) Kapua being on the makai side and Kahuku on the mauka side, above the woods on the pahoehoe, thence to a large hill named Puuelele, woods being on makai side of said hill Thence to Kumualii ^{2nd} a cave, where Kalahiki joins Kahuku, thence to Heiau of Kaakaiokaaha thence to a cave called Keauahua where Kahuku joins Keauhou. thence to Ahu a Umi thence to Maunalei on Mauna Loa where Kahuku joins Hamakua thence to Ohaikea on the Hilo slope where Kahuku joins Kaalaala and Kapapala. Have heard Keaka Nauka and another wish to put the boundary of Manukaa way into Kahuku and I have come to tell the true boundary and pali aku Boundary between Pakininui and Kahuku is at Kealakahewahewa. Kaumunala is at shore Kealakahewahewa is mauka thence to Puaahi (Note Witness asked to go to Kahuku and point out the boundaries, he is old and deaf, applicants request that as the old man seems tired and confused his testimony be taken at Kahuku on some other day, Thursday the 13th ______ to take the testimony at Kahuku.

Witness is a very old man and is tired and confused is unable to hear or answer the questions put to him)

Kamakana ^{k.} Sworn

I was born on Kahuku. Am kamaaina of the lands I am now living on lands this side of Kahuku was quite large large when they collected sandalwood My Great Grandparents Punoho and Nahea had charge of Kahuku and Kiao. Kumauna and Nauka told me the boundaries when I lived on Kahuku years ago.

Boundary as told me by them commences at Sea beach at a place called Kalaehumuhumu thence to Pohakuloa, a large rock, Thence to Puainako on the old road to Kona thence to Kahiawai a hollow this side of said hollow at the new Government road to Kona is where Kahuku joins Kahiawai thence to Kahonupu a hill thence to long rock called Pohakuloa. thence to a hill called Kahapaimamo thence to a hole or crater named Puuohookia where there are whirlwinds (Note I asked Nauka what lands are here, he told me it was the mauka boundary of Manukaa) this is mauka of the koa woods, on the pahoehoe, thence to Kumualii, a cave, thence to a hill, thence to cave of Ohialele, where the natives used to sleep, said cave is mauka of Honomalino. This is as far as I went with Kumauna and Nauka. they showed me the boundaries to said cave and told me Kahuku went clear to Keauhou We always used to take goats off of the mountain they and this cave of Ohialele, without opposition from anyone I went with Alexander when he surveyed the boundary of Pakini, Commencing at piles of rocks (do not know the name of the rocks) at Kaumuuala at the sea shore, thence to Puualii a small hill thence to Kaulukaumaha, a pile of rocks, said to be makai boundary of Kiao, thence I do not know the boundary until you get to Kilohana, a pile of rocks thence toward a pali said pali a small one at the end of Kiao.

From Pau's house the line runs mauka through Kaoma and Uaala covered by lava. thence to Hoolananialia a water hole between Pakini and Kahuku thence to Pukii a ridge, with stumps of ohia trees on it thence toward Kilauea Kahuku being mauka and Pakininui and Pakiniike makai to an ohia tree marked X thence to Pokia a water hole situated in a hollow. Near this place Pakininui Pakiniike and Kiaa join Kahuku thence to a pile of rocks thence to an ohia tree marked X this is as far as I went with the surveying party. Kumauna was the kamaaina, Naihe (Kuawaa now in Honolulu) Namaka and others were with us.

Mr Jones has not had any conversation with me in regard to the boundaries of Kahuku or urged me to say anything for his benefit. We had a talk on the subject soon after he came to Kau to live but not since that time.

 CX^d

Kumauna and Nauka told me the boundaries of Kahuku from the shore of Manukaa to Ohialele is Honomalino (Note that is what I have testified too today and the same as to the East side of Kahuku (I can go and point these boundaries if you wish Ohialele is mauka of Honomalino, not of Kapua Manukaa is not very wide before you come to the land Kaulanamauna, Nauka k. told me Kaulanamauna joins Honomalino in the koa woods, cutting off Kapua and joining with Kahuku at Ohialele.

Note Kona witnesses having come a long way are now to be brought in and testify to Kona boundaries the Kau boundaries to be taken up afterwards.

Nauka k. Sworn (SEE CONFESSION BELOW)

I was born at Kalihi in South Kona at the time of Kauhiholua, and after the building of the Peleleu canoes. Kaanalohe k. and Kakoo k. a son of his, both guides on the mountain, pointed out and told me the boundaries of Kahuku at the time I used to go on the mountain with them. (Note Witness kept saying he came to testify for his Haku pointing to WJ Martin, Was asked who his Haku was? and replied WJ Martin sent for me)

Commencing at the seashore the boundary between Manukaa and Kahuku is at a place called Kalaehumuhumu. thence to Puuulaula a red hill on the pahoehoe, thence to Kaoma a lae aa thence to Halepulekahiko, thence to Papalekumaiwa, makai of the old Government road, thence to Kamoku-limu, a cave of water on the mauka side of the new

Government road, thence to Haawikiwiki a point of trees (lae laau) thence to Hinaawaawa, a hollow on the Kau side of a hill called Puuolonolono thence between two hills thence the boundary runs between two hills called Puukuloa one hill being on Manukaa and the other on Kahuku. Thence to Kapoalaala a brittle shiny lava which breaks through when stepped on. Here Manuka and Kahuku end. The uwao all belonged to Kahuku, save a few in the woods which belonged to Manukaa, the geese all belonged to Kahuku Kaalaala of Kau cuts off Manukaa and Kahuku, and joins Keauhou of Kona. The pahoehoe near the edge of the woods, on the kau side of Kapeleoike, is the boundary of Kahuku and Kaalaala. Question. Do you solemnly swear that the above statement is true, that the pahoehoe near the woods on the Kau side of Kapeleoike is the boundary of Kahuku and Kaalaala? Witness would not answer the question but avoiding it kept on telling about other boundaries, after being warned several times he was fined for Contempt of Court.

Kapeleoike is an old lava stream from the top of the mountain into the woods and is the boundary of Waiohinu. Kaalaala cuts off Kahuku and Manukaa at the shiny pahoehoe. Just above the woods Waiohinu is cut off by Kaalaala and not by Kahuku. Puuhoohia is the boundary between Kaulanamauna and Manukaa said place belongs to Manukaa, Kahuku is cut off on the Kona side by Manukaa. The pahoehoe called Kaalohi is the mauka boundary of Kahuku and Kaalaala runs along said pahoehoe and cuts off Kahuku. Kapapala, Hilea or Punaluu do not come near Kahuku. Waiohinu cuts off Kahuku on the Kau side at Kahoolio on Kapeleoike at a large rock called Kapalio near the upper edge of woods. Half of the Peleoike running into the woods belongs to Waiohinu and half to Kahuku. This is in the koa woods, from there I have not come down on the boundary and do not know the boundaries makai have been there many time.

I do not know the boundaries of Pakininui.

 $\mathbf{C}\mathbf{X}^{d}$

I do not know about Pakini joining Kahuku, know nothing about boundary between Kiaa and Kahuku or about the boundary of Puueo. Know the boundary between Waiohinu and Kahuku but do not know what is the next land on Kona side of Waiohinu toward Kahuku. Kiolokaa is the next land to Waiohinu but does not touch Kahuku at all. Pakini joins Kahuku on the makai edge of the woods Puuehu is the next land to Kiolokaa and does not touch Kahuku.

The land of Puueo does not touch Kahuku. Mohoai cuts off Puueo the latter place running away into the woods.

(Note Witness swears to this statement)

Kahuku cuts off all these lands Puueo, Pakini &c clear to Waiohinu. Kaalaala cuts off Hilea above the woods on the pahoehoe.

Keaka told me to come and give correct evidence as to boundaries between Manukaa and Kahuku, he said Martin sent for me. Had some conversation with Martin in regards to boundaries but no one has told me what to say. (I stated about Kaalaala cutting off all Kau lands clear to Manukaa of my own knowledge. I lived on Manukaa during Kamehameha 1st reign at the time of Kuewaioka Lae, and was old enough to cook food at that time.

Know the boundaries above the woods but not in the woods. Know Kamakana ^{k.} having lived on Manukaa with him, but never went with him or showed him any boundaries. Know a place called Peahi on Kahuku in the center of the pahoehoe mauka of the koa forest. The hapu is very large there. There is a grove of koa trees Kau side of this place but no water in the vicinity. Halepohaha is makai of this place toward Kona, Halepohaku o Umi is at that place. Puainako is a place on this side of the old road to Kona this side of Kahiawai, an awaawa in the center of Manukaa the only place called Pohakuloa is an Ahua pohaku near (a good ways from) the shore, mauka of Puuopele two large hills on shore way in the land of Manukaa.

Another place called Pohakuloa is a large rock in the centre of Manukaa, Mauka loa, a puu mauka of that is called Hapaimamo. Said place taking its name from the color of the earth and stones being like to the yellow feathers of the Oo and the black feathers of the mamo bird, like on amakihi iiwi.

(I have never made any different statement than the above Keauhou comes across mauka of Honomalino and joins Manukaa cutting off Kapua in the woods Kaulanamauna runs to the cave Kumualii above the woods cut off by Honomalino and Manukaa. Puukeokeo is at the shiny lava on the boundary between Keauhou, Manukaa and Kaalaala, thence Keauhou and Kaalaala run to a large red hill called Puuulaula near Mauna Loa half way up the mountain on the Kona side there is a high ridge of stones running up the mountain Kaalaala is on one side of this ridge and Keauhou is on the other side. I do not know the boundary between Kapapala and Kaalaala. Kaohe from Hamakua runs over Mauna Kea, across the plain and joins Kaalaala, half way up Mauna Loa. Kaohe and Humuula run across and up Mauna Loa cutting off Keauhou and Kaalaala at Kualapa.

I used to go after uwao and my Kupuna showed me the boundaries of Kaohe and Humuula on the side of Mauna Loa up to Mokuweoweo. Mauna Loa has a large pond of water at the top of it called Waiau. (Note Witness swears this pond is on Mauna Loa at junction of Humuula and Kaohe at Pohakuhanalei, a large rock near Mokuweoweo at which you can stand and see the crater).

I have never been on Mauna Kea and do not know anything about Kamekoa Exploring Expedition have been on the top of Mauna Loa twice, with my Father, Ahukumakahi ^k once before Ahulau okole hi and once since then. There is a large water hole on the Kau side of the crater I was born at the time of Kauheeholua they had around the Island. Kala___ni in Kohala and Kanihokawala at Manukaa, before Kalaiana o ke Kiamoku at Honaunau. I was old enough to cook food at the time of the building of Kiholo.

Keakaokawai k. Sworn

I was born at Kaawaloa shortly before Kamehameha 1st death and now live at Hokukano North Kona I know parts of the boundaries of Kahuku Manukaa and Honomalino. Keauhou of Kona runs up to Mokuaweoweo. Kapaala comes to the crater on the other side. Humuula and Kaohe join Keauhou at Puukulua on the plain between Mauna Kea and Mauna Loa. Humuula comes up the side of the mountain below Pohakuhanalei this rock is along way from Mokuaweoweo, Kapapala comes near to this rock. Pohakuhanalei said rock was lost sight of during the earthquake time, there is a hill there now. I have been up there catching goats since the change made by the earthquake which was in 1868. Kahuku comes to this place. The steam first showed itself up there and afterwards the lava flowed out in the woods of Kahuku. A new crater makai of Pohakuhanalei is on the boundary between Kahuku and Keauhou. Kaulanamauna is cut off by Keauhou, do not know the name of the place, it is a long distance up the mountain from Puupuewai to Kahuku boundary. Kuluahi my Father showed me the boundaries between Kahuku and Keauhou when we were up in the mountain. Honomalino does not join Kahuku.

Keauhou is the only land in Kona that does join it.

The mauka boundary of Manukaa joining Keauhou at a grove of Koa and Mamani trees a short distance above the koa woods at a cave called Kanupa where natives used to sleep thence follows up a ridge of aa to the hill where Pohakuhanalei used to be.

(I have not seen Halepohaha but have heard that it is on Kahuku. The water on Mauna Loa is in a crack near Mokuaweoweo and is always frozen over said crack is on the Kona side of the crater.

My Father told us Kapapala was on the other side of the crater. Mila Ela missionary at Kaawaloa went up with us Keiki and Polepe afterwards lived on the mountain. This was the first time I went up.

The lands of Kealakekua, Kaawaloa, Kahauloa, Onouli, Honaunau, Keaha, Honokua, and Kaohe, all are cut off by Keauhou.

I went up to Kaulanamauna with my Father and he and he pointed out the mauka boundaries of Manukaa and Kahuku joining Keauhou, thence the boundary between Kahuku and Keauhou runs up a

ridge of the mountain, we were after birds at that time and I have never been there since. I know the boundary well up toward Pohakuhanalei but cannot tell where it is near the woods.

My Father lived at Waimea, a good while, and when we went into the mountain he pointed out the boundary of Kaohe Humuula &c. I have said that Kahuku and Kapapala join at the new crater below Pohakuhanalei. The sides of this new crater look as though they were made of brick. it is at a place where there used to be a hill called Pohakea, but is now a deep crater, From thence Keauhou and Kapapala run up to the crater Mokuaweoweo on the top of Mauna Loa Have never heard Kaalaala of Kau joining Keauhou and cutting off Kahuku neither of Kaalaala joining Kahuku and Keauhou, at the new crater but that Kahuku joins these lands at this place and that Kapapala and Keauhou run from thence to Mokuaweoweo.

Witness has been quite sick for several days, is tired and requires rest. Court adjourned till 12th inst as it is now Eleven Oclock at night.

(Sig) RA Lyman B.C. 3rd J.C. Waiohinu March 12th 1873.

Boundary Commission met according to adjournment from the 11th inst; Nine Oclock a.m.

Nauka k. His Confession

All the testimony I gave yesterday is untrue. I make this statement, that I may correct what I said.

The boundary at Kalaehumuhumu is correct, but all the testimony I gave in reference to the boundaries between Manukaa and Kahuku is false, and also what I stated in reference to the boundaries between Kaalaala and Kahuku and between Waiohinu and Kahuku is untrue.

I solemnly swear that this statement is true and that that the one I made yesterday is false.

Keaka ^{k.} is the person that told me to come here, but all that I said was of my own free will no one tried to influence me, and I have now asked a hearing that I might confess and do away with my fault.

(Note) Nauka k. A witness of yesterday having asked a hearing; it was granted by the Commissioner.

P Naihe k. Sworn

(I was born at Kohala came to Kahuku in 1847 and have resided on Pakini on Kahuku most of the time since. I have been in the habit of catching wild goats on Kahuku. Keaka k. was my first kamaaina and pointed out the boundaries to me. we lived at a place called Puueo and first went after goats on the pahoehoe called Kauiania, on Kahuku. Keaka said a place called Kamailoania, beyond Puainako belonged to Kahuku. Kaheawai was on Kahuku, but if the wild goats went beyond the awaawa of Kaheawai we had to let them go as beyond that was on the land of Manukaa Keaka Kila and others were

with me at Halepohaha catching goats we used to go as far as Puulonolono and Kapuhonu but beyond that they said the goats belonged to Manukaa. On the side toward Kona we used to go makai of Puuohoohia Kila k. who was kamaaina there said that the land below the koa grove called Kaewa, belonged to Manukaa; At another time we went to Kumualii cave and slept there all night In the morning we went as far as Ohialele, after goats they said it was on Kahuku. We could look down Palilua in Kona from there. Keaka at that time lived on Kahuku he moved onto Manukaa since 1860. We used to go after goats when the Board of Education owned Kahuku and also when Mr Harris owned it. Have heard that Keaka advertised changing the boundaries of Kahuku after he had moved to Manukaa. The boundary between Paakini and Kahuku at Sea shore on the east side of Kahuku is between Kaunueaea and Palaki is on Kahuku, a pile of stones marked the line thence to Kaulukaumaha where a pile of stones marks the boundary.

There are piles of stones on the line between Kaulukaumaha and the shore outside of Punaluu Pakini ceases at Kaulukaumaka and Kiao joins Kahuku. Kapuahi (now dead) pointed out these places as boundaries, when Mr Alexander surveyed the Kahuku line from shore. I was one of Mr Alexanders men. Know where Pau lives on Kiao. Pakininui joins Kahuku again near this point and Kiao ends. I cannot show the exact place. Thence to Puuokahuku where there is a blazed tree. Did not go to this hill at the time the tree was marked. I know Puuokahuku is the mauka boundary of Pakininui. Thence to an ohia tree on the boundary of Pakininui –Pakiniike and Na Keaa these lands all join here; thence the boundary runs to puna wai Kipukamanienie thence to an ahu makai of the land Waiaholua. Kumauna k. was the kamaaina who pointed out these boundaries to Mr. Alexander when we went to Ohialele, we had told him the boundary of Kahuku went to Ahu-a-Umi We used to go after goats on the Kau side of Kahuku and were told Waiohinu was makai of Kapeleoike we went after the goats on the pahoehoe which was said to belong to Kahuku, said pahoehoe being above Punaluu and Moaula. Was told the woods belonged to other lands. Have been to aa Poohina heard that Kapapala and Kaalaala join Kahuku there.

Naholo ^{k.} of Naalehu was the kamaaina there, he told me Waiohinu went to koakuukahi and above that was Kahuku. I work for WJ Martin.

 CX^{d}

If goats ran below Kahipa near Puulonolono below the Koa groves they were on Manukaa and the same way, going to Kumualii and Ohialele.

Kahuku extends nearly to the woods and I have always heard that Puukeokeo belongs to Kahuku.

The kamaainas told me all South Kona lands were cut off by Kahuku. Kumaunas son and Kila now dead showed me the boundaries. I do not know whether Kaiwikalaea ^{k.} is dead or not. The Koa woods mauka of Kapeleoike belong to Kahuku and those makai to Waiohinu. Have heard that Ohaikea, where natives used to live, is on Kahuku and that below that place the land belongs to Kapapala. I do not know what lands join on the Hamakua side.

CX^d by Kauhane

I first went after goats when Mr Armstrong had charge of the land, and have been in the habit of going every year since. We used to go in gangs of eight or ten Have been to Ahu o Umi and Umi road. Said road crosses Kapapala, from there you can look down on Punaluu. it is way above the woods. Was told the woods belong to Waiohinu. we went where we could see the aa poohina, but did not go to it. Have been with Kenao k., after goats, a few times. Went with him on Pakininui boundary when it was surveyed. Went near enough to aa poohina to see dry trees, but was several miles off from it. The Heiau of Umi is at Halepohaha on Umi road, know Ahu-o Umi in Kau toward Kapapala also the famous one in Kona.

LR Macomber wishing to correct a name of a place that he gave yesterday is allowed a hearing. Says there is a waterhole near a hollow, said hole was called by me Waiakalala, the real name is Kaheawai, it is near the boundary of Manukaa and Kahuku.

Kenao ^{k.} Sworn

I was born on Kahuku and lived there until I was 19 years of age. since then I have lived in Honolulu Twenty one years. Kahikilaue my Father (now dead) told me my age. My older brother Kaaua, Kila Kaleo and Kalua showed me boundaries when we went to catch wild goats. they showed me the boundaries between Kahuku and Manukaa.

I had to start the goats for them as I was a boy.

Kalaehumuhumu is the boundary on the old road at shore. Thence the boundary runs to Pohaku-loa to Puainako, thence to Kahiawai an awaawa on Manukaa this side of said awaawa is Kahuku thence the boundary runs to Kahonopu a hill thence to Puuohaihia from thence the boundary turns toward Kona and runs to Kumualii a cave in a grove of trees. Thence to Ohialele a cave Kahuku being mauka and Kona lands makai of said cave, which is situated in a grove of small trees. Thence the boundary runs to Puueleele. Was not told the exact spot called Puueleele, we slept at Ohialele and went after goats to Puueleele as they said our goats were at that place, then the boundary runs to Kumualii a cave. Thence to Kakaiokaaha a heiau and stone houses. Thence to Keanaohua, a cave, I went as far as this place and could come back in a day to Ohia-lele by cutting across the land. I do not know what land in Kona, cuts off Kahuku, have heard that Kahuku runs to Ahuaumi. Keanaohua is some distance above the woods between the woods and the mountain. I do not know the boundaries of lands on the top of the mountain or what land joins Kahuku, Have never been on the Kilauea side of the land above the woods, and do not know the boundaries there. Kapualei pointed pointed out the boundaries between Kahuku and Pakininui, to me at the time Alexander surveyed it. The boundaries I have told are the ones that were told and pointed out to me. Before I went to Honolulu. Do not think I could point out these boundaries now, as it is a long time since I have seen them.

CX^d

The goats run all over the land, and so we used to go to all these places after them. Kahonopu is in the middle of the woods at Puuohoohia. at this place the trees are very small. We used to chase the goats even when they went on to Kona lands, we did not go near Ahuaumi.

LE Swain Sworn

I have lived at Waiohinu Kau for the last ten years, I am Kaamaaina on part of Kahuku having lived there over three years catching wild goats and picking pulu. We used to catch goats on the mountain and also toward the shore near the Manukaa boundary. I saw the plot of Lower part of Kahuku boundary between Manukaa and Kahuku was at Puupele on seashore toward Kona and runs straight up through the road awaawa. Keaka told me the boundary at shore was at a small hill on Kona side called Kalaehumuhumu and runs up to large awaawa at the Government road. Charley Spencer also pointed out this same awaawa to me the first time I went to Kona and told me it was the boundary of Kahuku and Manukaa. It is the largest awaawa from Kahuku pali to Manukaa houses and is on the old road, I do not know the name of it. When I was picking pulu on Papa and Honomalino in Kona in the years 1869 and 1870 Nauka told me Kahuku joined Honomalino just above the woods. I asked as I wished to catch goats on the mountain, but he said the mountain belonged to Kahuku and that Manukaa did not run onto the mountain or have any goats there. I also had some conversation with Malaihi about it. I went as far as Waiahiki it is just above the woods on the land of Manukaa. I have always heard that Kahuku cuts off all Kona lands, and at the boundary of Keauhou there is quite a large pile of rocks.

Kaiwi and Naihe told me about boundaries at this point Kaiwi said he had seen the place and Kumauna was the one who told him it was the boundary.

After Keaka left my employ he said the boundary of Manukaa was about two or three miles this side of where he pointed it out while with me, He moved onto Manukaa and put a notice in the papers about the boundaries. The Browns when they owned Kahuku depended on the plan of lower part of land as surveyed by Alexander, for their boundaries I have seen the ohia tree in the woods which is marked I understood it was the boundary between Puueo and Kahuku I do not know the boundary between Kahuku and Waiohinu Kalakalohe said all the koa woods belonged to Kahuku. I do not know the boundaries on Kapapala side.

$\boldsymbol{C}\boldsymbol{X}^{d}$

The first time I heard that Kaalaala was a large land was the time goat thieves were taken up. Had always heard before that it was on alanui i hele kii manu. Puhi Kaiwe and perhaps Naihe, told me about Ahu pohaku at junction of Keauhou. Timoteo was one who also told me, he is now in Honolulu.

Kalakalohe k. Sworn

I was born in Waiohinu at the time of the Peleleu, and know the boundaries of Kahuku between Waiohinu and Kiolokaa. There is a lava flow called Kapeleoike that runs into the middle of the woods, Kiolokaa runs as far as this flow but the lava and Koa woods mauka are on Kahuku. There is a pile of stones on the lower edge of the flow which is the mauka boundary of Kiolokaa. the principal part of the koa woods belong to Kahuku. Waiohinu takes in a few koa trees mauka of Peleoike Kahuku runs toward Kilauea mauka of the woods and Waiohinu takes the woods. Kapeleoike is the boundary between Waiohinu and Kahuku until you reach the land of Kaalaiki. Namanu o Haalou is the name of the lae ohia on Kaalaiki where Waiohinu is cut off by Kaalaiki. I do not know anything about any of the rest of the boundaries of Kahuku from my own personal knowledge. The boundaries I have told you were pointed out to me by my parents when we went after birds. (In old times all birds above the woods belonged to Kahuku and if we were caught going after them, Kahuku people would take them away from us.

 CX^d

The sandal wood growing on the aa belongs to Kahuku the scattering trees in the woods to Waiohinu.

Haupu ^{k.} Sworn

I was born at Waiohinu about two years after Ahulau Oku. I know the boundaries between Waiohinu and Kahuku. I now live at the former place.

When we used to go after sandal wood the old people pointed out the boundary at Peleoike; makai of Peleoike is Waiohinu and mauka is Kahuku, there are a few scattering koa trees, on the boundary.

Ahu pohaku, is at the mauka boundary of Kiolokaa, thence Waiohinu takes the woods and Kapeleioke is the boundary between said land and Kahuku until you reach the land of Kaalaiki Na manu o Haalou is the name of the ohia grove, which is on Kaalaiki.

Kahuku land runs along this boundary on the outside of the woods. I do not know other boundaries of Kahuku.

 CX^d

J Kaonohi ^{k.} Sworn

I live at Keaiwa and am a kamaaina of that land was born in Hilo two years after Ahulau Oku. Moved to Kau when a boy and have lived here ever since. My parents showed me boundaries; my Father died when I was quite young. When Kamehameha 1st was Kue wai ma ka lai five of us ran away into the woods. Kaoowaa ^{k.} who was very young at the time went with us, I have never been on the mountain since. We went to catch birds, and staid (sic) on the mountain one and a half months. Heard that Kamehameha had departed and then came down we went after uwau.

At aapoohina Kahuku is on the left side of the aa facing the mountain and Makaka is on the Puna side. Have not been told where the mauka boundary of Makaka is my brother pointed out the boundary of

Kahuku to me near the woods but he did not show me the upper boundary of Makaka. I do not know where Kaalaala joins Kahuku have heard Makaka runs a good way up the mountain.

 CX^d

I, with others have leased Makakauka.

(Mr Kauhane states that Makaka, as far mauka as the koa woods is leased to himself and others but that they have no right above the koa)

Kaowaa ^{k.} Sworn

I was born at Hilea about the time of Hulupii and of Kuiwai ma ka Lae I ran away into the mountain with my parents and Kaonohi's parents. Apart of the time we staid at Waipaki and then at Puuloa on Maka now live at Moaula. Kaopu and Makaka join below the woods, Kahuku comes to aapohina mauka of Ninole. Ninole goes to the upper edge of the woods and is there cut off by Kahuku. Makaka comes to aapohina and is cut off by Kaalaala at the pahoehoe.

I have never been on the mountain since the time we ran away. Do not know the boundaries of Kahuku beyond this point. Have heard that the land on this side of the mountain, beyond aapoohina towards Kilauea, is Kahuku and on the other side Kaalaala.

 CX^d

Note

J Kauhane Government agent declines to examine witness as he was much too young when on the mountain to learn anything of the boundaries of the lands; but agrees to the boundaries of Manukaa as given by Kamakana ma and to boundaries of Pakininui.

Commission adjourned. To meet at Kahuku on the 13th inst at nine Oclock a.m.

Kahuku March 13th 1873

Boundary Commission met according to adjournment

Kumauna ^{k.} States Kaomao a pile of stones on the boundary between Pakininui and Kahuku is near Pau's house. Kaoma an ili of Pulena joins Kahuku thence the boundary runs to Puuike, a hill on the mauka boundary of Pakininui. Pakiniike joins Kahuku, the boundary running a little towards shore thence towards Kau cutting off Na Keaas Waiopua a kuaiwi where the natives used to mahiai was formerly the boundary thence the boundary runs in the ferns below the woods cutting off Mohoai Thence joining Puueo at an ohia tree in the edge of the woods thence toward the mountain in the woods, Kaleleau he kualapa is the boundary of Puueo, thence to Kapele, Waiohinu makai and Kahuku mauka ^runs along above

the woods, to Kaalaiki trees growing on the pahoehoe belong to Kahuku and the woods at a Poohina to Kaalaiki. Thence the boundary runs to Makaka, a land which runs further mauka than Kaalaiki and joins said land thence to Kaalaala which runs through the woods and pahoehoe to Kahuku. a heiau which was built by a Hilo Chief is on the boundary of Kaalaala where it is cut off by the land of Kahuku. said heiau is called Kakaiokaaha thence to Kapapala the pili belonging to Kapapala and the aa to Kahuku thence the boundary runs up the mountain to Mokuaweoweo, the crater being on Kapapala. I do not know the boundaries of Hamakua Kapapala and Kahuku.

From mauka boundary of Manukaa Kahuku cuts off all the Kona lands above the woods to a cave called Ohialele and to Puueleele, Kapuna comes near this hill, thence to Kumualii a sleeping place. Kalahiki is makai of said place, in the woods, thence to heiau Kakaiokaaha (he heiau no Umi) the place there is called Kaalaehu, where the people used to go down after food and water thence to Keanahua, and a little beyond this place Keauhou joins Kahuku, thence the boundary between Keauhou and Kahuku runs mauka to Ahuaumi thence to (Maunalei) or a large rock called Pohakuhanalei.

I have been told by my Grandparents that Kahuku extends to Ahuaumi. Have been as far as Kaanahua but could not see Ahuaumi from that place.

Hooupu told me these boundaries he said Pohakuhana-lei was the mauka boundary of Kahuku

Nauka k. was very young at the time of Kue wai o ka Lae, he has never been with me on the mountain.

Kamakana, and my children, have been frequently with me, and I have told them the boundaries Kanahua is a small cave where we used to camp situated on the pahoehoe and aa nearer the woods than the mountain.

The sea bounds Kahuku on the makai side and the land had ancient fishing rights. the cave Kauupa is between Puulonolono Puukeokeo and Pohaha on the aa, a hill called Hapaimamo is on Kahuku and the boundary between Kapuhonu, and Puu[h]ohia runs makai of this hill. I am an old canoe maker.

 CX^d

Kahuku is an Ahupuaa Kau Hawaii. I am a kamaaina of Kau and used to follow the bird catchers the children of Hooupu told me the boundaries Kaneakakaiuli ^{k.} used to go into the mountains with his Father. Keawekoa was husband to Kaaheiea, daughter of Kaneakakaina ^{k.} parents of my wife Ohuki k. was one of the old kamaainas Kumualii 2nd is where the Hamakua natives had the fight, when they came onto Kahuku after birds.

In ancient days the people of Kahuku did not go fishing, but were after birds of all kinds to eat and this is the reason all the land on the mountain belonged to Kahuku, my Mokuhonoai and others always took their weapons with them as they used to have fights, when they found people from other lands catching birds. The sandal wood belonged to Kahuku there was none in Kona except on Kapua, and when the other Kona people came on Kahuku after it the Kahuku people would take it away. Kaalaala had scattering koa had large koa on it Kapua and Honomalino are makai of Ohialele Puueleele is a small hill, I do not know for certain what land is makai of it, Have heard Papa and Opuloa are. It is not far from the

woods or from Kamualii 2nd (small cave). From this point you can ee the sea breaking on the points of Kalahiki and along the sea shore. I do not know the name of the land joining Kahuku at this place. Kakaiokaaha heiau o Umi on the road to Kona Kaala o Ehu a small heiau there are many stone houses there but I do not know the name of the place or land. Went down the canoe road to Hokukano. Puuohau is at the seashore Kau side of Hokukano. From heiau Kakaiakaaha the boundary runs to Kaanaohua, the small _ave lands adjoining are Kuamo or Lopeleke perhaps, they are not very far from the woods, thence to Keauhou boundary thence to:

Ahuaumi; I have not been as far as this place my Mokuhonoai pointed it out, towards Hualalai. I do not know the ano of the place. Have heard Kahuku is cut off by Hamakua and Waimea, Kahuku Kapapala, Hamakua and Waimea take the whole of Mauna Loa. Have only heard of one Ahuaumi above Kona. There are hale o Umi at Halepohaha, also a large number of them at the heiau, have not heard of any Ahu o Umi or Kauhale o Umi near Pohakuhanalei (Note Witness is old deaf and feeble suffering with asthma and has to rest frequently)

Cxd By Kauhane.

Kakaiokaaha on the boundary of Kaalaala and Kahuku is a small heiau on the pahoehoe above the woods, one of the stories of ancient days is, that a Chief got a great many birds on an ohia tree and carried it from the heiau Kakaiokaaha to Puulonolono, Kahuku Kaalaala and Kapapala join there, Kapapala goes to the top of the mountain. Ohaikea is on Kapapala, Makaka is in the woods and Kahuku on the pahoehoe. there are some koa trees on Kaalaala and Makaka, the latter land and

Kaalaiki join Kahuku on apoohina

C Hall Sworn (Witness JG Hoapili)

I live at Kainaliu Kona akau have lived on these Islands over forty years. Sometime in Hilo but most of the time in Kona. Know the land of Keauhou in Kona, I have often gone onto the plains above the woods and have come across from Kona to Kau twice above the woods, It was a long time ago. Came up through the woods to Hale o-Umi and looked at it, it was about eight or ten miles above the woods, but was covered up by the lava flow of 1845 or thereabouts, from there I went to Ahuaumi, up above here, slept there in a crack of the Pahoehoe. (The Father of Keakaokawai ^{k.} was my kamaaina.) From there we came to the Bay.

I think HaleoUmi is mauka of Kipahoehoe the distance between this and Ahuaumi is a bout fifteen or eighteen miles. Hale o Umi is on Keauhou heard that Ahuaumi is on the boundary of Kona and Kau about nine or ten miles from here.

Kini was my kamaaina the second time I came a across. Keakaokawai's Father piloted me all over Mauna Loa and Kea. One Ahuaumi is near Hualalai, (2nd Ahuaumi) he told me Kahuku and Keauhou ran straight up Mauna Loa following a ridge all the way. I have heard that Ahuaumi near Hualalai is on Keauhou.

Keauhou runs over to Puanahululu and meets Kaohe and Humuula thence runs up the mountain with Humuula, on the Hilo slope, to Pohakuhanalei.

Different Kamaainas have pointed out these different places. Kuahine of Puako and others showed me these places, the Father of Keike and Kini showed me boundaries on this side. Keakaakawai who is over here is the son of one of my kamaainas and he himself is a kamaaina on the mountain.

CX^d

I could talk better native when I came across from Kona to Kau than at the present day; came down from Ahuaumi here. I have been up from Kapua to Ahuaumi and understand that Keauhou cuts off Kapua below Ahuaumi, also Kaulanamauna is cut off and from there the boundary of Kau and Kona runs direct to the top of the mountain. My opinion of the direction of the line of boundary between the Districts is based on the direction at shore. There is no land in South Kohala running side and side with Kona lands to top of Mauna Loa cut off by Hamakua. Kona and Kau run to the top of the mountain, Humuula runs up a long way but not to the top. There are two places on the mountain called Pohakuhanalei, one is a rock on the North East slope the other a crater on the South slope, the latter is not pointed out as a boundary. I have only crossed the boundary. They pointed out to me, a ridge running up to the top of the mountain and to the other side said ridge running between the craters of Mokuaweoweo and Pohakuhanalei.

Pohakuhanalei is about South of Mokuaweoweo and I think it is in Kau, about one third of a mile. Have never heard what land Mokuaweoweo is on; have always heard that Kahuku joins Keauhou mauka and that Kahuku and Kapapala join at Pohakuhanalei on the North East slop of Mauna Loa, but I do not know how far this way they join. Have worked in the woods and above Kahuku mauka of Waiohinu catching goats and heard that Waiohinu cut off all the lands to Kapapala, can show pretty nearly the place where Hale o Umi was. Hale o Umi was built of six stones, and was so close to the mountain that I could not see far, towards Kau, or Kohala at Ahuaumi, boundary of Kona there are four or five piles of stones in a mawae or crack there are two red hills in an easterly direction from Ahuaumi, and a water hole near one of them, from this point it is two or three miles directly toward the sea before you come to the thick woods.

Commission adjourned to 9 a.m.

March 14th 1873.

Kahuku March 14th 1873

Boundary Commission met according to adjournment

J Kaulia ^{k.} Sworn

I live at Waiohinu Kau, and according to my parents statement, I was born about three years after the missionaries arrived on the Islands. Am kamaaina of Kahuku and, some other lands in Kau. In 1848 was Hope Luna Auhau, Moke Keawe and Kaahulama were also Hope Luna Auhau of Kau and Pipi Luna Auhau. Pipi ordered me to inquire about boundaries of land as it was at the time they were setting apart the la kohu and the Laau kohu o na konohiki.

Pipi had lived in Kau a long time, and told me the boundaries. He said Kalaehumuhumu was the boundary between Manuka and Kahuku and Kaumuuale between Kahuku and Pakini, and Kahiawai awaawa belonged to Manukaa, and from there to Kualapapili boundary of Kahuku and Pakini

Haumea was Konohiki of Kahuku at that time.

Uhu ia kohu and koa laau kohu. Afterwards, came to live at Kaanaholua (near Pohakuloa) on Kahuku and near the boundary of Manukaa and Kahuku, catching goats.

Kawaa and Maewa old people of Kahuku pointed out the boundary to me. At time of making old road to Kona, by S Laanui keeke o Lilikolani I wanted to get long poles, and he told me to go to awaawa o Kahiawai, as those on this side belonged to Kahuku and were kapu, he was konokihi of Manukaa at that time.

After Kamehameha III went on to the mountain from Kahuku, I went up, Haalulu an old kamaaina of Kahuku was my kamaaina, I do not know whether he is dead now or not. Paahao of Kahuku and others also went with us. Went to Hale pohaku and built a pen. Haalulu told me Puuohoohia was the boundary between Manukaa and Kahuku. We did not go there but went round to Ohialele a cave which he said was the boundary between Kahuku and Kona. I think it is mauka of Milolii, did not say what land joins there. We were catching goats for Kila of Kahuku and I never heard of Kona people claiming them.

After Kahuku became School Land I was Kahu Kula and Mr. Armstrong made me Konohiki of Kahuku This was in 1850 or as near as I can remember between that year and 1854. I took charge of the land according to the boundaries that I have stated without opposition. In 1870 I was konohiki of Manukaa and used to catch wild goats with Keaka ma Kakio ^{k.} claimed to be one of the lesees of land and got his kuleana. Keaka said the boundary was Waiakaalala near Puuohilea, between Kahuku and Manuka and tried to persuade me to catch goats there. Halulu told me Kahuku ran way beyond Ohialele and joined Keauhou of Kona.

I went with him to Puukeokeo, and he told me that Ahuaumi on Umi's road beyond Keokeo was the boundary between Keauhou and Kahuku.

I have been two or three times to Ohialele and Puukeokeo

Umi's road was very distinct in olden times.

 CX^d

Haalulu told me Kahuku went mauka of Kukuiopae. In 1857 I lived a year at Kapuna in Kona, the natives there said there were wild goats on the land. I told them I had heard the pahoehoe mauka of the woods was on Kahuku and they said the goats were in the koa woods.

Kaiwi Sworn

I was born at Kahuku Kau at the time of hookup mamo, ma ka Lae and have always lived there till a few weeks since my kupuna and kamaaina pointed out boundaries to me, as folks living on Kahuku were not allowed to take things from other lands. They told me Kalaehumuhumu was the boundary of Kahuku and Manuka at Sea shore, the sea bounding Kahuku makai thence to Pohakuloa, thence to Puuainako on the old road, thence to a large stone near awaawa, Kahiawai near the new road, thence follow up the Kau side of the awaawa to Kapuhonu from thence the next point on the boundary, that I know of is Puuohoohia between Kahuku and Manuka thence to Kumualii a cave, thence to Ohialele a cave on pahoehoe. I have been to Ohialele and this side of there since the lava flow saw a goat pen a little beyond Kumualii and close to the woods, Nauka k. built it and told me it was on Honomalino. I have been up to a cave way beyond Ohialele on the pahoehoe with sons of Kumauna (now dead) and brought goats from there to Halepohaha. it took two days to drive them. Since then, I do not remember how long since, I lived at Kukuiopae and went up to catch goats. While there saw this cave called by them Kaanapaakai and recognized it as the one I slept in before. they said the land belonged to Kukuiopae, said cave is a half mile or more from the woods. Never heard of Puuhilea being the boundary of Kahuku before seeing the notice in the paper, which was published by Keaka have always heard Keauhou joined Kahuku on the mountain. When Keaka lived on Kahuku we always used to chase goats at Puulonolono when he moved top Manuka he claimed Puulonolono for that land. Have seen two Ahua o Umi on Umi's road way beyond Puukeokeo I think they are further toward Kona than Ohialele Have not seen a place called Keanahua, Have heard Kahuku joins Kaalaala on the mountain but do not know the boundaries

CX^d JGH

There are a good many places on the mountain called Ahuaumi, and Hale o Umi and Alanui o Umi between Kahuku and Kona.

Paahao ^{k.} Sworn

I was born and now live on Pakini. have lived on Kahuku and often chased goats there.

Kaneakahuna and Haalulu old kamaainas pointed out some of the boundaries to me. Commencing at the sea shore at a place called Kalaehumuhumu thence mauka to Pohakuloa thence to Puainako thence to Kahiawai thence to Kahonopu thence to Puuohohia from thence to Kumualii a cave. Manuka ends at Puuohohohia and Kona joins Kahuku there.

Thence to Ohialele, was told Kahuku went up to Keauhou. Have been told by old kamaainas that Kahuku joins Kaalaala and Kapapala on Mauna Loa but have never seen the boundary have frequently been catching wild goats with Kaulia, now in Court. He was our luna.

I have often seen houses built by Kona natives and fires in them, and goats running down but have never seen the natives.

At the present time I am taking care of goats for WT Martin

CX^d JGH

Have seen several Kauhale o Umi in the mountain and a heiau o Umi, once after chasing goats beyond Keokeo, on my way home I saw a road which kamaainas told me was Umi's road and lead to Ahuaumi in Kona. Have not heard that the road. I saw is the boundary of Kahuku and have not seen the famous Ahuaumi. Have heard Kahuku and Keauhou join.

J Kauhane, Agent of Government Lands of Kau

States that he is satisfied with the evidence as to boundary between Manuka and Kahuku and that he has no testimony to introduce as to that boundary, but reserves his right to bring in evidence as to boundaries of Government lands adjoining Kahuku on the East side. The evidence to be heard on the return of Commissioners from Ohialele

Commission Adjourned until Monday the 17th day of March. When they will proceed to Ohialele to look at boundaries. RA Lyman Commissioner of Boundaries 3rd JC

The Boundary Commission met according to adjournment and proceeded to Ohialele March 17th 1873.

Journal of trip to Ohialele

We left Kahuku Monday March 17th 1873 at 7 a.m. Party. RA Lyman. CE Richardson. JG Hoapili, Geo WC Jones. WK Moi. C Macomber. Naihe. Kaiwi. Kenao. Kamakana. Kumauna and others. on the way we visited a large boulder on Kau side of Kahiawai a short distance makai of the Government road. At an elevation of 1800 feet. Said boulder overhangs the awaawa. At the Government road there is a pile of stones erected and white washed and Kahuku is cut in the pahoehoe near the awaawa. Saw Kahonupuu in the distance it bears N 30 E by pocket compass from the pile of white washed stones.

Kumauna remained at Manuka and Keaka joined us there, elevation 1660 feet.

Lunched at Kapua Elevation 1500 feet. Thence to Honomalino where Nauka's son Pilialo joined us. Thence to the upper edge of the woods on the mauka part of Honomalino where we pitched camp at an Elevation of 5500 feet.

March 18th 1873.

Went from camp to Ohialele on foot over a road of rough pahoehoe covered with bushes and grass Ohialele is a rocky knoll, of scrub ohia with a number of caves on it, a short distance below the koa woods. there is a clump of koa trees a few hundred feet makai. Erected a pile of rocks and cut the name Ohialele on the makai side elevation 5900 feet.

(Note JG Hoapili on part of Crown Commissioner and Government Land Agent in reply to being asked if the boundaries were satisfactory? Stated that he had no further evidence as to boundaries from Puuhoohia to Ohialele.)

From thence proceeded up the mountain to Umi's road elevation 7100 feet. Here we could see Pohakuhanalei on the top of Mauna Loa Puuulaula a small red hill under a black ridge of lava was a little makai of us Pohakuloa No3 on our left and a hill called Hanamauloa on our right. Thence we went to the hill called Hanamauloa elevation 7200 ft., for a better view but the cloulds (sic) shut the mountain in and we could only see black lava extending to the left of Ohialele said to reach as far as Puueleele

From Hanamauloa we returned to camp Kaulanamauna joins the land of Manuka at Puuohoohia

March 19th 1873

Left camp and proceeded in a South Easterly course to Puuohoohia. On the way crossed the junction of Kaulanamauna and Honomalino with Kahuku, below the cave Kumualii.

(Note Before leaving camp JG Hoapili, stated, that he had no further evidence to introduce as to boundary of Kahuku and adjoining lands from Ohialele to top of Mauna Loa) and returned to Kona. Erected a pile of stones on a hill makai side of crater of Puuhoohia. Thence proceeded to a hill or rocky mound about two miles makai of Puuohoohia almost in a direct line from there to Kahonopu Erected a pile of stones white washed them and cut X in a rock near the base of the pile of stones. Thence went mauka past the base of Hapaimamo down past Ahuana and Hale-pohaha to Kahuku Ranch premises.

Commission adjourned to meet at Keaiwa

March 21st 1873. to take testimony of J Kauhane witnesses as to boundaries of Government Lands as one of them is to old and feeble to come to Waiohinu or Kahuku.

RA Lyman Boundary Commissioner 3rd JC

Description of rocks and places on the boundary omitted in the Journal.

Puuohoohia is an extinct volcano the sides of the crater are covered with pumice and growth of scrub ohia pukeawe &c., the side toward the mountain is smooth regular outline, all the higher knolls being on the makai side. The natives say when the Kona winds are blowing a whirl wind is formed sending up clouds of sand re Elevation 5430 feet. at an elevation of 4820 feet there is a rocky knoll, the line of boundary follows along this knoll on black aa from Kahonupu to Puuohoohia Kahohopu from this point appears to be two large rocks on the pahoehoe with scrub ohia around them. Hapaimamo in Kahuku is a large smooth hill formed of pumice and sand with red spots on it and on the plain around it it is an old crater with a gap in the South side where a stream of aa has flowed out.

RA Lyman Commissioner of Boundaries 3JC

Kauhuhuula March 21st 1873

Boundary Commission met at 2 P.M according to adjournment

Present, Geo WC Jones, C.E. Richardson

J Kauhane on part of Hawaiian Government for Kau lands, WK Moi actg for JG Hoapili for Hawaiian Government lands in Kona Crown Commissioner and Her Ex R. Keelikolani

FS Lyman &c

Makaka k. Sworn On part of Government

I was born on Hilea at the time of Keona (First vessel of Kamehameha) I now live at Ninole kai, Kau, Hawaii, and have always lived there and at one time had charge of the land. went with Ohia, my Father in law and he showed me boundaries of Kahuku Makaka and Kaalaala, we went after sandal wood on Ninole, a land that runs from shore through the woods, he showed me a water hole on the pahoehoe near the edge of the woods called Wai- kaloa, and said Ninole joined Kaalaiki on the aa North East side of said water hole on aapoohina. Kahuku cuts off Kaalaiki and joins Ninole at two piles of stones in the middle of aapoohina (he mau ahu manu no Kona- manu) where Makaka people used to place bird nets. here Kahuku joins Makaka and both lands run up the mountain side by side to where the aa joins the pahoehoe there Kaalaala joins Kahuku, at a large hole, with several smaller ones nearby. Waiohinu joins Kaalaiki at Waikaloa. I do not know the boundary between Kahuku and Waiohinu The woods are about as far as from this house over to the gulch makai, the groves on the Kona side of the water hole are not ten fathoms from it and are on Waiohinu. Do not know the name of lae laau – Have only been there once, Kahuku joins Ninole in the aa and not on the Kona side of it, the only boundary of Kaalaala I know of is where Kahuku joins it mauka of the aa Kaalaiki and Ninole join Kahuku at ahu manu

Makaka also joins at this place.

I do not know of any place called Namanu o Haalou but know that Waiohinu joins Kalaiki on the Kona side of Waikaloa, waterhole .

CX^d

(I was grown up and married when I went after sandal wood. Have only seen the ahu once Have been up once to the hole on the pahoehoe which is the boundary of Kahuku, Kaalaala, and Makaka. I can point them out. Kona side of of the hole is Kahuku they run up the mountain I do not know the boundaries on top of the mountain have never heard that Kahuku joins Kapapala or that Kapapala joins Keauhou of Kona on the mountain. Have heard that all the persons who went up on the mountain with me are dead.

Was called on Wednesday to come as a witness on this case, Have talked with some of the people this morning about it. Have not talked with Holona in regard to the boundaries. My son had gone to sea. I have relations at Kalaiki and Hilea but I do not live with them, Ahia's son is my moopuna. Have seen Hale pohaha, when I went on the mountain. It is a black rocky hill with no vegetation on it. Do not know of Keokeo Hapaimamo Ihuanu or Kapoalaala or any other hills around there. I was so far off that I could not tell what the hill was composed of.

Nahala k. Sworn

I was born and now live on Paauau, when I was young I went to see Kuewai ma ka Lae. Have lived on lands adjoining Paauau and am a kamaaina of Kau. I know and have heard about part of the mountain. Went up with Keau ken my mothers brother to catch goats on Makaka my adopted Father had charge of the land Nahale and Kumakahomu and others (now dead) went with us, went up three times, but only on Makaka. we went along above the woods to Waikaloa which place the kamaainas told me was on Kaalaiki, was not told whether Kahuku joins Kaalaiki or not but Makaka does join at the North East side of the water hole, said hole being on the grass above the woods. The aa is about as far as from here to Paauau pali and belongs to Kahuku. The pahoehoe on the North East side is Makaka. When Haalou from Kahuku came after birds Makaka people prevented him from coming onto the pahoehoe. The aapoohina belongs to Kahuku, except a lihi ike, There are three caves on the pahoehoe near the aa said caves are on Makaka, do not know the names.

This is as far as I went they told me Kahuku ran up by Makaka to Pohakuhanalei on the top of Mauna Loa and Kaalaala joined Kahuku there. I do not know other boundaries of Kahuku as we did not go where we could see them.

I have never seen or heard of any heiau above the woods. Have not heard that Kahuku joins Kapapala or that Kapapala joins Keauhou of Kona.

 CX^d

There are a great many lands between here and Ninole I know the boundaries as far as I have been and had them pointed out to me. Do not know boundaries of other lands. It is a long time since I went onto the mountain for birds I know all the boundaries of Makaka as they were pointed out to me. Went after goats on Makaka when Swain was on Kahuku, and Spencers, Father in law, owned the land of Kahuku

The Government having no other witnesses Boundary Commission stands adjouned until further notice is given to all parties.

RA Lyman

<u>Boundary Commissioner</u> 3rd J.C.

Hilo March 28th 1873

Boundary Commission met to take testimony of Wahine, Kahuakai, and Keliilohe as the Commissioner wishes more definite evidence as to the boundary between Kahuku and land adjoining in Kau, on the mountain. Present WH Reed on part of Kahuku Ranch Co. and Crown Lands. GW Akau Hapai on part of Government in place of J Kauhane.

Wahine k. Sworn

I was born at Waimea, at the time of ordaining the heiau at Kawaihae. Moved to Kapapala Kau at the time Kuakini appointed Tax Collecters around Hawaii think it was about the middle of that year. Now live and have been living for several years past at Panau Puna Hawaii Lived at Kapapala a great many years went on Mauna Loa with the Exploring Expedition in 1842 and camped at Mokuweoweo Keaweehu was our guide he was a kamaaina of Kapapala he said Kapapala was on this side of the mountain taking in Mokuweoweo, and Kaalaala the other side of the crater. He said Kahuku joined Kaalaala, cutting off all other Kau lands above the woods. Do not know where Kaalaala joins Kahuku or if Keaiwa joins it at all Keaweehu told Pea in our presence that the pili is on small lands and pahoehoe on Kahuku, this was on the mountain, but he did not point out the boundaries between lands He said the Kaikunane lived on Kaalaala and Kaikuahine (???? ????) lived on Kapapala and gave her brother right of way across Kapapala to Keawewai and Hamakua for bird catchers to go and catch uwao and geese on Kaalaala but on the slope between Kapapala and Kahuku the land of Kaalaala extended up. Keaweehu said Kaalaala and Kapapala joined Kaohe, but did not say where

 CX^d

Kahuakai k. Sworn

I was born on Keauhou ili of Kapapala and was old enough to go with my parents at the time of the Ohaikea, have been living for the past three years at Panau Puna Island of Hawaii am a kamaaina of Keauhou but not of other lands. My parents never pointed out boundaries to me. I have been up to where they use to get out canoes on Keauhou, but not on Kapapala Keauhou is Kupono of Kapapala

 CX^d

Keliilohe k. Sworn

I am a kamaaina of Keauhou not of Kapapala, Do not know and have not heard what the boundaries of Kahuku are.

Kaoio ^{k.} Sworn

I was born at Kapapala Kau. Have heard after the Hookupu olona at Kalalau Ko____ was Luna. I now live at Waiakea am kamaaina of places near where I was born and have heard about boundaries of Kau lands on the mountain from Ana k. and Aheakealani, Ana now lives on Kaalaala, but Aheakealani is dead they told me Kaalaala was between Kapapala and Kahuku, they told me boundaries between Kaalaala and Kahuku, I have forgotten the boundaries near the woods, but remember they said Kaalaala went to Pohakuhanalei and Kahuku near there below Mokuweoweo. have heard Kahuku joins

Keaiwa above the woods Ana and Kaonohi told me this. My Father used to me a kamaaina of Kapapala, and told me boundaries.

 CX^d

Note Awakamanu of Olaa is said to be a kamaaina

Commission Adjourned till further notice RA Lyman Boundary Commissioner 3rd J.C.

Office of Boundary Commissioner Hilo May 14th 1873

The Boundary Commission met to take Testimony of Kenoi and Awakamanu as to boundaries of Kahuku, after due notice to all parties interested. Present Geo WC Jones. CE Richardson and WH Reed on part of applicants. J Kauhane for Hawaiian Government. WP Ragsdale actg for JG Hoapili on part of Crown Commissioner and Hawaiian Government for Kona lands

Kenoi ^{k.} Sworn

I was born at Kapapala at the time of the building of Kiholo am a kamaaina of Kapapala and know the boundary between lands of Kahuku and Kapapala. My kupuna used to point out boundaries to me when we went on the mountain to catch birds. Keaweehu, father of my wife, and Kama his nephew showed them to me. Keaweehu was an old bird catcher Kapapala first joins Kahuku at Aapoohina Kaalaala joins Keaiwa through the woods and there both lands are cut off by Kahuku and Kapapala. we did not pay much attention in old times to what lands were in the woods. I have never been up to them used to go to Kapapala. these lands are all cut off on the edge of the woods. The pali above the woods is called Aaaloa, the pahoehoe on the pali is called Papaulaula, there Kaalaala ends and Kahuku joins Kapapala. Keaiwa joins Kaalaala to this pali and is cut off there by Kapapala. The aapoohina is a short distance from the Papaulaula. The land of Moaula joins Kahuku and Keaiwa at a Poohina Where the grass grows belongs to these lands and the pahoehoe to Kahuku. The apoohina is all on Kahuku, and the pahoehoe, on the North side belongs to Kapapala. From this point the boundary between Kapapala and Kahuku is the Northern edge of Apoohina, running up to Pohakuhanalei a large hill near the top of the mountain. At the time we went on the mountain they pointed out to us points that we could not go beyond the

Apoohina and where the Kahuku people could not come beyond but did not tell us where the small lands ended.

CX^d By J Kauhane

We used to go on the mountain to catch mamo oo uwao and geese, the latter belonged to Kaalaala There was a road from Kaalaala running past Richardson's, clear to Humuula the land belonged to Kapapala, and everything on it, but the Kaalaala people of Kaalaala could go after geese and other birds anywhere on Kapapala, and all persons going over the road had to divide the birds with Kaalaala people. In the time when Liiloa was the Chief and Nuunu and Kakohi were the kahunas, they took the birds and put the kapu on the Uwao and Nene. But the Oo and Mamo were left Kapapala and the people of that land could take them and divide with the Chief of Kapapala.

Awakamanu ^{k.} Sworn

I was born at Kahuku at time of Okuu and and lived there until the time of Hookupu mamo at the Lae (1835) in time of Kamehameha III. Am a kamaaina of Kahuku now live on Olaa in Puna. I used to go after birds and the boundaries were pointed out to me by Moo k. for if we of Kahuku caught birds on other lands, they were taken away from us. Kalaehumuhumu is boundary between Manuka and Kahuku, thence to awaawa called Kahiawai by the road. Kahuku running on this side, thence to a large hole with water in it called Kamokulimo, thence to Puulonolono a grove of trees, the boundary on Kona side of grove, thence to hill called Puuhoohia, Manuka ends at this hill and Kahuku runs over to Ohialele cutting off the land of Kaulanamauna and Kapua and Honomalino, Ohialele is a mound with a cave, from this point you can see the surf break at Kapua, Kahuku joins lands of Keauhou at Pauewalu. (A place where Moo k killed eight Kona men. They shut him up in a cave and when he got out he killed them.) From Ohialele the boundary between Kahuku and Honomalino runs to a grove of trees called Kamokupukela Ohia trees on the pahoehoe beyond Ohialele. I think about a mile distant. Kamokupukala is on Kahuku the boundary between Honomalino and Kahuku runs makai of this grove to Pauewalu above the woods. Pauewalu is a lae aa along distance from Ohialele. Ohialele is a high ridge of Aa that breaks through when you walk on it and is about half way between Puuohoohia and Pauewalu Honomalino reaches to this point. I think we never went beyond here to catch birds as Keauhou folks would take them away. The boundary between Kahuku and Keauhou runs mauka to a water hole Waio, where the cattle that were let go from Holuloa used to drink. I do not know as I could identify the place now. The high Aa is boundary

Kahuku is in Kau side of aa.

There are two small red hills near the aa a good ways above Umi's road. The water hole Waio is close to the foot of the mountain, mamami grows there the aa from Pauewalu ending, before you reach the hole. Cannot see woods from there. Do not know anything about the boundary of Kahuku and Keauhou above this place. Pakininui joins Kahuku at Kulauala and runs up in to the woods to Kilohana. the koa is all on Kahuku, the Pele o ike is in the woods, I have not been up the boundaries, through these woods

went to Apoohina. There Moo ^k told me Kahuku and Kapapala and Makaka joined Makaka makai and Kapapala on the North side of Apoohina. From thence Kapapala and Kahuku run to Pohakuhanalei. have been to this place called Pohakuhanalei. Kaalaala claimed the geese on this side of Apoohina but the land belonged to Kapapala. I never hear Kaalaala had any land there. Did not have the boundaries of lands makai of Kahuku pointed out to me.

CX^d By Government Agent.

If we went after geese this side of the aa Kaalaala people took them away. If we went after uwao Kapapapala people took them away. If we went below apoohina to catch oo Makaka people took them away. I have seen water holes, below Apoohina, near the woods but do not know the name of them. --continued Book B Folio 310

Commission adjourned until further notice to all parties interested.

RA Lyman

Boundary Commissioner 3rd J.C.

Notes from a Journal - October 21, 1873

Left Kapapala and camped that night at Kauhuhuule gulch elevation 6300 feet.

October 22nd Proceeded towards a round hill on the western slope of Mauna Loa. Struck AaPoohina at an elevation of 7300 feet. There we could see aa running to top of Mauna Loa, and further down, on the edge of the woods the latter being covered with bushes and soil with a little moss. First struck aa near the woods, mauka of a knoll in the woods, covered with koa and ohia.

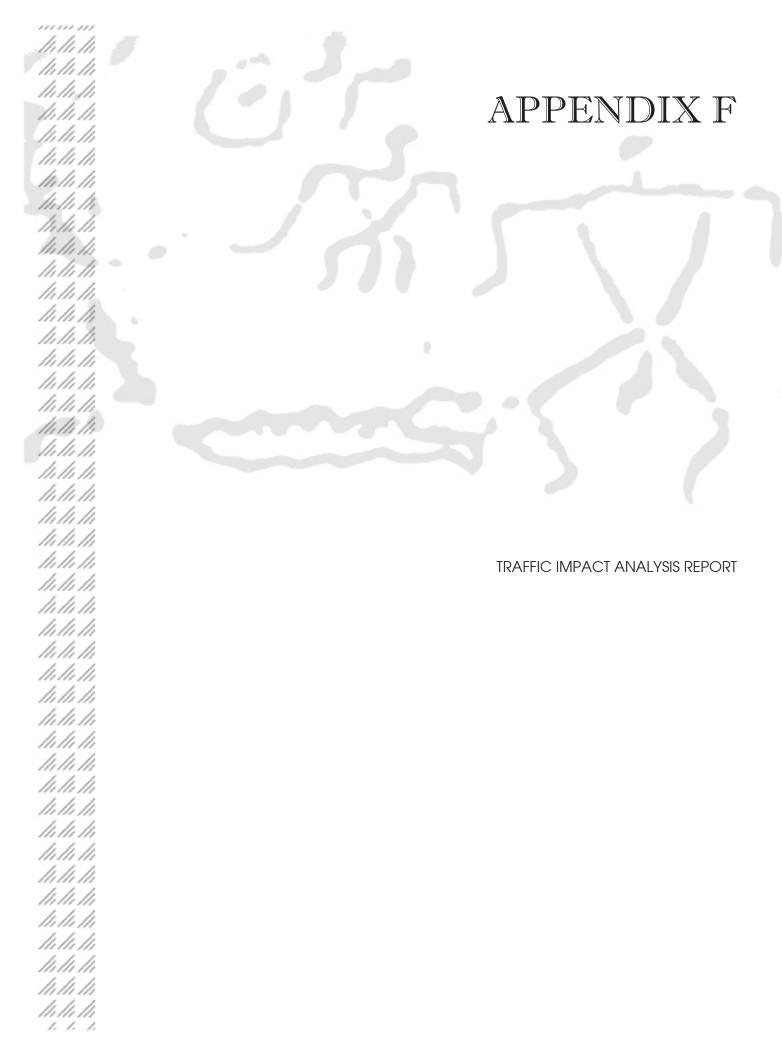
After traveling over an hour came to aa running into the woods, said aa being overgrown more or less with gray moss, grass and bushes. This aa is said to run to shore, between the lands of Ninole and Kaalaiki in crossing it we came to the remains of two platforms or ahu of stone. Left the aa at two o'clock in the afternoon at an elevation of 6100 feet and came to camp at five Oclock at an elevation of 5200 feet, in a koa grove by Pele oike from thence we went to Kaalaiki Kahuku, & thence to Kaakaiki

Kaalaiki October 23, 1873

Kaele k[ane] Sworn

I was born at Hilea at the time of Kiholo know the land of Kahuku having lived there twenty years Went with Kumauna ^{k.} after sandal wood Kaalaiki and Waiohinu join at Namamo o Haalou lae ohia went after sandal wood, scrub ohia Koa lands and Kahuku makai. Thence along a line of tall woods on Kaalaiki to aapoohina. Waikaloa being on the Kona side of aapohina. There is a pond about 25 feet long half a mile from here and a very short distance from the woods. Hilea corners there thence along Hileanui to aapoohina, on Kona side thence along Ninole taking in all the aa, the makai end of said aa being covered with soil. I have always heard it was all Kahuku running up to Pohakuhanalei and joining Kaalaala. Have not heard that Makaka joins Kahuku. this is all I know do not know anything about Waikaloa Puuike or Punaluu.

RA Lyman Comm. Boundaries 3rd J.C.



TRAFFIC IMPACT ANALYSIS REPORT FOR THE PROPOSED

KAHUKU VILLAGE

KA`U, HAWAII

TAX MAP KEY: (3) 9-2-001:072

PREPARED FOR

NANI KAHUKU AINA, LLC

JULY 12, 2011

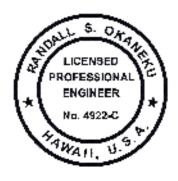


TRAFFIC IMPACT ANALYSIS REPORT FOR THE PROPOSED

KAHUKU VILLAGE

KA'U, HAWAII

TAX MAP KEY: (3) 9-2-001:072



THIS WORK WAS PREPARED BY ME OR UNDER MY SUPPRY 5 ON.

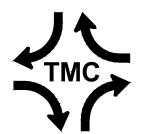


Table of Contents

				<u>Page</u>		
I.	Intro	Introduction				
	A.	Purpo	Purpose of the Study			
	B.	Scope	Scope of the Study			
	C.	Projec	Project Description			
	D.	Envir	Environs			
	E.	Metho	Methodologies			
		1.	Capacity Analysis Methodology	10		
		2.	Trip Generation Methodology	11		
II.	Existing Conditions					
	A.	Area Roadway System				
	B.	Existi	Existing Traffic Volumes and Operating Conditions			
		1.	Field Investigation	12		
		2.	Existing AM Peak Hour Traffic	12		
		3.	Existing PM Peak Hour Traffic	12		
III.	Future Peak Hour Traffic					
	A.	Backg	ground Growth in Traffic	13		
	B.	Future	e Peak Hour Traffic Analysis Without Project	14		
IV.	Traf	fic Impac	ct Analysis	14		
	A.	Trip Generation Characteristics				
	B.	Traffi	Traffic Assignments			
	C.	Year 2	Year 2015 Peak Hour Traffic Impact Analysis With Project			
	D.	Year 2	Year 2021 Peak Hour Traffic Analysis With Project			

Table of Contents (Cont'd.)

				Page
	E.	Year	2024 Peak Hour Traffic Analysis With Project	22
	F.	Year	2030 Peak Hour Traffic Impact Analysis With Project	25
V.	Evac	uation I	Plan	30
VI.	Reco	mmend	lations and Conclusions	31
	A.	Reco	ommendations	31
		1.	Prior to the Year 2016	31
		2.	Phases 1 and 2 (Years 2016-2021)	32
		3.	Phase 3 (Years 2017-2024)	32
		4.	Phase 4 (Years 2025-2030)	32
	B.	Conc	clusions	33

List of Figures

	<u>Page</u>
Figure 1. Location Map	3
Figure 2. Proposed Access	4
Figure 3. Kahuku Village Conceptual Master Plan	8
Figure 4. Kahuku Village Phasing Plan	9
Figure 5. 2015 Peak Hour Traffic Assignment	20
Figure 6. 2015 Peak Hour Traffic With Project	21
Figure 7. 2021 Peak Hour Traffic Assignments	23
Figure 8. 2021 Peak Hour Traffic With Project	24
Figure 9. 2024 Peak Hour Traffic Assignments	26
Figure 10. 2024 Peak Hour Traffic With Project	27
Figure 11. 2030 Peak Hour Traffic Assignments	28
Figure 12. 2030 Peak Hour Traffic With Project	29

List of Tables

	<u>Page</u>
Table 1. Land Use Summary	5
Table 2. Intersection Level of Service Criteria (HCM)	10
Table 3. Two-Lane Highway Level of Service Criteria (HCM)	11
Table 4. Existing Peak Hour Capacity Analysis	13
Table 5. Future Peak Hour Traffic Without Project	14
Table 6. Trip Generation Characteristics	15
Table 7. Regional Population and Vehicle Estimates	30
Table 8. Kahuku Village Population and Vehicle Estimates	31
Table 9. Summary of Intersection Capacity Analysis With Project	33
Table 10. Summary of Two-Lane Highway Capacity Analysis With Project	35

TRAFFIC IMPACT ANALYSIS REPORT FOR THE PROPOSED

KAHUKU VILLAGE

KA'U, HAWAII

TAX MAP KEY: (3) 9-2-001:072

I. Introduction

A. Purpose of the Study

The purpose of this traffic study is to analyze the traffic impacts resulting from the development of the Kahuku Village in Ka`u, Hawai`i by Nani Kahuku Aina, LLC. This report presents the findings and recommendations of the traffic impact analysis.

B. Scope of the Study

- 1. Evaluation of existing roadways and traffic conditions.
- 2. Development of trip generation characteristics of the proposed project.
- 3. Evaluation of future roadway and traffic conditions without the proposed project.
- 4. Recommendations of traffic improvements, as necessary, that would mitigate the future highway deficiencies without the proposed project.
- 5. Identification and analysis of traffic impacts resulting from the development of the proposed project.
- 6. Recommendations of traffic improvements, as necessary, that would mitigate the traffic impacts identified in this traffic study.

C. Project Description

Kahuku Village will consist of the Hawaiian Heritage Center, and a mixed-used residential and commercial village. The 16,457±acre project site is identified as Tax Map Key (3) 9-2-001:072. The property is situated between the Hawaiian Ocean View Ranchos to the west, the Damon Trust Lands and Kamehameha Schools property to the east, Mamalahoa Highway to the north and the Pacific Ocean to the south. Kona International Airport is located about 56 miles to the northwest of the project site. Hilo International Airport is located about 76 miles to the northeast of the project site. The vicinity of the proposed project is depicted on Figure 1.

The proposed Hawaiian Heritage Center (HHC) is envisioned as a "living classroom", which will promote the education and application of traditional Hawaiian practices and natural and cultural resources management. The Hawaiian Heritage Center facilities will include a visitor's center, a gift shop, classrooms, meeting space, laboratories, dormitory housing for researchers and students, a caretaker's residence, comfort stations, and campgrounds. HHC can be compared with the Polynesian Cultural Center in Laie, Oahu, but on a less commercial scale. Prior to Phase 1 (Year 2016), HHC is expected to operate at a very low level. A 40-room dormitory is proposed to accommodate the students and Visitors can be accommodated by a proposed 60-unit eco-lodge or research staff. "tentalows". The pre-2016 development of the project will be limited by the existing dirt road access from Mamalahoa Highway to the coast, which is located along the west boundary of the project site. At the beginning of the development of Phase 1 in the Year 2016, the Main Access Road is expected to be constructed, at which time the dirt road access will be closed or used to provide emergency access to the property. The proposed Main Access Road and the mixed-used village will provide the necessary infrastructure to expand the HHC facilities to include a dormitory with a total of 100 rooms and the ecolodge with a total of 100 tentalows. The infrastructure is also expected to accommodate the increased visitor demand, which is expected to grow from 100 visitors per day, prior to the Year 2016, up to 1,980 visitors per day by the Year 2027, according to the Kahuku Village Commercial Market Assessment, prepared by Colliers Monroe Freidlander Consulting, dated February 3, 2011.

The mixed-use village will be situated on about 1,600 acres on the makai portion of the property. The 1,600 acres are the subject of the State Land Use District Boundary Amendment Petition Area. The mixed-used village will include 1,050 single- and multifamily residential units, a 200,000 square feet of gross floor area (SFGFA) retail-commercial component, an 18-hole golf course, two 250-room hotels, a civic centermakai, a Veterans Affairs Facility, and parks. About one-third of the single- and multifamily homes are expected to be occupied by full-time residents. About one-half of the homes are expected to be occupied by part-time residents. About one-sixth of the homes (single-family units) are expected to be rented to transients (visitors) on a short term basis. The mixed-use village is proposed to be developed in four Phases, beginning in the Year 2016, and reaching completion in the Year 2027. The phasing of the development plan was based upon the Kahuku Village Market Study, which was prepared by Ricky Cassiday.

Access to the Kahuku Village is proposed at an at-grade intersection on Mamalahoa Highway, about 5 miles west of South Point Road. The Main Access Road is expected to be constructed by the Year 2016. A gated access road will be extended to the Hawaiian Ocean View Ranchos for emergency use only. Figure 2 depicts the proposed access location.

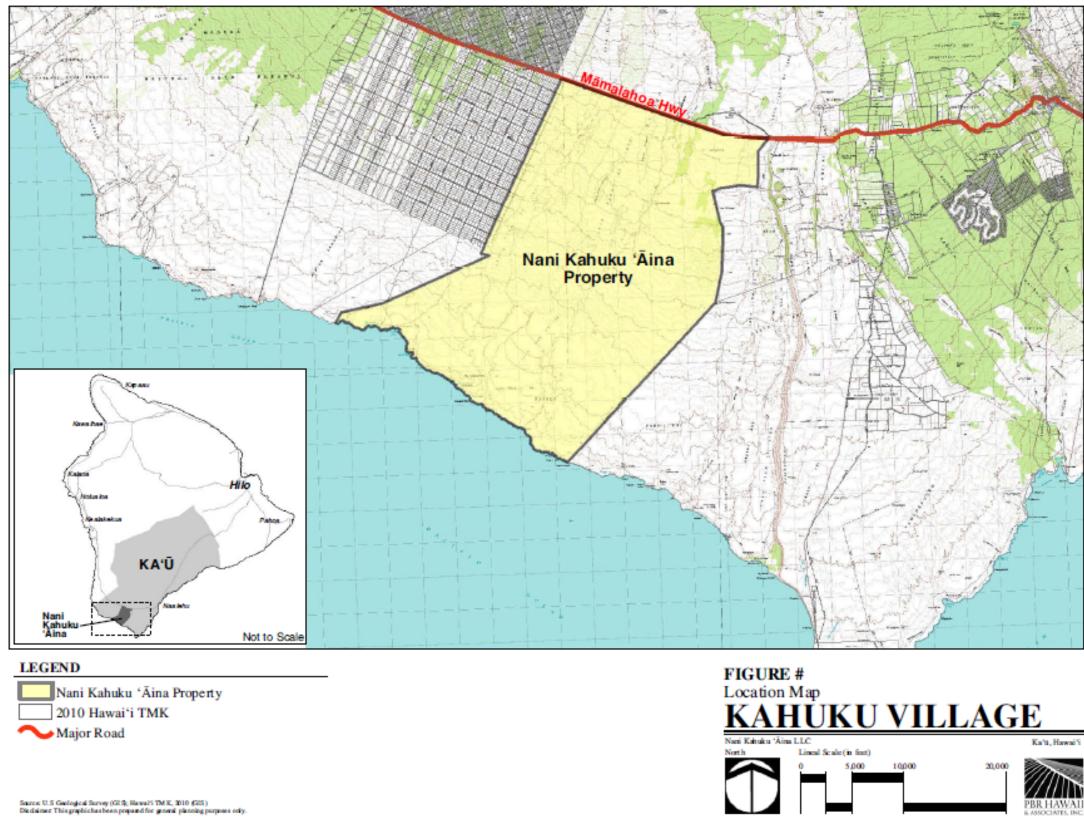


Figure 1. Location Map

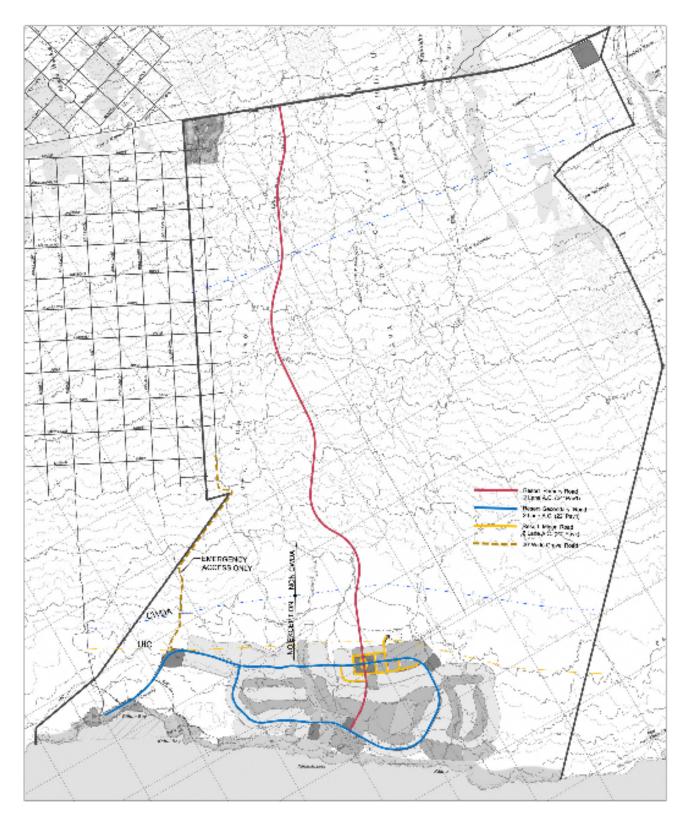


Figure 2. Proposed Access

Approximately 125 acres of land at the northwest corner of the project site, fronting Mamalahoa Highway, will be dedicated to the State of Hawaii and the County of Hawaii for the civic facilities, such as an elementary school, satellite police station, fire station, and regional park. At this writing, the State of Hawaii and the County of Hawaii have not had the opportunity to consider various alternative scenarios and time frames that may be feasible for the development of the dedicated property. Access to the mauka civic lands will be provided from Mamalahoa Highway. While the trip generation characteristics are included in the Mamalahoa Highway traffic projections, the Civic Center-Mauka access is not included in this traffic impact analysis. It is anticipated that a separate traffic impact analysis report will be prepared for the Mauka civic lands when they are developed by the State of Hawaii and the County of Hawaii.

For the purpose of this traffic impact analysis, Phases 1 and 2 were combined to represent the first increment of development, and were analyzed at their completion by the Year 2021. Phase 3 was analyzed at its completion by the Year 2024. The final Phase 4 of Kahuku Village is expected to reach completion by the Year 2027. Full build-out and occupancy of the proposed project was analyzed at the Year 2030 to represent the 20-year planning time frame. Table 1 summarizes the proposed Kahuku Village development plan.

Table 1. Land Use Summary						
Year Phase		Land Use	Description	Units		
2017	D 2016	Eco-Lodge	Tentalows	40		
2015	Pre-2016	HHC Dormitory	Staff/Student Housing	60		
		Eco-Lodge	Tentalows	60		
		HHC Dormitory	Staff/Student Housing	40		
		HHC Retail/Office (1,000 SFGFA)	Gift Shop and Admin. Office	10		
2016-	1-2	Single-Family (SF) Homes	15,000	89		
2021		SF Transient Rentals	15,000 square foot lots, 1-3 acre estates	73		
		SF Recreational Homes		90		
		Civic Center-Makai (1,000 SFGFA)	3,000 SFGFA	3		
		Multi-Family (MF) Homes	Residential Condominiums	18		

Table 1. Land Use Summary (Cont'd.)					
Year Phase		Land Use	Description	Units	
		MF Recreational Homes	Resort Condominiums	87	
2016-	1-2 (Cont'd.)	Golf Course (Holes)	330 acres	18	
2021 (Cont'd.)		TT 4 1	Resort Hotel	150	
		Hotel	Time Share Units	100	
		Retail (1,000 SFGFA) Shopping Center		40	
		Single-Family Units	15,000	48	
		SF Transient Rentals	15,000 square foot lots, 1-3 acre estates	79	
	3	SF Recreational Homes		144	
		Civic Center-Makai (1,000 SFGFA)	7,000 SFGFA Building	7	
2022- 2024		Veterans Affairs Center (Beds)	45,000 SFGFA Building	130	
2021		Multi-Family Homes	Residential Condominiums	164	
		MF Recreational Homes	Resort Condominiums	200	
			Resort Hotel	150	
		Hotel	Time Share	100	
		Retail (1,000 SFGFA)	Shopping Center	70	
		Single-Family Units	15,000 6,414	5	
		SF Transient Rentals	15,000 square foot lots, 1-3 acre estates	16	
		SF Recreational Homes		17	
2025- 2030	4	Multi-Family Homes	Residential Condominiums	15	
		MF Recreational Homes	Resort Condominiums	5	
		Retail (1,000 SFGFA)	Shopping Center	90	

Table 1. Land Use Summary (Cont'd.)					
Year Phase		Land Use	Description	Units	
		Eco-Lodge	Tentalows	100	
		HHC Dormitory	Staff/Student Housing	100	
		Single-Family Units	15 000	142	
		SF Transient Rentals	15,000 square foot lots, 1-3 acre estates	168	
		SF Recreational Homes		251	
Master		Civic Center-Makai (1,000 SFGFA)	10,000 SFGFA Building	10	
Plan 2015-	Totals	Golf Course (Holes)	330-acre, 18 Holes	18	
2030		VA Facility (Beds)	130 beds, 45,000 SFGFA	130	
		Multi-Family Homes	Residential Condominiums	197	
		MF Recreational Homes	Resort Condominiums	292	
		Golf Course (Holes)	330 acres	18	
		П. 1	Resort Hotel	300	
		Hotel	Time Share Units	200	
		Retail (1,000 SFGFA)	Shopping Center	200	

The conceptual master plan and the phasing plan are depicted on Figures 3 and 4, respectively.

D. Environs

The project site is located in the District of Ka'u, which is located on the southern and eastern slopes of Mauna Loa. While Ka'u is the largest district on the Island of Hawaii, it has the second smallest population. The project site is currently undeveloped. Existing recreational uses include fishing and overnight camping. Current scientific research uses involve agencies such as the U. S. Fish and Wildlife Service, the University of Hawaii, NASA, and the U. S. National Park Service. Adjacent land uses include the large lot subdivisions of Hawaiian Ocean View Ranchos and Hawaiian Ocean View Estates, where most of the lots remain undeveloped.

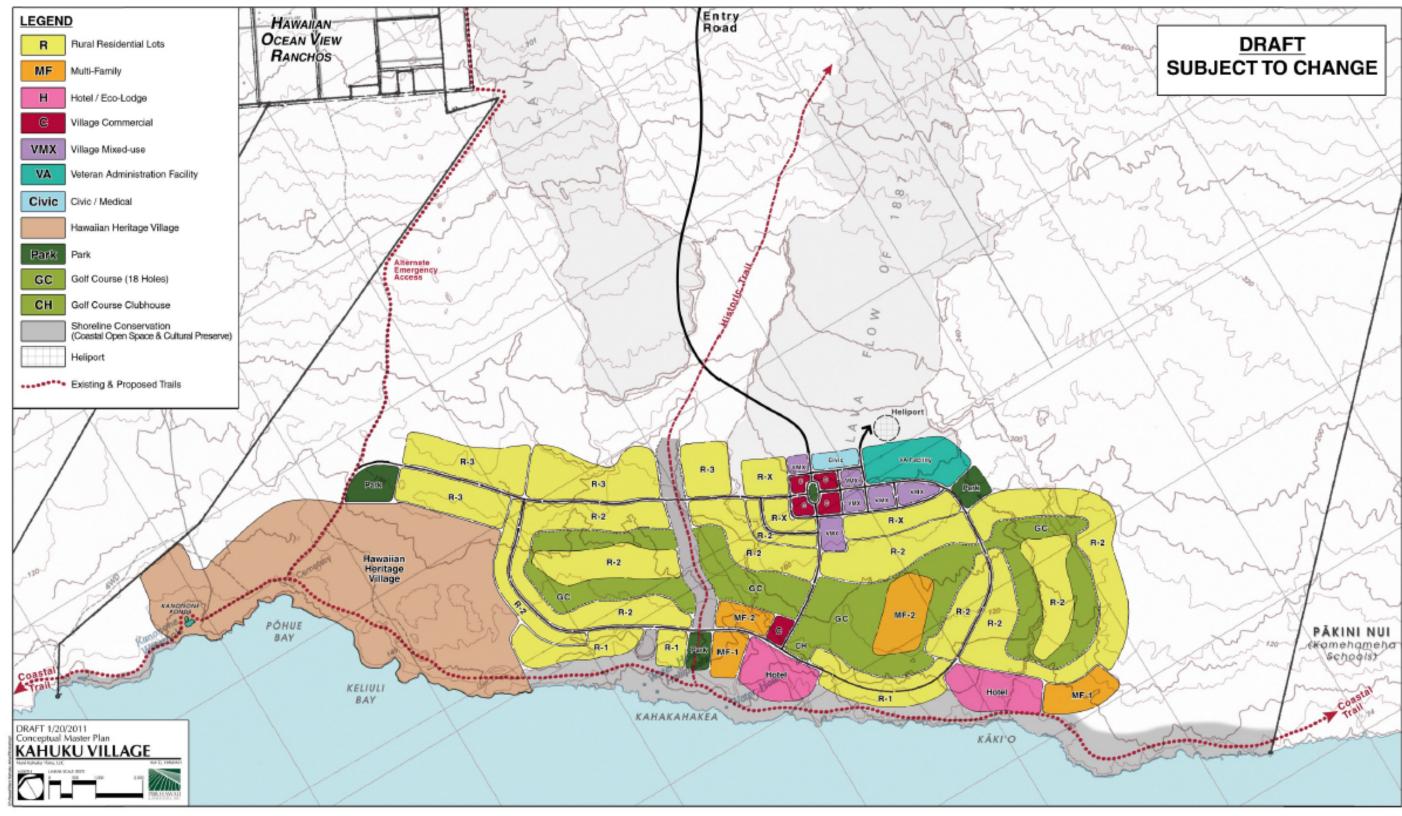


Figure 3. Kahuku Village Conceptual Master Plan

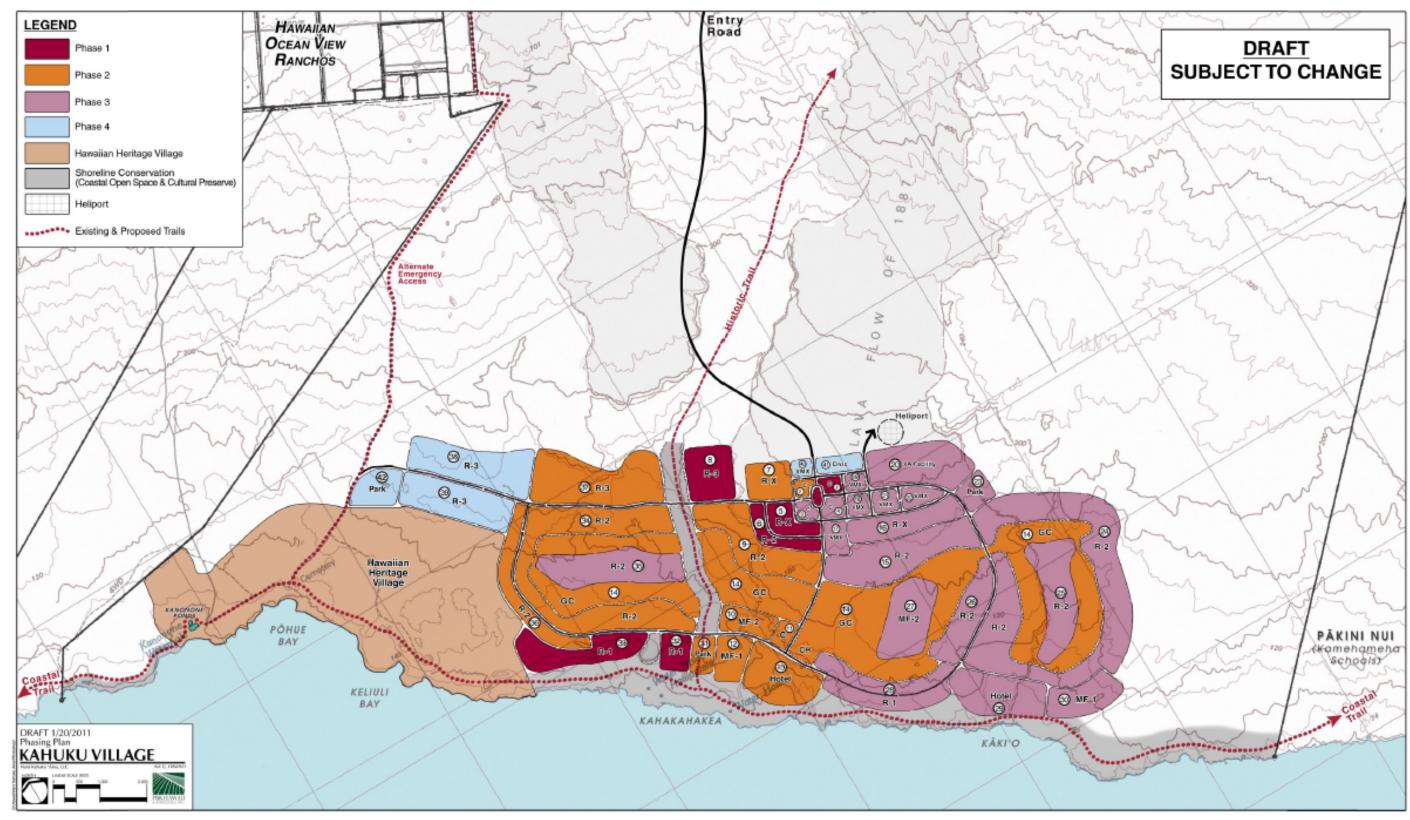


Figure 4. Kahuku Village Phasing Plan

E. Methodologies

1. Capacity Analysis Methodology

The highway capacity analysis, performed for this study, is based upon procedures presented in the <u>Highway Capacity Manual</u> (HCM), published by the Transportation Research Board.

HCM defines Level of Service (LOS) as "a quality measure describing operational conditions within a traffic stream". Several factors are included in determining LOS such as: speed, travel time, freedom to maneuver, traffic interruptions, driver comfort, and convenience. Intersection LOS is primarily based upon delay. LOS's "A", "B", and "C" are considered satisfactory Levels of Service. The County of Hawaii considers LOS "D" to be a "minimum desirable" operating Level of Service. LOS "E" is an undesirable condition, and LOS "F" is an unacceptable condition.

Intersection Level of Service is based primarily on average vehicle delay (d), which is expressed in terms of average seconds of delay per vehicle. Table 2 summarizes the intersection LOS criteria.

Table 2. Intersection Level of Service Criteria (HCM)					
1.00		Signalized Control	Unsignalized Control		
LOS	Delay d	Description	Delay d	Description	
A	<i>d</i> ≤10	Few stops, little or no delay	<i>d</i> ≤10	Little or no delays	
В	10< <i>d</i> ≤20	Good progression, short cycle lengths	10< <i>d</i> ≤15	Short delays	
С	20< <i>d</i> ≤35	Cycle failures begin to occur, i.e., vehicles stop at more than one red phase	15 <d≤25< td=""><td>Average delays</td></d≤25<>	Average delays	
D	35< <i>d</i> ≤55	Noticeable number of cycle failures, unfavorable progression	25 <d≤35< td=""><td>Long delays</td></d≤35<>	Long delays	
Е	55 <d≤80< td=""><td>Frequent cycle failures, poor progression, long delays</td><td>35<d≤50< td=""><td>Very long delays</td></d≤50<></td></d≤80<>	Frequent cycle failures, poor progression, long delays	35 <d≤50< td=""><td>Very long delays</td></d≤50<>	Very long delays	
F	<i>d</i> >80	Many cycle failures, high delays	<i>d</i> >50	Extreme delays	

The Level of Service for a two-lane highway is based upon average speed in miles per hour (mph) and "percent time-spent-following" (PTSF). PTSF is a result of vehicle platoons following slow-moving vehicles combined with limited opportunities for passing due to terrain or opposing traffic. Table 3 summarizes the two-lane highway Level of Service.

Table 3. Two-Lane Highway Level of Service Criteria (HCM)					
LOS	PTSF (%)	Average Speed (mph)			
A	≤ 35	> 55			
В	> 35 – 50	> 50 - 55			
С	> 50 - 65	> 45 – 50			
D	> 65 - 80	> 40 – 45			
E	> 80	≤ 40			
F	v/c > 1.00	Varies			

"Volume-to-capacity" (v/c) ratio is a measure indicating the relative traffic demand to the roadway's capacity. HCM defines capacity as "the maximum number of vehicles that can pass a given point during a specified period under prevailing roadway, traffic flow, and traffic control conditions." A v/c ratio of 0.50 indicates that the traffic demand is utilizing 50 percent of the roadway's capacity. Under signalized control, the v/c ratio refers to the maximum v/c ratio on any given traffic movement at an intersection. Worksheets for the capacity analysis, performed throughout this report, are compiled in the Appendix.

2. Trip Generation Methodology

The trip generation methodology is based upon generally accepted techniques developed by the Institute of Transportation Engineers (ITE) and published in <u>Trip Generation</u>, 8th Edition. ITE trip rates are developed by correlating the total vehicle trip generation data with various activity/land use characteristics, such as the vehicle trips per hour (vph) per dwelling unit (DU).

The trip generation characteristics for the proposed project are based upon ITE trip rates for the respective land uses envisioned for the proposed master-planned development. Where trip rates for certain types of land uses were not developed by ITE, trips rates for similar uses were used. The trip rates used in this analysis were derived from regression equations, developed by ITE, or the average trip rates when the data was insufficient to develop regression equations.

II. Existing Conditions

A. Area Roadway System

Mamalahoa Highway (also known as the Hawaii Belt Road) is a two-way, two-lane, high quality, arterial highway between Keaau and Kailua-Kona. Mamalahoa Highway is the primary arterial highway in the Ka'u District. The posted speed on Mamalahoa Highway, in the vicinity of the proposed project, is 55 miles per hour.

B. Existing Traffic Volumes and Operating Conditions

1. Field Investigation

The field investigation was conducted on September 16-17, 2009 on Mamalahoa Highway at the existing scenic lookout near 75 Mile Marker (MM), during the morning peak period of traffic between the hours of 6:30 AM and 9:00 AM, and during the afternoon peak period of traffic between the hours of 3:30 PM and 6:30 PM. The traffic counts were updated with State Department of Transportation (DOT) data that was collected from April 27-28, 2010 on Mamalahoa Highway at 70.22 MM, which is located between the project site and South Point Road. Regional traffic data on Mamalahoa Highway also were obtained from DOT near Hookena at 101.10 MM, which is located about 25 miles to the northwest of the project site, dated April 20-21, 2010; and north of Pahala at 46.06 MM, which is located about 30 miles to the northeast of the project site, dated April 27-28, 2010

2. Existing AM Peak Hour Traffic

The AM peak hour of traffic on Mamalahoa Highway occurred between the hours of 8:00 AM and 9:00 AM. The AM peak hour traffic volume on Mamalahoa Highway was about 180 vehicles per hour (vph), total for both directions. The AM peak direction of traffic was eastbound with a 56/44 percent split. In the vicinity of the project, Mamalahoa Highway operated at LOS "B" with a v/c ratio of 0.07, during the existing AM peak hour of traffic.

Northwest of the project site, Mamalahoa Highway carried about 470 vph, total for both directions in the Hookena region. Mamalahoa Highway operated at LOS "D", with a v/c ratio of 0.18. Mamalahoa Highway carried about 190 vph, total for both directions, in the Pahala region, which is located to the northeast of the project site. Mamalahoa Highway operated at LOS "C" with a v/c ratio of 0.08.

3. Existing PM Peak Hour Traffic

The existing PM peak hour of traffic on Mamalahoa Highway occurred between 4:00 PM and 5:00 PM. The PM peak hour traffic volumes on Mamalahoa Highway was about 230 vph, total for both directions. The PM peak direction of traffic was westbound with a 55/45 percent split. Mamalahoa Highway operated at LOS "B" with a v/c ratio of 0.09, during the existing PM peak hour of traffic.

Mamalahoa Highway carried about 490 vph, total for both directions, in the Hookena region. Mamalahoa Highway operated at LOS "D", with a v/c ratio of 0.18. In the Pahala region, Mamalahoa Highway carried about 220 vph, total for both directions. Mamalahoa Highway operated at LOS "C" with a v/c ratio of 0.07. Table 4 summarizes the existing AM and PM peak hour traffic conditions.

Table 4. Existing Peak Hour Capacity Analysis												
	Mamalahoa Highway Location											
Peak	Hookena (101 MM)			Project Vicinity (70 MM)			Pahala (46 MM)					
Hour	VPH	LOS	V/C	LOS	V/C	VPH	LOS	V/C				
AM	471	D	0.18	183	В	0.07	186	С	0.08			
PM	489 D 0.18 231 B 0.09 219 C 0.07											

III. Future Peak Hour Traffic

A. Background Growth in Traffic

Historical traffic count data, collected on Mamalahoa Highway, in the vicinities of South Point Road (70 MM), Hookena (101 MM), and Pahala (46 MM), were obtained from DOT. Linear regression analysis of the DOT data indicated that the annual growth in traffic on Mamalahoa Highway averaged about 2.0 percent per year in the vicinity of the proposed project. Background growth factors of 1.10, 1.22, 1.28, and 1.40 were applied to the existing traffic on Mamalahoa Highway, in the vicinity of the proposed project, to estimate the Years 2015, 2021, 2024, and 2030 future traffic demands, respectively.

The annual growth in traffic on Mamalahoa Highway, in the Hookena region (northwest of the project site), averaged about 2.5 percent per year. Background growth factors of 1.125, 1.275, 1.35, and 1.50 were applied to the existing traffic on Mamalahoa Highway, in the vicinity of 101 MM, to estimate the Years 2015, 2021, 2024, and 2030 future traffic demands, respectively.

In the Pahala region (northeast of the project site), the annual growth in traffic on Mamalahoa Highway averaged about 1.7 percent per year. Background growth factors of 1.085, 1.187, 1.238, and 1.34 were applied to the existing traffic on Mamalahoa Highway, in the vicinity of 46 MM, to estimate the Years 2015, 2021, 2024, and 2030 future traffic demands, respectively.

B. Future Peak Hour Traffic Analysis Without Project

In the project vicinity, Mamalahoa Highway is expected to continue to operate at LOS "B", during the AM peak hour of traffic through the Year 2030 without the proposed project. By the Year 2021, Mamalahoa Highway is expected to operate at LOS "C", during the PM peak hour of traffic. Mamalahoa Highway is expected to continue to operate at LOS "D" in the Hookena region through the Year 2030 without the proposed project. In the Pahala region, Mamalahoa Highway is expected to operate at LOS "C" through the Year 2030 without the proposed project. The future AM and PM peak hour traffic conditions without the proposed project are summarized in Table 5.

	Table 5. Future Peak Hour Traffic Without Project												
				M	amalahoa	Highway	Location	1					
	Peak	Hooke	ena (101	MM)	Project	Vicinity (70 MM)	Paha	la (46 I	MM)			
Year	Hour	VPH	LOS	V/C	VPH	LOS	V/C	VPH	LOS	V/C			
2015	AM	530	D	0.20	201	В	0.08	202	С	0.08			
2015	PM	550	D	0.19	255	В	0.10	238	С	0.08			
2021	AM	600	D	0.22	223	В	0.09	221	С	0.09			
2021	PM	623	D	0.22	282	С	0.11	260	С	0.09			
2024	AM	636	D	0.24	235	В	0.09	230	С	0.09			
2024	PM	660	D	0.23	295	С	0.11	271	С	0.09			
2020	AM	706	D	0.26	256	В	0.10	249	С	0.10			
2030	PM	733	D	0.25	323	С	0.12	293	С	0.10			

IV. Traffic Impact Analysis

A. Trip Generation Characteristics

The Hawaiian Heritage Center is expected to consist of several trip generation components. The Hawaiian Heritage Center (HHC) accommodations or eco-lodge will consist of tentalows, i.e., tents that include basic daily services, such as communal meals and room maintenance. ITE has not developed trip generation rates for such accommodations. Therefore, the ITE trip rates for a motel were used to estimate the trip generation characteristics for the HHC eco-lodge. HHC also will include housing for research staff and students. The ITE trip rates for apartments were used to estimate the trip generation characteristics of the staff/student housing. The third component of the

HHC trip generation is the visitor base, which expected to reach 1,980 visitors per day at full build out of the proposed project. A trip generation analysis was conducted at the Polynesian Cultural Center in Laie, Oahu by The Traffic Management Consultant. The results of the analysis were used as the basis for estimating the trip generation characteristics of the visitors to HHC.

The trip generation for the part-time single- and multi-family residences were based upon the ITE rates for recreational homes. The trip generation for the single-family units, which are expected to rented to transients, were based upon the ITE rates for hotel units.

The Civic Center-Makai was analyzed using ITE trip rates for a 10,000 SFGFA government office complex. The Civic Center-Mauka was analyzed using ITE trip rates for an 400-student elementary school and a 15,000 SFGFA government office complex. The Veterans Affairs Center was analyzed using ITE trip rates for a 130-bed hospital.

Kahuku Village Commercial Market Assessment presented a retail demand analysis for the commercial component of the proposed project. Retail demand was based upon the average daily population of Kahuku Village, which consisted of the HHC, resident, and hotel components. Therefore, with the exception of pass-by traffic from Mamalahoa Highway, the retail traffic of the proposed project is expected to be generated internally. Pass-by traffic would consist of traffic, already passing by the project site on Mamalahoa Highway, that would be attracted to the retail activities of the proposed project. The percentages of pass-by trips of the shopping centers were compiled by ITE. The results of the analysis were published in the Trip Generation Handbook, October 1998. The average PM peak hour pass-by trip percentage for of 34 percent was taken from Table 5.4 of the Trip Generation Handbook.

The proposed Kahuku Village is expected to generate a total of 1,107 vph during the AM peak hour of traffic -615 vph entering the site and 492 vph exiting the site. During the PM peak hour of traffic, the proposed project is expected to generate a total of 1,771 vph -870 vph entering the site and 901 vph exiting the site. The trip generation characteristics for the proposed project are summarized in Table 6.

	Table 6. Trip Generation Characteristics											
*7	Land Use	T T •.	AM Pea	ık Hou	r (vph)	PM Peak Hour (vph)						
Year	(ITE Code)	Units	Enter	Exit	Total	Enter	Exit	Total				
	HHC Lodging (320)	60 Units	10	17	27	15	13	28				
2015	HHC Visitors	100 Persons	1	1	2	5	5	10				
2015	HHC Dormitory (220)	38 Persons	4	17	21	11	6	17				
	Year	15	35	50	31	24	55					

	Table 6. Trip Generation Characteristics (Cont'd.)												
	Land Use	***	AM Pea	ık Hou	r (vph)	PM Pea	k Houi	r (vph)					
Year	(ITE Code)	Units	Enter	Exit	Total	Enter	Exit	Total					
	HHC Lodging (320)	40 Units	6	11	17	10	8	18					
	HHC Visitors	710 Persons	11	4	15	32	35	67					
	HHC Dormitory (220)	122 Persons	7	25	32	31	17	48					
	Single-Family Housing (210)	61 DU	18	54	72	60	35	95					
	SF-Transient Rentals (310)	73 DU	17	11	28	23	20	43					
2021	Residential Condos (230)	18 DU	2	11	13	10	5	15					
	SF/MF Recreational Homes (260)	177 DU	19	9	28	19	27	46					
	Civic Center-Makai (730)	3000 SFGFA	6	1	7	3	6	9					
	Golf Course (430)	18 Holes	32	8	40	23	28	51					
	Shopping Center	40000 SFGFA	20	0	20	58	58	116					
	Resort Hotel (330)	150 Rooms	14	5	19	16	21	37					
	Time Share (520)	100 DU	32	16	48	29	42	71					
	Year	2021 Subtotals	184	155	339	314	302	616					
	Year 2021 Cumul	ative Subtotals	199	190	389	345	326	671					

	Table 6. Trip Generation Characteristics (Cont'd.)												
	Land Use	***	AM Pea	ık Hou	r (vph)	PM Pea	k Houi	(vph)					
Year	(ITE Code)	Units	Enter	Exit	Total	Enter	Exit	Total					
	HHC Visitors	840 Persons	12	6	18	38	42	80					
	HHC Dormitory (220)	110 Persons	5	23	28	28	15	43					
	Single-Family Housing (210)	48 DU	8	25	33	28	17	45					
	SF-Transient Rentals (310)	79 DU	25	16	41	25	22	47					
	Residential Condos (230)	164 DU	12	58	70	56	27	83					
2024	SF/MF Recreational Homes (260)	344 DU	37	19	56	37	53	90					
2024	Civic Center-Makai (730)	7000 SFGFA	14	1	15	6	14	20					
	VA Facility (610)	130 Bed	65	27	92	56	100	156					
	Shopping Center	70000 SFGFA	15	0	15	57	57	114					
	Civic Center-Mauka (730)	15000 SFGFA	30	4	34	13	29	42					
	Elementary School	400 Students	79	65	144	29	31	60					
	Resort Hotel (330)	150 Rooms	43	17	60	26	35	61					
	Time Share (520)	100 DU	39	19	58	30	43	73					
	Year	384	280	664	429	485	914						
	Year 2024 Cumul	ative Subtotals	583	470	1053	774	811	1585					

	Table 6. Trip Generation Characteristics (Cont'd.)												
	Land Use		AM Pea	ık Hou	r (vph)	PM Pea	k Hour	(vph)					
Year	(ITE Code)	Units	Enter	Exit	Total	Enter	Exit	Total					
	HHC Visitors	330 Persons	5	2	7	15	16	31					
	HHC Dormitory (220)	40 Persons	2	8	10	10	5	15					
	Single-Family Housing (210)	5 DU	1	3	4	3	1	4					
	SF-Transient Rentals (310)	16 DU	5	3	8	5	5	10					
2030	Residential Condos (230)	15 DU	1	5	6	4	3	7					
	SF/MF Recreational Homes (260)	22 DU	2	1	3	2	3	5					
	Shopping Center	90000 SFGFA	16	0	16	57	57	114					
	Year	32	22	54	96	90	186						
	HHC Lodging (320)	100 Units	16	28	44	25	21	46					
	HHC Visitors	1980 Persons	29	13	42	90	98	188					
	HHC Dormitory (220)	310 Persons	18	73	91	80	43	123					
	Single-Family Housing (210)	142 DU	27	82	109	91	53	144					
Totals	SF-Transient Rentals (310)	168 DU	47	30	77	53	47	100					
	Residential Condos (230)	197 DU	15	74	89	70	35	105					
	SF/MF Recreational Homes (260)	543 DU	58	29	87	58	83	141					
	Civic Center-Makai (730)	10 SFGFA	20	2	22	9	20	29					
	Civic Center-Mauka (730)	15000 SFGFA	30	4	34	13	29	42					

	Table 6. Trip Generation Characteristics (Cont'd.)												
*7	Land Use		AM Pea	ık Hou	r (vph)	PM Peak Hour (vph)							
Year	(ITE Code)	Units	Enter	Exit	Total	Enter	Exit	Total					
	Elementary School	400 Students	79	65	144	29	31	60					
	VA Facility (610)	130 Beds	65	27	92	56	100	156					
Totals	Golf (430)	18 Holes	32	8	40	23	28	51					
(Cont'd)	Shopping Center	200000 SFGFA	51	0	51	172	172	344					
	Resort Hotel (330)	300 Rooms	57	22	79	42	56	98					
	Time Share (520)	200 DU	71	35	106	59	85	144					
		Project Totals	615	492	1107	870	901	1771					

B. Traffic Assignments

The AM and PM peak hour site-generated traffic assignments were based upon existing traffic circulation patterns on Mamalahoa Highway.

C. Year 2015 Peak Hour Traffic Impact Analysis With Project

The traffic movements at the intersection of Mamalahoa Highway and the existing dirt road access are expected to operate at LOS "A", during the Year 2015 AM peak hour of traffic with the proposed project. Mamalahoa Highway is expected to operate at LOS "B", with a v/c ratio of 0.09, in the vicinity of the proposed project. Northwest of the project vicinity in Hookena, Mamalahoa Highway is expected to operate at LOS "D", with a v/c ratio of 0.20. Mamalahoa Highway is expected to operate at LOS "C", with a v/c ratio of 0.09, to the northeast of the project vicinity in Pahala.

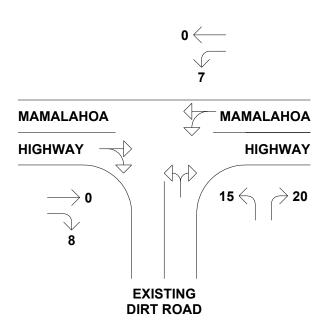
During the Year 2015 PM peak hour of traffic with the proposed project, the existing dirt road access is expected to operate at LOS "B" at Mamalahoa Highway. The other traffic movements at the intersection are expected to operate at LOS "A". In the vicinity of the proposed project, Mamalahoa Highway is expected to operate at LOS "C", with a v/c ratio of 0.10. Mamalahoa Highway is expected to operate at LOS "D", with a v/c ratio of 0.20 to the northwest of the project vicinity in Hookena. Northeast of the project vicinity in Pahala, Mamalahoa Highway is expected to operate at LOS "C", with a v/c ratio of 0.09.

The Year 2015 AM and PM peak hour site-generated traffic assignments are depicted on Figure 5. Figure 6 depicts the Year 2015 AM and PM peak hour traffic with the proposed project.

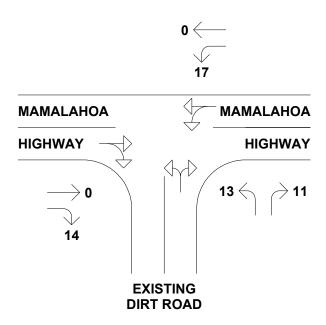


LEGEND





2015 AM PEAK HOUR SITE TRAFFIC



2015 PM PEAK HOUR SITE TRAFFIC

Figure 5. 2015 Peak Hour Traffic Assignment

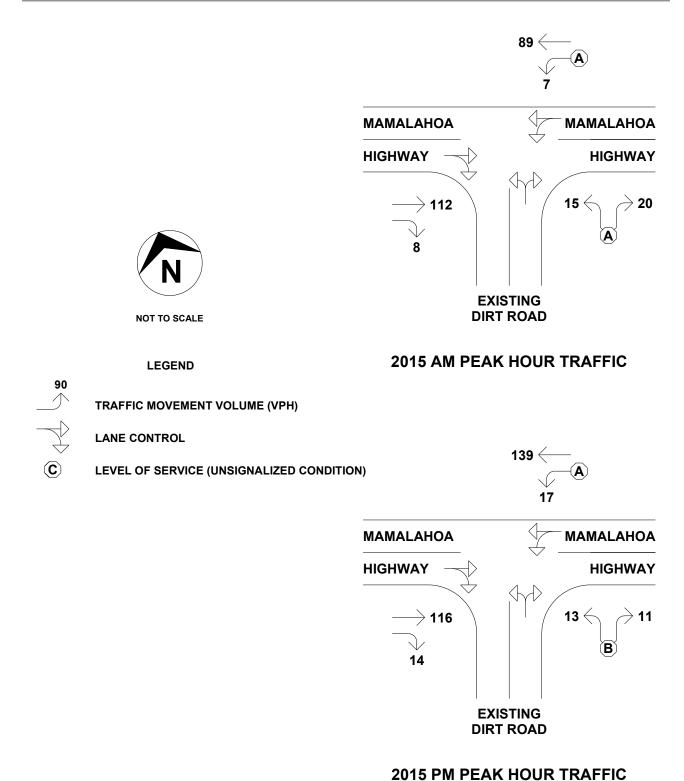


Figure 6. 2015 Peak Hour Traffic With Project

D. Year 2021 Peak Hour Traffic Analysis With Project

The Main Access Road is expected to be constructed by the Year 2016. The Main Access Road should intersect Mamalahoa Highway at a stop-controlled, channelized Tee-intersection with separate left-turn and right-turn lanes. Mamalahoa Highway should be widened to provide an exclusive left-turn deceleration lane in the westbound direction, and right-turn deceleration and acceleration lanes in the eastbound direction.

During the Year 2021 AM peak hour of traffic with the proposed project, the left-turn and right-turn movements from the Main Access Road are expected to operate at LOS "B". The other traffic movements at the intersection of Mamalahoa Highway and the Main Access Road are expected to operate at LOS "A". Mamalahoa Highway is expected to operate at LOS "C", with a v/c ratio of 0.16, in the vicinity of the proposed project. Mamalahoa Highway is expected to operate at LOS "D", with a v/c ratio of 0.29 to the northwest of the project vicinity in Hookena. Northeast of the project vicinity in Pahala, Mamalahoa Highway is expected to operate at LOS "C", with a v/c ratio of 0.17.

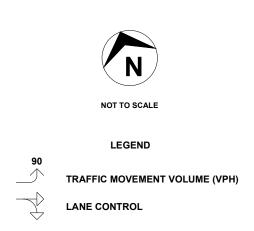
The Main Access Road is expected to operate at LOS "C" at Mamalahoa Highway, during the Year 2021 PM peak hour of traffic with the proposed project. The other traffic movements at the intersection are expected to operate at LOS "A". In the vicinity of the proposed project, Mamalahoa Highway is expected to operate at LOS "C", with a v/c ratio of 0.20. Northwest of the project vicinity in Hookena, Mamalahoa Highway is expected to operate at LOS "D", with a v/c ratio of 0.31. Northeast of the project vicinity in Pahala, Mamalahoa Highway is expected to operate at LOS "C", with a v/c ratio of 0.18.

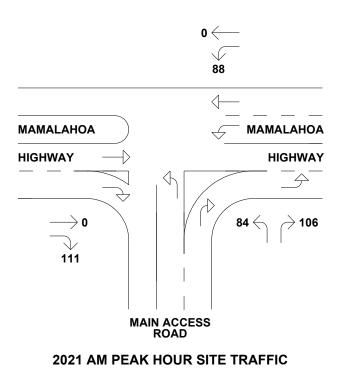
Figure 7 depicts the Year 2021 AM and PM peak hour site-generated traffic assignments. The Year 2021 AM and PM peak hour traffic with the proposed project are depicted on Figure 8.

E. Year 2024 Peak Hour Traffic Analysis With Project

By the Year 2024, the Main Access Road should be signalized at Mamalahoa Highway. The storage lengths of the exclusive left-turn lane on Mamalahoa Highway and the exclusive right-turn lane on the Main Access Road should be extended, as necessary, to accommodate the increase in traffic demands and the traffic signal control.

The intersection of Mamalahoa Highway and the Main Access Road is expected to operate at an overall LOS "B", with a maximum v/c ratio of 0.66, during the Year 2024 AM peak hour of traffic with the proposed project. The left-turn movements to and from the Main Access Road are expected to operate at LOS "C". The through movement on eastbound Mamalahoa Highway also is expected to operate at LOS "C". The other traffic movements at the intersection of Mamalahoa Highway and the Main Access Road are expected to operate at LOS "A". In the vicinity of the proposed project. Mamalahoa Highway is expected to operate at LOS "C", with a v/c ratio of 0.28. Mamalahoa Highway is expected to operate at LOS "E", with a v/c ratio of 0.43 to the northwest of the project vicinity in Hookena. Northeast of the project vicinity in Pahala, Mamalahoa Highway is expected to operate at LOS "D", with a v/c ratio of 0.29.





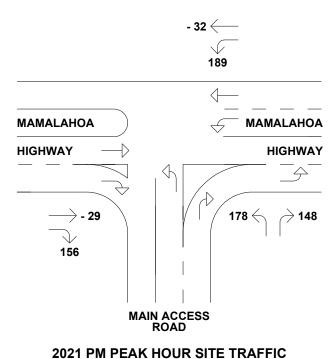
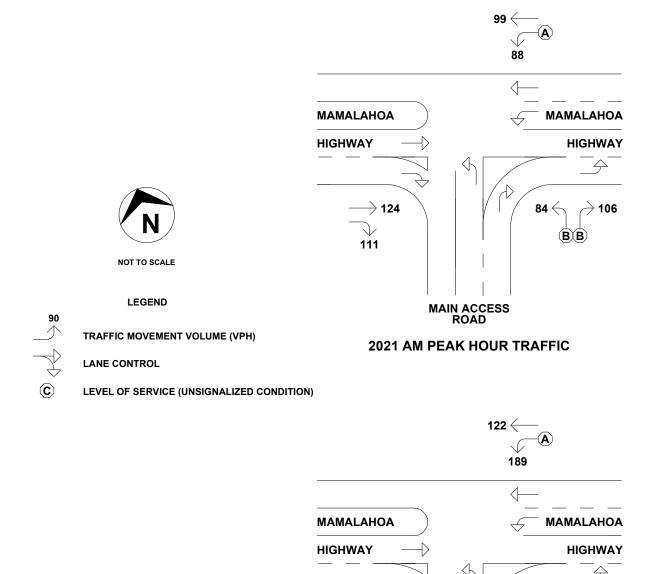


Figure 7. 2021 Peak Hour Traffic Assignments



2021 PM PEAK HOUR TRAFFIC

MAIN ACCESS ROAD **178** ←

(C)(C)

Figure 8. 2021 Peak Hour Traffic With Project

→ 102

156

During the Year 2024 PM peak hour of traffic with the proposed project, the Mamalahoa Highway and Main Access Road intersection is expected to operate at an overall LOS "C", with a maximum v/c ratio of 0.83. The left-turn movements to and from the Main Access Road are expected to operate at LOS "D". The other traffic movements at the intersection are expected to operate at satisfactory Levels of Service, i.e., LOS "C" or better. Mamalahoa Highway is expected to operate at LOS "D", with a v/c ratio of 0.34, in the vicinity of the proposed project. Northwest of the project vicinity in Hookena, Mamalahoa Highway is expected to operate at LOS "E", with a v/c ratio of 0.46. Mamalahoa Highway is expected to operate at LOS "D", with a v/c ratio of 0.32, to the northeast of the project vicinity in Pahala.

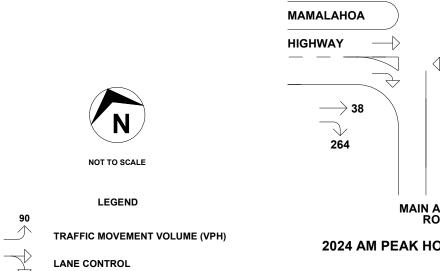
The Year 2024 AM and PM peak hour site-generated traffic assignments are depicted on Figure 9. The Year 2024 AM and PM peak hour traffic with the proposed project are depicted on Figure 10.

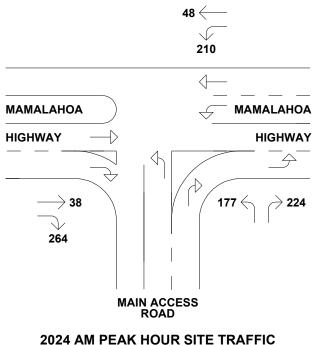
F. Year 2030 Peak Hour Traffic Impact Analysis With Project

The intersection of Mamalahoa Highway and the Main Access Road is expected to operate at an overall LOS "B", with a maximum v/c ratio of 0.69, during the Year 2030 AM peak hour of traffic with the proposed project. All the traffic movements at the intersection are expected to operate at satisfactory Levels of Service. Mamalahoa Highway is expected to operate at LOS "C", with a v/c ratio of 0.30, in the vicinity of the proposed project. Mamalahoa Highway is expected to operate at LOS "E", with a v/c ratio of 0.46 to the northwest of the project vicinity in Hookena,. Northeast of the project vicinity in Pahala, Mamalahoa Highway is expected to operate at LOS "D", with a v/c ratio of 0.30.

The Mamalahoa Highway and Main Access Road intersection is expected to operate at an overall LOS "C", with a maximum v/c ratio of 0.91, during the Year 2030 PM peak hour of traffic with the proposed project. The left-turn movements to and from the Main Access Road are expected to operate at LOS "D". The other traffic movements at the intersection are expected to operate at satisfactory Levels of Service. Mamalahoa Highway is expected to operate at LOS "D", with a v/c ratio of 0.36, in the vicinity of the proposed project. Mamalahoa Highway is expected to operate at LOS "E", with a v/c ratio of 0.49, to the northwest of the project vicinity in Hookena. Mamalahoa Highway is expected to operate at LOS "D", with a v/c ratio of 0.34, to the northeast of the project vicinity in Pahala.

Figure 11 depicts the Year 2030 AM and PM peak hour site-generated traffic assignments. The Year 2030 AM and PM peak hour traffic with the proposed project are depicted on Figure 12.





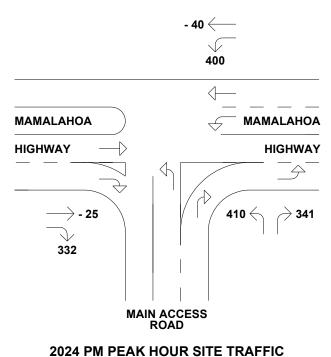
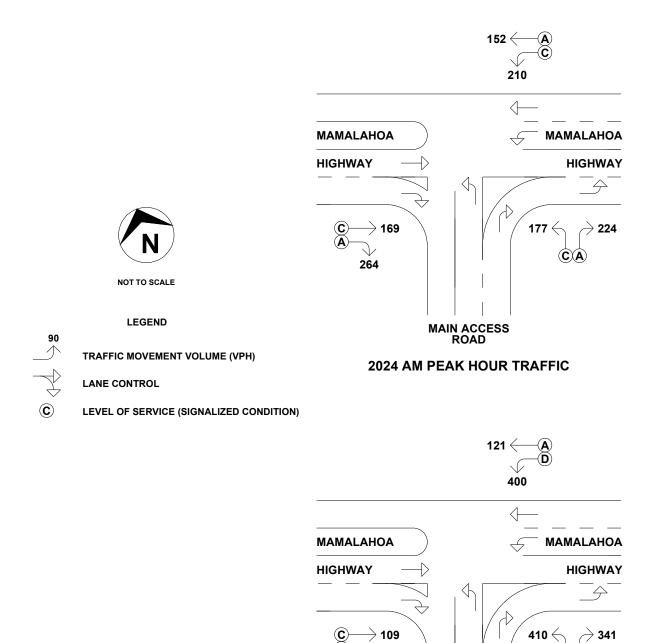


Figure 9. 2024 Peak Hour Traffic Assignments

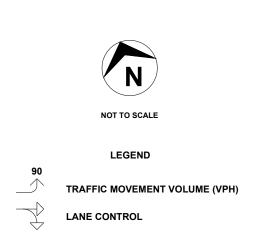


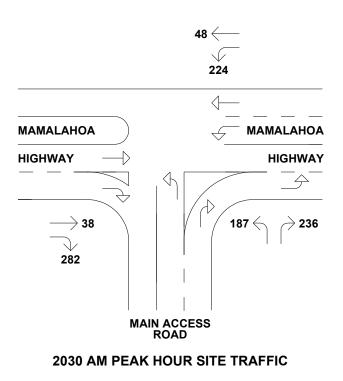
2024 PM PEAK HOUR TRAFFIC

MAIN ACCESS ROAD

Figure 10. 2024 Peak Hour Traffic With Project

332





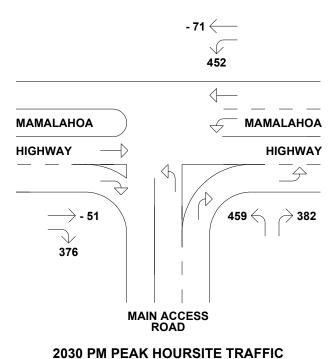
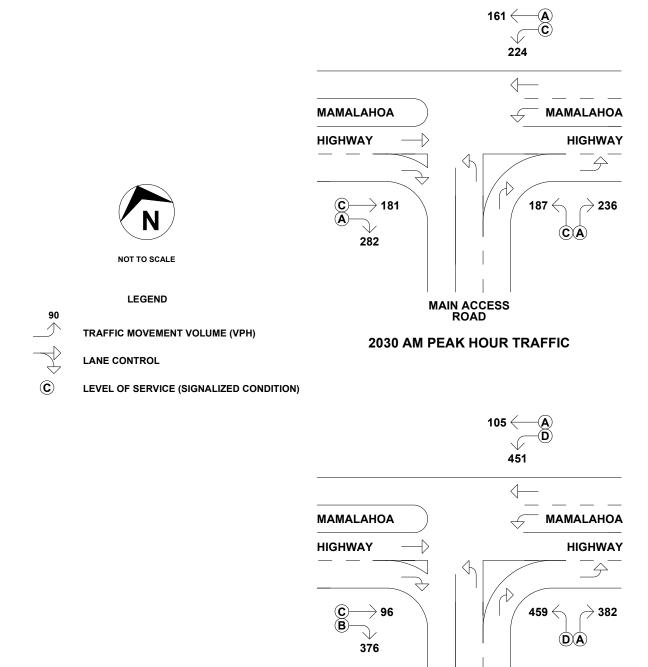


Figure 11. 2030 Peak Hour Traffic Assignments



2030 PM PEAK HOUR TRAFFIC

MAIN ACCESS ROAD

Figure 12. 2030 Peak Hour Traffic With Project

An alternative analysis was conducted for the Year 2030 PM peak hour traffic with the proposed project at the Main Access Road intersection, in accordance with the DOT Modern Roundabouts Policy Guideline, dated December 18, 2009, which states that modern roundabouts should be considered as an alternative intersection design. DOT's policy is currently limited to single-lane roundabouts. As such, the combined traffic volumes on the entry roadway and on the conflicting circulatory roadway should be less than 1,100 vph. This capacity constraint is expected to be exceeded during the Year 2030 PM peak hour of traffic with the proposed project in terms of passenger car units per hour, which are adjusted for heavy vehicles. The roundabout configuration would result in LOS "F" conditions on eastbound Mamalahoa Highway, during the Year 2030 PM peak hour of traffic. Therefore, a modern roundabout is not recommended for the intersection of Mamalahoa Highway and the Main Access Road. The roundabout analysis is included in the Appendix.

V. Evacuation Plan

The proposed Kahuku Village could represent significant increases in the de facto resident and visitor populations in the region. The County of Hawaii has raised concerns over the carrying capacity of the two-lane Mamalahoa Highway in event of a regional emergency evacuation. This preliminary analysis estimates the volume of traffic that can be expected to evacuate the region either to the toward the west to Kealakekua or the toward the east to Keaau. Under these emergency conditions, all traffic is expected to be prevented from entering the region, and Mamalahoa Highway will operate as a two-lane, one-way highway. Under "force flow" conditions, the capacity of a two-lane, one-way highway is estimated at 3,000 vph.

The State of Hawaii Data Book reported 118,905 vehicles were available to 62,472 occupied units in 2009 in the County of Hawaii, which averages 1.9 vehicles per household (HH). The Data Book also reported an average household size of 2.47 persons per occupied housing unit for the County of Hawaii in 2010. Finally, a estimated population growth of 1.5 percent per year to the Year 2030 is based upon the a regression analysis performed on the County of Hawaii population growth between the Years 1990 and 2010. Table 7 summarizes the existing and Year 2030 populations and the estimated number of vehicles in region without the proposed project.

Table 7. Regional Population and Vehicle Estimates										
Region 2010 Population 2030 Population 2030 Households 2030 Vehicle										
Ocean View	4,437	5,768	2,335	4,437						
Naalehu	866	1,126	456	866						
Pahala	1,356	1,763	714	1,356						
Totals	6,659	8,657	3,505	6,659						

The estimated number people on the proposed site at full build out on any given day is about 9,080 persons. Table 8 summarizes the existing and Year 2030 populations and the estimated number of vehicles in region without the proposed project.

Table 8. Kahuku Village Population and Vehicle Estimates										
Description	Persons	Persons/Vehicle	Vehicles							
HHV Site Seers	1,980	2.0	990							
HHV Researchers	310	1.0	310							
Recreational Day Trippers	1,500	2.0	750							
Construction Workforce	600	1.0	600							
Transient Hotel/Tentalows	1,122	2.0	561							
Hotel Visitors (non-overnights)	360	2.0	180							
Golfers	360	1.0	360							
Residences (DU)	1,050	1.9 Veh/DU	1,995							
Visitor to Residences	470	2.0	235							
Total	9,080	N/A	5,981							

A total of 12,640 vehicles can be expected to evacuate the region. At 3,000 vph, it would take about 4.2 hours to evacuate the region. Additional time will be required to convert Mamalahoa Highway into a one-way highway. Police officers should be stationed at major intersections in the region as well as at both ends of the evacuation area. This analysis is considered to be conservative by assuming that, at the time of the alert, all residents are in region and the proposed project is fully populated.

VI. Recommendations and Conclusions

A. Recommendations

1. Prior to the Year 2016

The existing dirt road is expected to provide temporary access, which will be closed when the Main Access Road is constructed. Furthermore, the existing dirt road is expected to operate at LOS "B" or better during the peak hours of traffic. Therefore, no highway improvements are recommended at this time.

2. Phases 1 and 2 (Years 2016-2021)

The following highway improvements are recommended with the development of Phase 1 and 2 of the proposed project:

- a. The two-lane, two-way Main Access Road should be constructed between Mamalahoa Highway and the future mixed-use village.
- b. The Main Access Road should be stop-controlled at its channelized intersection with Mamalahoa Highway.
- c. Mauka bound Main Access Road should be constructed with separate left-turn and right lanes at its intersection with Mamalahoa Highway. The exclusive right-turn lane should be a minimum of 100 feet in length.
- d. An exclusive left-turn lane should be constructed on westbound Mamalahoa Highway at the Main Access Road with a minimum 50 feet of storage length. The appropriate deceleration length should be added to the left-turn storage length.
- e. An exclusive right-turn deceleration lane should be constructed on eastbound Mamalahoa Highway at the Main Access Road.
- f. A right-turn acceleration lane from the Main Access Road should be constructed on eastbound Mamalahoa Highway.

3. Phase 3 (Years 2017-2024)

The following highway improvements are recommended with the development of Phase 3 the proposed project:

- a. The Main Access Road should be signalized at its intersection with Mamalahoa Highway, with an exclusive left-turn phase from westbound Mamalahoa Highway.
- b. The exclusive left-turn lane on westbound Mamalahoa Highway at the Main Access Road should be extended, as necessary, to provide a 325 feet of storage length. The appropriate deceleration length should be added to the left-turn storage length.
- c. The exclusive right-turn lane on mauka bound Main Access Road should be extended, as necessary, to provide 350 feet of storage length.

4. Phase 4 (Years 2025-2030)

No further highway improvements are recommended with the development of Phase 4.

B. Conclusions

Kahuku Village will be located a distance of about five (5) miles from Mamalahoa Highway. The proposed access road will traverse a terrain that varies from about 2,000 feet at Mamalahoa Highway to sea level at the coastline. An emergency access road to the neighboring Hawaiian Ocean View Ranchos can be made available if access to the Main Access Road is closed.

The Main Access Road is proposed to be stop-controlled at its channelized intersection with Mamalahoa Highway, through the first two phases of development, up to the Year 2023. This traffic impact analysis indicates that traffic signalization may be required by the third phase (Year 2024). A traffic signal warrant analysis should be conducted prior to the design and construction of the signalized intersection.

. The traffic improvements, recommended herein, are expected to maintain the minimum desirable Level of Service "D" or better conditions at the intersection of Mamalahoa Highway and the Main Access Road with the full build-out and occupancy of the proposed Kahuku Village through the Year 2030. Tables 9 and 10 summarize the capacity analysis in terms of various measures of effectiveness (MOE).

	Table 9. Summary of Intersection Capacity Analysis With Project											
	Peak		Eastbound		Westh	oound	Northbound					
Year	Hour	MOE	TH	RT	LT	TH	LT	RT				
	AM	LOS	A	A	A	A	A	A				
		v/c	0.08	0.08	0.01	0.01	0.05	0.05				
2015		Delay	0	0	0.6	0.6	9.5	9.5				
2015		LOS	A	A	A	A	В	В				
	PM	v/c	0.09	0.09	0.01	0.01	0.04	0.04				
		Delay	0	0	0.8	0.8	10.0	10.0				

Table 9. Summary of Intersection Capacity Analysis With Project (Cont'd)												
	Peak		Easth	ound	Westl	oound	North	bound				
Year	Hour	MOE	ТН	RT	LT	TH	LT	RT				
		LOS	A	A	A	A	В	В				
	AM	v/c	0.08	0.07	0.07	0.06	0.17	0.17				
2021		Delay	0	0	7.7	0	11.1	11.1				
		LOS	A	A	A	A	С	С				
	PM	v/c	0.07	0.10	0.14	0.09	0.54	0.54				
		Delay	0	0	7.8	0	18.7	18.7				
		LOS	С	A	С	A	С	A				
	AM	v/c	0.48	0.51	0.66	0.19	0.50	0.15				
2024		Delay	22.1	6.3	32.5	7.1	22.7	0.2				
		LOS	С	A	D	A	D	A				
	PM	v/c	0.47	0.66	0.85	0.17	0.83	0.23				
		Delay	34.4	10.0	43.7	9.8	39.0	0.3				
		LOS	С	A	С	A	С	A				
	AM	v/c	0.49	0.54	0.69	0.20	0.52	0.16				
2030		Delay	22.2	6.7	34.8	7.3	23.2	0.2				
		LOS	С	В	D	A	D	A				
	PM	v/c	0.44	0.71	0.91	0.15	0.89	0.26				
		Delay	35.0	10.8	50.8	9.6	46.4	0.4				

Ta	Table 10. Summary of Two-Lane Highway Capacity Analysis With Project											
			Mamalahoa Highway Location									
	Peak	Hook	ena (101	MM)	Project	Vicinity (70 MM)	Paha	la (46 ľ	MM)		
Year	Hour	VPH	LOS	V/C	VPH	LOS	V/C	VPH	LOS	V/C		
2015	AM	553	D	0.20	228	В	0.09	229	С	0.09		
2015	PM	557	D	0.20	283	С	0.10	266	С	0.09		
2021	AM	793	D	0.29	414	С	0.16	414	С	0.17		
2021	PM	886	D	0.31	545	С	0.20	523	С	0.18		
2024	AM	1194	Е	0.43	775	С	0.28	770	D	0.29		
2024	PM	1294	Е	0.46	925	D	0.34	901	D	0.32		
2020	AM	1289	Е	0.46	820	С	0.30	813	D	0.30		
2030	PM	1400	Е	0.49	987	D	0.36	957	D	0.34		

TRAFFIC IMPACT ANALYSIS REPORT FOR THE PROPOSED KAHUKU VILLAGE KA`U, HAWAII

TAX MAP KEY: (3) 9-2-001:072

APPENDIX A TRAFFIC COUNT DATA

TRAFFIC COUNT DATA

FILE NAME: Mamalahoa Hwy

PROJECT: Nani Kahuku PERIOD: AM Peak

LOCATION: South Point Hawaii NORTH:

E-W STREET Mamalahoa Highway TECHNICIAN: RSO/Video N-S STREET: Lookout DATE: 9/17/09

			Mama	lahoa H	lighway	,			Looko	ut					
TIME	E	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	TOTAL	HRLY
6:15	6:30	0	13	0	0	17	0	0	0	0	C) 0	0	30	
6:30	6:45	0	24	0	0	13	0	0	0	0	() 0	0	37	
6:45	7:00	0	16	0	0	13	0	0	0	0	() 0	0	29	
7:00	7:15	0	27	0	0	16	0	0	0	0	() 0	0	43	139
7:15	7:30	0	15	0	0	15	0	0	0	0	C	0	0	30	139
7:30	7:45	0	22	0	0	12	0	0	0	0	C	0	0	34	136
7:45	8:00	0	26	0	0	20	0	0	0	0	C	0	0	46	153
8:00	8:15	0	24	0	0	18	0	0	0	0	C	0	0	42	152
8:15	8:30	0	19	0	0	23	0	0	0	0	C	0	0	42	164
8:30	8:45	0	26	0	0	22	0	0	0	0	C	0	0	48	178
8:45	9:00	0	15	0	0	17	0	0	0	0	C) 0	0	32	164
AM PEA	AK HOU	JR													
7:45	8:45	0	95	0	0	83	0	0	0	0	(0	0	178	178
PHF			0.91			0.94								0.93	PHF

TRAFFIC COUNT DATA FILE NAME: Mamalahoa Hwy

PROJECT: Nani Kahuku PERIOD: PM Peak

LOCATION: South Point Hawaii NORTH:

E-W STREET Mamalahoa Highway TECHNICIAN: PT/Video N-S STREET Lookout DATE: 9/16/09

			Mamal	ahoa H	ighway				Looko	ut						
TIME	Е	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	7	TOTAL	
15:45	16:00	0	17	0	0	27	0	0	0	0	C)	0	0	44	
16:00	16:15	0	29	0	0	27	0	0	0	0	C)	0	0	56	
16:15	16:30	0	21	0	0	29	0	0	0	0	C)	0	0	50	
16:30	16:45	0	18	0	0	37	0	0	0	0	C)	0	0	55	205
16:45	17:00	0	24	0	0	27	0	0	0	0	C)	0	0	51	212
17:00	17:15	0	19	0	0	25	0	0	0	0	C)	0	0	44	200
17:15	17:30	0	29	0	0	29	0	0	0	0	C)	0	0	58	208
17:30	17:45	0	22	0	0	21	0	0	0	0	C)	0	0	43	196
17:45	18:00	0	18	0	0	28	0	0	0	0	C)	0	0	46	191
18:00	18:15	0	24	0	0	11	0	0	0	0	C)	0	0	35	182
18:15	18:30	0	19	0	0	22	0	0	0	0	C)	0	0	41	165
PM PE	AK HOU	JR														
16:00	17:00	0	92	0	0	120	0	0	0	0	C)	0	0	212	212
PHF			0.79			1.11									0.95 P	PHF

Hawaii Department of Transportation

Highways Division Highways Planning Survey Section

2010 Program Count - Summary

Site ID: B71001107022 Town: Hawaii DIR 1: +MP DIR 2:-MP Final AADT: 0
Functional Class: RURAL:MINOR ARTERIAL Count Type: CLASS Counter Type: Tube Route No: 11

Location: MAMALAHOA Hwy - KAHUKU RANCH ROAD TO ORC

TIME-AM	DIR 1	DIR 2	TOTAL	TIME-AM	DIR 1	DIR 2	TOTAL	TIME-PM	DIR 1	DIR 2	TOTAL	TIME-PM	DIR 1	DIR 2	TOTAL
DATE: 04/											_				
12:00-12:15	1	0	1	06:00-06:15	21	8	29	12:00-12:15	15	32	47	06:00-06:15	14	23	37
12:15-12:30	1	1	2	06:15-06:30	18	9	27	12:15-12:30	16	25	41	06:15-06:30	24	26	50
12:30-12:45	0	1	1	06:30-06:45	17	19	36	12:30-12:45	19	22	41	06:30-06:45	18	19	37
12:45-01:00	1	0	1	06:45-07:00	20	27	47	12:45-01:00	19	26	45	06:45-07:00	22	7	29
01:00-01:15	0	0	0	07:00-07:15	10	12	22	01:00-01:15	23	18	41	07:00-07:15	13	16	29
01:15-01:30	0	0	0	07:15-07:30	14	16	30	01:15-01:30	21	18	39	07:15-07:30	11	8	19
01:30-01:45	0	1	1	07:30-07:45	12	21	33	01:30-01:45	20	26	46	07:30-07:45	14	15	29
01:45-02:00	0	0	0	07:45-08:00	17	16	33	01:45-02:00	30	25	55	07:45-08:00	11	6	17
02:00-02:15	0	0	0	08:00-08:15	17	23	40	02:00-02:15	21	24	45	08:00-08:15	15	7	22
02:15-02:30	0	1	1	08:15-08:30	23	28	51	02:15-02:30	23	24	47	08:15-08:30	7	6	13
02:30-02:45	0	0	0	08:30-08:45	14	28	42	02:30-02:45	36	23	59	08:30-08:45	5	11	16
02:45-03:00	1	0	1	08:45-09:00	18	24	42	02:45-03:00	29	17	46	08:45-09:00	8	3	11
03:00-03:15	1	0	1	09:00-09:15	17	26	43	03:00-03:15	28	16	44	09:00-09:15	10	4	14
03:15-03:30	0	0	0	09:15-09:30	15	28	43	03:15-03:30	16	25	41	09:15-09:30	21	5	26
03:30-03:45	0	0	0	09:30-09:45	21	28	49	03:30-03:45	33	27	60	09:30-09:45	7	3	10
03:45-04:00	4	1	5	09:45-10:00	17	30	47	03:45-04:00	30	22	52	09:45-10:00	8	2	10
04:00-04:15	7	0	7	10:00-10:15	21	27	48	04:00-04:15	25	30	55	10:00-10:15	8	7	15
04:15-04:30	4	1	5	10:15-10:30	25	34	59	04:15-04:30	30	26	56	10:15-10:30	7	3	10
04:30-04:45	9	1 3	10 19	10:30-10:45	23 23	40 29	63 52	04:30-04:45	36 34	28 25	64 59	10:30-10:45	2 4	1	3 5
04:45-05:00 05:00-05:15	16 8	9	19	10:45-11:00 11:00-11:15	23 15	29 38	52	04:45-05:00 05:00-05:15	34	25 29	60	10:45-11:00 11:00-11:15	1	4	5 5
05:00-05:15	0 11	4	17	11:15-11:30	10	38 27	37	05:00-05:15	26	29 19	45	11:15-11:30	1	1	2
05:30-05:45	14	6	20	11:30-11:45	15	33	37 48	05:30-05:45	26	24	45 48	11:30-11:45	3	1	4
05:45-06:00	15	8	23	11:45-12:00	15	25	40	05:45-06:00	23	15	38	11:45-12:00	1	1	2
00.40 00.00	10							00.40 00.00	20	10		11.40 12.00	'	•	
AM COMMUTI		*	:00) I	DIR 1	DIF	R 2				RIOD (15:00-1	9:00)	DIR 1		DIR 2	
TWO DIREC	_							TWO DIRE				04.4	- DM - 01	- 45 DM	
	AK HR TIN			08:00 AM to			475		PEAK HR				5 PM to 05		000
	AK HR VC FACTOR (°		,	72	10	3	175 6.40		K FACTO	VOLUME		131		108	239 8.74
AM - D (,	70)		41.14	58.	96	100.00	PM - I		n (%)		54.81		45.19	100.00
DIRECTION	,		•	+1.14	30.	.00	100.00	DIRECTIO	` '	ıK		34.01		45.15	100.00
	AK HR TIM	ΛΕ	(06:00 AM to 07:00	AM 08	:00 AM to 0	09·00 AM		PEAK HR			04:15 PM to 05	5:15 PM	04:00 PM t	o 05:00 PM
	AK HR VO			76	10		,0.00 ,			VOLUME		131		109	0 00.00 1
AM PERIOD (00:00-12:0	0)						PM PERIOD	(12:00-2	4:00)					
TWO DIREC		,						TWO DIRE		,					
	AK HR TIN			10:15 AM to	11:15 AM				PEAK HR			04:15	5 PM to 05	5:15 PM	
AM - PE	AK HR VC	DLUME	8	36	14	1	227	PM - F	PEAK HR	VOLUME		131		108	239
AM - K F	FACTOR (S	%)					8.31	PM - ł	K FACTO	R (%)					8.74
AM - D ((%)		(37.89	62	.11	100.00	PM - [O (%)			54.81		45.19	100.00
NON-COMMU	TER PERI	OD (09:00-1	15:00)					6-HR, 12-HI	R, 24-HR	PERIODS		DIR 1 DI	R 2	Total	_
TWO DIREC	TIONAL P	EAK						AM 6-HR	PERIOD ((06:00-12:00)		418 59	16	1,014	
PEAK H	IR TIME			10:15 AM to	11:15 AN			AM 12-HR	PERIOD	(00:00-12:00))	511 63	3	1,144	
PEAK H	IR VOLUM	E	8	36	14	1	227	PM 6-HR	PERIOD ((12:00-18:00)		608 56	6	1,174	
DIRECTION	AL PEAK							PM 12-HR	PERIOD	(12:00-24:00))	843 74	-6	1,589	
PEAK H	HR TIME		(01:45 PM to 02:45	PM 10	15 AM to 1	11:15 AM	24 HOUR	PERIOD			1,354 1,3	379	2,733	
PEAK H	HR VOLUM	1E		110	14	1		D (%)				49.54 50	.46	100.00	

Hawaii Department of Transportation

Highways Division Highways Planning Survey Section

2010 Program Count - Summary

Site ID: B71001107022 Town: Hawaii DIR 1: +MP DIR 2:-MP Final AADT: 0
Functional Class: RURAL:MINOR ARTERIAL Count Type: CLASS Counter Type: Tube Route No: 11

Location: MAMALAHOA Hwy - KAHUKU RANCH ROAD TO ORC

TIME ANA	DIR 1	DIR 2	TOTAL	TIME-AM	DIR 1	DIR 2	TOTAL	TIME DM	DIR 1	DIR 2	TOTAL	TIME DM	DIR 1	DIR 2	TOTAL
TIME-AM		DIR 2	TOTAL	I IIVIE-AIVI	DIK I	DIR 2	TOTAL	TIME-PM	DIK I	DIR 2	TOTAL	TIME-PM	DIK I	DIR 2	TOTAL
DATE: 04/		_		00 00 00 15	0.5	10	07	10.00.10.15	07	00		00 00 00 15	4.5	40	07
12:00-12:15 12:15-12:30	2 1	1	3 2	06:00-06:15 06:15-06:30	25 14	12 16	37 30	12:00-12:15 12:15-12:30	27 26	30 25	57 51	06:00-06:15 06:15-06:30	15 19	12 19	27 38
12:15-12:30	0	2	2	06:30-06:45	23	20	43	12:30-12:45	26 21	32	51 53	06:30-06:45	19	19	38 28
12:45-01:00	0	1	1	06:45-07:00	23 16	21	37	12:45-01:00	19	29	48	06:45-07:00	13	12	25 25
01:00-01:15	1	1	2	07:00-07:15	12	21	33	01:00-01:15	20	23	43	07:00-07:15	14	14	28
01:15-01:30	0	0	0	07:15-07:30	19	26	45	01:15-01:30	16	23 27	43	07:15-07:30	18	14	32
01:30-01:45	1	2	3	07:30-07:45	9	20	29	01:30-01:45	20	19	39	07:30-07:45	14	8	22
01:45-02:00	0	1	1	07:45-08:00	7	14	21	01:45-02:00	25	23	48	07:45-08:00	5	12	17
02:00-02:15	0	0	0	08:00-08:15	25	21	46	02:00-02:15	11	19	30	08:00-08:15	8	5	13
02:15-02:30	0	0	0	08:15-08:30	21	25	46	02:15-02:30	29	23	52	08:15-08:30	13	6	19
02:30-02:45	0	0	0	08:30-08:45	25	32	57	02:30-02:45	22	21	43	08:30-08:45	7	0	7
02:45-03:00	2	3	5	08:45-09:00	18	23	41	02:45-03:00	40	17	57	08:45-09:00	8	4	12
03:00-03:15	0	0	0	09:00-09:15	16	28	44	03:00-03:15	37	23	60	09:00-09:15	5	5	10
03:15-03:30	1	1	2	09:15-09:30	24	36	60	03:15-03:30	29	22	51	09:15-09:30	3	5	8
03:30-03:45	3	0	3	09:30-09:45	20	38	58	03:30-03:45	34	25	59	09:30-09:45	8	7	15
03:45-04:00	6	2	8	09:45-10:00	26	27	53	03:45-04:00	26	23	49	09:45-10:00	7	1	8
04:00-04:15	2	1	3	10:00-10:15	23	40	63	04:00-04:15	27	22	49	10:00-10:15	4	4	8
04:15-04:30	10	3	13	10:15-10:30	23	29	52	04:15-04:30	33	32	65	10:15-10:30	4	4	8
04:30-04:45	9	3	12	10:30-10:45	30	27	57	04:30-04:45	23	22	45	10:30-10:45	2	1	3
04:45-05:00	17	5	22	10:45-11:00	11	22	33	04:45-05:00	30	18	48	10:45-11:00	1	1	2
05:00-05:15	8	5	13	11:00-11:15	24	32	56	05:00-05:15	30	16	46	11:00-11:15	3	1	4
05:15-05:30	10	8	18	11:15-11:30	12	38	50	05:15-05:30	33	24	57	11:15-11:30	0	4	4
05:30-05:45	9	3	12	11:30-11:45	12	32	44	05:30-05:45	34	17	51	11:30-11:45	0	3	3
05:45-06:00	17	12	29	11:45-12:00	22	21	43	05:45-06:00	24	18	42	11:45-12:00	0	0	0
AM COMMUT	ER PERIO	D (05:00-09:0	1 (0)	DIR 1	DIF	3.2		PM COMMI	ITER PER	RIOD (15:00-1	9.00)	DIR 1		DIR 2	
TWO DIREC			,0,	51111	Dii			TWO DIRI		•	3.00)	Direct		DITT	
	EAK HR TIN			08:00 AM to	09:00 AM			_	PEAK HR			03:30) PM to 04	1:30 PM	
	EAK HR VC		8	39	10		190			VOLUME		120		102	222
	FACTOR (9						6.89		K FACTO						8.05
AM - D	(%)	•	4	16.84	53.	.16	100.00	PM - I	D (%)	, ,		54.05		45.95	100.00
DIRECTION	AL PEAK							DIRECTIO	NAL PEA	K					
AM - PE	AK HR TIM	1E	(08:00 AM to 09:00	AM 08:	:00 AM to 0	09:00 AM	PM - F	PEAK HR	TIME		04:45 PM to 05	:45 PM	03:30 PM t	o 04:30 PM
AM - PE	AK HR VO	LUME	8	39	10	1		PM - F	PEAK HR	VOLUME		127		102	
AM PERIOD (00:00-12:00	0)						PM PERIOD	(12:00-24	4:00)					
TWO DIREC	CTIONAL P	EAK						TWO DIRE	ECTIONAL	L PEAK					
AM - PE	EAK HR TIN	ЛE		09:15 AM to	10:15 AM			PM - I	PEAK HR	TIME		02:45	PM to 03	3:45 PM	
	EAK HR VC		Ç	93	14	1	234			VOLUME		140		87	227
AM - K I	FACTOR (9	%)					8.48	PM - I	K FACTOR	₹ (%)					8.23
AM - D	(%)		- 3	39.74	60.	.26	100.00	PM - I	O (%)			61.67		38.33	100.00
NON-COMMU	JTER PERI	OD (09:00-15	5:00)					6-HR, 12-HI	R, 24-HR	PERIODS		DIR 1 DI	R 2	Total	
TWO DIREC	CTIONAL P	EAK						AM 6-HR	PERIOD (06:00-12:00)		457 62	1	1,078	
PEAK H	HR TIME			09:15 AM to	10:15 AM			AM 12-HF	PERIOD	(00:00-12:00)	556 67	6	1,232	
PEAK H	HR VOLUM	E	Ç	93	14	1	234	PM 6-HR	PERIOD (12:00-18:00)		636 55	0	1,186	
DIRECTION	IAL PEAK							PM 12-HF	PERIOD	(12:00-24:00)	823 70	4	1,527	
PEAK I	HR TIME		(9:45 AM to 10:45	AM 09:	15 AM to	10:15 AM	24 HOUR	PERIOD	•		1,379 1,3	380	2,759	
PEAK I	HR VOLUM	1E		102	14	1		D (%)				49.98 50	.02	100.00	

Hawaii Department of Transportation

Highways Division Highways Planning Survey Section

2010 Program Count - Summary

Site ID: B71001110110Town: HawaiiDIR 1: +MPDIR 2:-MPFinal AADT: 0Functional Class: RURAL:MINOR ARTERIALCount Type: CLASSCounter Type: TubeRoute No: 11

Location: MAMALAHOA Hwy - HOOKENA BEACH ROAD TO KE

			•													
TIME-AM	DIR 1	DIR 2	TOTAL	TIME-AM	DIR 1	DIR 2	TOTAL	TIME-PM	DIR 1	DIR 2	TOTAL	TIME	E-PM	DIR 1	DIR 2	TOTAL
DATE: 04	/20/2010															
12:00-12:15	0	5	5	06:00-06:15	73	8	81	12:00-12:15	31	45	76	06:00	-06:15	30	59	89
12:15-12:30	2	1	3	06:15-06:30	86	9	95	12:15-12:30	43	45	88	06:15	-06:30	29	61	90
12:30-12:45	2	0	2	06:30-06:45	87	9	96	12:30-12:45	34	36	70	06:30	-06:45	23	54	77
12:45-01:00	1	5	6	06:45-07:00	91	17	108	12:45-01:00	33	46	79	06:45	5-07:00	19	41	60
01:00-01:15	2	1	3	07:00-07:15	83	26	109	01:00-01:15	40	45	85	07:00	-07:15	19	32	51
01:15-01:30	1	0	1	07:15-07:30	115	34	149	01:15-01:30	36	39	75		-07:30	19	31	50
01:30-01:45	2	2	4	07:30-07:45	79	35	114	01:30-01:45	25	50	75		-07:45	28	40	68
01:45-02:00	0	1	1	07:45-08:00	55	42	97	01:45-02:00	52	45	97		-08:00	14	15	29
02:00-02:15	0	0	0	08:00-08:15	39	31	70	02:00-02:15	42	51	93		-08:15	10	25	35
02:15-02:30	1	1	2	08:15-08:30	52	28	80	02:15-02:30	53	64	117		-08:30	6	24	30
02:30-02:45	1	3	4	08:30-08:45	42	30	72	02:30-02:45	48	38	86		-08:45	21	25	46
02:45-03:00	2	0	2	08:45-09:00	60	49	109	02:45-03:00	39	66	105		5-09:00	10	20	30
03:00-03:15	4	0	4	09:00-09:15	57	36	93	03:00-03:15	42	63	105		0-09:15	7	20	27
03:15-03:30	3	2	5	09:15-09:30	46	38	84	03:15-03:30	40	77	117		5-09:30	9	17	26
03:30-03:45	8	0	8	09:30-09:45	45	43	88	03:30-03:45	42	62	104		-09:45	12	15	27
03:45-04:00	2	2	4	09:45-10:00	60	48	108	03:45-04:00	40	70	110		5-10:00	7	14	21
04:00-04:15	7	2 1	9 9	10:00-10:15	51	46	97	04:00-04:15	34	90	124 92		10:15	4	18	22
04:15-04:30	8 21	2	23	10:15-10:30	59	50 40	109	04:15-04:30 04:30-04:45	31	61	92 105		5-10:30	10	6 11	16 19
04:30-04:45 04:45-05:00	28	2	30	10:30-10:45 10:45-11:00	44 44	40 32	84 76	04:30-04:45	37 39	68 101	140)-10:45 5-11:00	8 8	18	19 26
05:00-05:15	31	6	37	11:00-11:15	49	34	83	05:00-05:15	39	79	110)-11:15	4	9	13
05:15-05:30	32	5	37	11:15-11:30	49	45	89	05:15-05:30	35	83	118		5-11:30	2	9	11
05:30-05:45	34	3	37	11:30-11:45	41	39	80	05:30-05:45	32	93	125)-11:45	2	6	8
05:45-06:00	58	8	66	11:45-12:00	54	28	82	05:45-06:00	40	76	116		5-12:00	1	5	6
										-						
AM COMMUT			00) D	IR 1	DIR	2				RIOD (15:00-1	9:00)	DIR 1			DIR 2	
TWO DIREC				00 45 444				TWO DIRI					04.45	DM += 00	45 DM	
	EAK HR TIN		0.	06:45 AM to			400		PEAK HR			107	04:45	PM to 05		400
	EAK HR VO FACTOR (%	_	30	08	112		480 8.21		K FACTO	VOLUME		137			356	493 8.44
AM - D	,	70)	7(6.67	23.3	13	100.00	PM - 1		11 (70)		27.79			72.21	100.00
DIRECTION	. ,		/ \	5.07	20.0		100.00	DIRECTIO	. ,	ιK		21.13			12.21	100.00
	AK HR TIM	1E	06	6:30 AM to 07:30	AM 07:1	5 AM to	08:15 AM		PEAK HR			03:00 F	PM to 04	:00 PM	04:45 PM t	o 05:45 PM
AM - PE	AK HR VO	LUME	3	76	142			PM - F	PEAK HR	VOLUME		164			356	
AM PERIOD (00:00-12:00))						PM PERIOD	(12:00-2	4:00)						
TWO DIREC		,						TWO DIRE								
AM - PE	EAK HR TIN	ΛE		06:45 AM to	07:45 AM				PEAK HR				04:45	PM to 05	5:45 PM	
AM - PE	AK HR VO	LUME	36	68	112		480	PM - F	PEAK HR	VOLUME		137			356	493
AM - K	FACTOR (%	%)					8.21	PM - I	K FACTO	R (%)						8.44
AM - D	(%)		70	6.67	23.3	33	100.00	PM - I	O (%)			27.79			72.21	100.00
NON-COMMU	JTER PERI	OD (09:00-1	5:00)					6-HR, 12-HI	R, 24-HR	PERIODS		DIR 1	DIF	R 2	Total	
TWO DIREC	CTIONAL PI	EAK						AM 6-HR	PERIOD ((06:00-12:00)		1,456	79	7	2,253	
PEAK H	IR TIME			09:30 AM to	10:30 AM				,	(00:00-12:00))	1,706	849	9	2,555	
PEAK H	R VOLUMI	E	2	15	187		402	PM 6-HR	PERIOD ((12:00-18:00)		919	1,4	93	2,412	
DIRECTION	IAL PEAK								,	(12:00-24:00))	1,221	2,0		3,289	
PEAK I	HR TIME		09	9:30 AM to 10:30	AM 02:0	00 PM to	03:00 PM	24 HOUR		/		2,927	2,9		5,844	
PEAK I	HR VOLUM	ΙE	2	15	219			D (%)				50.09	49.	.91	100.00	

Hawaii Department of Transportation

Highways Division Highways Planning Survey Section

2010 Program Count - Summary

Site ID: B71001110110

Town: Hawaii

DIR 1: +MP
DIR 2:-MP
Final AADT: 0

Counter Type: Tube
Route No: 11

Location: MAMALAHOA Hwy - HOOKENA BEACH ROAD TO KE

TIME-AM	DIR 1	DIR 2	TOTAL	TIME-AM	DIR 1	DIR 2	TOTAL	TIME-PM	DIR 1	DIR 2	TOTAL	TIME-PM	DIR 1	DIR 2	TOTAL
DATE: 04		DIN 2	TOTAL	I IIVIL-AIVI	ו חוט	DIN 2	TOTAL	I IIVIE-FIVI	ו חוט	DIN Z	TOTAL	I IIVIE-FIVI	ו חוט	DIN 2	TOTAL
		0	0	00:00 00:15	70	0	70	10:00 10:15	34	00	70	00:00 00:15	00	07	100
12:00-12:15 12:15-12:30	3 2	6 1	9 3	06:00-06:15 06:15-06:30	70 87	6 10	76 97	12:00-12:15 12:15-12:30	34 39	36 35	70 74	06:00-06:15 06:15-06:30	36 39	67 57	103 96
12:30-12:45	1	8	9	06:30-06:45	75	20	97 95	12:30-12:45	39 46	39	74 85	06:30-06:45	23	57 57	80
12:45-01:00	2	4	6	06:45-07:00	98	25	123	12:45-01:00	46	40	86	06:45-07:00	30	48	78
01:00-01:15	1	0	1	07:00-07:15	89	24	113	01:00-01:15	35	56	91	07:00-07:15	21	46	67
01:15-01:30	0	1	1	07:15-07:30	95	23	118	01:15-01:30	43	43	86	07:15-07:30	20	25	45
01:30-01:45	3	2	5	07:30-07:45	77	31	108	01:30-01:45	57	45	102	07:30-07:45	18	34	52
01:45-02:00	0	3	3	07:45-08:00	56	34	90	01:45-02:00	42	49	91	07:45-08:00	22	29	51
02:00-02:15	0	1	1	08:00-08:15	49	32	81	02:00-02:15	39	63	102	08:00-08:15	17	29	46
02:15-02:30	1	1	2	08:15-08:30	60	34	94	02:15-02:30	38	53	91	08:15-08:30	14	37	51
02:30-02:45	1	2	3	08:30-08:45	49	40	89	02:30-02:45	43	41	84	08:30-08:45	8	25	33
02:45-03:00	2	1	3	08:45-09:00	53	38	91	02:45-03:00	31	54	85	08:45-09:00	13	25	38
03:00-03:15	7	1	8	09:00-09:15	51	34	85	03:00-03:15	28	60	88	09:00-09:15	9	12	21
03:15-03:30	2	1	3	09:15-09:30	47	50	97	03:15-03:30	55	64	119	09:15-09:30	5	12	17
03:30-03:45	5	2	7	09:30-09:45	48	29	77	03:30-03:45	54	60	114	09:30-09:45	9	13	22
03:45-04:00	6	1	7	09:45-10:00	42	32	74	03:45-04:00	45	61	106	09:45-10:00	9	17	26
04:00-04:15	7	0	7	10:00-10:15	55	39	94	04:00-04:15	36	76	112	10:00-10:15	11	12	23
04:15-04:30	10	2	12	10:15-10:30	40	49	89	04:15-04:30	38	87	125	10:15-10:30	7	8	15
04:30-04:45	19	1	20	10:30-10:45	27	50	77	04:30-04:45	39	66	105	10:30-10:45	7	12	19
04:45-05:00	30	3	33	10:45-11:00	40	39	79	04:45-05:00	38	87	125	10:45-11:00	5	16	21
05:00-05:15	36	5	41	11:00-11:15	58	33	91	05:00-05:15	43	81	124	11:00-11:15	3	9	12
05:15-05:30	29	7	36	11:15-11:30	39	55	94	05:15-05:30	38	72	110	11:15-11:30	2	8	10
05:30-05:45	40	5	45	11:30-11:45	35	34	69	05:30-05:45	37	88	125	11:30-11:45	2	4	6
05:45-06:00	39	8	47	11:45-12:00	43	48	91	05:45-06:00	30	78	108	11:45-12:00	0	5	5
AM COMMUT	ER PERIO	D (05:00-09:0)O) [DIR 1	DIF	R 2		PM COMMU	JTER PEF	RIOD (15:00-1	9:00)	DIR 1		DIR 2	
TWO DIREC	CTIONAL P	EAK						TWO DIRI	ECTIONAL	L PEAK					
AM - PE	EAK HR TIN	ЛΕ		06:45 AM to	07:45 AM			PM - I	PEAK HR	TIME		04:45	5 PM to 05	5:45 PM	
	EAK HR VC		3	59	103	3	462	PM - I	PEAK HR	VOLUME		156		328	484
	FACTOR (9	%)					7.90		K FACTO	R (%)					8.27
AM - D	` '		7	7.71	22.	29	100.00	PM - I	` '	1.6		32.23		67.77	100.00
DIRECTION		4=		0.45.45407.45	444 00	00 4444	00.00.414	DIRECTIC				00.45 DM. 04	45 DM	04.45.014	05 45 DM
	AK HR TIM AK HR VO			6:45 AM to 07:45	AM 08:	00 AM to 0)9:00 AM		PEAK HR			03:15 PM to 04	1:15 PM	04:45 PM t 328	to 05:45 PM
					14-	T						130		320	
AM PERIOD (,						PM PERIOD TWO DIRE		,					
	EAK HR TIN			06:45 AM to	07:45 414			_	PEAK HR			04:45	5 PM to 05	: 45 DM	
	EAK HR VC		9	59 VO.45 AW 10	103 103		462			VOLUME		156) FIVI LO US	328	484
	FACTOR (9				100	,	7.90		C FACTOR			100		020	8.27
AM - D	,	,	7	7.71	22.	29	100.00	PM - [- (,-,		32.23		67.77	100.00
NON-COMMU	JTER PERI	OD (09:00-15	5:00)					6-HR, 12-HI	R. 24-HR I	PERIODS		DIR 1 DI	R 2	Total	
TWO DIREC	CTIONAL P	EAK	,					AM 6-HR	PERIOD (06:00-12:00)		1,383 80	9	2,192	
	IR TIME			01:30 PM to	02:30 PM				•	(00:00-12:00)		1,629 87		2,504	
	R VOLUM	E	1	76	210		386			12:00-18:00)			134	2,408	
DIRECTION									,	(12:00-24:00)		- ,	041	3,345	
	HR TIME		C	9:15 AM to 10:15	AM 02:	00 PM to 0	03:00 PM	24 HOUR		,,			916	5,849	
	HR VOLUM	ΙE		92	21		***	D (%)					.85	100.00	
/			•	-				- (/						,	

Hawaii Department of Transportation

Highways Division Highways Planning Survey Section

2010 Program Count - Summary

Site ID: B71001104606Town: HawaiiDIR 1: +MPDIR 2:-MPFinal AADT: 0Functional Class: RURAL:MINOR ARTERIALCount Type: CLASSCounter Type: TubeRoute No: 11

Location: MAMALAHOA Hwy - KAPAPALA RANCH ROAD TO N

			•												
TIME-AM	DIR 1	DIR 2	TOTAL	TIME-AM	DIR 1	DIR 2	TOTAL	TIME-PM	DIR 1	DIR 2	TOTAL	TIME-F	M DIR	1 DIR 2	TOTAL
DATE: 04	/27/2010														
12:00-12:15	1	3	4	06:00-06:15	12	14	26	12:00-12:15	24	18	42	06:00-0	8:15 11	17	28
12:15-12:30	0	0	0	06:15-06:30	12	12	24	12:15-12:30	36	17	53	06:15-0	6:30 11	13	24
12:30-12:45	1	2	3	06:30-06:45	19	10	29	12:30-12:45	17	14	31	06:30-0	6:45 12	2 17	29
12:45-01:00	0	0	0	06:45-07:00	16	11	27	12:45-01:00	19	15	34	06:45-0	7:00 12	2 10	22
01:00-01:15	1	0	1	07:00-07:15	19	21	40	01:00-01:15	14	28	42	07:00-07	7:15 8	8	16
01:15-01:30	1	0	1	07:15-07:30	32	18	50	01:15-01:30	19	16	35	07:15-0		2 5	17
01:30-01:45	0	0	0	07:30-07:45	32	24	56	01:30-01:45	30	28	58	07:30-0			24
01:45-02:00	0	0	0	07:45-08:00	25	15	40	01:45-02:00	20	19	39	07:45-08			17
02:00-02:15	2	0	2	08:00-08:15	19	14	33	02:00-02:15	10	30	40	08:00-08			11
02:15-02:30	1	0	1	08:15-08:30	15	14	29	02:15-02:30	11	30	41	08:15-08			13
02:30-02:45	0	0	0	08:30-08:45	20	17	37	02:30-02:45	23	35	58	08:30-08			15
02:45-03:00	0	1	1	08:45-09:00	21	20	41	02:45-03:00	14	23	37	08:45-09			16
03:00-03:15	0	0	0	09:00-09:15	23	22	45	03:00-03:15	28	28	56	09:00-09			13
03:15-03:30	0	2	2	09:15-09:30	26	17	43	03:15-03:30	24	25	49	09:15-09			11
03:30-03:45	1	4	5	09:30-09:45	20	17	37	03:30-03:45	35	30	65	09:30-09			14
03:45-04:00	1	6	7	09:45-10:00	28	25	53	03:45-04:00	18	14	32	09:45-10			6
04:00-04:15	2 0	2	4	10:00-10:15	17	22	39	04:00-04:15	16	33	49	10:00-10			6 4
04:15-04:30	0	2 3	2	10:15-10:30	28	16 12	44 47	04:15-04:30 04:30-04:45	26	31 24	57 58	10:15-10			4
04:30-04:45 04:45-05:00	2	3	3 5	10:30-10:45 10:45-11:00	35 22	20	47 42	04:30-04:45	34 28	24 27	58 55	10:30-10 10:45-1			3
05:00-05:15	3	3 7	10	11:00-11:15	34	19	53	05:00-05:15	13	19	32	11:00-1			0
05:00-05:15	9	12	21	11:15-11:30	21	15	36	05:15-05:30	17	21	38	11:15-1			2
05:30-05:45	10	10	20	11:30-11:45	20	22	42	05:30-05:45	15	32	47	11:30-1			5
05:45-06:00	8	13	21	11:45-12:00	17	15	32	05:45-06:00	18	22	40	11:45-12			3
		-													
AM COMMUT			00) DI	IR 1	DIF	2				RIOD (15:00-1	9:00)	DIR 1		DIR 2	
TWO DIREC								TWO DIRI					0.4.00 DNA	05 00 DM	
	EAK HR TIN			07:00 AM to			100		PEAK HR				04:00 PM to		040
	EAK HR VO		10	08	78		186 7.59		PEAK HR K FACTO	VOLUME		104		115	219 8.94
AM - D	FACTOR (9	(0)	50	3.06	41.9	24	100.00	PM - 1		n (%)		47.49		52.51	100.00
DIRECTION	. ,		50	5.00	41.	74	100.00	DIRECTIO	. ,	ιK		47.43		32.31	100.00
	AK HR TIM	IF	07	7:15 AM to 08:15	AM 07:	00 AM to	08:00 AM		PEAK HR			03:00 PM	to 04:00 PM	04:00 PM	to 05:00 PM
	AK HR VO		10		78		00.007			VOLUME		105		115	
AM PERIOD (00:00-12:00))						PM PERIOD	(12:00-2	4:00)					
TWO DIREC		,						TWO DIRE							
	EAK HR TIN			07:00 AM to	08:00 AM				PEAK HR				04:00 PM to	05:00 PM	
	EAK HR VO		10		78		186			VOLUME		104		115	219
AM - K	FACTOR (%	%)					7.59	PM - I	K FACTO	R (%)					8.94
AM - D	(%)		58	3.06	41.9	94	100.00	PM - [O (%)			47.49		52.51	100.00
NON-COMMU	JTER PERI	OD (09:00-15	5:00)					6-HR, 12-HI	R, 24-HR	PERIODS		DIR 1	DIR 2	Total	
TWO DIREC	CTIONAL P	EAK	•					AM 6-HR	PERIOD ((06:00-12:00)		533	412	945	
	HR TIME			10:15 AM to	11:15 AM					(00:00-12:00))	576	482	1,058	
	HR VOLUM	E	11	19	67		186			(12:00-18:00)		509	579	1,088	
DIRECTION										(12:00-24:00))	636	755	1,391	
	HR TIME		10	0:15 AM to 11:15	AM 02:0	00 PM to	03:00 PM	24 HOUR		,		1,212	1,237	2,449	
	HR VOLUM	F	11		118			D (%)				49.49	50.51	100.00	
. =/ (()		_			. 10			- (/0)					50.0.	.00.00	

Hawaii Department of Transportation

Highways Division Highways Planning Survey Section

2010 Program Count - Summary

Site ID: B71001104606 Town: Hawaii DIR 1: +MP DIR 2:-MP Final AADT: 0
Functional Class: RURAL:MINOR ARTERIAL Count Type: CLASS Counter Type: Tube Route No: 11

Location: MAMALAHOA Hwy - KAPAPALA RANCH ROAD TO N

DATE: 04/28/2010 Color	TIME-AM	DIR 1	DIR 2	TOTAL	TIME-AM	DIR 1	DIR 2	TOTAL	TIME-PM	DIR 1	DIR 2	TOTAL	TIME-PM	DIR 1	DIR 2	TOTAL
12:15:12:30				_								_				
1230-1245 3	12:00-12:15	0	0	0	06:00-06:15	2	11	13	12:00-12:15	19	17	36	06:00-06:15	21	13	34
1248-01-00 0 0 0 0 0 0 0 048-07-00 28 8 3 08 1248-01-00 33 12 4 5 0648-07-00 7 7 14 21 01-00-01-15 1 0 0 0 0 0 0755-07-30 11 12 23 0 01-00-01-15 19 17 36 07-00-07-15 6 17 23 01-15-01-30 0 0 0 0 0 0755-07-30 11 12 2 33 01-15-01-30 24 2 0 44 071-15-07-30 10 16 26 01-03-01-15 1 0 0 0 0 0 0 0755-07-30 11 12 2 33 01-15-01-30 24 2 0 44 071-15-07-30 10 16 26 01-03-01-15 1 0 0 0 0 0 0 0 0755-07-30 11 12 2 33 01-15-01-30 24 3 07-30-07-45 10 0 6 8 18 01-03-01-15 1 0 0 0 0 0 0 0 0 0755-07-30 11 18 2 33 01-15-01-30 24 3 07-30-07-45 10 0 6 8 14 01-03-01-15 1 0 0 0 0 0 0 0 0 0755-07-30 11 18 12 20 02-00-02-15 19 23 10 00-00-01-5 10 6 8 14 02-01-02-15 1 0 0 0 0 0 0 0 15-08-30 18 12 2 20 02-00-02-15 19 23 10 00-00-01-5 0 6 7 13 02-15-02-30 0 0 0 0 0 0 0 0 0 0845-09-00 13 3 13 2 20 02-00-02-15 19 23 3 08-15-08-30 6 7 7 13 02-30-02-25 0 0 0 0 0 0 0 0845-09-00 13 3 13 2 20 02-00-02-15 19 23 3 08-15-08-30 6 7 7 13 02-30-02-25 1 0 0 0 0 0 0 0845-09-00 13 3 13 2 20 02-00-02-15 19 23 3 08-15-08-30 6 7 7 13 02-30-02-25 1 0 0 0 0 0 0 0845-09-00 13 3 13 2 20 02-00-02-15 19 23 3 08-15-08-30 14 12 2 3 09-15-08-30 14 12 2 3 09-15-08-30 11 10 03-09-03-15 17 25 3 3 08-00-00-04 4 8 8 12 20 03-00-03-15 10 3 3 09-15-08-30 11 14 14 030 044 09-15-08-30 14 7 8 8 12 20 03-00-03-15 17 25 3 3 08-00-00-05 14 18 12 20 03-00-03-15 17 25 3 3 08-00-00-05 14 18 18 12 20 03-00-03-15 17 25 3 3 08-00-00-05 14 18 18 18 18 18 18 18 18 18 18 18 18 18	12:15-12:30	0	1	1	06:15-06:30	11	18	29	12:15-12:30	17	10	27	06:15-06:30	8	16	24
01-00-01-15 1 0 0 1 0.70-00-715 12 8 2 0 01-00-01-15 19 17 8 0 70-00-715 10 16 28 10 15-01-10 0 0 0 0 0 0.70-07-15 07-30 11 12 23 011-5-01-30 24 20 44 07-15-07-30 10 16 28 01-30-01-45 1 1 1 1 2 2 07-30-07-45 10 16 18 28 01-30-01-45 23 20 44 07-5-07-45 10 16 18 14 14 02-00-01-5 1 1 0 0 1 0 00-00-01-5 15 15 8 23 01-30-01-45 23 20 44 07-5-07-45 10 16 8 18 14 14 02-00-01-5 1 1 0 0 1 0 00-00-01-5 15 15 8 23 02-00-02-15 19 34 07-5-0-60-01 6 8 14 14 02-00-01-5 1 1 0 0 0 1 0 00-00-01-5 15 15 8 23 02-00-02-15 19 24 31 0 00-00-01-5 14 6 10 02-00-01-5 0 0 0 0 0 0 0 00-00-01-5 0 0 0 0 0 0 00-00-01-5 0 0 0 0 0 0 00-00-01-5 0 0 0 0 0 0 00-00-01-5 0 0 0 0 0 0 00-00-01-5 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	12:30-12:45	3	2	5	06:30-06:45	22	12	34	12:30-12:45	16	19	35	06:30-06:45	10	18	28
01-15-01-30 0 0 0 0.71-16-07-30 11 12 23 01-15-01-30 24 20 44 07-15-07-30 10 16 28 10-15-01-30 01-15-07-30 10 16 28 16-15-01-35-02-00 0 0 0 0 07-35-08-00 6 12 18 01-35-02-00 15 19 34 07-35-08-00 6 8 14 16-01-01-02-15-02-00 0 0 0 0 0 08-15-08-30 8 12 20 00-02-15 9 22 31 08-00-08-15 14 6 10-01-02-15-02-00 0 0 0 0 08-15-08-30 8 12 20 00-02-15 9 22 31 08-00-08-15 14 6 10-01-02-15-02-00 0 0 0 0 08-15-08-30 8 12 20 00-02-15 9 22 31 08-00-08-15 14 6 10-01-02-15-02-00 0 0 0 0 08-15-08-30 8 12 20 00-02-15 9 22 31 08-15-08-30 6 7 7 13-02-02-02-15 9 0 0 0 0 0 08-15-08-30 8 12 20 00-02-15 9 0 22 31 08-15-08-30 6 15 38 34 02-20-02-15 9 0 22 31 08-02-08-15 14 30 44 02-24-08-30 16 12 30 30-08-15 15 13 44 02-24-08-30 16 12 30 30-08-15 10 3 3 09-08-15 10 3 3 11 14 08-00-02-15 9 2 33 08-15-09-00 4 18 8 12 20 00-02-15 9 13 08-15-09-00 14 18 12 20 33-09-03-15 10 3 3 09-15-09-30 11 14 08-00-03-15 7 2 32 09-09-15 14 18 12 20 33-09-03-15 10 12 3 3 09-15-09-30 11 14 08-00-03-15 7 2 32 09-09-15 14 18 12 2 33-09-03-15 14 18 19 30 44 09-03-15 7 2 32 09-09-15 14 18 18 12 2 33-09-03-15 14 18 18 18 18 18 18 18 18 18 18 18 18 18	12:45-01:00	0	0	0	06:45-07:00	28	8	36	12:45-01:00	33	12	45	06:45-07:00	7	14	21
013901456 1 1 1 2 07390745 10 18 8 28 013901145 23 20 20 43 07290745 10 6 8 18 14 01450200 15 1 9 44 07545800 6 8 8 14 02000215 1 9 22 31 08000815 4 6 8 01 02000215 1 1 0 0 0 1 08000815 15 8 8 22 0200215 2 9 22 31 08000815 4 5 6 7 13 0221502230 0 0 0 0 0 0 88150830 88 12 2 00 20160230 5 8 18 23 08150830 14 3 08150830 14 1 3 0 0 08150830 13 13 28 022450230 5 1 8 23 08150830 14 1 3 0 08150830 14 1 2 0 08150830 13 11 14 08000815 7 25 32 08000815 14 1 8 1 8 1 8 1 2 0 08150830 14 1 3 0 08150830 14 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	01:00-01:15	1	0	1	07:00-07:15	12	8	20	01:00-01:15	19	17	36	07:00-07:15	6	17	23
01-56-02-00 0 0 0 0 07-45-08-00 6 12 18 0145-02-00 15 19 34 07-45-08-00 6 8 14 14 02-02-00-01-5 1 0 0 1 08-00-08-15 15 8 23 02-00-02-15 9 22 31 08-10-08-30 6 7 13 02-02-02-02-15 9 22 31 08-10-08-30 6 7 13 3 28 02-02-02-15 9 22 33 08-15-08-30 6 7 13 3 4 02-02-02-02-15 9 0 0 0 0 0 08-45-09-00 13 13 13 28 02-45-03-00 6 3 2 38 08-45-09-00 4 8 12 2 0 03-03-03-15 9 3 3 11 14 03-00-03-15 7 25 32 09-00-08-15 4 8 12 2 0 03-03-03-15 9 3 3 11 14 03-00-03-15 7 25 32 09-00-08-15 4 8 12 2 0 03-03-03-15 9 3 11 1 14 03-00-03-15 7 25 32 09-00-08-15 4 8 12 2 0 03-03-03-15 9 3 11 1 14 03-00-03-15 7 25 32 09-00-08-15 4 8 12 2 0 03-03-03-15 9 3 11 1 14 03-00-03-15 7 25 32 09-00-08-15 4 8 12 0 03-03-03-15 9 3 1 1 1 14 03-00-03-15 9 3 1 1 1 14 03-03-03-14 9 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	01:15-01:30	0	0	0	07:15-07:30	11	12	23	01:15-01:30	24	20	44	07:15-07:30	10	16	26
0.00 0.00	01:30-01:45	1	1		07:30-07:45	10	18	28	01:30-01:45	23	20	43	07:30-07:45	10	6	16
Delication Color	01:45-02:00	0	0	0	07:45-08:00	6	12	18	01:45-02:00	15	19	34	07:45-08:00	6	8	14
02-30-02-45 0																
0.245 0.300 0 0 0 0 0 0 0 0 0																
33.00 03.15 0 3 3 0.90.00 91.5 3 11 14 25 0.30.00 31.5 7 25 32 0.90.00 91.5 4 8 12														•		
03:30 03:45 0 0 3 0 09:15-09:30 11 11 14 25 03:15-03:30 14 30 44 09:15-09:30 1 7 8 8 03:30 03:30 03:45 0 0 3 0 09:30-09:45 4 0 20 60 03:30 03:45 02 9 22 51 09:30-09:45 4 4 4 8 8 03:45-04:00 0 2 2 09:45-10:00 23 11 34 00:45-04:00 14 20 34 09:45-10:00 6 4 1 10 04:00-04:15 1 4 5 10:00-10:15 25 17 42 04:00-04:15 7 24 31 10:00-10:15 0 3 8 8 10 10:45-10:00 0 0 0 10:15-10:30 41 24 65 04:15-04:30 19 21 40 10:15-10:30 3 8 11 04:30-04:45 1 3 4 10:30-10:45 32 16 48 04:30-04:45 14 26 40 10:30-10:45 2 3 3 5 04:45-05:00 4 5 9 9 10:45-11:30 22 16 44 04:45-05:00 4 1 8 32 10:45-11:30 2 2 1 3 3 05:00-05:15 4 7 11 11:00-11:15 37 22 59 05:00-05:15 23 36 59 11:00-11:15 1 0 0 1 1 05:15-05:30 6 7 13 11:15-11:30 30 20 50 05:15-05:30 2 2 24 4 6 11:15-11:30 3 1 1 4 05:30-05:45 7 20 27 11:30-11:45 20 22 14 05:30-05:45 14 16 30 11:30-11:45 10 0 4 05:45-06:00 2 11 1 3 11:45-12:00 32 14 4 4 6 05:30-05:45 14 16 30 11:30-11:45 10 0 4 4 05:45-06:00 2 11 1 3 11:45-12:00 32 14 4 4 6 05:30-05:45 14 16 30 11:30-11:45 10 0 4 05:45-06:00 2 11 10 11:30-11:45 20 22 2 42 05:30-05:45 14 16 30 11:30-11:45 10 0 4 05:45-06:00 2 11 10 11:30-11:45 20 22 12 12 05:30-05:45 14 16 30 11:30-11:45 10 0 4 05:45-06:00 2 11 10 11:30-11:45 10 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0																
03.45 0 3 3 09.30 09.45 40 20 60 03.20 34.5 29 22 51 09.30 54.5 4 4 8 8 10.345 50.00 6 10.345 50.00 20 34.5 10.00 6 10.345 50.00 10.345 50.00 6 10.345 50.00 6 10.345 50.00 6 10.345 50.00 6 10.345 50.00 6 10.345 50.00 6 10.345 50.00 6 10.345 50.00 6 10.345 50.00 6 10.345 50.00 6 10.345 50.00 6 10.345 50.00 6 10.345 50.00 6 10.345 50.00 6 10.345 50.00 6 10.34																
0.00 0 2 2 0.00 0.00 2 0.00														•		
Main															•	
0 1 0 10 10-15-10-30 41 24 65 04:15-04-30 19 21 40 10:15-10-30 3 8 11 04:30-04:45 1 3 4 10:30-10-45 32 16 48 04:30-04-45 14 26 40 10:30-10-45 2 3 5 05:00-05:15 4 7 11 11:00-11:15 37 22 59 05:00-05:15 23 36 59 11:00-11:15 1 0 0 1 05:15-05:30 6 7 13 11:15-11:30 30 20 50 05:15-05:30 22 24 46 11:15-11:30 3 1 4 05:30-05:45 7 20 27 11:30-11:45 20 22 42 05:30-05:45 14 16 30 11:15-11:30 3 1 4 05:45-06:00 2 11 13 11:15-11:30 30 20 50 05:10-05:30 22 24 46 11:15-11:30 3 1 1 05:45-06:00 2 11 13 11:15-11:30 32 14 46 05:45-06:00 15 19 34 11:45-12:00 0 0 0 0 05:45-06:00 2 11 13 13 11:45-12:00 32 14 46 05:45-06:00 15 19 34 11:45-12:00 0 0 0 0 05:45-06:00 2 11 13 13 11:45-12:00 32 14 46 05:45-06:00 15 19 34 11:45-12:00 0 0 0 0 05:00-05:45 7 20 27 11:30-11:45 20 22 42 05:30-05:45 14 16 30 11:45-12:00 0 0 0 0 05:00-05:45 7 20 27 11:30-11:45 20 22 42 05:30-05:45 14 16 30 11:45-12:00 0 0 0 0 05:00-05:45 7 20 27 11:30-11:45 20 32 14 46 05:45-06:00 15 19 34 11:45-12:00 0 0 0 0 05:00-05:00-09:00															•	
0.436-0.04-45		•													-	
04:45:05:00																
05:00-05:15																
05:15-05:30 6 7 13 11:15-11:30 30 20 20 50 05:15-05:30 22 24 46 11:15-11:30 3 11 4 05:30-05:45 7 20 27 11:30-11:45 20 22 42 05:30-05:45 14 16 30 11:30-11:45 0 4 4 4 05:40-06:00 2 11 13 11:45-12:00 32 14 46 05:45-06:00 15 19 34 11:45-12:00 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0															•	
05:30-05:45 7 20 27 11:30-11:45 20 22 42 05:30-05:45 14 16 30 11:30-11:45 0 4 4 4 4 4 4 4 4 4		-													-	•
M COMMUTER PERIOD (05:00-09:00)															-	•
AM COMMUTER PERIOD (05:00-09:00) TWO DIRECTIONAL PEAK AM - PEAK HR TIME AM - PEAK HR TIME AM - PEAK HR TIME AM - PEAK HR VOLUME AM - PEAK HR VOLUM																· ·
TWO DIRECTIONAL PEAK TWO DIRECTIONAL PEAK 04:30 PM to 05:30 PM AM - PEAK HR TIME 04:30 PM to 05:30 PM AM - PEAK HR TIME 04:30 PM to 05:30 PM AM - PEAK HR TIME AM - PEAK HR TIME 04:30 PM to 05:30 PM 177 AM - REAK HR TIME AM - PEAK HR TIME 73 104 177 8.38 AM - D (%) AM - D (%) 41.24 58.76 100.00 BASA AM - D (%) AM - PEAK HR TIME 06:30 AM to 07:30 AM 05:30 AM to 06:30 AM PM - PEAK HR TIME 05:00 PM to 06:00 PM 04:30 PM to 05:30 PM 100.00 PM - PEAK HR TIME 05:00 PM to 06:00 PM 04:30 PM to 05:30 PM PM - PEAK HR TIME 05:00 PM to 06:00 PM 04:30 PM to 05:30 PM PM - PEAK HR TIME 05:00 PM to 06:00 PM 04:30 PM to 05:30 PM PM - PEAK HR TIME 05:00 PM to 06:00 PM 04:30 PM to 05:30 PM PM - PEAK HR TIME 05:00 PM to 06:00 PM 04:30 PM to 05:30 PM PM - PEAK HR TIME 05:00 PM to 06:00 PM 04:30 PM to 05:30 PM PM - PEAK HR TIME 04:30 PM to 06:00 PM 04:30 PM to 05:30 PM PM - PEAK HR TIME 04:30 PM to 06:00 PM																
AM - PEAK HR TIME 06:15 AM to 07:15 AM PM - PEAK HR TIME 04:30 PM to 05:30 PM AM - PEAK HR VOLUME 73 46 119 PM - PEAK HR VOLUME 73 104 177 AM - D (%) 61:34 38:66 100:00 PM - D (%) 41:24 58:76 100:00 DIRECTIONAL PEAK AM - PEAK HR TIME 06:30 AM to 07:30 AM 05:30 AM to 06:30 AM PM - PEAK HR TIME 05:00 PM to 06:00 PM 04:30 PM to 05:30 PM AM PERIOD (00:00-12:00) TWO DIRECTIONAL PEAK PM PERIOD (12:00-24:00) TWO DIRECTIONAL PEAK AM - PEAK HR TIME 10:15 AM to 11:15 AM PM - PEAK HR TIME 04:30 PM to 05:30 PM 177 AM - PEAK HR TIME 10:15 AM to 11:15 AM PM - PEAK HR TIME 04:30 PM to 05:30 PM 177 AM - PEAK HR TIME 10:15 AM to 11:15 AM PM - PEAK HR TIME 73 104 177 AM - PEAK HR TIME 10:15 AM to 11:15 AM PM - PEAK HR TIME 73 104 177 AM - PEAK HR TIME 10:15 AM to 11:15 AM PM - PEAK HR TIME 73 104 177			*	:00) [DIR 1	DIF	₹2					9:00)	DIR 1		DIR 2	
AM - PEAK HR VOLUME AM - K FACTOR (%) AM - D(%) DIRECTIONAL PEAK AM - PEAK HR VOLUME AM - PEAK HR TIME AM - PEAK HR TIM		_			00 45 414	07.45.41			_	-			04.00	DM+- 05	5.00 DM	
AM - K FACTOR (%) 61.34 38.66 100.00 PM - D (%) 41.24 58.76 100.00 DIRECTIONAL PEAK AM - D (%) 41.24 58.76 100.00 100.00 AM - PEAK HR TIME 06:30 AM to 07:30 AM 05:30 AM to 06:30 AM PM - PEAK HR TIME 05:00 PM to 06:00 PM 04:30 PM to 05:30 PM AM - PEAK HR VOLUME 73 PM - PEAK HR VOLUME 74 104 104 AM - PEAK HR TIME 10:15 AM to 11:15 AM PM - PEAK HR TIME 05:00 PM to 06:00 PM 04:30 PM to 05:30 PM AM - PEAK HR TIME 10:15 AM to 11:15 AM PM - PEAK HR TIME 04:30 PM to 05:30 PM 104 177 AM - PEAK HR TOLUME 138 78 216 PM - PEAK HR VOLUME 73 104 177 AM - PEAK HR VOLUME 138 78 216 PM - PEAK HR VOLUME 73 104 177 AM - D (%) 63.89 36.11 100.00 PM - D (%) 41.24 58.76 100.00 NON-COMMUTER PERIOD (09:00-15:00) 40.00 40.00 40.00 40.00 40.00 </td <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td>110</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td>J FIVI LO US</td> <td></td> <td>177</td>								110						J FIVI LO US		177
AM - D (%) DIRECTIONAL PEAK AM - PEAK HR TIME 06:30 AM to 07:30 AM 60 5:30 AM to 06:30 AM PM - PEAK HR TIME 05:00 PM to 06:00 PM to 06:00 PM 104:30 PM to 05:30 PM AM - PEAK HR VOLUME 73 60 PM PM - PEAK HR TIME 05:00 PM 104:30 PM to 05:30 PM PM - PEAK HR TIME 05:00 PM 104:30 PM to 05:30 PM PM - PEAK HR VOLUME 74 104 104 104 104 104 104 104 104 104 10				4	3	40							73		104	
DIRECTIONAL PEAK AM - PEAK HR TIME 06:30 AM to 07:30 AM 05:30 AM to 06:30 AM PM - PEAK HR TIME 05:00 PM to 06:00 PM 04:30 PM to 05:30 PM PM - PEAK HR TIME PM - PEAK HR TIME PM - PEAK HR VOLUME PM - PEAK HR TIME 04:30 PM to 05:30 PM PM - PEAK HR TIME PM - PEAK HR VOLUME PM - PEAK HR VOLUM		,	70)	6	31.34	38	66				11 (70)		41 24		58 76	
AM - PEAK HR TIME AM - PEAK HR VOLUME 73 0 AM to 07:30 AM 60 05:30 AM to 06:30 AM PM - PEAK HR VOLUME 74 05:00 PM 04:30 PM to 05:30 PM 104 AM - PEAK HR VOLUME 74 05:00 PM 104 AM PERIOD (00:00-12:00) TWO DIRECTIONAL PEAK AM - PEAK HR TIME 10:15 AM to 11:15 AM PM - PEAK HR TIME 10:15 AM PM - PEAK HR TIME 10:15 AM PEAK HR VOLUME 138 78 216 PM - PEAK HR VOLUME 73 104 177 AM - K FACTOR (%) 63.89 36.11 100.00 PM - D (%) 41.24 58.76 100.00 NON-COMMUTER PERIOD (09:00-15:00) TWO DIRECTIONAL PEAK PERIOD (09:00-15:00) TWO DIRECTIONAL PEAK PERIOD (09:00-15:00) TWO DIRECTIONAL PEAK PERIOD (09:00-10:00) 465 347 812 PEAK HR TIME 10:15 AM to 11:15 AM AM 12-HR PERIOD (00:00-12:00) 497 418 915 PEAK HR VOLUME 138 78 216 PM 6-HR PERIOD (12:00-18:00) 382 516 898 DIRECTIONAL PEAK PEAK PEAK PEAK PERIOD (12:00-24:00) 501 696 1,197 PEAK HR TIME 10:15 AM to 11:15 AM 02:00 PM to 03:00 PM 24 HOUR PERIOD 998 1,114 2,112	,	,		`	71.01	00.	00	100.00		. ,	ΛK				00.70	100.00
AM PERIOD (00:00-12:00) TWO DIRECTIONAL PEAK AM - PEAK HR TIME AM - PEAK HR VOLUME AM - PEAK HR TOLOM			ΛE	(06:30 AM to 07:30	AM 05:	30 AM to (06:30 AM					05:00 PM to 06	8:00 PM	04:30 PM t	o 05:30 PM
TWO DIRECTIONAL PEAK AM - PEAK HR TIME AM - PEAK HR TIME AM - PEAK HR VOLUME AM - REACTOR (%) AM - REACTOR (%) AM - DEAK HR VOLUME AM - REACTOR (%) AM - DEAK HR VOLUME	AM - PE	AK HR VO	LUME	7	73	60			PM - F	PEAK HR	VOLUME		74		104	
AM - PEAK HR TIME 10:15 AM to 11:15 AM 78 216 PM - PEAK HR TIME 73 104:30 PM to 05:30 PM 10.43 PM to 05:30 PM 10.44 P	AM PERIOD (0	00:00-12:00	0)						PM PERIOD	(12:00-24	4:00)					
AM - PEAK HR VOLUME AM - K FACTOR (%) 138 78 216 PM - PEAK HR VOLUME PM - K FACTOR (%) 10.23 PM - K FACTOR (%) 8.38 PM - D (%) 41.24 58.76 100.00 PM - D (%)	TWO DIREC	TIONAL P	EAK						TWO DIRE	ECTIONAL	L PEAK					
AM - K FACTOR (%) AM - D (%) 63.89 36.11 100.00 PM - D (%) 41.24 58.76 100.00 NON-COMMUTER PERIOD (09:00-15:00) TWO DIRECTIONAL PEAK PEAK HR TIME 10:15 AM to 11:15 AM AM 12-HR PERIOD (00:00-12:00) PM - D (%) AM 6-HR, 12-HR, 24-HR PERIODS AM 6-HR PERIOD (06:00-12:00) A65 347 812 AM 6-HR PERIOD (00:00-12:00) A97 418 915 PEAK HR VOLUME 138 78 216 PM 6-HR PERIOD (12:00-18:00) 382 516 898 DIRECTIONAL PEAK PM 12-HR PERIOD (12:00-24:00) 501 696 1,197 PEAK HR TIME 10:15 AM to 11:15 AM 02:00 PM to 03:00 PM 24 HOUR PERIOD 998 1,114 2,112	AM - PE	AK HR TIN	ИE		10:15 AM to	11:15 AM			PM - F	PEAK HR	TIME		04:30) PM to 05	5:30 PM	
AM - D (%) 63.89 36.11 100.00 PM - D (%) 41.24 58.76 100.00 NON-COMMUTER PERIOD (09:00-15:00) NON-COMMUTER PERIOD (09:00-15:00) 6-HR, 12-HR, 24-HR PERIODS DIR 1 DIR 2 Total TWO DIRECTIONAL PEAK PEAK HR TIME 10:15 AM to 11:15 AM 216 PM 6-HR PERIOD (00:00-12:00) 497 418 915 PEAK HR VOLUME 138 78 216 PM 6-HR PERIOD (12:00-18:00) 382 516 898 DIRECTIONAL PEAK PM 12-HR PERIOD (12:00-24:00) 501 696 1,197 PEAK HR TIME 10:15 AM to 11:15 AM 02:00 PM to 03:00 PM 24 HOUR PERIOD 998 1,114 2,112			_		138	78							73		104	
NON-COMMUTER PERIOD (09:00-15:00) TWO DIRECTIONAL PEAK PEAK HR TIME 10:15 AM to 11:15 AM 78 216 PM 6-HR PERIOD (06:00-12:00) AM 12-HR PERIOD (00:00-12:00) AM 12-HR PERIOD (00:00-12:00) AM 12-HR PERIOD (00:00-12:00) BY 2 AM 12-HR PERIOD (00:00-12:00) AM 12-HR PERIOD (12:00-18:00) BY 347 AM 12-HR PERIOD (00:00-12:00) BY 418 BY 15 BY 16 BY 16 BY 18 BY 15 BY 16 BY 18 BY 18		,	%)								R (%)					
TWO DIRECTIONAL PEAK PEAK HR TIME 10:15 AM to 11:15 AM AM 6-HR PERIOD (06:00-12:00) 465 347 812 AM 6-HR PERIOD (00:00-12:00) 497 418 915 PEAK HR VOLUME 138 78 216 PM 6-HR PERIOD (12:00-18:00) 382 516 898 DIRECTIONAL PEAK PM 12-HR PERIOD (12:00-24:00) FEAK HR TIME 10:15 AM to 11:15 AM 02:00 PM to 03:00 PM 24 HOUR PERIOD 998 1,114 2,112	AM - D ((%)		(33.89	36.	11	100.00	PM - [O (%)			41.24		58.76	100.00
PEAK HR TIME 10:15 AM to 11:15 AM AM 12-HR PERIOD (00:00-12:00) 497 418 915 PEAK HR VOLUME 138 78 216 PM 6-HR PERIOD (12:00-18:00) 382 516 898 DIRECTIONAL PEAK PM 12-HR PERIOD (12:00-24:00) 501 696 1,197 PEAK HR TIME 10:15 AM to 11:15 AM 02:00 PM to 03:00 PM 24 HOUR PERIOD 998 1,114 2,112	NON-COMMU	TER PERI	OD (09:00-1	5:00)					6-HR, 12-HI	R, 24-HR	PERIODS		DIR 1 DI	R 2	Total	
PEAK HR VOLUME 138 78 216 PM 6-HR PERIOD (12:00-18:00) 382 516 898 DIRECTIONAL PEAK PM 12-HR PERIOD (12:00-24:00) 501 696 1,197 PEAK HR TIME 10:15 AM to 11:15 AM 02:00 PM to 03:00 PM 24 HOUR PERIOD 998 1,114 2,112	TWO DIREC	TIONAL P	EAK						AM 6-HR	PERIOD ((06:00-12:00)		465 34	7	812	
DIRECTIONAL PEAK PM 12-HR PERIOD (12:00-24:00) 501 696 1,197 PEAK HR TIME 10:15 AM to 11:15 AM 02:00 PM to 03:00 PM 24 HOUR PERIOD 998 1,114 2,112	PEAK H	R TIME			10:15 AM to	11:15 AM			AM 12-HR	PERIOD	(00:00-12:00)	497 41	8	915	
PEAK HR TIME 10:15 AM to 11:15 AM 02:00 PM to 03:00 PM 24 HOUR PERIOD 998 1,114 2,112	PEAK H	R VOLUM	E	•	138	78		216	PM 6-HR	PERIOD ((12:00-18:00)		382 51	6	898	
	DIRECTION	AL PEAK									(12:00-24:00)	501 69	16	1,197	
PEAK HR VOLUME 138 101 D (%) 47.25 52.75 100.00	PEAK H	IR TIME			0:15 AM to 11:15	AM 02:	00 PM to 0	03:00 PM	24 HOUR	PERIOD			998 1,	114	2,112	
	PEAK F	R VOLUM	1E		138	10	1		D (%)				47.25 52	75	100.00	

TRAFFIC IMPACT ANALYSIS REPORT FOR THE PROPOSED KAHUKU VILLAGE KA`U, HAWAII

TAX MAP KEY: (3) 9-2-001:072

APPENDIX B CAPACITY ANALYSIS WORKSHEETS EXISTING TRAFFIC CONDITIONS

HCS+: Two-Lane Highways Release 5.4

Two-	Way Two-Lane Highv	ay Segment A	nalysis		
Analyst Agency/Co. Date Performed Analysis Time Period Highway From/To Jurisdiction Analysis Year Description Kahuku Vil	RSO Traffic Managemer 3/11/2011 AM Peak Hour Mamalahoa Highway Kahuku Ranch Rd t State of Hawaii 2010 lages	7			
	Input	Data			
Highway class Class 1 Shoulder width 8. Lane width 12 Segment length 5. Terrain type Le Grade: Length Up/down	.0 ft % Tru 0 mi % Red vel % No-	-hour factor, acks and buse creational ve -passing zone as points/mi	s hicles	0.85 10 0 10 7	% % % /mi
Two-way hourly volume, Directional split	56 / 44 %				
	Average Trave	el Speed			
Grade adjustment factor PCE for trucks, ET PCE for RVs, ER Heavy-vehicle adjustmen Two-way flow rate, (note Highest directional spl	t factor, -1) vp	1.00 1.7 1.0 0.935 230 te-2) 129	-		
Free-Flow Speed from Fi Field measured speed, S Observed volume, Vf Estimated Free-Flow Spe Base free-flow speed, B Adj. for lane and shoul Adj. for access points,	FM ed: FFS der width, fLS	- - 55.0 0.0 1.8	mi/h veh/h mi/h mi/h mi/h		
Free-flow speed, FFS		53.3	mi/h		
Adjustment for no-passi Average travel speed, A	-	0.4 51.1	mi/h mi/h		

Percent Time-Spent-Following		
Grade adjustment factor, fG	1.00	
PCE for trucks, ET	1.1	
PCE for RVs, ER	1.0	
Heavy-vehicle adjustment factor, fHV	0.990	
Two-way flow rate, (note-1) vp	217	pc/h
Highest directional split proportion (note-2)	122	-
Base percent time-spent-following, BPTSF	17.4	ે
Adj. for directional distribution and no-passing zones, fd/np	6.0	
Percent time-spent-following, PTSF	23.4	90
Level of Service and Other Performance Measu:	res	
Level of service, LOS	В	
Volume to capacity ratio, v/c	0.07	
Peak 15-min vehicle-miles of travel, VMT15	269	veh-mi
Peak-hour vehicle-miles of travel, VMT60	915	veh-mi
Peak 15-min total travel time, TT15	5.3	veh-h

Notes:

- 1. If $vp \ge 3200 \text{ pc/h}$, terminate analysis-the LOS is F. 2. If highest directional split $vp \ge 1700 \text{ pc/h}$, terminate analysis-the LOS is F.

HCS+: Two-Lane Highways Release 5.4

Two-Way Two-Lane Highway S	Segment A	nalysis		
Analyst RSO Agency/Co. Traffic Management Co Date Performed 3/11/2011 Analysis Time Period AM Peak Hour Highway Mamalahoa Highway From/To Hookena Beach Rd 101 Jurisdiction State of Hawaii Analysis Year 2010 Description Kahuku Villages				
Input Data	ì			
Highway class Class 1 Shoulder width 3.0 ft Peak-hour Lane width 12.0 ft % Trucks Segment length 5.0 mi % Recreat Terrain type Level % No-pass Grade: Length mi Access po	and buse cional ve sing zone	s hicles	0.86 11 0 50 10	% % % /mi
Directional split 77 / 23 %				
Average Travel Sp	eed			
Grade adjustment factor, fG PCE for trucks, ET PCE for RVs, ER Heavy-vehicle adjustment factor, Two-way flow rate, (note-1) vp Highest directional split proportion (note-2)	1.00 1.7 1.0 0.929 590 454	pc/h pc/h		
Free-Flow Speed from Field Measurement: Field measured speed, SFM Observed volume, Vf Estimated Free-Flow Speed: Base free-flow speed, BFFS Adj. for lane and shoulder width, fLS Adj. for access points, fA	- - 55.0 2.6 2.5	mi/h veh/h mi/h mi/h mi/h		
Free-flow speed, FFS	49.9	mi/h		
Adjustment for no-passing zones, fnp Average travel speed, ATS	2.7 42.6	mi/h mi/h		

Percent Time-Spent-Following					
Grade adjustment factor, fG	1.00				
PCE for trucks, ET	1.1				
PCE for RVs, ER	1.0				
Heavy-vehicle adjustment factor, fHV	0.989				
Two-way flow rate, (note-1) vp	554	pc/h			
Highest directional split proportion (note-2)	427				
Base percent time-spent-following, BPTSF	38.6	%			
Adj.for directional distribution and no-passing zones, fd/np	20.5				
Percent time-spent-following, PTSF	59.1	%			
Level of Service and Other Performance Measur	res				
Level of service, LOS	D				
Volume to capacity ratio, v/c	0.18				
Peak 15-min vehicle-miles of travel, VMT15	685	veh-mi			
Peak-hour vehicle-miles of travel, VMT60	2355	veh-mi			
Peak 15-min total travel time, TT15	16.1	veh-h			
Volume to capacity ratio, v/c Peak 15-min vehicle-miles of travel, VMT15 Peak-hour vehicle-miles of travel, VMT60	0.18 685 2355	veh-mi			

- 1. If $vp \ge 3200 \text{ pc/h}$, terminate analysis-the LOS is F. 2. If highest directional split $vp \ge 1700 \text{ pc/h}$, terminate analysis-the LOS is F.

HCS+: Two-Lane Highways Release 5.4

Two-W	ay Two-Lane Highway S	egment A	nalysis		
Agency/Co. Date Performed Analysis Time Period Highway From/To Jurisdiction	RSO Traffic Management Co 3/11/2011 AM Peak Hour Mamalahoa Highway Kapalapala Ranch Rd 4 State of Hawaii 2010 ages				
	Input Data				
Highway class Class 1 Shoulder width 3.0 Lane width 12. Segment length 5.0 Terrain type Lev Grade: Length Up/down Two-way hourly volume, V	0 ft % Trucks mi % Recreat el % No-pass mi Access po	and buse ional vel ing zone	s hicles	0.83 13 0 10 5	% % % /mi
Directional split	58 / 42 %				
	Average Travel Sp	eed			
Grade adjustment factor, PCE for trucks, ET PCE for RVs, ER Heavy-vehicle adjustment Two-way flow rate, (note-Highest directional spli	factor, 1) vp	1.00 1.7 1.0 0.917 244 142	pc/h pc/h		
Free-Flow Speed from Fie Field measured speed, SF Observed volume, Vf Estimated Free-Flow Speed Base free-flow speed, BF Adj. for lane and should Adj. for access points,	M ed: FFS Ler width, fLS	- - 55.0 2.6 1.3	mi/h veh/h mi/h mi/h mi/h		
Free-flow speed, FFS		51.2	mi/h		
Adjustment for no-passin Average travel speed, AT	= = = = = = = = = = = = = = = = = = =	0.4 48.8	mi/h mi/h		

Percent Time-Spent-Following					
Grade adjustment factor, fG	1.00				
PCE for trucks, ET	1.1				
PCE for RVs, ER	1.0				
Heavy-vehicle adjustment factor, fHV	0.987				
Two-way flow rate, (note-1) vp	227	pc/h			
Highest directional split proportion (note-2)	132				
Base percent time-spent-following, BPTSF	18.1	96			
Adj.for directional distribution and no-passing zones, fd/np	6.3				
Percent time-spent-following, PTSF	24.4	90			
Level of Service and Other Performance Measur	res				
Level of service, LOS	С				
Volume to capacity ratio, v/c	0.08				
Peak 15-min vehicle-miles of travel, VMT15	280	veh-mi			
Peak-hour vehicle-miles of travel, VMT60	930	veh-mi			
Peak 15-min total travel time, TT15	5.7	veh-h			

- 1. If $vp \ge 3200 \text{ pc/h}$, terminate analysis-the LOS is F. 2. If highest directional split $vp \ge 1700 \text{ pc/h}$, terminate analysis-the LOS is F.

HCS+: Two-Lane Highways Release 5.4

Two-Way Two-La	ane Highway Se	egment A	nalysis		
Date Performed 3/11/2013 Analysis Time Period PM Peak F Highway Mamalahoa	Hour a Highway anch Rd to Orc		У		
	Input Data_				
Highway class Class 1 Shoulder width 8.0 ft Lane width 12.0 ft Segment length 5.0 mi Terrain type Level Grade: Length mi Up/down % Two-way hourly volume, V 231		and buse lonal vel ing zone	s hicles	0.90 11 0 10 7	% % % /mi
Directional split 55 / 4	45 %				
Avera	age Travel Spe	eed			
Grade adjustment factor, fG PCE for trucks, ET PCE for RVs, ER Heavy-vehicle adjustment factor, Two-way flow rate, (note-1) vp Highest directional split proport	tion (note-2)	1.00 1.7 1.0 0.929 276 152	pc/h pc/h		
Free-Flow Speed from Field Measur Field measured speed, SFM Observed volume, Vf Estimated Free-Flow Speed: Base free-flow speed, BFFS Adj. for lane and shoulder width, Adj. for access points, fA		- - 55.0 0.0 1.8	mi/h veh/h mi/h mi/h mi/h		
Free-flow speed, FFS		53.3	mi/h		
Adjustment for no-passing zones, Average travel speed, ATS	fnp	0.5 50.6	mi/h mi/h		

Percent Time-Spent-Following					
Grade adjustment factor, fG	1.00				
PCE for trucks, ET	1.1				
PCE for RVs, ER	1.0				
Heavy-vehicle adjustment factor, fHV	0.989				
Two-way flow rate, (note-1) vp	259	pc/h			
Highest directional split proportion (note-2)	142				
Base percent time-spent-following, BPTSF	20.4	용			
Adj.for directional distribution and no-passing zones, fd/np	6.0				
Percent time-spent-following, PTSF	26.3	ଚ			
Level of Service and Other Performance Measur	res				
Level of service, LOS	В				
Volume to capacity ratio, v/c	0.09				
Peak 15-min vehicle-miles of travel, VMT15	321	veh-mi			
Peak-hour vehicle-miles of travel, VMT60	1155	veh-mi			
Peak 15-min total travel time, TT15	6.3	veh-h			
Volume to capacity ratio, v/c Peak 15-min vehicle-miles of travel, VMT15 Peak-hour vehicle-miles of travel, VMT60	0.09 321 1155	veh-mi			

- 1. If $vp \ge 3200 \text{ pc/h}$, terminate analysis-the LOS is F. 2. If highest directional split $vp \ge 1700 \text{ pc/h}$, terminate analysis-the LOS is F.

HCS+: Two-Lane Highways Release 5.4

Two-Way Two-Lane Highway Se	egment A	nalysis		
Analyst RSO Agency/Co. Traffic Management Cor Date Performed 3/11/2011 Analysis Time Period PM Peak Hour Highway Mamalahoa Highway From/To Hookena Beach Rd 101.0 Jurisdiction State of Hawaii Analysis Year 2010 Description Kahuku Villages				
Input Data_				
Highway class Class 1 Shoulder width 3.0 ft Peak-hour Lane width 12.0 ft % Trucks of Segment length 5.0 mi % Recreat: Terrain type Level % No-pass: Grade: Length mi Access positive to the second of	and buse ional ve ing zone	s hicles	0.92 11 0 50	% % % /mi
Directional split 70 / 30 %				
Average Travel Spe	eed			
Grade adjustment factor, fG PCE for trucks, ET PCE for RVs, ER Heavy-vehicle adjustment factor, Two-way flow rate, (note-1) vp Highest directional split proportion (note-2)	1.00 1.7 1.0 0.929 572 400	pc/h pc/h		
Free-Flow Speed from Field Measurement: Field measured speed, SFM Observed volume, Vf Estimated Free-Flow Speed: Base free-flow speed, BFFS Adj. for lane and shoulder width, fLS Adj. for access points, fA	- - 55.0 2.6 2.5	mi/h veh/h mi/h mi/h mi/h		
Free-flow speed, FFS	49.9	mi/h		
Adjustment for no-passing zones, fnp Average travel speed, ATS	2.8 42.7	mi/h mi/h		

Percent Time-Spent-Following				
Grade adjustment factor, fG	1.00			
PCE for trucks, ET	1.1			
PCE for RVs, ER	1.0			
Heavy-vehicle adjustment factor, fHV	0.989			
Two-way flow rate, (note-1) vp	537	pc/h		
Highest directional split proportion (note-2)	376	1 - /		
Base percent time-spent-following, BPTSF	37.6	용		
Adj.for directional distribution and no-passing zones, fd/np	18.0			
Percent time-spent-following, PTSF	55.6	90		
Level of Service and Other Performance Measu:	res			
Level of service, LOS	D			
Volume to capacity ratio, v/c	0.18			
Peak 15-min vehicle-miles of travel, VMT15	664	veh-mi		
Peak-hour vehicle-miles of travel, VMT60	2445	veh-mi		
Peak 15-min total travel time, TT15	15.5	veh-h		

- 1. If $vp \ge 3200 \text{ pc/h}$, terminate analysis-the LOS is F. 2. If highest directional split $vp \ge 1700 \text{ pc/h}$, terminate analysis-the LOS is F.

HCS+: Two-Lane Highways Release 5.4

Two-Way Two-Lane Highway Se	egment A	nalysis		
Analyst RSO Agency/Co. Traffic Management Cor Date Performed 3/11/2011 Analysis Time Period PM Peak Hour Highway Mamalahoa Highway From/To Kapalapala Ranch Rd 46 Jurisdiction State of Hawaii Analysis Year 2010 Description Kahuku Villages				
Input Data_				
Highway class Class 1 Shoulder width 3.0 ft Peak-hour Lane width 12.0 ft % Trucks of Segment length 5.0 mi % Recreated to the Segment type Level % No-passed Grade: Length mi Access position Up/down % Two-way hourly volume, V 219 veh/h	and buse Lonal vel Lng zone	s hicles	0.94 3 0 10 5	% % % /mi
Directional split 53 / 47 %				
Average Travel Spe	eed			
Grade adjustment factor, fG PCE for trucks, ET PCE for RVs, ER Heavy-vehicle adjustment factor, Two-way flow rate, (note-1) vp Highest directional split proportion (note-2)	1.00 1.7 1.0 0.979 238 126	pc/h pc/h		
Free-Flow Speed from Field Measurement: Field measured speed, SFM Observed volume, Vf Estimated Free-Flow Speed: Base free-flow speed, BFFS Adj. for lane and shoulder width, fLS Adj. for access points, fA	- - 55.0 2.6 1.3	mi/h veh/h mi/h mi/h mi/h		
Free-flow speed, FFS	51.2	mi/h		
Adjustment for no-passing zones, fnp Average travel speed, ATS	0.4 48.9	mi/h mi/h		

Percent Time-Spent-Following				
Grade adjustment factor, fG	1.00			
PCE for trucks, ET	1.1			
PCE for RVs, ER	1.0			
Heavy-vehicle adjustment factor, fHV	0.997			
Two-way flow rate, (note-1) vp	234	pc/h		
Highest directional split proportion (note-2)	124	F - /		
Base percent time-spent-following, BPTSF	18.6	용		
Adj.for directional distribution and no-passing zones, fd/np	5.7			
Percent time-spent-following, PTSF	24.2	90		
Level of Service and Other Performance Measu:	res			
Level of service, LOS	С			
Volume to capacity ratio, v/c	0.07			
Peak 15-min vehicle-miles of travel, VMT15	291	veh-mi		
Peak-hour vehicle-miles of travel, VMT60	1095	veh-mi		
Peak 15-min total travel time, TT15	6.0	veh-h		

- 1. If $vp \ge 3200 \text{ pc/h}$, terminate analysis-the LOS is F. 2. If highest directional split $vp \ge 1700 \text{ pc/h}$, terminate analysis-the LOS is F.

TRAFFIC IMPACT ANALYSIS REPORT FOR THE PROPOSED KAHUKU VILLAGE KA`U, HAWAII

TAX MAP KEY: (3) 9-2-001:072

APPENDIX C

CAPACITY ANALYSIS WORKSHEETS
2015 PEAK HOUR TRAFFIC WITHOUT PROJECT

HCS+: Two-Lane Highways Release 5.4

	IWO-Way IWO-Lan	ne Highway Se	gment A	nalysis		
Analyst	RSO					
Agency/Co.	Traffic Ma	anagement Con	sultant			
Date Performed	3/11/2011	- 5				
nalysis Time Peri		our				
Iighway	Mamalahoa					
rom/To		nch Rd to Orc	hid Pkw	V		
Turisdiction	State of H			_		
Analysis Year	2015 Witho	out Project				
escription Kahuk		J				
		Input Data				
Highway class Cla	ass 1					
Shoulder width		Peak-hour	factor,	PHF	0.85	
Lane width	12.0 ft	% Trucks a			10	왕
Segment length	5.0 mi	% Recreation	onal ve	hicles	0	용
errain type	Level	% No-passi:	ng zone	S	10	용
Grade: Length	mi	Access poi	_		7	/mi
Up/down	96	_				
Two-way hourly vol						
Directional split						
Directional split		l % ge Travel Spe	ed			
Directional split Grade adjustment f	Averag		ed			
	Averag					
Grade adjustment f PCE for trucks, ET PCE for RVs, ER	Averag		1.00			
Grade adjustment f PCE for trucks, ET PCE for RVs, ER	Averag		1.00			
Grade adjustment f PCE for trucks, ET PCE for RVs, ER Heavy-vehicle adju	Average		1.00 1.7 1.0	pc/h		
Grade adjustment for trucks, ET PCE for RVs, ER leavy-vehicle adju	Average Average Sactor, fG Sustment factor, (note-1) vp	ge Travel Spe	1.00 1.7 1.0 0.935 253	pc/h pc/h		
Grade adjustment f	Average Average actor, fG actor, fG astment factor, (note-1) vp al split proporti	ge Travel Spec	1.00 1.7 1.0 0.935 253			
Grade adjustment for trucks, ETPCE for trucks, ETPCE for RVs, ERPLANTED ADJUSTMENT OF THE PROPERTY OF THE PROP	Average factor, fG for street factor, for (note-1) vp fall split proportion for Field Measure	ge Travel Spec	1.00 1.7 1.0 0.935 253			
Grade adjustment for trucks, ET PCE for RVs, ER Reavy-vehicle adjustment for the state of the st	Average factor, fG stment factor, (note-1) vp al split proportion for Field Measure eed, SFM	ge Travel Spec	1.00 1.7 1.0 0.935 253	pc/h		
Grade adjustment for trucks, ET PCE for RVs, ER Heavy-vehicle adjustment, Free-Flow Speed fr	Average Average actor, fG astment factor, (note-1) vp al split proportion Field Measure aced, SFM	ge Travel Spec	1.00 1.7 1.0 0.935 253	pc/h mi/h		
Grade adjustment for trucks, ET of trucks, ET of the control of th	Average factor, fG factor, fG factor, fG factor, fo for all split proportions for Field Measure feed, SFM for Speed:	ge Travel Spec	1.00 1.7 1.0 0.935 253	pc/h mi/h		
Grade adjustment for trucks, ET of trucks, ET of trucks, ER of the second secon	Average factor, fG factor, fG factor, fG factor, fG factor, for foote-1) vp factor for field Measure feed, SFM for Speed:	ge Travel Spector (note-2)	1.00 1.7 1.0 0.935 253 142	pc/h mi/h veh/h		
Grade adjustment for trucks, ET PCE for RVs, ER Heavy-vehicle adjustment for the second for the	Average Eactor, fG stment factor, (note-1) vp al split proportion Field Measure eed, SFM of ow Speed: eed, BFFS shoulder width,	ge Travel Spector (note-2)	1.00 1.7 1.0 0.935 253 142	mi/h veh/h mi/h		
Grade adjustment for trucks, ET of trucks, ET of trucks, ER of the second state of the	Average Eactor, fG Factor, fG Factor, fG Factor, fG Factor, for the second split proportion of the second split proportion o	ge Travel Spector (note-2)	1.00 1.7 1.0 0.935 253 142	mi/h veh/h mi/h mi/h		
Grade adjustment for trucks, ET of trucks, ET of trucks, ER of the second secon	Average factor, fG factor, fG factor, fG factor, fG factor, for factor, for factor, for factor, for field Measure feed, SFM for Speed: feed, BFFS factor, fA factor, fA factor, fA	ge Travel Spector (note-2) ement:	1.00 1.7 1.0 0.935 253 142 - - 55.0 0.0 1.8	mi/h veh/h mi/h mi/h mi/h		

Percent Time-Spent-Following					
Grade adjustment factor, fG	1.00				
PCE for trucks, ET	1.1				
PCE for RVs, ER	1.0				
Heavy-vehicle adjustment factor, fHV	0.990				
Two-way flow rate, (note-1) vp	239	pc/h			
Highest directional split proportion (note-2)	134	-			
Base percent time-spent-following, BPTSF	18.9	%			
Adj.for directional distribution and no-passing zones, fd/np	6.1				
Percent time-spent-following, PTSF	25.0	90			
Level of Service and Other Performance Measu:	res				
Level of service, LOS	В				
Volume to capacity ratio, v/c	0.08				
Peak 15-min vehicle-miles of travel, VMT15	296	veh-mi			
Peak-hour vehicle-miles of travel, VMT60	1005	veh-mi			
Peak 15-min total travel time, TT15	5.8	veh-h			

- 1. If $vp \ge 3200 \text{ pc/h}$, terminate analysis-the LOS is F. 2. If highest directional split $vp \ge 1700 \text{ pc/h}$, terminate analysis-the LOS is F.

HCS+: Two-Lane Highways Release 5.4

Two-Way Two-Lane Highway Se	egment A	nalysis		
Analyst RSO Agency/Co. Traffic Management Con Date Performed 3/11/2011 Analysis Time Period AM Peak Hour Highway Mamalahoa Highway From/To Hookena Beach Rd 101.0 Jurisdiction State of Hawaii Analysis Year 2015 Without Project Description Kahuku Villages				
Input Data				
Highway class Class 1 Shoulder width 3.0 ft Peak-hour Lane width 12.0 ft % Trucks of Segment length 5.0 mi % Recreat: Terrain type Level % No-pass: Grade: Length mi Access position Up/down % Two-way hourly volume, V 530 veh/h	and buse ional ve ing zone	s hicles	0.86 11 0 50	% % /mi
Directional split 77 / 23 %				
Average Travel Spe	eed			
Grade adjustment factor, fG PCE for trucks, ET PCE for RVs, ER Heavy-vehicle adjustment factor, Two-way flow rate, (note-1) vp Highest directional split proportion (note-2)	1.00 1.2 1.0 0.978 630 485	pc/h pc/h		
Free-Flow Speed from Field Measurement: Field measured speed, SFM Observed volume, Vf Estimated Free-Flow Speed: Base free-flow speed, BFFS Adj. for lane and shoulder width, fLS Adj. for access points, fA	- - 55.0 2.6 2.5	mi/h veh/h mi/h mi/h mi/h		
Free-flow speed, FFS	49.9	mi/h		
Adjustment for no-passing zones, fnp Average travel speed, ATS	2.6 42.4	mi/h mi/h		

Percent Time-Spent-Following						
Grade adjustment factor, fG	1.00					
PCE for trucks, ET	1.1					
PCE for RVs, ER	1.0					
Heavy-vehicle adjustment factor, fHV	0.989					
Two-way flow rate, (note-1) vp	623	pc/h				
Highest directional split proportion (note-2)	480	-				
Base percent time-spent-following, BPTSF	42.2	%				
Adj.for directional distribution and no-passing zones, fd/np	19.1					
Percent time-spent-following, PTSF	61.3	%				
Level of Service and Other Performance Measu:	res					
Level of service, LOS	D					
Volume to capacity ratio, v/c	0.20					
Peak 15-min vehicle-miles of travel, VMT15	770	veh-mi				
Peak-hour vehicle-miles of travel, VMT60	2650	veh-mi				
Peak 15-min total travel time, TT15	18.2	veh-h				

- 1. If $vp \ge 3200 \text{ pc/h}$, terminate analysis-the LOS is F. 2. If highest directional split $vp \ge 1700 \text{ pc/h}$, terminate analysis-the LOS is F.

HCS+: Two-Lane Highways Release 5.4

Two-Way T	wo-Lane Highway	y Segment A	nalysis		
Date Performed 3/11 Analysis Time Period AM P Highway Mama From/To Kapa Jurisdiction Stat	fic Management /2011 eak Hour lahoa Highway lapala Ranch Ro e of Hawaii Without Projeo	1 46.06 MP			
	Input Da	ata			
Highway class Class 1 Shoulder width 3.0 Lane width 12.0 Segment length 5.0 Terrain type Level Grade: Length Up/down Two-way hourly volume, V	ft % Truck mi % Recre % No-pa mi Access % 202 veh/h	our factor, as and buse eational ve assing zone points/mi	s hicles	0.83 13 0 10 5	% % % /mi
Directional split 58	/ 42 %				
	Average Travel	Speed			
Grade adjustment factor, fG PCE for trucks, ET PCE for RVs, ER Heavy-vehicle adjustment fac Two-way flow rate, (note-1) v Highest directional split pr	р	1.00 1.7 1.0 0.917 266 -2) 154	pc/h pc/h		
Free-Flow Speed from Field M Field measured speed, SFM Observed volume, Vf Estimated Free-Flow Speed: Base free-flow speed, BFFS Adj. for lane and shoulder w Adj. for access points, fA		- - 55.0 2.6 1.3	mi/h veh/h mi/h mi/h mi/h		
Free-flow speed, FFS		51.2	mi/h		
Adjustment for no-passing zo Average travel speed, ATS	nes, fnp	0.5 48.6	mi/h mi/h		

Percent Time-Spent-Following						
1.00						
1.1						
1.0						
0.987						
247	pc/h					
143						
19.5	96					
6.3						
25.8	%					
ces						
С						
0.08						
304	veh-mi					
1010	veh-mi					
6.3	veh-h					
	1.1 1.0 0.987 247 143 19.5 6.3 25.8 C 0.08 304 1010					

- 1. If $vp \ge 3200 \text{ pc/h}$, terminate analysis-the LOS is F. 2. If highest directional split $vp \ge 1700 \text{ pc/h}$, terminate analysis-the LOS is F.

HCS+: Two-Lane Highways Release 5.4

Two-	Way Two-Lar	ne Highway Se	egment A	nalysis		
Analyst Agency/Co. Date Performed Analysis Time Period Highway From/To Jurisdiction Analysis Year Description Kahuku Vil	3/11/2011 PM Peak Ho Mamalahoa Kahuku Rar State of E 2015 Witho	Highway nch Rd to Orc		У		
		Input Data_				
Highway class Class 1 Shoulder width 8. Lane width 12 Segment length 5. Terrain type Le Grade: Length Up/down Two-way hourly volume, Directional split	.0 ft 0 mi vel mi %	<pre>% Trucks a % Recreati % No-passi Access poi veh/h</pre>	and buse: onal vel .ng zone:	s hicles	0.90 11 0 10 7	% % /mi
	Averaç	ge Travel Spe	ed			
Grade adjustment factor PCE for trucks, ET PCE for RVs, ER Heavy-vehicle adjustmen Two-way flow rate, (note Highest directional spl	, fG t factor, -1) vp		1.00 1.7 1.0 0.929 305	pc/h pc/h		
Free-Flow Speed from Fi Field measured speed, S Observed volume, Vf Estimated Free-Flow Spe Base free-flow speed, B Adj. for lane and shoul Adj. for access points,	FM ed: FFS der width,		- - 55.0 0.0 1.8	mi/h veh/h mi/h mi/h mi/h		
Free-flow speed, FFS			53.3	mi/h		
Adjustment for no-passi Average travel speed, A		np	0.6 50.3	mi/h mi/h		

Percent Time-Spent-Following						
Grade adjustment factor, fG	1.00					
PCE for trucks, ET	1.1					
PCE for RVs, ER	1.0					
Heavy-vehicle adjustment factor, fHV	0.989					
Two-way flow rate, (note-1) vp	286	pc/h				
Highest directional split proportion (note-2)	157	_				
Base percent time-spent-following, BPTSF	22.2	8				
Adj. for directional distribution and no-passing zones, fd/np	6.0					
Percent time-spent-following, PTSF	28.2	90				
Level of Service and Other Performance Measu	res					
Level of service, LOS	В					
Volume to capacity ratio, v/c	0.10					
Peak 15-min vehicle-miles of travel, VMT15	354	veh-mi				
Peak-hour vehicle-miles of travel, VMT60	1275	veh-mi				
Peak 15-min total travel time, TT15	7.0	veh-h				

- 1. If $vp \ge 3200 \text{ pc/h}$, terminate analysis-the LOS is F. 2. If highest directional split $vp \ge 1700 \text{ pc/h}$, terminate analysis-the LOS is F.

HCS+: Two-Lane Highways Release 5.4

Two-	-Way Two-Lane	e Highway Se	egment A	nalysis		
Analyst Agency/Co. Date Performed Analysis Time Period Highway From/To Jurisdiction Analysis Year Description Kahuku Vil	3/11/2011 PM Peak Hou Mamalahoa F Hookena Bea State of Ha 2015 Withou	Highway ach Rd 101.0 awaii				
		Input Data				
Lane width 12 Segment length 5. Terrain type Le Grade: Length Up/down Two-way hourly volume,	0 mi evel mi %		and buse onal ve ng zone	s hicles	0.92 11 0 50 10	% % % /mi
Directional split	70 / 30	9				
	Average	e Travel Spe	eed			
Grade adjustment factor PCE for trucks, ET PCE for RVs, ER Heavy-vehicle adjustment Two-way flow rate, (note Highest directional spl	nt factor, e-1) vp	on (note-2)	1.00 1.2 1.0 0.978 611 428	pc/h pc/h		
Free-Flow Speed from Fi Field measured speed, S Observed volume, Vf Estimated Free-Flow Spe Base free-flow speed, E Adj. for lane and shoul Adj. for access points,	eed: BFFS der width, f		- - 55.0 2.6 2.5	mi/h veh/h mi/h mi/h mi/h		
Free-flow speed, FFS			49.9	mi/h		
Adjustment for no-passi Average travel speed, A		np	2.7 42.5	mi/h mi/h		

Percent Time-Spent-Following						
1.00						
1.1						
1.0						
0.989						
604	pc/h					
423						
41.2	%					
17.1						
58.3	%					
res						
D						
0.19						
747	veh-mi					
2750	veh-mi					
17.6	veh-h					
	1.1 1.0 0.989 604 423 41.2 17.1 58.3 es D 0.19 747 2750					

- 1. If $vp \ge 3200 \text{ pc/h}$, terminate analysis-the LOS is F.
- 2. If highest directional split vp >= 1700 pc/h, terminate analysis-the LOS is F.

HCS+: Two-Lane Highways Release 5.4

Two-	-Way Two-Lane Highway S	egment A	nalysis		
Analyst Agency/Co. Date Performed Analysis Time Period Highway From/To Jurisdiction Analysis Year Description Kahuku Vil	Mamalahoa Highway Kapalapala Ranch Rd 4 State of Hawaii 2015 Without Project				
	Input Data	·			
Highway class Class 1 Shoulder width 3. Lane width 12 Segment length 5. Terrain type Le Grade: Length Up/down	0 mi % Recreat	and buse ional ve ing zone	s hicles	0.94 3 0 10 5	% % % /mi
Two-way hourly volume, Directional split	53 / 47 %				
	Average Travel Sp	eed			
Grade adjustment factor PCE for trucks, ET PCE for RVs, ER Heavy-vehicle adjustmen Two-way flow rate, (note Highest directional spl	nt factor, e-1) vp	1.00 1.7 1.0 0.979 259 137	-		
Free-Flow Speed from Fi Field measured speed, S Observed volume, Vf Estimated Free-Flow Spe Base free-flow speed, E Adj. for lane and shoul Adj. for access points,	eed: BFFS der width, fLS	- - 55.0 2.6 1.3	mi/h veh/h mi/h mi/h mi/h		
Free-flow speed, FFS		51.2	mi/h		
Adjustment for no-passi Average travel speed, A	= =	0.5 48.7	mi/h mi/h		

Percent Time-Spent-Following					
Grade adjustment factor, fG	1.00				
PCE for trucks, ET	1.1				
PCE for RVs, ER	1.0				
Heavy-vehicle adjustment factor, fHV	0.997				
Two-way flow rate, (note-1) vp	254	pc/h			
Highest directional split proportion (note-2)	135				
Base percent time-spent-following, BPTSF	20.0	용			
Adj.for directional distribution and no-passing zones, fd/np	5.7				
Percent time-spent-following, PTSF	25.7	%			
Level of Service and Other Performance Measur	res				
Level of service, LOS	С				
Volume to capacity ratio, v/c	0.08				
Peak 15-min vehicle-miles of travel, VMT15	316	veh-mi			
Peak-hour vehicle-miles of travel, VMT60	1190	veh-mi			
Peak 15-min total travel time, TT15	6.5	veh-h			

- 1. If $vp \ge 3200 \text{ pc/h}$, terminate analysis-the LOS is F. 2. If highest directional split $vp \ge 1700 \text{ pc/h}$, terminate analysis-the LOS is F.

TRAFFIC IMPACT ANALYSIS REPORT FOR THE PROPOSED KAHUKU VILLAGE KA`U, HAWAII

TAX MAP KEY: (3) 9-2-001:072

APPENDIX D

CAPACITY ANALYSIS WORKSHEETS
2021 PEAK HOUR TRAFFIC WITHOUT PROJECT

HCS+: Two-Lane Highways Release 5.4

Two-Way Two-Lane Highway S	egment A	nalysis		
Analyst RSO Agency/Co. Traffic Management Co Date Performed 3/11/2011 Analysis Time Period AM Peak Hour Highway Mamalahoa Highway From/To Kahuku Ranch Rd to Or Jurisdiction State of Hawaii Analysis Year 2021 Without Project Description Kahuku Villages	chid Pkw	У		
Input Data				
Highway class Class 1 Shoulder width 8.0 ft Peak-hour Lane width 12.0 ft % Trucks Segment length 5.0 mi % Recreat Terrain type Level % No-pass Grade: Length mi Access po Up/down %	and buse ional vel ing zone	s hicles	0.85 10 0 10 7	% % % /mi
Two-way hourly volume, V 223 veh/h Directional split 56 / 44 %				
Average Travel Sp	eed			
Grade adjustment factor, fG PCE for trucks, ET PCE for RVs, ER Heavy-vehicle adjustment factor, Two-way flow rate, (note-1) vp Highest directional split proportion (note-2)	1.00 1.7 1.0 0.935 281 157	pc/h pc/h		
Free-Flow Speed from Field Measurement: Field measured speed, SFM Observed volume, Vf Estimated Free-Flow Speed: Base free-flow speed, BFFS Adj. for lane and shoulder width, fLS Adj. for access points, fA	- - 55.0 0.0 1.8	mi/h veh/h mi/h mi/h mi/h		
Free-flow speed, FFS	53.3	mi/h		
Adjustment for no-passing zones, fnp Average travel speed, ATS	0.5	mi/h mi/h		

Percent Time-Spent-Following						
Grade adjustment factor, fG	1.00					
PCE for trucks, ET	1.1					
PCE for RVs, ER	1.0					
Heavy-vehicle adjustment factor, fHV	0.990					
Two-way flow rate, (note-1) vp	265	pc/h				
Highest directional split proportion (note-2)	148	_				
Base percent time-spent-following, BPTSF	20.8	용				
Adj.for directional distribution and no-passing zones, fd/np	6.1					
Percent time-spent-following, PTSF	26.9	90				
Level of Service and Other Performance Measu:	res					
Level of service, LOS	В					
Volume to capacity ratio, v/c	0.09					
Peak 15-min vehicle-miles of travel, VMT15	328	veh-mi				
Peak-hour vehicle-miles of travel, VMT60	1115	veh-mi				
Peak 15-min total travel time, TT15	6.5	veh-h				

- 1. If $vp \ge 3200 \text{ pc/h}$, terminate analysis-the LOS is F. 2. If highest directional split $vp \ge 1700 \text{ pc/h}$, terminate analysis-the LOS is F.

HCS+: Two-Lane Highways Release 5.4

Two-	-Way Two-Lane H	Highway Se	gment A	nalysis		
Analyst Agency/Co. Date Performed Analysis Time Period Highway From/To Jurisdiction Analysis Year Description Kahuku Vil	RSO Traffic Manag 3/11/2011 AM Peak Hour Mamalahoa Hig Hookena Beach State of Hawa 2021 Without	ghway n Rd 101.0				
	Ir	nput Data_				
Segment length 5.	2.0 ft % .0 mi % evel %	Peak-hour Trucks as Recreati No-passi Access poi	nd buses onal vel ng zones	s nicles	0.86 11 0 50	% % % /mi
Directional split						
	Average T	ravel Spe	ed			
Grade adjustment factor PCE for trucks, ET PCE for RVs, ER Heavy-vehicle adjustment Two-way flow rate, (note Highest directional spin	nt factor, e-1) vp	(note-2)	1.00 1.2 1.0 0.978 713 549	pc/h pc/h		
Free-Flow Speed from Frield measured speed, Sobserved volume, Vf Estimated Free-Flow Speed, Flow Speed	SFM eed: BFFS Lder width, fLS		- - 55.0 2.6 2.5	mi/h veh/h mi/h mi/h mi/h		
Free-flow speed, FFS			49.9	mi/h		
Adjustment for no-passi Average travel speed, A			2.4 42.0	mi/h mi/h		

Percent Time-Spent-Following					
Grade adjustment factor, fG		1.00			
PCE for trucks, ET		1.1			
PCE for RVs, ER		1.0			
Heavy-vehicle adjustment factor, fHV		0.989			
Two-way flow rate, (note-1) vp		705	pc/h		
Highest directional split proportion (note-2)		543	_		
Base percent time-spent-following, BPTSF		46.2	ଚ୍ଚ		
Adj.for directional distribution and no-passing zones,	fd/np	16.6			
Percent time-spent-following, PTSF		62.7	%		
Level of Service and Other Performance	Measu	res			
Level of service, LOS		D			
Volume to capacity ratio, v/c		0.22			
Peak 15-min vehicle-miles of travel, VMT15		872	veh-mi		
Peak-hour vehicle-miles of travel, VMT60		3000	veh-mi		
Peak 15-min total travel time, TT15		20.8	veh-h		
Two-way flow rate, (note-1) vp Highest directional split proportion (note-2) Base percent time-spent-following, BPTSF Adj.for directional distribution and no-passing zones, Percent time-spent-following, PTSF	1	705 543 46.2 16.6 62.7 ces D 0.22 872 3000	% % veh-mi		

- 1. If $vp \ge 3200 \text{ pc/h}$, terminate analysis-the LOS is F. 2. If highest directional split $vp \ge 1700 \text{ pc/h}$, terminate analysis-the LOS is F.

HCS+: Two-Lane Highways Release 5.4

Two-	-Way Two-Lane Highway Se	egment A	nalysis		
Analyst Agency/Co. Date Performed Analysis Time Period Highway From/To Jurisdiction Analysis Year Description Kahuku Vil	Mamalahoa Highway Kapalapala Ranch Rd 4 State of Hawaii 2021 Without Project				
	Input Data				
		and buses ional vel ing zones	s hicles	0.83 13 0 10	% % /mi
Two-way hourly volume, Directional split	V 221 veh/h 58 / 42 % Average Travel Spo	ed.			
Grade adjustment factor PCE for trucks, ET PCE for RVs, ER Heavy-vehicle adjustmen Two-way flow rate, (note Highest directional spl	r, fG at factor, e-1) vp	1.00 1.7 1.0 0.917 290	pc/h pc/h		
Free-Flow Speed from Fi Field measured speed, S Observed volume, Vf Estimated Free-Flow Spe Base free-flow speed, E Adj. for lane and shoul Adj. for access points,	eed: eFFS der width, fLS	- - 55.0 2.6 1.3	mi/h veh/h mi/h mi/h mi/h		
Free-flow speed, FFS		51.2	mi/h		
Adjustment for no-passi Average travel speed, A	=	0.5 48.4	mi/h mi/h		

Percent Time-Spent-Following					
Grade adjustment factor, fG	1.00				
PCE for trucks, ET	1.1				
PCE for RVs, ER	1.0				
Heavy-vehicle adjustment factor, fHV	0.987				
Two-way flow rate, (note-1) vp	270	pc/h			
Highest directional split proportion (note-2)	157				
Base percent time-spent-following, BPTSF	21.1	%			
Adj.for directional distribution and no-passing zones, fd/np	6.3				
Percent time-spent-following, PTSF	27.4	90			
Level of Service and Other Performance Measur	res				
Level of service, LOS	С				
Volume to capacity ratio, v/c	0.09				
Peak 15-min vehicle-miles of travel, VMT15	333	veh-mi			
Peak-hour vehicle-miles of travel, VMT60	1105	veh-mi			
Peak 15-min total travel time, TT15	6.9	veh-h			

- 1. If $vp \ge 3200 \text{ pc/h}$, terminate analysis-the LOS is F.
- 2. If highest directional split vp >= 1700 pc/h, terminate analysis-the LOS is F.

HCS+: Two-Lane Highways Release 5.4

Two-	-Way Two-Lan	e Highway Se	egment A	nalysis	
Analyst Agency/Co. Date Performed Analysis Time Period Highway From/To Jurisdiction Analysis Year Description Kahuku Vil	3/11/2011 PM Peak Ho Mamalahoa Kahuku Ran State of H 2021 Witho	Highway ch Rd to Oro awaii		У	
		Input Data			
Highway class Class 1 Shoulder width 8 Lane width 12 Segment length 5 Terrain type Le Grade: Length Up/down Two-way hourly volume, Directional split	.0 mi evel mi %	<pre>% Recreati % No-passi Access poi veh/h</pre>	onal ve	hicles	% % /mi
	Averag	e Travel Spe	eed		
Grade adjustment factor PCE for trucks, ET PCE for RVs, ER Heavy-vehicle adjustmen Two-way flow rate, (note Highest directional spi	nt factor, e-1) vp	on (note-2)	1.00 1.7 1.0 0.929 337 185	pc/h pc/h	
Free-Flow Speed from F: Field measured speed, Stops of the Speed Free-Flow Speed, Free-Flow	SFM eed: BFFS Lder width,		- - 55.0 0.0 1.8	mi/h veh/h mi/h mi/h mi/h	
Free-flow speed, FFS			53.3	mi/h	
Adjustment for no-pass:	ing zones, f ATS	np	0.7 50.0	mi/h mi/h	

Percent Time-Spent-Following					
Grade adjustment factor, fG	1.00				
PCE for trucks, ET	1.1				
PCE for RVs, ER	1.0				
Heavy-vehicle adjustment factor, fHV	0.989				
Two-way flow rate, (note-1) vp	317	pc/h			
Highest directional split proportion (note-2)	174				
Base percent time-spent-following, BPTSF	24.3	9			
Adj.for directional distribution and no-passing zones, fd/np	6.0				
Percent time-spent-following, PTSF	30.4	%			
Level of Service and Other Performance Measur	ces				
Level of service, LOS	С				
Volume to capacity ratio, v/c	0.11				
Peak 15-min vehicle-miles of travel, VMT15	392	veh-mi			
Peak-hour vehicle-miles of travel, VMT60	1410	veh-mi			
Peak 15-min total travel time, TT15	7.8	veh-h			

- 1. If $vp \ge 3200 \text{ pc/h}$, terminate analysis-the LOS is F. 2. If highest directional split $vp \ge 1700 \text{ pc/h}$, terminate analysis-the LOS is F.

HCS+: Two-Lane Highways Release 5.4

	Two-Way Two-Lar	e Highway Se	egment A	nalysis		
Analyst	RSO					
Agency/Co.		nagement Cor	nsultant			
Date Performed	3/11/2011	magement con	is ar carre			
Analysis Time Perio	· ·	.11.70				
-						
Highway	Mamalahoa		1111			
From/To		each Rd 101.0	TMP			
Jurisdiction	State of H					
Analysis Year		out Project				
Description Kahuku	Villages					
		Input Data_				
Highway class Clas						
Shoulder width	3.0 ft	Peak-hour	factor,	PHF	0.92	
Lane width	12.0 ft	% Trucks a	and buse	S	11	%
Segment length	5.0 mi	% Recreati	lonal ve	hicles	0	%
Terrain type	Level	% No-passi	ing zone	S	50	%
Grade: Length	mi	Access poi	lnts/mi		10	/mi
Up/down	90					
Two-way hourly volum Directional split	70 / 30		aed			
	Averag	ge Travel Spe	eeu			
Grade adjustment fa	ctor, fG		1.00			
PCE for trucks, ET			1.2			
PCE for RVs, ER			1.0			
Heavy-vehicle adjus	tment factor,		0.978			
Two-way flow rate, (note-1) vp		692	pc/h		
Highest directional		on (note-2)	484	pc/h		
Free-Flow Speed from	m Field Measure	ement:				
Field measured spee			_	mi/h		
Observed volume, Vf			_	veh/h		
Estimated Free-Flow				•		
Base free-flow speed			55.0	mi/h		
Adj. for lane and si		fLS	2.6	mi/h		
Adj. for access poi		~	2.5	mi/h		
,•	/			/		
Free-flow speed, FF	S		49.9	mi/h		
Adiustment for no-n						
11d dD CIIICIIC TOT IIO D	assing zones f	nn	2 4	mi/h		
Average travel spee	assing zones, f	np	2.4 42.1	mi/h mi/h		

Percent Time-Spent-Following					
Grade adjustment factor, fG	1.00				
PCE for trucks, ET	1.1				
PCE for RVs, ER	1.0				
Heavy-vehicle adjustment factor, fHV	0.989				
Two-way flow rate, (note-1) vp	685	pc/h			
Highest directional split proportion (note-2)	480				
Base percent time-spent-following, BPTSF	45.2	%			
Adj.for directional distribution and no-passing zones, fd/np	15.0				
Percent time-spent-following, PTSF	60.2	양			
Level of Service and Other Performance Measu:	res				
Level of service, LOS	D				
Volume to capacity ratio, v/c	0.22				
Peak 15-min vehicle-miles of travel, VMT15	846	veh-mi			
Peak-hour vehicle-miles of travel, VMT60	3115	veh-mi			
Peak 15-min total travel time, TT15	20.1	veh-h			

- 1. If $vp \ge 3200 \text{ pc/h}$, terminate analysis-the LOS is F. 2. If highest directional split $vp \ge 1700 \text{ pc/h}$, terminate analysis-the LOS is F.

HCS+: Two-Lane Highways Release 5.4

Two-Way Two-Lane Highway Se	egment A	nalysis		
Analyst RSO Agency/Co. Traffic Management Cor Date Performed 3/11/2011 Analysis Time Period PM Peak Hour Highway Mamalahoa Highway From/To Kapalapala Ranch Rd 46 Jurisdiction State of Hawaii Analysis Year 2021 Without Project Description Kahuku Villages				
Input Data_				
Highway class Class 1 Shoulder width 3.0 ft Peak-hour Lane width 12.0 ft % Trucks a Segment length 5.0 mi % Recreati Terrain type Level % No-passi Grade: Length mi Access poi Up/down % Two-way hourly volume, V 260 veh/h	and buse lonal vel lng zone	s hicles	0.94 3 0 10 5	% % % /mi
Directional split 53 / 47 %				
Average Travel Spe	eed			
Grade adjustment factor, fG PCE for trucks, ET PCE for RVs, ER Heavy-vehicle adjustment factor, Two-way flow rate, (note-1) vp Highest directional split proportion (note-2)	1.00 1.7 1.0 0.979 282 149	pc/h pc/h		
Free-Flow Speed from Field Measurement: Field measured speed, SFM Observed volume, Vf Estimated Free-Flow Speed: Base free-flow speed, BFFS Adj. for lane and shoulder width, fLS Adj. for access points, fA	- - 55.0 2.6 1.3	mi/h veh/h mi/h mi/h mi/h		
Free-flow speed, FFS	51.2	mi/h		
Adjustment for no-passing zones, fnp Average travel speed, ATS	0.5 48.4	mi/h mi/h		

Percent Time-Spent-Following					
Grade adjustment factor, fG	1.00				
PCE for trucks, ET	1.1				
PCE for RVs, ER	1.0				
Heavy-vehicle adjustment factor, fHV	0.997				
Two-way flow rate, (note-1) vp	277	pc/h			
Highest directional split proportion (note-2)	147				
Base percent time-spent-following, BPTSF	21.6	용			
Adj.for directional distribution and no-passing zones, fd/np	5.8				
Percent time-spent-following, PTSF	27.4	왕			
Level of Service and Other Performance Measur	res				
Level of service, LOS	С				
Volume to capacity ratio, v/c	0.09				
Peak 15-min vehicle-miles of travel, VMT15	346	veh-mi			
Peak-hour vehicle-miles of travel, VMT60	1300	veh-mi			
Peak 15-min total travel time, TT15	7.1	veh-h			

- 1. If $vp \ge 3200 \text{ pc/h}$, terminate analysis-the LOS is F.
- 2. If highest directional split vp >= 1700 pc/h, terminate analysis-the LOS is F.

TRAFFIC IMPACT ANALYSIS REPORT FOR THE PROPOSED KAHUKU VILLAGE KA`U, HAWAII

TAX MAP KEY: (3) 9-2-001:072

APPENDIX E

CAPACITY ANALYSIS WORKSHEETS
2024 PEAK HOUR TRAFFIC WITHOUT PROJECT

HCS+: Two-Lane Highways Release 5.4

Two-Wa	ay Two-Lan	e Highway Se	egment A	nalysis		
Agency/Co. To the proof of the performed solution and the period of the	3/11/2011 MM Peak Ho Mamalahoa Kahuku Ran State of H 2024 Witho	Highway ch Rd to Orc				
		Input Data				
Highway class Class 1 Shoulder width 8.0 Lane width 12.0 Segment length 5.0 Terrain type Leve Grade: Length Up/down Two-way hourly volume, V Directional split 5	ft mi el mi %		and buse onal ve ng zone	s hicles	0.85 10 0 10 7	% % /mi
Directional Spilt 5	00 / 44	6				
	Averag	e Travel Spe	eed			
Grade adjustment factor, PCE for trucks, ET PCE for RVs, ER Heavy-vehicle adjustment Two-way flow rate,(note-1 Highest directional split	factor,	on (note-2)	1.00 1.7 1.0 0.935 296 166	pc/h pc/h		
Free-Flow Speed from Fiel Field measured speed, SFM Observed volume, Vf Estimated Free-Flow Speed Base free-flow speed, BFF Adj. for lane and shoulde Adj. for access points, f	d: rs er width,		- - 55.0 0.0 1.8	mi/h veh/h mi/h mi/h mi/h		
Free-flow speed, FFS			53.3	mi/h		
Adjustment for no-passing Average travel speed, ATS		np	0.6 50.4	mi/h mi/h		

Percent Time-Spent-Following					
Grade adjustment factor, fG	1.00				
PCE for trucks, ET	1.1				
PCE for RVs, ER	1.0				
Heavy-vehicle adjustment factor, fHV	0.990				
Two-way flow rate, (note-1) vp	279	pc/h			
Highest directional split proportion (note-2)	156				
Base percent time-spent-following, BPTSF	21.7	96			
Adj.for directional distribution and no-passing zones, fd/np	6.1				
Percent time-spent-following, PTSF	27.8	%			
Level of Service and Other Performance Measur	res				
Level of service, LOS	В				
Volume to capacity ratio, v/c	0.09				
Peak 15-min vehicle-miles of travel, VMT15	346	veh-mi			
Peak-hour vehicle-miles of travel, VMT60	1175	veh-mi			
Peak 15-min total travel time, TT15	6.9	veh-h			

- If vp >= 3200 pc/h, terminate analysis-the LOS is F.
 If highest directional split vp >= 1700 pc/h, terminate analysis-the LOS is F.

HCS+: Two-Lane Highways Release 5.4

Two-	-Way Two-Lane l	Highway Se	gment A	nalysis		
Analyst Agency/Co. Date Performed Analysis Time Period Highway From/To Jurisdiction Analysis Year Description Kahuku Vil	Mamalahoa Hio Hookena Beacl State of Hawa 2024 Without	ghway h Rd 101.0 aii				
	I	nput Data_				
Lane width 12 Segment length 5. Terrain type Le Grade: Length Up/down Two-way hourly volume,	2.0 ft 2.0 mi 2.2 evel 2.2 mi 2.2 %	Peak-hour % Trucks a % Recreati % No-passi Access poi	nd buses onal vel ng zones	s nicles	0.86 11 0 50	% % % /mi
Directional split	77 / 23	9				
	Average '	Travel Spe	ed			
Grade adjustment factor PCE for trucks, ET PCE for RVs, ER Heavy-vehicle adjustmen Two-way flow rate, (note Highest directional spi	nt factor, e-1) vp	(note-2)	1.00 1.2 1.0 0.978 756 582	pc/h pc/h		
Free-Flow Speed from Frield measured speed, Sobserved volume, Vf Estimated Free-Flow Speed, Flow Speed, Flow for lane and should Adj. for access points,	eed: BFFS .der width, fL:		- - 55.0 2.6 2.5	mi/h veh/h mi/h mi/h mi/h		
Free-flow speed, FFS			49.9	mi/h		
Adjustment for no-passi Average travel speed, A			2.3	mi/h mi/h		

Percent Time-Spent-Following		
Grade adjustment factor, fG	1.00	
PCE for trucks, ET	1.1	
PCE for RVs, ER	1.0	
Heavy-vehicle adjustment factor, fHV	0.989	
Two-way flow rate, (note-1) vp	748	pc/h
Highest directional split proportion (note-2)	576	-
Base percent time-spent-following, BPTSF	48.2	용
Adj.for directional distribution and no-passing zones, fd/np	15.2	
Percent time-spent-following, PTSF	63.4	90
Level of Service and Other Performance Measu:	res	
Level of service, LOS	D	
Volume to capacity ratio, v/c	0.24	
Peak 15-min vehicle-miles of travel, VMT15	924	veh-mi
Peak-hour vehicle-miles of travel, VMT60	3180	veh-mi
Peak 15-min total travel time, TT15	22.1	veh-h

- 1. If $vp \ge 3200 \text{ pc/h}$, terminate analysis-the LOS is F. 2. If highest directional split $vp \ge 1700 \text{ pc/h}$, terminate analysis-the LOS is F.

HCS+: Two-Lane Highways Release 5.4

Two	-Way Two-Lan	e Highway Se	egment A	nalysis		
Analyst Agency/Co. Date Performed Analysis Time Period Highway From/To Jurisdiction Analysis Year Description Kahuku Vi	3/11/2011 AM Peak Horn Mamalahoa E Kapalapala State of Horn 2024 Withorn	Highway Ranch Rd 46 awaii				
		Input Data				
	.0 ft 2.0 ft .0 mi evel mi %	<pre>% Trucks a % Recreati % No-passi Access poi veh/h</pre>	and buse onal ve ng zone	s hicles	0.83 13 0 10 5	% % /mi
			o d			
	Average	e Travel Spe	eea			
Grade adjustment factor PCE for trucks, ET PCE for RVs, ER Heavy-vehicle adjustme Two-way flow rate, (not Highest directional sp	nt factor, e-1) vp	on (note-2)	1.00 1.7 1.0 0.917 302 175	pc/h pc/h		
Free-Flow Speed from F Field measured speed, Observed volume, Vf Estimated Free-Flow Sp Base free-flow speed, Adj. for lane and shou Adj. for access points	sfM eed: BFFS lder width,		- - 55.0 2.6 1.3	mi/h veh/h mi/h mi/h mi/h		
Free-flow speed, FFS			51.2	mi/h		
Adjustment for no-pass Average travel speed,	-	np	0.6 48.2	mi/h mi/h		

Percent Time-Spent-Following					
Grade adjustment factor, fG	1.00				
PCE for trucks, ET	1.1				
PCE for RVs, ER	1.0				
Heavy-vehicle adjustment factor, fHV	0.987				
Two-way flow rate, (note-1) vp	281	pc/h			
Highest directional split proportion (note-2)	163				
Base percent time-spent-following, BPTSF	21.9	90			
Adj.for directional distribution and no-passing zones, fd/np	6.3				
Percent time-spent-following, PTSF	28.2	%			
Level of Service and Other Performance Measu:	res				
Level of service, LOS	С				
Volume to capacity ratio, v/c	0.09				
Peak 15-min vehicle-miles of travel, VMT15	346	veh-mi			
Peak-hour vehicle-miles of travel, VMT60	1150	veh-mi			
Peak 15-min total travel time, TT15	7.2	veh-h			
,					

- 1. If $vp \ge 3200 \text{ pc/h}$, terminate analysis-the LOS is F. 2. If highest directional split $vp \ge 1700 \text{ pc/h}$, terminate analysis-the LOS is F.

HCS+: Two-Lane Highways Release 5.4

Two-Way Two-Lane Highway	Segment A	nalysis		
Analyst RSO Agency/Co. Traffic Management C Date Performed 3/11/2011 Analysis Time Period PM Peak Hour Highway Mamalahoa Highway From/To Kahuku Ranch Rd to O Jurisdiction State of Hawaii Analysis Year 2024 Without Project Description Kahuku Villages	rchid Pkw			
Input Dat	a			
Lane width 12.0 ft % Trucks Segment length 5.0 mi % Recrea	tional ve sing zone	s hicles	0.90 11 0 10 7	% % % /mi
Directional split 55 / 45 %				
Average Travel S	peed			
Grade adjustment factor, fG PCE for trucks, ET PCE for RVs, ER Heavy-vehicle adjustment factor, Two-way flow rate, (note-1) vp Highest directional split proportion (note-2	1.00 1.7 1.0 0.929 353) 194	pc/h pc/h		
Free-Flow Speed from Field Measurement: Field measured speed, SFM Observed volume, Vf Estimated Free-Flow Speed: Base free-flow speed, BFFS Adj. for lane and shoulder width, fLS Adj. for access points, fA	- - 55.0 0.0 1.8	mi/h veh/h mi/h mi/h mi/h		
Free-flow speed, FFS	53.3	mi/h		
Adjustment for no-passing zones, fnp Average travel speed, ATS	0.7 49.8	mi/h mi/h		

Percent Time-Spent-Following					
Grade adjustment factor, fG	1.00				
PCE for trucks, ET	1.1				
PCE for RVs, ER	1.0				
Heavy-vehicle adjustment factor, fHV	0.989				
Two-way flow rate, (note-1) vp	331	pc/h			
Highest directional split proportion (note-2)	182				
Base percent time-spent-following, BPTSF	25.2	%			
Adj.for directional distribution and no-passing zones, fd/np	6.1				
Percent time-spent-following, PTSF	31.3	90			
Level of Service and Other Performance Measu:	res				
Level of service, LOS	С				
Volume to capacity ratio, v/c	0.11				
Peak 15-min vehicle-miles of travel, VMT15	410	veh-mi			
Peak-hour vehicle-miles of travel, VMT60	1475	veh-mi			
Peak 15-min total travel time, TT15	8.2	veh-h			
Peak 15-min vehicle-miles of travel, VMT15 Peak-hour vehicle-miles of travel, VMT60	410 1475	veh-mi			

- 1. If $vp \ge 3200 \text{ pc/h}$, terminate analysis-the LOS is F. 2. If highest directional split $vp \ge 1700 \text{ pc/h}$, terminate analysis-the LOS is F.

HCS+: Two-Lane Highways Release 5.4

Two-Way Two-Lane Highwa	y Segment Analysis	
Analyst RSO Agency/Co. Traffic Management Date Performed 3/11/2011 Analysis Time Period PM Peak Hour Highway Mamalahoa Highway From/To Hookena Beach Rd 1 Jurisdiction State of Hawaii Analysis Year 2024 Without Proje Description Kahuku Villages	01.01MP	
Input D	oata	
Lane width 12.0 ft % Truc Segment length 5.0 mi % Recr Terrain type Level % No-p	cour factor, PHF 0.92 eks and buses 11 % reational vehicles 0 % reassing zones 50 % repoints/mi 10 /mi	
Directional split 70 / 30 %		
Average Travel	Speed	
Grade adjustment factor, fG PCE for trucks, ET PCE for RVs, ER Heavy-vehicle adjustment factor, Two-way flow rate, (note-1) vp Highest directional split proportion (note	1.00 1.2 1.0 0.978 733 pc/h :-2) 513 pc/h	
Free-Flow Speed from Field Measurement: Field measured speed, SFM Observed volume, Vf Estimated Free-Flow Speed: Base free-flow speed, BFFS Adj. for lane and shoulder width, fLS Adj. for access points, fA	- mi/h - veh/h 55.0 mi/h 2.6 mi/h 2.5 mi/h	
Free-flow speed, FFS	49.9 mi/h	
Adjustment for no-passing zones, fnp Average travel speed, ATS	2.3 mi/h 41.9 mi/h	

pc/h
-
용
90
veh-mi
veh-mi
veh-h

- 1. If $vp \ge 3200 \text{ pc/h}$, terminate analysis-the LOS is F. 2. If highest directional split $vp \ge 1700 \text{ pc/h}$, terminate analysis-the LOS is F.

HCS+: Two-Lane Highways Release 5.4

Two	-Way Two-Lan	e Highway Se	egment A	nalysis		
Analyst Agency/Co. Date Performed Analysis Time Period Highway From/To Jurisdiction Analysis Year Description Kahuku Vi	3/11/2011 PM Peak Horman Mamalahoa Exapalapala State of Horman Managaran State of Horman Managaran Managar	Highway Ranch Rd 46 awaii				
		Input Data				
Lane width 1 Segment length 5	.0 ft 2.0 ft .0 mi evel mi %		and buse onal ve ng zone	s hicles	0.94 3 0 10 5	% % % /mi
	Average	e Travel Spe	eed			
Grade adjustment facto PCE for trucks, ET PCE for RVs, ER Heavy-vehicle adjustment Two-way flow rate, (note Highest directional sp	nt factor, e-1) vp	on (note-2)	1.00 1.7 1.0 0.979 294 156	pc/h pc/h		
Free-Flow Speed from F Field measured speed, Observed volume, Vf Estimated Free-Flow Sp Base free-flow speed, Adj. for lane and shou Adj. for access points	SFM eed: BFFS lder width,		- - 55.0 2.6 1.3	mi/h veh/h mi/h mi/h mi/h		
Free-flow speed, FFS			51.2	mi/h		
Adjustment for no-pass Average travel speed,		np	0.6 48.3	mi/h mi/h		

Grade adjustment factor, fG	1.00	
PCE for trucks, ET	1.1	
PCE for RVs, ER	1.0	
Heavy-vehicle adjustment factor, fHV	0.997	
Two-way flow rate, (note-1) vp	289	pc/h
Highest directional split proportion (note-2)	153	-
Base percent time-spent-following, BPTSF	22.4	용
Adj.for directional distribution and no-passing zones, fd/np	5.8	
	28.3	8
Level of Service and Other Performance Measur	es	
Level of service, LOS	С	
Volume to capacity ratio, v/c	0.09	
Peak 15-min vehicle-miles of travel, VMT15	360	veh-mi
Peak-hour vehicle-miles of travel, VMT60	1355	veh-mi
Peak 15-min total travel time, TT15	7.5	veh-h

- 1. If $vp \ge 3200 \text{ pc/h}$, terminate analysis-the LOS is F. 2. If highest directional split $vp \ge 1700 \text{ pc/h}$, terminate analysis-the LOS is F.

TRAFFIC IMPACT ANALYSIS REPORT FOR THE PROPOSED KAHUKU VILLAGE KA`U, HAWAII

TAX MAP KEY: (3) 9-2-001:072

APPENDIX F

CAPACITY ANALYSIS WORKSHEETS
2030 PEAK HOUR TRAFFIC WITHOUT PROJECT

HCS+: Two-Lane Highways Release 5.4

Two-Way Two-Lane Highway S	egment A	nalysis		
Analyst RSO Agency/Co. Traffic Management Co Date Performed 3/11/2011 Analysis Time Period AM Peak Hour Highway Mamalahoa Highway From/To Kahuku Ranch Rd to Or Jurisdiction State of Hawaii Analysis Year 2030 Without Project Description Kahuku Villages		У		
Input Data				
Highway class Class 1 Shoulder width 8.0 ft Peak-hour Lane width 12.0 ft % Trucks Segment length 5.0 mi % Recreat Terrain type Level % No-pass Grade: Length mi Access po Up/down %	and buse ional ve ing zone	s hicles	0.85 10 0 10 7	% % % /mi
Two-way hourly volume, V 256 veh/h Directional split 56 / 44 %				
Average Travel Sp	eed			
Grade adjustment factor, fG PCE for trucks, ET PCE for RVs, ER Heavy-vehicle adjustment factor, Two-way flow rate, (note-1) vp Highest directional split proportion (note-2)	1.00 1.7 1.0 0.935 322 180	pc/h pc/h		
Free-Flow Speed from Field Measurement: Field measured speed, SFM Observed volume, Vf Estimated Free-Flow Speed: Base free-flow speed, BFFS Adj. for lane and shoulder width, fLS Adj. for access points, fA	- - 55.0 0.0 1.8	mi/h veh/h mi/h mi/h mi/h		
Free-flow speed, FFS	53.3	mi/h		
Adjustment for no-passing zones, fnp Average travel speed, ATS	0.6 50.1	mi/h mi/h		

Percent Time-Spent-Following		
Grade adjustment factor, fG	1.00	
PCE for trucks, ET	1.1	
PCE for RVs, ER	1.0	
Heavy-vehicle adjustment factor, fHV	0.990	
Two-way flow rate, (note-1) vp	304	pc/h
Highest directional split proportion (note-2)	170	-
Base percent time-spent-following, BPTSF	23.4	용
Adj.for directional distribution and no-passing zones, fd/np	6.1	
Percent time-spent-following, PTSF	29.5	%
Level of Service and Other Performance Measu:	res	
Level of service, LOS	В	
Volume to capacity ratio, v/c	0.10	
Peak 15-min vehicle-miles of travel, VMT15	376	veh-mi
Peak-hour vehicle-miles of travel, VMT60	1280	veh-mi
Peak 15-min total travel time, TT15	7.5	veh-h

- If vp >= 3200 pc/h, terminate analysis-the LOS is F.
 If highest directional split vp >= 1700 pc/h, terminate analysis-the LOS is F.

HCS+: Two-Lane Highways Release 5.4

Two-	-Way Two-Lane Highway S	egment A	nalysis		
Analyst Agency/Co. Date Performed Analysis Time Period Highway From/To Jurisdiction Analysis Year Description Kahuku Vil	Mamalahoa Highway Hookena Beach Rd 101. State of Hawaii 2030 Without Project				
	Input Data				
Highway class Class 1 Shoulder width 3. Lane width 12 Segment length 5. Terrain type Le Grade: Length Up/down	2.0 ft % Trucks	and buse: ional vel ing zone:	s hicles	0.86 11 0 50	% % % /mi
Two-way hourly volume, Directional split		eed			
Grade adjustment factor PCE for trucks, ET PCE for RVs, ER Heavy-vehicle adjustmen Two-way flow rate, (note Highest directional spl	at factor,	1.00 1.2 1.0 0.978 839	pc/h		
Free-Flow Speed from Fi Field measured speed, S Observed volume, Vf Estimated Free-Flow Spe Base free-flow speed, E Adj. for lane and shoul Adj. for access points,	eed: BFFS .der width, fLS	- - 55.0 2.6 2.5	mi/h veh/h mi/h mi/h mi/h		
Free-flow speed, FFS		49.9	mi/h		
Adjustment for no-passi Average travel speed, A	= =	2.1 41.3	mi/h mi/h		

Percent Time-Spent-Following		
Grade adjustment factor, fG	1.00	
PCE for trucks, ET	1.1	
PCE for RVs, ER	1.0	
Heavy-vehicle adjustment factor, fHV	0.989	
Two-way flow rate, (note-1) vp	830	pc/h
Highest directional split proportion (note-2)	639	
Base percent time-spent-following, BPTSF	51.8	%
Adj.for directional distribution and no-passing zones, fd/np	13.3	
Percent time-spent-following, PTSF	65.1	%
Level of Service and Other Performance Measu	res	
Level of service, LOS	D	
Volume to capacity ratio, v/c	0.26	
Peak 15-min vehicle-miles of travel, VMT15	1026	veh-mi
Peak-hour vehicle-miles of travel, VMT60	3530	veh-mi
Peak 15-min total travel time, TT15	24.8	veh-h

- 1. If $vp \ge 3200 \text{ pc/h}$, terminate analysis-the LOS is F.
- 2. If highest directional split vp >= 1700 pc/h, terminate analysis-the LOS is F.

HCS+: Two-Lane Highways Release 5.4

Two-	-Way Two-Lane	e Highway Se	egment A	nalysis		
Analyst Agency/Co. Date Performed Analysis Time Period Highway From/To Jurisdiction Analysis Year Description Kahuku Vil	3/11/2011 AM Peak Hou Mamalahoa H Kapalapala State of Ha 2030 Withou	Highway Ranch Rd 46 awaii				
		Input Data				
Lane width 12 Segment length 5.	0 mi evel mi %		and buse onal vel ng zone	s hicles	0.83 13 0 10 5	% % % /mi
Directional Spire	36 / 42	5				
	Average	e Travel Spe	eed			
Grade adjustment factor PCE for trucks, ET PCE for RVs, ER Heavy-vehicle adjustmen Two-way flow rate, (note Highest directional spl	nt factor, e-1) vp	on (note-2)	1.00 1.7 1.0 0.917 327 190	pc/h pc/h		
Free-Flow Speed from Fi Field measured speed, S Observed volume, Vf Estimated Free-Flow Spe Base free-flow speed, E Adj. for lane and shoul Adj. for access points,	eed: BFFS Lder width, 1		- - 55.0 2.6 1.3	mi/h veh/h mi/h mi/h mi/h		
Free-flow speed, FFS			51.2	mi/h		
Adjustment for no-passi Average travel speed, A		np	0.6 48.0	mi/h mi/h		

Percent Time-Spent-Following		
Grade adjustment factor, fG	1.00	
PCE for trucks, ET	1.1	
PCE for RVs, ER	1.0	
Heavy-vehicle adjustment factor, fHV	0.987	
Two-way flow rate, (note-1) vp	304	pc/h
Highest directional split proportion (note-2)	176	
Base percent time-spent-following, BPTSF	23.4	9
Adj.for directional distribution and no-passing zones, fd/np	6.2	
Percent time-spent-following, PTSF	29.7	ે
Level of Service and Other Performance Measur	res	
Level of service, LOS	С	
Volume to capacity ratio, v/c	0.10	
Peak 15-min vehicle-miles of travel, VMT15	375	veh-mi
Peak-hour vehicle-miles of travel, VMT60	1245	veh-mi
Peak 15-min total travel time, TT15	7.8	veh-h

- 1. If $vp \ge 3200 \text{ pc/h}$, terminate analysis-the LOS is F. 2. If highest directional split $vp \ge 1700 \text{ pc/h}$, terminate analysis-the LOS is F.

HCS+: Two-Lane Highways Release 5.4

Two-Way '	Two-Lar	ne Highway Se	egment A	nalysis		
Date Performed 3/1 Analysis Time Period PM : Highway Mam From/To Kah Jurisdiction Sta	1/2011 Peak Ho alahoa uku Rar te of H	Highway ach Rd to Orc Hawaii out Project	chid Pkw	У		
		Input Data_				
Highway class Class 1 Shoulder width 8.0 Lane width 12.0 Segment length 5.0 Terrain type Level Grade: Length Up/down Two-way hourly volume, V Directional split 55	mi %		and buse onal vel ng zone	s hicles	0.90 11 0 10 7	% % /mi
	_Averaç	ge Travel Spe	eed			
Grade adjustment factor, fG PCE for trucks, ET PCE for RVs, ER Heavy-vehicle adjustment factor Two-way flow rate, (note-1) Highest directional split p	ctor, vp	on (note-2)	1.00 1.7 1.0 0.929 387 213	pc/h pc/h		
Free-Flow Speed from Field I Field measured speed, SFM Observed volume, Vf Estimated Free-Flow Speed: Base free-flow speed, BFFS Adj. for lane and shoulder Adj. for access points, fA			- - 55.0 0.0 1.8	mi/h veh/h mi/h mi/h mi/h		
Free-flow speed, FFS			53.3	mi/h		
Adjustment for no-passing zo Average travel speed, ATS	ones, f	īnp	0.8	mi/h mi/h		

Percent Time-Spent-Following		
Grade adjustment factor, fG	1.00	
PCE for trucks, ET	1.1	
PCE for RVs, ER	1.0	
Heavy-vehicle adjustment factor, fHV	0.989	
Two-way flow rate, (note-1) vp	363	pc/h
Highest directional split proportion (note-2)	200	
Base percent time-spent-following, BPTSF	27.3	90
Adj.for directional distribution and no-passing zones, fd/np	6.1	
Percent time-spent-following, PTSF	33.4	%
Level of Service and Other Performance Measur	ces	
Level of service, LOS	С	
Volume to capacity ratio, v/c	0.12	
Peak 15-min vehicle-miles of travel, VMT15	449	veh-mi
Peak-hour vehicle-miles of travel, VMT60	1615	veh-mi
Peak 15-min total travel time, TT15	9.1	veh-h

- 1. If $vp \ge 3200 \text{ pc/h}$, terminate analysis-the LOS is F. 2. If highest directional split $vp \ge 1700 \text{ pc/h}$, terminate analysis-the LOS is F.

HCS+: Two-Lane Highways Release 5.4

Two-	-Way Two-Lan	e Highway Se	gment A	nalysis		
Analyst Agency/Co. Date Performed Analysis Time Period Highway From/To Jurisdiction Analysis Year Description Kahuku Vil	3/11/2011 PM Peak Ho Mamalahoa Hookena Be State of H 2030 Witho	Highway ach Rd 101.0 awaii				
		Input Data				
Highway class Class 1 Shoulder width 3. Lane width 12 Segment length 5. Terrain type Le Grade: Length Up/down Two-way hourly volume, Directional split	0 mi evel mi %	<pre>% Recreati % No-passi Access poi veh/h</pre>	onal vel ng zone:	nicles	0.92 11 0 50 10	% % /mi
	Averag	e Travel Spe	ed			
Grade adjustment factor PCE for trucks, ET PCE for RVs, ER Heavy-vehicle adjustmen Two-way flow rate, (note Highest directional spl	f, fG at factor, e-1) vp		1.00 1.2 1.0 0.978 814	pc/h pc/h		
Free-Flow Speed from Fi Field measured speed, S		ment:	- -	mi/h veh/h		
Estimated Free-Flow Spe Base free-flow speed, B Adj. for lane and shoul	BFFS der width,	fLS	55.0 2.6 2.5	mi/h mi/h mi/h		
Observed volume, Vf Estimated Free-Flow Spe Base free-flow speed, B Adj. for lane and shoul Adj. for access points, Free-flow speed, FFS	BFFS der width,	fLS	2.6	mi/h		

Percent Time-Spent-Following		
Grade adjustment factor, fG	1.00	
PCE for trucks, ET	1.1	
PCE for RVs, ER	1.0	
Heavy-vehicle adjustment factor, fHV	0.989	
Two-way flow rate, (note-1) vp	806	pc/h
Highest directional split proportion (note-2)	564	
Base percent time-spent-following, BPTSF	50.8	%
Adj.for directional distribution and no-passing zones, fd/np	11.8	
Percent time-spent-following, PTSF	62.6	90
Level of Service and Other Performance Measu:	res	
Level of service, LOS	D	
Volume to capacity ratio, v/c	0.25	
Peak 15-min vehicle-miles of travel, VMT15	996	veh-mi
Peak-hour vehicle-miles of travel, VMT60	3665	veh-mi
Peak 15-min total travel time, TT15	24.0	veh-h

- 1. If $vp \ge 3200 \text{ pc/h}$, terminate analysis-the LOS is F.
- 2. If highest directional split vp >= 1700 pc/h, terminate analysis-the LOS is F.

HCS+: Two-Lane Highways Release 5.4

Two-Way Two-Lane Highway Se	egment A	nalysis		
Analyst RSO Agency/Co. Traffic Management Co. Date Performed 3/11/2011 Analysis Time Period PM Peak Hour Highway Mamalahoa Highway From/To Kapalapala Ranch Rd 4 Jurisdiction State of Hawaii Analysis Year 2030 Without Project Description Kahuku Villages				
Input Data				
Highway class Class 1 Shoulder width 3.0 ft Peak-hour Lane width 12.0 ft % Trucks of the segment length 5.0 mi % Recreat Terrain type Level % No-pass Grade: Length mi Access por Up/down % Two-way hourly volume, V 293 veh/h	and buse ional ve ing zone	s hicles	0.94 3 0 10 5	% % % /mi
Directional split 53 / 47 %				
Average Travel Sp	eed			
Grade adjustment factor, fG PCE for trucks, ET PCE for RVs, ER Heavy-vehicle adjustment factor, Two-way flow rate, (note-1) vp Highest directional split proportion (note-2)	1.00 1.7 1.0 0.979 318 169	pc/h pc/h		
Free-Flow Speed from Field Measurement: Field measured speed, SFM Observed volume, Vf Estimated Free-Flow Speed: Base free-flow speed, BFFS Adj. for lane and shoulder width, fLS Adj. for access points, fA	- - 55.0 2.6 1.3	mi/h veh/h mi/h mi/h mi/h		
Free-flow speed, FFS	51.2	mi/h		
Adjustment for no-passing zones, fnp Average travel speed, ATS	0.6 48.1	mi/h mi/h		

1.00	
1.1	
1.0	
0.997	
313	pc/h
166	
24.1	ે
5.9	
30.0	9
es	
C	
0.10	
390	veh-mi
1465	veh-mi
8.1	veh-h
1 1 1 2 5 3 1 2 3 1	.0 0.997 313 .66 24.1 5.9 30.0 es

- 1. If $vp \ge 3200 \text{ pc/h}$, terminate analysis-the LOS is F. 2. If highest directional split $vp \ge 1700 \text{ pc/h}$, terminate analysis-the LOS is F.

TRAFFIC IMPACT ANALYSIS REPORT FOR THE PROPOSED KAHUKU VILLAGE KA`U, HAWAII

TAX MAP KEY: (3) 9-2-001:072

APPENDIX G

CAPACITY ANALYSIS WORKSHEETS
2015 PEAK HOUR TRAFFIC WITH PROJECT

	-	•	•	-	1	1			
Movement	EBT	EBR	WBL	WBT	NBL	NBR			
Lane Configurations	ĵ.			4	¥				
Volume (veh/h)	112	8	7	89	15	20			
Sign Control	Free			Free	Stop				
Grade	0%			0%	0%				
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92			
Hourly flow rate (vph)	122	9	8	97	16	22			
Pedestrians									
Lane Width (ft)									
Walking Speed (ft/s)									
Percent Blockage									
Right turn flare (veh)									
<i>y</i> 1	None			None					
Median storage veh)									
Upstream signal (ft)									
pX, platoon unblocked			400		000	400			
vC, conflicting volume			130		238	126			
vC1, stage 1 conf vol									
vC2, stage 2 conf vol			400		000	400			
vCu, unblocked vol			130 4.1		238	126			
tC, single (s)			4.1		6.4	6.2			
tC, 2 stage (s) tF (s)			2.2		3.5	3.3			
p0 queue free %			99		98	98			
cM capacity (veh/h)			1455		746	924			
. , ,					740	924			
Direction, Lane #	EB 1	WB 1	NB 1						
Volume Total	130	104	38						
Volume Left	0	8	16						
Volume Right	9	0	22						
cSH	1700	1455	839						
Volume to Capacity	0.08	0.01	0.05						
Queue Length 95th (ft	•	0	4						
Control Delay (s)	0.0	0.6	9.5						
Lane LOS	0.0	A	A						
Approach Delay (s)	0.0	0.6	9.5						
Approach LOS			Α						
Intersection Summary	,								
Average Delay			1.5						
Intersection Capacity	Utiliza	tion 2	20.5%	[0	CU Lev	el of Ser	vice	Α	
Analysis Period (min)			15						

HCS+: Two-Lane Highways Release 5.4

Two-Way Two-Lane Hig	hway Segment Analysis
Analyst RSO Agency/Co. Traffic Managem Date Performed 3/11/2011 Analysis Time Period AM Peak Hour Highway Mamalahoa Highw From/To Kahuku Ranch Rd Jurisdiction State of Hawaii Analysis Year 2015 With Proje Description Kahuku Villages	ay to Orchid Pkwy
Inpu	t Data
Lane width 12.0 ft % T Segment length 5.0 mi % R Terrain type Level % N Grade: Length mi Acc Up/down %	k-hour factor, PHF 0.85 rucks and buses 9 % ecreational vehicles 0 % o-passing zones 10 % ess points/mi 7 /mi
Two-way hourly volume, V 228 veh Directional split 58 / 42 %	
Average Tra	vel Speed
Grade adjustment factor, fG PCE for trucks, ET PCE for RVs, ER Heavy-vehicle adjustment factor, Two-way flow rate, (note-1) vp Highest directional split proportion (n	1.00 1.7 1.0 0.941 285 pc/h ote-2) 165 pc/h
Free-Flow Speed from Field Measurement: Field measured speed, SFM Observed volume, Vf Estimated Free-Flow Speed: Base free-flow speed, BFFS Adj. for lane and shoulder width, fLS Adj. for access points, fA	- mi/h - veh/h 55.0 mi/h 0.0 mi/h 1.8 mi/h
Free-flow speed, FFS	53.3 mi/h
Adjustment for no-passing zones, fnp Average travel speed, ATS	0.5 mi/h 50.5 mi/h

Percent Time-Spent-Following		
Grade adjustment factor, fG	1.00	
PCE for trucks, ET	1.1	
PCE for RVs, ER	1.0	
Heavy-vehicle adjustment factor, fHV	0.991	
Two-way flow rate, (note-1) vp	271	pc/h
Highest directional split proportion (note-2)	157	
Base percent time-spent-following, BPTSF	21.2	%
Adj.for directional distribution and no-passing zones, fd/np	6.3	
Percent time-spent-following, PTSF	27.5	엉
Level of Service and Other Performance Measu	res	
Level of service, LOS	В	
Volume to capacity ratio, v/c	0.09	
Peak 15-min vehicle-miles of travel, VMT15	335	veh-mi
Peak-hour vehicle-miles of travel, VMT60	1140	veh-mi
Peak 15-min total travel time, TT15	6.6	veh-h

- 1. If $vp \ge 3200 \text{ pc/h}$, terminate analysis-the LOS is F. 2. If highest directional split $vp \ge 1700 \text{ pc/h}$, terminate analysis-the LOS is F.

HCS+: Two-Lane Highways Release 5.4

Two-Way Two-Lane Highwa	ay Segment Analysis
Analyst RSO Agency/Co. Traffic Management Date Performed 3/11/2011 Analysis Time Period AM Peak Hour Highway Mamalahoa Highway From/To Hookena Beach Rd 1 Jurisdiction State of Hawaii Analysis Year 2015 With Project Description Kahuku Villages	
Input I	Data
Lane width 12.0 ft % Truck Segment length 5.0 mi % Recr Terrain type Level % No-p Grade: Length mi Access Up/down %	hour factor, PHF 0.86 cks and buses 7 % reational vehicles 0 % passing zones 50 % s points/mi 10 /mi
Two-way hourly volume, V 553 veh/h Directional split 76 / 24 % Average Travel	l Speed
Grade adjustment factor, fG PCE for trucks, ET PCE for RVs, ER Heavy-vehicle adjustment factor, Two-way flow rate, (note-1) vp Highest directional split proportion (note	1.00 1.2 1.0 0.986 652 pc/h
Free-Flow Speed from Field Measurement: Field measured speed, SFM Observed volume, Vf Estimated Free-Flow Speed: Base free-flow speed, BFFS Adj. for lane and shoulder width, fLS Adj. for access points, fA	- mi/h - veh/h 55.0 mi/h 2.6 mi/h 2.5 mi/h
Free-flow speed, FFS	49.9 mi/h
Adjustment for no-passing zones, fnp Average travel speed, ATS	2.6 mi/h 42.3 mi/h

pc/h
-
용
90
veh-mi
veh-mi
veh-h

- 1. If $vp \ge 3200 \text{ pc/h}$, terminate analysis-the LOS is F.
- 2. If highest directional split vp >= 1700 pc/h, terminate analysis-the LOS is F.

HCS+: Two-Lane Highways Release 5.4

Two-Way Two-Lane Highway Se	egment A	nalysis		
Analyst RSO Agency/Co. Traffic Management Con Date Performed 3/11/2011 Analysis Time Period AM Peak Hour Highway Mamalahoa Highway From/To Kapalapala Ranch Rd 40 Jurisdiction State of Hawaii Analysis Year 2015 With Project Description Kahuku Villages				
Input Data				
Highway class Class 1 Shoulder width 3.0 ft Peak-hour Lane width 12.0 ft % Trucks of Segment length 5.0 mi % Recreated % No-pass: Grade: Length mi Access positive with the segment point of the segment of the segment length length of the segment length of the segment length of the segme	and buse ional vei ing zone	s hicles	0.83 12 0 10 5	% % % /mi
Directional split 60 / 40 %	and			
Average Travel Spe	eea			
Grade adjustment factor, fG PCE for trucks, ET PCE for RVs, ER Heavy-vehicle adjustment factor, Two-way flow rate, (note-1) vp Highest directional split proportion (note-2)	1.00 1.7 1.0 0.923 299 179	pc/h pc/h		
Free-Flow Speed from Field Measurement: Field measured speed, SFM Observed volume, Vf Estimated Free-Flow Speed: Base free-flow speed, BFFS Adj. for lane and shoulder width, fLS Adj. for access points, fA	- - 55.0 2.6 1.3	mi/h veh/h mi/h mi/h mi/h		
Free-flow speed, FFS	51.2	mi/h		
Adjustment for no-passing zones, fnp Average travel speed, ATS	0.6 48.3	mi/h mi/h		

Percent Time-Spent-Following						
Grade adjustment factor, fG	1.00					
PCE for trucks, ET	1.1					
PCE for RVs, ER	1.0					
Heavy-vehicle adjustment factor, fHV	0.988					
Two-way flow rate, (note-1) vp	279	pc/h				
Highest directional split proportion (note-2)	167					
Base percent time-spent-following, BPTSF	21.7	90				
Adj.for directional distribution and no-passing zones, fd/np	6.5					
Percent time-spent-following, PTSF	28.2	90				
Level of Service and Other Performance Measur	ces					
Level of service, LOS	С					
Volume to capacity ratio, v/c	0.09					
Peak 15-min vehicle-miles of travel, VMT15	345	veh-mi				
Peak-hour vehicle-miles of travel, VMT60	1145	veh-mi				
Peak 15-min total travel time, TT15	7.1	veh-h				

- 1. If $vp \ge 3200 \text{ pc/h}$, terminate analysis-the LOS is F. 2. If highest directional split $vp \ge 1700 \text{ pc/h}$, terminate analysis-the LOS is F.

	-	•	•	←		-			
Movement	EBT	EBR	WBL	WBT	NBL	NBR			
Lane Configurations	ĵ.			4	¥				
Volume (veh/h)	116	14	17	139	13	11			
Sign Control	Free			Free	Stop				
Grade	0%			0%	0%				
Peak Hour Factor	0.88	0.92	0.92	0.80	0.92	0.92			
Hourly flow rate (vph)	132	15	18	174	14	12			
Pedestrians									
Lane Width (ft)									
Walking Speed (ft/s)									
Percent Blockage									
Right turn flare (veh)									
Median type	None			None					
Median storage veh)									
Upstream signal (ft)									
pX, platoon unblocked	l								
vC, conflicting volume			147		350	139			
vC1, stage 1 conf vol									
vC2, stage 2 conf vol									
vCu, unblocked vol			147		350	139			
tC, single (s)			4.1		6.4	6.2			
tC, 2 stage (s)									
tF (s)			2.2		3.5	3.3			
p0 queue free %			99		98	99			
cM capacity (veh/h)			1435		639	909			
Direction, Lane #	EB 1	WB 1	NB 1						
Volume Total	147	192	26						
Volume Left	0	18	14						
Volume Right	15	0	12						
cSH	1700	1435	739						
Volume to Capacity	0.09	0.01	0.04						
Queue Length 95th (ft	,	1	3						
Control Delay (s)	0.0	8.0	10.0						
Lane LOS		Α	В						
Approach Delay (s)	0.0	8.0	10.0						
Approach LOS			В						
Intersection Summary									
Average Delay			1.2						
Intersection Capacity	Utiliza	tion 2	28.5%	[0	CU Lev	el of Se	rvice	Α	
Analysis Period (min)			15						

HCS+: Two-Lane Highways Release 5.4

Two-	-Way Two-Lane	Highway Se	gment A	nalysis		
Analyst Agency/Co. Date Performed Analysis Time Period Highway From/To Jurisdiction Analysis Year Description Kahuku Vil	Mamalahoa Hi Kahuku Ranch State of Haw 2015 With Pr	ghway Rd to Orc aii		У		
	I	nput Data_				
Lane width 12 Segment length 55 Terrain type Le Grade: Length Up/down	2.0 ft .0 mi evel mi %	Peak-hour % Trucks a % Recreati % No-passi Access poi	nd buse onal vel	s hicles	0.90 10 0 10 7	% % % /mi
Two-way hourly volume, Directional split	55 / 45	00	o d			
	Average	Travel Spe	ea			
Grade adjustment factor PCE for trucks, ET PCE for RVs, ER Heavy-vehicle adjustmen Two-way flow rate, (note Highest directional spi	nt factor, e-1) vp	(note-2)	1.00 1.7 1.0 0.935 336 185			
Free-Flow Speed from Frield measured speed, Sobserved volume, Vf Estimated Free-Flow Speed, Fadj. for lane and should Adj. for access points,	- - 55.0 0.0 1.8	mi/h veh/h mi/h mi/h mi/h				
Free-flow speed, FFS			53.3	mi/h		
Adjustment for no-pass: Average travel speed, A			0.7 50.0	mi/h mi/h		

Percent Time-Spent-Following						
Grade adjustment factor, fG	1.00					
PCE for trucks, ET	1.1					
PCE for RVs, ER	1.0					
Heavy-vehicle adjustment factor, fHV	0.990					
Two-way flow rate, (note-1) vp	318	pc/h				
Highest directional split proportion (note-2)	175	-				
Base percent time-spent-following, BPTSF	24.4	용				
Adj.for directional distribution and no-passing zones, fd/np	6.0					
Percent time-spent-following, PTSF	30.4	96				
Level of Service and Other Performance Measur	res					
Level of service, LOS	С					
Volume to capacity ratio, v/c	0.10					
Peak 15-min vehicle-miles of travel, VMT15	393	veh-mi				
Peak-hour vehicle-miles of travel, VMT60	1415	veh-mi				
Peak 15-min total travel time, TT15	7.9	veh-h				

- 1. If $vp \ge 3200 \text{ pc/h}$, terminate analysis-the LOS is F. 2. If highest directional split $vp \ge 1700 \text{ pc/h}$, terminate analysis-the LOS is F.

HCS+: Two-Lane Highways Release 5.4

Tw	o-Way Two-Lane	e Highway Se	egment A	nalysis		
Analyst Agency/Co. Date Performed Analysis Time Period Highway From/To Jurisdiction Analysis Year Description Kahuku V	3/11/2011 PM Peak Hou Mamalahoa F Hookena Bea State of Ha 2015 With F	Highway ach Rd 101.0 awaii				
		Input Data				
Lane width Segment length	3.0 ft 12.0 ft 5.0 mi Level mi %		and buse onal ve ng zone	s hicles	0.92 10 0 50 10	% % /mi
		e Travel Spe	and			
Grade adjustment fact PCE for trucks, ET PCE for RVs, ER Heavy-vehicle adjustm Two-way flow rate, (no Highest directional s	or, fG ent factor, te-1) vp		1.00 1.2 1.0 0.980 640	pc/h pc/h		
Free-Flow Speed from Field measured speed, Observed volume, Vf Estimated Free-Flow S Base free-flow speed, Adj. for lane and sho Adj. for access point	SFM peed: BFFS ulder width, f		- - 55.0 2.6 2.5	mi/h veh/h mi/h mi/h mi/h		
Free-flow speed, FFS			49.9	mi/h		
Adjustment for no-pas Average travel speed,	2.6 42.3	mi/h mi/h				

Percent Time-Spent-Following		
Grade adjustment factor, fG	1.00	
PCE for trucks, ET	1.1	
PCE for RVs, ER	1.0	
Heavy-vehicle adjustment factor, fHV	0.990	
Two-way flow rate, (note-1) vp	633	pc/h
Highest directional split proportion (note-2)	437	
Base percent time-spent-following, BPTSF	42.7	%
Adj.for directional distribution and no-passing zones, fd/np	16.3	
Percent time-spent-following, PTSF	59.0	%
Level of Service and Other Performance Measur	res	
Level of service, LOS	D	
Volume to capacity ratio, v/c	0.20	
Peak 15-min vehicle-miles of travel, VMT15	784	veh-mi
Peak-hour vehicle-miles of travel, VMT60	2885	veh-mi
Peak 15-min total travel time, TT15	18.5	veh-h

- 1. If $vp \ge 3200 \text{ pc/h}$, terminate analysis-the LOS is F.
- 2. If highest directional split vp >= 1700 pc/h, terminate analysis-the LOS is F.

HCS+: Two-Lane Highways Release 5.4

Two-	-Way Two-Lane	Highway Se	egment A	nalysis		
Analyst Agency/Co. Date Performed Analysis Time Period Highway From/To Jurisdiction Analysis Year Description Kahuku Vil	3/11/2011 PM Peak Hou Mamalahoa H Kapalapala State of Ha 2015 With F	lighway Ranch Rd 46 waii				
		Input Data				
Lane width 12 Segment length 5. Terrain type Le Grade: Length Up/down Two-way hourly volume,			and buses onal vel ng zones	s nicles	0.94 3 0 10 5	% % % /mi
Directional split	54 / 46	%				
	Average	Travel Spe	eed			
Grade adjustment factor PCE for trucks, ET PCE for RVs, ER Heavy-vehicle adjustmen Two-way flow rate, (note Highest directional spl	nt factor, e-1) vp	on (note-2)	1.00 1.7 1.0 0.979 289 156	pc/h pc/h		
Free-Flow Speed from Frield measured speed, Sobserved volume, Vf Estimated Free-Flow Speed, Base free-flow speed, Adj. for lane and should Adj. for access points,	SFM eed: 3FFS lder width, f		- - 55.0 2.6 1.3	mi/h veh/h mi/h mi/h mi/h		
Free-flow speed, FFS			51.2	mi/h		
Adjustment for no-passi Average travel speed, A	0.5 48.4	mi/h mi/h				

Percent Time-Spent-Following		
Grade adjustment factor, fG	1.00	
PCE for trucks, ET	1.1	
PCE for RVs, ER	1.0	
Heavy-vehicle adjustment factor, fHV	0.997	
Two-way flow rate, (note-1) vp	284	pc/h
Highest directional split proportion (note-2)	153	
Base percent time-spent-following, BPTSF	22.1	9
Adj.for directional distribution and no-passing zones, fd/np	5.9	
Percent time-spent-following, PTSF	28.0	ે
Level of Service and Other Performance Measur	ces	
Level of service, LOS	С	
Volume to capacity ratio, v/c	0.09	
Peak 15-min vehicle-miles of travel, VMT15	354	veh-mi
Peak-hour vehicle-miles of travel, VMT60	1330	veh-mi
Peak 15-min total travel time, TT15	7.3	veh-h

- 1. If $vp \ge 3200 \text{ pc/h}$, terminate analysis-the LOS is F.
- 2. If highest directional split vp >= 1700 pc/h, terminate analysis-the LOS is F.

TRAFFIC IMPACT ANALYSIS REPORT FOR THE PROPOSED KAHUKU VILLAGE KA`U, HAWAII

TAX MAP KEY: (3) 9-2-001:072

APPENDIX H

CAPACITY ANALYSIS WORKSHEETS
2021 PEAK HOUR TRAFFIC WITH PROJECT

	→	•	•	+	1	1		
Movement	EBT	EBR	WBL	WBT	NBL	NBR		
Lane Configurations	4	7	*	1	*	7		
Volume (veh/h)	124	111	88	99	84	106		
Sign Control	Free			Free	Stop			
Grade	0%			0%	0%			
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92		
Hourly flow rate (vph)		121	96	108	91	115		
Pedestrians								
Lane Width (ft)								
Walking Speed (ft/s)								
Percent Blockage								
Right turn flare (veh)						16		
` ,	None			None				
Median storage veh)								
Upstream signal (ft)								
pX, platoon unblocked	d							
vC, conflicting volume			135		434	135		
vC1, stage 1 conf vol								
vC2, stage 2 conf vol								
vCu, unblocked vol			135		434	135		
tC, single (s)			4.1		6.4	6.2		
tC, 2 stage (s)								
tF (s)			2.2		3.5	3.3		
p0 queue free %			93		83	87		
cM capacity (veh/h)			1450		541	914		
Direction, Lane #	EB 1	EB 2	WB 1	WB 2	NB 1			
Volume Total	135	121	96	108	207			
Volume Left	0	0	96	0	91			
Volume Right	0	121	0	0	115			
cSH	1700	1700	1450	1700	1224			
Volume to Capacity	0.08	0.07	0.07	0.06	0.17			
Queue Length 95th (ft) 0	0	5	0	15			
Control Delay (s)	0.0	0.0	7.7	0.0	11.1			
Lane LOS			Α		В			
Approach Delay (s)	0.0		3.6		11.1			
Approach LOS					В			
Intersection Summary	'							
Average Delay			4.5					
Intersection Capacity	Utilizat	ion	26.1%	I	CU Lev	el of Ser	vice A	
Analysis Period (min)			15					
, ,								

HCS+: Two-Lane Highways Release 5.4

Two-Way Two-Lane Highway S	egment A	nalysis		
Analyst RSO Agency/Co. Traffic Management Co. Date Performed 7/11/2011 Analysis Time Period AM Peak Hour Highway Mamalahoa Highway From/To Kahuku Ranch Rd to Or Jurisdiction State of Hawaii Analysis Year 2021 With Project Description Kahuku Villages		У		
Input Data				
Highway class Class 1 Shoulder width 8.0 ft Peak-hour Lane width 12.0 ft % Trucks Segment length 5.0 mi % Recreat Terrain type Level % No-pass Grade: Length mi Access po Up/down % Two-way hourly volume, V 417 veh/h Directional split 55 / 45 %	and buse ional ve ing zone	s hicles	0.85 6 0 10 8	% % /mi
Average Travel Sp	eed			
Grade adjustment factor, fG PCE for trucks, ET PCE for RVs, ER Heavy-vehicle adjustment factor, Two-way flow rate, (note-1) vp Highest directional split proportion (note-2)	1.00 1.7 1.0 0.960 511	pc/h pc/h		
Free-Flow Speed from Field Measurement: Field measured speed, SFM Observed volume, Vf Estimated Free-Flow Speed: Base free-flow speed, BFFS Adj. for lane and shoulder width, fLS Adj. for access points, fA	- - 55.0 0.0 2.0	mi/h veh/h mi/h mi/h mi/h		
Free-flow speed, FFS	53.0	mi/h		
Adjustment for no-passing zones, fnp Average travel speed, ATS	0.8 48.2	mi/h mi/h		

Percent Time-Spent-Following		
Grade adjustment factor, fG	1.00	
PCE for trucks, ET	1.1	
PCE for RVs, ER	1.0	
Heavy-vehicle adjustment factor, fHV	0.994	
Two-way flow rate, (note-1) vp	494	pc/h
Highest directional split proportion (note-2)	272	-
Base percent time-spent-following, BPTSF	35.2	%
Adj.for directional distribution and no-passing zones, fd/np	5.9	
Percent time-spent-following, PTSF	41.2	90
Level of Service and Other Performance Measu:	res	
Level of service, LOS	С	
Volume to capacity ratio, v/c	0.16	
Peak 15-min vehicle-miles of travel, VMT15	613	veh-mi
Peak-hour vehicle-miles of travel, VMT60	2085	veh-mi
Peak 15-min total travel time, TT15	12.7	veh-h

- 1. If $vp \ge 3200 \text{ pc/h}$, terminate analysis-the LOS is F. 2. If highest directional split $vp \ge 1700 \text{ pc/h}$, terminate analysis-the LOS is F.

HCS+: Two-Lane Highways Release 5.4

Two-	-Way Two-Lane Highway S	egment A	nalysis		
Analyst Agency/Co. Date Performed Analysis Time Period Highway From/To Jurisdiction Analysis Year Description Kahuku Vil	Mamalahoa Highway Hookena Beach Rd 101. State of Hawaii 2021 With Project				
	Input Data				
Highway class Class 1 Shoulder width 3. Lane width 12 Segment length 5. Terrain type Le Grade: Length Up/down	2.0 ft % Trucks	and buse: ional vel ing zone:	s hicles	0.86 5 0 50	% % % /mi
Two-way hourly volume, Directional split		eed			
Grade adjustment factor PCE for trucks, ET PCE for RVs, ER Heavy-vehicle adjustmen Two-way flow rate, (note Highest directional spl	nt factor,	1.00 1.2 1.0 0.990 934	pc/h		
Free-Flow Speed from Fi Field measured speed, S Observed volume, Vf Estimated Free-Flow Spe Base free-flow speed, F Adj. for lane and shoul Adj. for access points,	eed: BFFS Lder width, fLS	- - 55.0 2.6 2.5	mi/h veh/h mi/h mi/h mi/h		
Free-flow speed, FFS		49.9	mi/h		
Adjustment for no-passi Average travel speed, A		1.9 40.7	mi/h mi/h		

Percent Time-Spent-Following		
Grade adjustment factor, fG	1.00	
PCE for trucks, ET	1.1	
PCE for RVs, ER	1.0	
Heavy-vehicle adjustment factor, fHV	0.995	
Two-way flow rate, (note-1) vp	929	pc/h
Highest directional split proportion (note-2)	641	-
Base percent time-spent-following, BPTSF	55.8	읭
Adj.for directional distribution and no-passing zones, fd/np	10.7	
Percent time-spent-following, PTSF	66.5	90
Level of Service and Other Performance Measur	res	
Level of service, LOS	D	
Volume to capacity ratio, v/c	0.29	
Peak 15-min vehicle-miles of travel, VMT15	1156	veh-mi
Peak-hour vehicle-miles of travel, VMT60	3975	veh-mi
Peak 15-min total travel time, TT15	28.4	veh-h

- 1. If $vp \ge 3200 \text{ pc/h}$, terminate analysis-the LOS is F.
- 2. If highest directional split vp >= 1700 pc/h, terminate analysis-the LOS is F.

HCS+: Two-Lane Highways Release 5.4

Two-Way Tw	o-Lane Highway S	egment A	nalysis		
Date Performed 7/11/ Analysis Time Period AM Pe Highway Mamal From/To Kapal Jurisdiction State	ic Management Co 2011 ak Hour ahoa Highway apala Ranch Rd 4 of Hawaii With Project				
	Input Data				
2	ft % Trucks mi % Recreat % No-pass mi Access po % 15 veh/h	and buse ional ve ing zone	s hicles	0.83 8 0 10 5	% % % /mi
A	verage Travel Sp	eed			
Grade adjustment factor, fG PCE for trucks, ET PCE for RVs, ER Heavy-vehicle adjustment fact Two-way flow rate, (note-1) vp Highest directional split pro	or,	1.00 1.7 1.0 0.947 528	pc/h pc/h		
Free-Flow Speed from Field Me Field measured speed, SFM Observed volume, Vf Estimated Free-Flow Speed: Base free-flow speed, BFFS Adj. for lane and shoulder wi Adj. for access points, fA		- - 55.0 2.6 1.3	mi/h veh/h mi/h mi/h mi/h		
Free-flow speed, FFS		51.2	mi/h		
Adjustment for no-passing zon Average travel speed, ATS	es, fnp	0.8 46.2	mi/h mi/h		

Percent Time-Spent-Following		
Grade adjustment factor, fG	1.00	
PCE for trucks, ET	1.1	
PCE for RVs, ER	1.0	
Heavy-vehicle adjustment factor, fHV	0.992	
Two-way flow rate, (note-1) vp	504	pc/h
Highest directional split proportion (note-2)	282	_
Base percent time-spent-following, BPTSF	35.8	ଚ
Adj.for directional distribution and no-passing zones, fd/np	5.9	
Percent time-spent-following, PTSF	41.7	왕
Level of Service and Other Performance Measur	res	
Level of service, LOS	С	
Volume to capacity ratio, v/c	0.17	
Peak 15-min vehicle-miles of travel, VMT15	625	veh-mi
Peak-hour vehicle-miles of travel, VMT60	2075	veh-mi
Peak 15-min total travel time, TT15	13.5	veh-h

- 1. If $vp \ge 3200 \text{ pc/h}$, terminate analysis-the LOS is F. 2. If highest directional split $vp \ge 1700 \text{ pc/h}$, terminate analysis-the LOS is F.

	\rightarrow	•	•	+	$ \blacksquare $	-	
Movement	EBT	EBR	WBL	WBT	NBL	NBR	
Lane Configurations	1	7	*		**	7	
Volume (veh/h)	102	156	189	122	178	148	
Sign Control	Free			Free	Stop		
Grade	0%			0%	0%		
Peak Hour Factor	0.88	0.92	0.92	0.80	0.92	0.92	
Hourly flow rate (vph)	116	170	205	152	193	161	
Pedestrians							
Lane Width (ft)							
Walking Speed (ft/s)							
Percent Blockage							
Right turn flare (veh)						16	
Median type	None			None			
Median storage veh)							
Upstream signal (ft)							
pX, platoon unblocked	d						
vC, conflicting volume	:		116		679	116	
vC1, stage 1 conf vol							
vC2, stage 2 conf vol							
vCu, unblocked vol			116		679	116	
tC, single (s)			4.1		6.4	6.2	
tC, 2 stage (s)							
tF (s)			2.2		3.5	3.3	
p0 queue free %			86		46	83	
cM capacity (veh/h)			1473		359	936	
Direction, Lane #	EB 1	EB 2	WB 1	WB 2	NB 1		
Volume Total	116	170	205	152	354		
Volume Left	0	0	205	0	193		
Volume Right	0	170	0	0	161		
cSH	1700	1700	1473	1700	657		
Volume to Capacity	0.07	0.10	0.14	0.09	0.54		
Queue Length 95th (ff		0	12	0	81		
Control Delay (s)	0.0	0.0	7.8	0.0	18.7		
Lane LOS			Α		С		
Approach Delay (s)	0.0		4.5		18.7		
Approach LOS					С		
Intersection Summary	1						
Average Delay			8.2				
Intersection Capacity	Utilizat	ion :	33.7%	10	CU Lev	el of Se	ervice A
Analysis Period (min)			15				

HCS+: Two-Lane Highways Release 5.4

Two-Way Two-Lane Highway S	Segment A	nalysis		
Analyst RSO Agency/Co. Traffic Management Co Date Performed 7/11/2011 Analysis Time Period PM Peak Hour Highway Mamalahoa Highway From/To Kahuku Ranch Rd to O: Jurisdiction State of Hawaii Analysis Year 2021 With Project Description Kahuku Villages				
Input Data	à			
Highway class Class 1 Shoulder width 8.0 ft Peak-hou: Lane width 12.0 ft % Trucks Segment length 5.0 mi % Recreat Terrain type Level % No-pass Grade: Length mi Access po	and buse cional ve sing zone	s hicles	0.90 6 0 10 7	% % /mi
Directional split 55 / 45 %				
Average Travel Sp	peed			
Grade adjustment factor, fG PCE for trucks, ET PCE for RVs, ER Heavy-vehicle adjustment factor, Two-way flow rate, (note-1) vp Highest directional split proportion (note-2)	1.00 1.2 1.0 0.988 631 347	pc/h pc/h		
Free-Flow Speed from Field Measurement: Field measured speed, SFM Observed volume, Vf Estimated Free-Flow Speed: Base free-flow speed, BFFS Adj. for lane and shoulder width, fLS Adj. for access points, fA	- - 55.0 0.0 1.8	mi/h veh/h mi/h mi/h mi/h		
Free-flow speed, FFS	53.3	mi/h		
Adjustment for no-passing zones, fnp Average travel speed, ATS	0.8 47.6	mi/h mi/h		

Percent Time-Spent-Following							
Grade adjustment factor, fG	1.00						
PCE for trucks, ET	1.1						
PCE for RVs, ER	1.0						
Heavy-vehicle adjustment factor, fHV	0.994						
Two-way flow rate, (note-1) vp	627	pc/h					
Highest directional split proportion (note-2)	345	-					
Base percent time-spent-following, BPTSF	42.4	ଚ					
Adj.for directional distribution and no-passing zones, fd/np	5.5						
Percent time-spent-following, PTSF	47.8	%					
Level of Service and Other Performance Measur	res						
Level of service, LOS	С						
Volume to capacity ratio, v/c	0.20						
Peak 15-min vehicle-miles of travel, VMT15	779	veh-mi					
Peak-hour vehicle-miles of travel, VMT60	2805	veh-mi					
Peak 15-min total travel time, TT15	16.4	veh-h					

- 1. If $vp \ge 3200 \text{ pc/h}$, terminate analysis-the LOS is F.
- 2. If highest directional split vp >= 1700 pc/h, terminate analysis-the LOS is F.

HCS+: Two-Lane Highways Release 5.4

Two-	-Way Two-Lane	e Highway Se	egment A	nalysis		
Analyst Agency/Co. Date Performed Analysis Time Period Highway From/To Jurisdiction Analysis Year Description Kahuku Vi	7/11/2011 PM Peak Hou Mamalahoa F Hookena Bea State of Ha 2021 With F	Highway ach Rd 101.0 awaii				
		Input Data				
Lane width 12 Segment length 5	.0 mi evel mi %		and buse lonal ve lng zone	s hicles	0.92 7 0 50 10	% % /mi
	Average	e Travel Spe	eed			
Grade adjustment factor PCE for trucks, ET PCE for RVs, ER Heavy-vehicle adjustmen Two-way flow rate, (note Highest directional spir	r, fG nt factor, e-1) vp		1.00 1.2 1.0 0.986 991	pc/h pc/h		
Free-Flow Speed from F: Field measured speed, S Observed volume, Vf Estimated Free-Flow Speed, Base free-flow speed, Adj. for lane and should Adj. for access points	SFM eed: 3FFS lder width, f		- - 55.0 2.6 2.5	mi/h veh/h mi/h mi/h mi/h		
Free-flow speed, FFS			49.9	mi/h		
Adjustment for no-passa Average travel speed, A		np	1.8	mi/h mi/h		

/h
eh-mi
eh-mi
eh-h

- 1. If $vp \ge 3200 \text{ pc/h}$, terminate analysis-the LOS is F.
- 2. If highest directional split vp >= 1700 pc/h, terminate analysis-the LOS is F.

HCS+: Two-Lane Highways Release 5.4

Two	-Way Two-Lane	e Highway Se	egment A	nalysis		
Analyst Agency/Co. Date Performed Analysis Time Period Highway From/To Jurisdiction Analysis Year Description Kahuku Vi	7/11/2011 PM Peak How Mamalahoa F Kapalapala State of Ha 2021 With F	Highway Ranch Rd 46 awaii				
		Input Data				
Lane width 12 Segment length 5			and buse onal vel ng zone	s hicles	0.94 3 0 10 5	% % % /mi
Directional Spire			_			
	Average	e Travel Spe	eed			
Grade adjustment factor PCE for trucks, ET PCE for RVs, ER Heavy-vehicle adjustment Two-way flow rate, (note Highest directional spiral	nt factor, e-1) vp	on (note-2)	1.00 1.7 1.0 0.979 585 322	pc/h pc/h		
Free-Flow Speed from Frield measured speed, Sobserved volume, Vf Estimated Free-Flow Speed, Base free-flow speed, Adj. for lane and should Adj. for access points	- - 55.0 2.6 1.3	mi/h veh/h mi/h mi/h mi/h				
Free-flow speed, FFS			51.2	mi/h		
Adjustment for no-pass: Average travel speed,		np	0.8 45.8	mi/h mi/h		

Percent Time-Spent-Following							
Grade adjustment factor, fG	1.00						
PCE for trucks, ET	1.1						
PCE for RVs, ER	1.0						
Heavy-vehicle adjustment factor, fHV	0.997						
Two-way flow rate, (note-1) vp	575	pc/h					
Highest directional split proportion (note-2)	316						
Base percent time-spent-following, BPTSF	39.7	90					
Adj.for directional distribution and no-passing zones, fd/np	5.7						
Percent time-spent-following, PTSF	45.4	%					
Level of Service and Other Performance Measu:	res						
Level of service, LOS	С						
Volume to capacity ratio, v/c	0.18						
Peak 15-min vehicle-miles of travel, VMT15	717	veh-mi					
Peak-hour vehicle-miles of travel, VMT60	2695	veh-mi					
Peak 15-min total travel time, TT15	15.7	veh-h					

- 1. If $vp \ge 3200 \text{ pc/h}$, terminate analysis-the LOS is F.
- 2. If highest directional split vp >= 1700 pc/h, terminate analysis-the LOS is F.

TRAFFIC IMPACT ANALYSIS REPORT FOR THE PROPOSED KAHUKU VILLAGE KA`U, HAWAII

TAX MAP KEY: (3) 9-2-001:072

APPENDIX I

CAPACITY ANALYSIS WORKSHEETS
2024 PEAK HOUR TRAFFIC WITH PROJECT

	\rightarrow	-	•	-	1	-
Lane Group	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations	1	7	*	1	ሻ	7
Volume (vph)	169	264	210	152	177	224
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Storage Length (ft)		530	530		0	400
Storage Lanes		1	1		1	1
Taper Length (ft)		100	100		100	100
Satd. Flow (prot)	1792	1583	1770	1638	1770	1583
Flt Permitted			0.950		0.950	
Satd. Flow (perm)	1792	1583	1770	1638	1770	1583
Right Turn on Red		Yes				Yes
Satd. Flow (RTOR)		287				243
Link Speed (mph)	55			55	30	
Link Distance (ft)	3000			1100	1000	
Travel Time (s)	37.2			13.6	22.7	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Heavy Vehicles (%)	6%	2%	2%	16%	2%	2%
Shared Lane Traffic		2 /0	Z /0	10 /0	2 /0	2 /0
Lane Group Flow (v)	` '	287	228	165	192	243
Turn Type	pii) 10 1	Perm	Prot	103	132	Free
Protected Phases	4	r eiiii	3	8	2	1166
Permitted Phases	4	1	3	0	_	Free
Detector Phases	4	4	3	8	2	riee
	4	4	3	ŏ	2	
Switch Phase	4.0	4.0	4.0	4.0	4.0	
Minimum Initial (s)	4.0	4.0	4.0	4.0	4.0	
Minimum Split (s)	22.0	22.0	10.0	22.0	22.0	0.0
Total Split (s)	22.0	22.0	16.0	38.0	22.0	0.0
Total Split (%)	36.7%					0.0%
Yellow Time (s)	5.0	5.0	5.0	5.0	5.0	
All-Red Time (s)	1.0	1.0	1.0	1.0	1.0	
Lost Time Adjust (s)		0.0	0.0	0.0	0.0	0.0
Total Lost Time (s)	6.0	6.0	6.0	6.0	6.0	4.0
Lead/Lag	Lag	Lag	Lead			
Lead-Lag Optimize?)					
Recall Mode	None	None	None	None	Min	
Act Effct Green (s)	10.6	10.6	9.7	26.4	10.6	49.3
Actuated g/C Ratio	0.22	0.22	0.20	0.54	0.22	1.00
v/c Ratio	0.48	0.51	0.66	0.19	0.50	0.15
Control Delay	22.1	6.3	32.5	7.1	22.7	0.2
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	22.1	6.3	32.5	7.1	22.7	0.2
LOS	C	Α	02.0 C	Α	C	Α
Approach Delay	12.5		C	21.9	10.2	^
Approach LOS	12.5 B			21.9 C	10.2 B	
		0	59	21	48	0
Queue Length 50th	(11) 40	U	59	21	40	U

		•	•		•	•	
Lane Group	EBT	EBR	WBL	WBT	NBL	NBR	
Queue Length 95th (ft) 103	49	#179	55	108	0	
Internal Link Dist (ft)	2920			1020	920		
Turn Bay Length (ft)		530	530			400	
Base Capacity (vph)	594	717	367	1086	587	1583	
Starvation Cap Reduc	tn 0	0	0	0	0	0	
Spillback Cap Reductr	ո 0	0	0	0	0	0	
Storage Cap Reductn	0	0	0	0	0	0	
Reduced v/c Ratio	0.31	0.40	0.62	0.15	0.33	0.15	

Intersection Summary

Area Type: Other

Cycle Length: 60

Actuated Cycle Length: 49.3

Natural Cycle: 60

Control Type: Actuated-Uncoordinated

Maximum v/c Ratio: 0.66

Intersection Signal Delay: 14.5 Intersection LOS: B
Intersection Capacity Utilization 45.3% ICU Level of Service A

Analysis Period (min) 15

95th percentile volume exceeds capacity, queue may be longer.

Queue shown is maximum after two cycles.

Splits and Phases: 3: Mamalahoa Hwy & Main Access



HCS+: Two-Lane Highways Release 5.4

Two	-Way Two-Lane	e Highway Se	egment A	nalysis		
Analyst Agency/Co. Date Performed Analysis Time Period Highway From/To Jurisdiction Analysis Year Description Kahuku Vi	7/11/2011 AM Peak How Mamalahoa Mahuku Rand State of Ha 2024 With Mana	Highway ch Rd to Ord awaii		У		
		Input Data				
	.0 ft 2.0 ft .0 mi evel mi %	% Trucks a % Recreati % No-passi Access poi veh/h	and buse onal ve ng zone	s hicles	0.85 6 0 10 8	% % % /mi
Directional Spire						
	Average	e Travel Spe	eed			
Grade adjustment facto PCE for trucks, ET PCE for RVs, ER Heavy-vehicle adjustme Two-way flow rate, (not Highest directional sp	nt factor, e-1) vp	on (note-2)	1.00 1.2 1.0 0.988 899 467	pc/h pc/h		
Free-Flow Speed from F Field measured speed, Observed volume, Vf Estimated Free-Flow Sp Base free-flow speed, Adj. for lane and shou Adj. for access points	SFM eed: BFFS lder width,		- - 55.0 0.0 2.0	mi/h veh/h mi/h mi/h mi/h		
Free-flow speed, FFS			53.0	mi/h		
Adjustment for no-pass Average travel speed,	_	np	0.6 45.4	mi/h mi/h		

Percent Time-Spent-Following							
Grade adjustment factor, fG	1.00						
PCE for trucks, ET	1.1						
PCE for RVs, ER	1.0						
Heavy-vehicle adjustment factor, fHV	0.994						
Two-way flow rate, (note-1) vp	894	pc/h					
Highest directional split proportion (note-2)	465						
Base percent time-spent-following, BPTSF	54.4	9					
Adj.for directional distribution and no-passing zones, fd/np	4.0						
Percent time-spent-following, PTSF	58.4	ે					
Level of Service and Other Performance Measur	res						
Level of service, LOS	С						
Volume to capacity ratio, v/c	0.28						
Peak 15-min vehicle-miles of travel, VMT15	1110	veh-mi					
Peak-hour vehicle-miles of travel, VMT60	3775	veh-mi					
Peak 15-min total travel time, TT15	24.5	veh-h					

- 1. If $vp \ge 3200 \text{ pc/h}$, terminate analysis-the LOS is F. 2. If highest directional split $vp \ge 1700 \text{ pc/h}$, terminate analysis-the LOS is F.

HCS+: Two-Lane Highways Release 5.4

Two	o-Way Two-Lane	e Highway Se	egment A	nalysis		
Analyst Agency/Co. Date Performed Analysis Time Period Highway From/To Jurisdiction Analysis Year Description Kahuku V	7/11/2011 AM Peak How Mamalahoa H Hookena Bea State of Ha 2024 With H	Highway ach Rd 101.0 awaii				
		Input Data				
Lane width Segment length	3.0 ft 12.0 ft 5.0 mi Level mi %		and buse onal ve	s hicles	0.86 3 0 50 10	% % % /mi
-		e Travel Spe	ed			
Grade adjustment factor PCE for trucks, ET PCE for RVs, ER Heavy-vehicle adjustment Two-way flow rate, (not Highest directional sp	ent factor,		1.00 1.1 1.0 0.997 1363	pc/h pc/h		
Free-Flow Speed from I Field measured speed, Observed volume, Vf Estimated Free-Flow Sp Base free-flow speed, Adj. for lane and show Adj. for access points	SFM peed: BFFS alder width,		- - 55.0 2.6 2.5	mi/h veh/h mi/h mi/h mi/h		
Free-flow speed, FFS			49.9	mi/h		
Adjustment for no-pass Average travel speed,		np	1.1	mi/h mi/h		

Percent Time-Spent-Following						
Grade adjustment factor, fG	1.00					
PCE for trucks, ET	1.00					
PCE for RVs, ER	1.0					
Heavy-vehicle adjustment factor, fHV	1.000					
Two-way flow rate, (note-1) vp	1359	pc/h				
Highest directional split proportion (note-2)	815	F - /				
Base percent time-spent-following, BPTSF	69.7	00				
Adj.for directional distribution and no-passing zones, fd/np	6.6					
Percent time-spent-following, PTSF	76.3	%				
Level of Service and Other Performance Measur	res					
Level of service, LOS	E					
Volume to capacity ratio, v/c	0.43					
Peak 15-min vehicle-miles of travel, VMT15	1699	veh-mi				
Peak-hour vehicle-miles of travel, VMT60	5845	veh-mi				
Peak 15-min total travel time, TT15	44.5	veh-h				

- If vp >= 3200 pc/h, terminate analysis-the LOS is F.
 If highest directional split vp >= 1700 pc/h, terminate analysis-the LOS is F.

HCS+: Two-Lane Highways Release 5.4

Two-Way Two-Lane Highway S	egment A	nalysis		
Analyst RSO Agency/Co. Traffic Management Co. Date Performed 7/11/2011 Analysis Time Period AM Peak Hour Highway Mamalahoa Highway From/To Kapalapala Ranch Rd 4 Jurisdiction State of Hawaii Analysis Year 2024 With Project Description Kahuku Villages				
Input Data				
Highway class Class 1 Shoulder width 3.0 ft Peak-hour Lane width 12.0 ft % Trucks Segment length 5.0 mi % Recreat Terrain type Level % No-pass Grade: Length mi Access po Up/down % Two-way hourly volume, V 750 veh/h Directional split 53 / 47 %	and buse ional ve ing zone	s hicles	0.83 5 0 10 5	% % % /mi
Average Travel Sp	eed			
Grade adjustment factor, fG PCE for trucks, ET PCE for RVs, ER Heavy-vehicle adjustment factor, Two-way flow rate, (note-1) vp Highest directional split proportion (note-2)	1.00 1.2 1.0 0.990 913	pc/h pc/h		
Free-Flow Speed from Field Measurement: Field measured speed, SFM Observed volume, Vf Estimated Free-Flow Speed: Base free-flow speed, BFFS Adj. for lane and shoulder width, fLS Adj. for access points, fA	- - 55.0 2.6 1.3	mi/h veh/h mi/h mi/h mi/h		
Free-flow speed, FFS	51.2	mi/h		
Adjustment for no-passing zones, fnp Average travel speed, ATS	0.6 43.4	mi/h mi/h		

Percent Time-Spent-Following		
Grade adjustment factor, fG	1.00	
PCE for trucks, ET	1.1	
PCE for RVs, ER	1.0	
Heavy-vehicle adjustment factor, fHV	0.995	
Two-way flow rate, (note-1) vp	908	pc/h
Highest directional split proportion (note-2)	481	1
Base percent time-spent-following, BPTSF	55.0	용
Adj.for directional distribution and no-passing zones, fd/np	3.8	
Percent time-spent-following, PTSF	58.8	%
Level of Service and Other Performance Measu:	res	
Level of service, LOS	D	
Volume to capacity ratio, v/c	0.29	
Peak 15-min vehicle-miles of travel, VMT15	1130	veh-mi
Peak-hour vehicle-miles of travel, VMT60	3750	veh-mi
Peak 15-min total travel time, TT15	26.0	veh-h

- 1. If $vp \ge 3200 \text{ pc/h}$, terminate analysis-the LOS is F. 2. If highest directional split $vp \ge 1700 \text{ pc/h}$, terminate analysis-the LOS is F.

	\rightarrow	-	•	•	1	-
Lane Group	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations	1	7	*	1	*	7
Volume (vph)	109	332	400	121	410	341
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Storage Length (ft)		530	530		0	400
Storage Lanes		1	1		1	1
Taper Length (ft)		100	100		100	100
Satd. Flow (prot)	1759	1583	1770	1681	1770	1583
FIt Permitted			0.950		0.950	
Satd. Flow (perm)	1759	1583	1770	1681	1770	1583
Right Turn on Red		Yes				Yes
Satd. Flow (RTOR)		361				371
Link Speed (mph)	55			55	30	
Link Distance (ft)	6000			1100	1000	
Travel Time (s)	74.4			13.6	22.7	
Peak Hour Factor	0.88	0.92	0.92	0.80	0.92	0.92
Heavy Vehicles (%)	8%	2%	2%	13%	2%	2%
Shared Lane Traffic						
Lane Group Flow (v	` '	361	435	151	446	371
Turn Type	,	Perm	Prot			Free
Protected Phases	4		3	8	2	
Permitted Phases		4				Free
Detector Phase	4	4	3	8	2	
Switch Phase						
Minimum Initial (s)	4.0	4.0	4.0	4.0	4.0	
Minimum Split (s)	22.0	22.0	10.0	22.0	22.0	
Total Split (s)	23.0	23.0	27.0	50.0	30.0	0.0
Total Split (%)	28.8%					0.0%
Yellow Time (s)	5.0	5.0	5.0	5.0	5.0	
All-Red Time (s)	1.0	1.0	1.0	1.0	1.0	
Lost Time Adjust (s)		0.0	0.0	0.0	0.0	0.0
Total Lost Time (s)	6.0	6.0	6.0	6.0	6.0	4.0
Lead/Lag	Lag		Lead	0.0	3.3	1.0
Lead-Lag Optimize?		_49	_500			
Recall Mode		None	None	None	Min	
Act Effct Green (s)	10.6	10.6	20.3	37.0	21.4	70.6
Actuated g/C Ratio	0.15	0.15	0.29	0.52	0.30	1.00
v/c Ratio	0.13	0.13	0.29	0.32	0.83	0.23
Control Delay	34.4	10.0	43.7	9.8	39.0	0.23
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	34.4	10.0	43.7	9.8	39.0	0.0
LOS	34.4 C	10.0	43.7 D	9.6 A	39.0 D	0.3 A
Approach Delay	16.2	A	D	35.0	21.4	A
• •	16.2 B			35.0 C	21.4 C	
Approach LOS	92	43	220	58	342	0
Stops (vph)	92	43	328	36	342	U

	_	•	•		'	- /
Lane Group	EBT	EBR	WBL	WBT	NBL	NBR
Fuel Used(gal)	7	14	25	6	8	3
CO Emissions (g/hr)	462	985	1773	424	583	188
NOx Emissions (g/hr)	90	192	345	83	113	36
VOC Emissions (g/hr)	107	228	411	98	135	43
Dilemma Vehicles (#)	6	0	0	7	0	0

Intersection Summary

Area Type: Other

Cycle Length: 80

Actuated Cycle Length: 70.6

Natural Cycle: 80

Control Type: Actuated-Uncoordinated

Maximum v/c Ratio: 0.85

Intersection Signal Delay: 24.3 Intersection LOS: C
Intersection Capacity Utilization 61.5% ICU Level of Service B

Analysis Period (min) 15

Splits and Phases: 3: Mamalahoa Hwy & Main Access



HCS+: Two-Lane Highways Release 5.4

Two-Wa	ay Two-Lan	e Highway Se	egment A	nalysis		
Agency/Co. Date Performed Analysis Time Period Highway From/To Jurisdiction	7/11/2011 PM Peak Ho Mamalahoa : Kahuku Ran State of H 2024 With	Highway ch Rd to Ord awaii				
		Input Data				
Highway class Class 1 Shoulder width 8.0 Lane width 12.0 Segment length 5.0 Terrain type Leve Grade: Length Up/down Two-way hourly volume, V) ft mi el mi %		and buse ional ve ing zone	s hicles	0.90 4 0 10 7	% % % /mi
Directional split	54 / 46	00				
	Averag	e Travel Spe	eed			
Grade adjustment factor, PCE for trucks, ET PCE for RVs, ER Heavy-vehicle adjustment Two-way flow rate, (note-1) Highest directional split	factor, L) vp	on (note-2)	1.00 1.2 1.0 0.992 1088 588	pc/h pc/h		
Free-Flow Speed from Field Field measured speed, SFN Observed volume, Vf Estimated Free-Flow Speed Base free-flow speed, BFN Adj. for lane and shoulded Adj. for access points, in	d: FS er width,		- - 55.0 0.0 1.8	mi/h veh/h mi/h mi/h mi/h		
Free-flow speed, FFS			53.3	mi/h		
Adjustment for no-passing Average travel speed, ATS		np	0.5 44.3	mi/h mi/h		

Percent Time-Spent-Following		
Grade adjustment factor, fG	1.00	
PCE for trucks, ET	1.1	
PCE for RVs, ER	1.0	
Heavy-vehicle adjustment factor, fHV	0.996	
Two-way flow rate, (note-1) vp	1083	pc/h
Highest directional split proportion (note-2)	585	± .
Base percent time-spent-following, BPTSF	61.4	용
Adj.for directional distribution and no-passing zones, fd/np	3.1	
Percent time-spent-following, PTSF	64.5	ଚ
Level of Service and Other Performance Measur	res	
Lovel of convice IOC	D	
Level of service, LOS	_	
Volume to capacity ratio, v/c	0.34	, ,
Peak 15-min vehicle-miles of travel, VMT15	1349	veh-mi
Peak-hour vehicle-miles of travel, VMT60	4855	veh-mi
Peak 15-min total travel time, TT15	30.4	veh-h

- 1. If $vp \ge 3200 \text{ pc/h}$, terminate analysis-the LOS is F. 2. If highest directional split $vp \ge 1700 \text{ pc/h}$, terminate analysis-the LOS is F.

HCS+: Two-Lane Highways Release 5.4

Two	-Way Two-Lane	Highway Se	gment A	nalysis		
Analyst Agency/Co. Date Performed Analysis Time Period Highway From/To Jurisdiction Analysis Year Description Kahuku Vii	RSO Traffic Mana 7/11/2011 PM Peak Hour Mamalahoa Hi Hookena Beac State of Hav 2024 With Pr	r ighway ch Rd 101.0 waii				
		Input Data_				
Segment length 5	2.0 ft .0 mi evel mi %	Peak-hour % Trucks a % Recreati % No-passi Access poi	nd buse onal vel	s nicles	0.92 3 0 50	% % /mi
Directional split		olo				
	Average	Travel Spe	ed			
Grade adjustment factor PCE for trucks, ET PCE for RVs, ER Heavy-vehicle adjustmen Two-way flow rate, (note Highest directional spi	nt factor, e-1) vp	n (note-2)	1.00 1.1 1.0 0.997 1460 832	pc/h pc/h		
Free-Flow Speed from Frield measured speed, Sobserved volume, Vf Estimated Free-Flow Speed, I Adj. for lane and should Adj. for access points.	SFM eed: BFFS Lder width, fI		- - 55.0 2.6 2.5	mi/h veh/h mi/h mi/h mi/h		
Free-flow speed, FFS			49.9	mi/h		
Adjustment for no-pass: Average travel speed, i)	1.0 37.6	mi/h mi/h		

Percent Time-Spent-Following		
Grade adjustment factor, fG	1.00	
PCE for trucks, ET	1.0	
PCE for RVs, ER	1.0	
Heavy-vehicle adjustment factor, fHV	1.000	
Two-way flow rate, (note-1) vp	1455	pc/h
Highest directional split proportion (note-2)	829	_
Base percent time-spent-following, BPTSF	72.2	ે
Adj.for directional distribution and no-passing zones, fd/np	6.0	
Percent time-spent-following, PTSF	78.1	%
Level of Service and Other Performance Measu:	res	
Level of service, LOS	E	
Volume to capacity ratio, v/c	0.46	
Peak 15-min vehicle-miles of travel, VMT15	1819	veh-mi
Peak-hour vehicle-miles of travel, VMT60	6695	veh-mi
Peak 15-min total travel time, TT15	48.4	veh-h

- 1. If $vp \ge 3200 \text{ pc/h}$, terminate analysis-the LOS is F. 2. If highest directional split $vp \ge 1700 \text{ pc/h}$, terminate analysis-the LOS is F.

HCS+: Two-Lane Highways Release 5.4

Two-	-Way Two-Lane	Highway Se	gment A	nalysis		
Analyst Agency/Co. Date Performed Analysis Time Period Highway From/To Jurisdiction Analysis Year Description Kahuku Vii	RSO Traffic Mana 7/11/2011 PM Peak Hour Mamalahoa Hi Kapalapala R State of Haw 2024 With Pr	ghway ghway anch Rd 46 aii				
	I	nput Data_				
Segment length 5. Terrain type Le Grade: Length Up/down Two-way hourly volume,	2.0 ft .0 mi evel mi %	Peak-hour % Trucks a % Recreati % No-passi Access poi	nd buse onal vel ng zone	s hicles	0.94 6 0 10 5	% % % /mi
Directional split	53 / 47	ଚ				
	Average	Travel Spe	ed			
Grade adjustment factor PCE for trucks, ET PCE for RVs, ER Heavy-vehicle adjustmen Two-way flow rate, (note Highest directional spi	nt factor, e-1) vp	(note-2)	1.00 1.2 1.0 0.988 1020 541	pc/h pc/h		
Free-Flow Speed from Frield measured speed, Sobserved volume, Vf Estimated Free-Flow Speed, Flow Speed	SFM eed: BFFS Lder width, fL		- - 55.0 2.6 1.3	mi/h veh/h mi/h mi/h mi/h		
Free-flow speed, FFS			51.2	mi/h		
Adjustment for no-pass: Average travel speed, A			0.5 42.7	mi/h mi/h		

1.00	
1.1	
1.0	
0.994	
1013	pc/h
537	
59.0	90
3.4	
62.4	90
es	
D	
0.32	
1259	veh-mi
4735	veh-mi
29.5	veh-h
	1.1 1.0 0.994 1013 537 59.0 3.4 62.4 es D 0.32 1259 4735

- 1. If $vp \ge 3200 \text{ pc/h}$, terminate analysis-the LOS is F.
- 2. If highest directional split vp >= 1700 pc/h, terminate analysis-the LOS is F.

TRAFFIC IMPACT ANALYSIS REPORT FOR THE PROPOSED KAHUKU VILLAGE KA`U, HAWAII

TAX MAP KEY: (3) 9-2-001:072

APPENDIX J

CAPACITY ANALYSIS WORKSHEETS
2030 PEAK HOUR TRAFFIC WITH PROJECT

	-	•	•	←	1	_
Lane Group	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations	†	7	*	†	*	7
Volume (vph)	181	282	224	161	187	236
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Storage Length (ft)		530	530		0	400
Storage Lanes		1	1		1	1
Taper Length (ft)	4000	100	100	4000	100	100
Satd. Flow (prot)	1863	1524	1770	1638	1770	1583
Flt Permitted	1062	1524	0.950 1770	1638	0.950	1583
Satd. Flow (perm) Right Turn on Red	1863	Yes	1770	1030	1770	Yes
Satd. Flow (RTOR)		307				257
Link Speed (mph)	55	307		55	30	231
Link Distance (ft)	3000			1100	1000	
Travel Time (s)	37.2			13.6	22.7	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Heavy Vehicles (%)	2%	6%	2%	16%	2%	2%
Shared Lane Traffic		0,0	_,,	, .	_,,	_,,
Lane Group Flow (v)	` '	307	243	175	203	257
Turn Type	,	Perm	Prot			Free
Protected Phases	4		3	8	2	
Permitted Phases		4				Free
Detector Phase	4	4	3	8	2	
Switch Phase						
Minimum Initial (s)	4.0	4.0	4.0	4.0	4.0	
Minimum Split (s)	22.0	22.0	10.0	22.0	22.0	
Total Split (s)	22.0	22.0	16.0	38.0	22.0	0.0
Total Split (%)	36.7%					0.0%
Yellow Time (s)	5.0	5.0	5.0	5.0	5.0	
All-Red Time (s)	1.0	1.0	1.0	1.0	1.0	
Lost Time Adjust (s)		0.0	0.0	0.0	0.0	0.0
Total Lost Time (s)	6.0	6.0	6.0	6.0	6.0	4.0
Lead/Lag	Lag	Lag	Lead			
Lead-Lag Optimize?		Mar-	Mars	Maria	N # :	
Recall Mode			None		Min	40.0
Act Effct Green (s)	10.8	10.8	9.9	26.7	10.9	49.9
Actuated g/C Ratio v/c Ratio	0.22	0.22	0.20	0.54	0.22	1.00
	0.49 22.2	0.54 6.7	0.69 34.8	0.20 7.3	0.52	0.16
Control Delay Queue Delay	0.0	0.0	0.0	0.0	0.0	0.2
Total Delay	22.2	6.7	34.8	7.3	23.2	0.0
LOS	22.2 C	Ο.7	34.0 C	7.3 A	23.2 C	Ο.2
Approach Delay	12.7	^	J	23.3	10.4	
Approach LOS	12.7 B			23.3 C	В	
Queue Length 50th		0	65	23	52	0
Queue Length John	(11)	U	03	23	52	U

		-	•	•		,	•	
Lane G	Group	EBT	EBR	WBL	WBT	NBL	NBR	
Queue	Length 95th (ft) 109	51	#195	59	114	0	
Interna	al Link Dist (ft)	2920			1020	920		
Turn B	ay Length (ft)		530	530			400	
Base C	Capacity (vph)	609	705	362	1072	579	1583	
Starva	tion Cap Reduc	tn 0	0	0	0	0	0	
Spillba	ck Cap Reducti	n 0	0	0	0	0	0	
Storag	e Cap Reductn	0	0	0	0	0	0	
Reduc	ed v/c Ratio	0.32	0.44	0.67	0.16	0.35	0.16	

Intersection Summary

Area Type: Other

Cycle Length: 60

Actuated Cycle Length: 49.9

Natural Cycle: 60

Control Type: Actuated-Uncoordinated

Maximum v/c Ratio: 0.69

Intersection Signal Delay: 15.1 Intersection LOS: B
Intersection Capacity Utilization 47.3% ICU Level of Service A

Analysis Period (min) 15

95th percentile volume exceeds capacity, queue may be longer.

Queue shown is maximum after two cycles.

Splits and Phases: 3: Mamalahoa Hwy & Main Access



HCS+: Two-Lane Highways Release 5.4

Two-Way Two-Lane Highway	Segment A	nalysis		
Analyst RSO Agency/Co. Traffic Management Co. Date Performed 7/11/2011 Analysis Time Period AM Peak Hour Highway Mamalahoa Highway From/To Kahuku Ranch Rd to Co. Jurisdiction State of Hawaii Analysis Year 2030 With Project Description Kahuku Villages				
Input Dat	a			
Segment length 5.0 mi % Recreation Recreation type Level % No-pass Grade: Length mi Access properties of the segment type with the segment type the segment typ	ar factor, and buse tional vesting zone points/mi	s hicles	0.85 6 0 10 8	% % % /mi
Two-way hourly volume, V 802 veh/h Directional split 52 / 48 %				
Average Travel S	speed			
Grade adjustment factor, fG PCE for trucks, ET PCE for RVs, ER Heavy-vehicle adjustment factor, Two-way flow rate, (note-1) vp Highest directional split proportion (note-2)	1.00 1.2 1.0 0.988 955 497	pc/h pc/h		
Free-Flow Speed from Field Measurement: Field measured speed, SFM Observed volume, Vf Estimated Free-Flow Speed: Base free-flow speed, BFFS Adj. for lane and shoulder width, fLS Adj. for access points, fA	- - 55.0 0.0 2.0	mi/h veh/h mi/h mi/h mi/h		
Free-flow speed, FFS	53.0	mi/h		
Adjustment for no-passing zones, fnp Average travel speed, ATS	0.6 45.0	mi/h mi/h		

Percent Time-Spent-Following						
Grade adjustment factor, fG PCE for trucks, ET PCE for RVs, ER Heavy-vehicle adjustment factor, fHV Two-way flow rate, (note-1) vp Highest directional split proportion (note-2) Base percent time-spent-following, BPTSF Adj.for directional distribution and no-passing zones, fd/np Percent time-spent-following, PTSF	1.00 1.1 1.0 0.994 949 493 56.6 3.7 60.3	pc/h %				
Level of Service and Other Performance Measur	res					
Level of service, LOS Volume to capacity ratio, v/c Peak 15-min vehicle-miles of travel, VMT15 Peak-hour vehicle-miles of travel, VMT60 Peak 15-min total travel time, TT15	C 0.30 1179 4010 26.2	veh-mi veh-mi veh-h				

Notes:

- 1. If $vp \ge 3200 \text{ pc/h}$, terminate analysis-the LOS is F. 2. If highest directional split $vp \ge 1700 \text{ pc/h}$, terminate analysis-the LOS is F.

HCS+: Two-Lane Highways Release 5.4

Two-Wa	y Two-Lan	e Highway Se	egment A	nalysis		
Agency/Co. T Date Performed 7 Analysis Time Period A Highway M From/To H Jurisdiction S	/11/2011 M Peak Ho Lamalahoa Lookena Be Late of H 030 With	Highway ach Rd 101.(awaii				
		Input Data				
Highway class Class 1 Shoulder width 3.0 Lane width 12.0 Segment length 5.0 Terrain type Leve Grade: Length Up/down Two-way hourly volume, V Directional split 66	mi el mi %		and buse ional ve ing zone	s hicles	0.86 3 0 50 10	% % % /mi
1			and			
	Averag	e Travel Spe	eea			
Grade adjustment factor, PCE for trucks, ET PCE for RVs, ER Heavy-vehicle adjustment Two-way flow rate, (note-1 Highest directional split	factor,	on (note-2)	1.00 1.1 1.0 0.997 1478 887	pc/h pc/h		
Free-Flow Speed from Fiel Field measured speed, SFM Observed volume, Vf Estimated Free-Flow Speed Base free-flow speed, BFF Adj. for lane and shoulde Adj. for access points, f	- - 55.0 2.6 2.5	mi/h veh/h mi/h mi/h mi/h				
Free-flow speed, FFS			49.9	mi/h		
Adjustment for no-passing Average travel speed, ATS		np	1.0 37.4	mi/h mi/h		

Percent Time-Spent-Following		
Grade adjustment factor, fG	1.00	
PCE for trucks, ET	1.0	
PCE for RVs, ER	1.0	
Heavy-vehicle adjustment factor, fHV	1.000	
Two-way flow rate, (note-1) vp	1473	pc/h
Highest directional split proportion (note-2)	884	
Base percent time-spent-following, BPTSF	72.6	90
Adj.for directional distribution and no-passing zones, fd/np	5.9	
Percent time-spent-following, PTSF	78.5	%
Level of Service and Other Performance Measur	ces	
Level of service, LOS	E	
Volume to capacity ratio, v/c	0.46	
Peak 15-min vehicle-miles of travel, VMT15	1842	veh-mi
Peak-hour vehicle-miles of travel, VMT60	6335	veh-mi
Peak 15-min total travel time, TT15	49.2	veh-h

Notes:

- 1. If $vp \ge 3200 \text{ pc/h}$, terminate analysis-the LOS is F. 2. If highest directional split $vp \ge 1700 \text{ pc/h}$, terminate analysis-the LOS is F.

HCS+: Two-Lane Highways Release 5.4

Two-	-Way Two-Lane	e Highway Se	egment A	nalysis		
Analyst Agency/Co. Date Performed Analysis Time Period Highway From/To Jurisdiction Analysis Year Description Kahuku Vii	7/11/2011 AM Peak Horn Mamalahoa I Kapalapala State of Horn 2030 With	Highway Ranch Rd 46 awaii				
		Input Data				
Lane width 12 Segment length 5	.0 mi evel mi % V 795		and buse onal vel	s hicles	0.83 5 0 10 5	% % % /mi
Directional Spire						
	Average	e Travel Spe	eed			
Grade adjustment factor PCE for trucks, ET PCE for RVs, ER Heavy-vehicle adjustmen Two-way flow rate, (note Highest directional spir	nt factor, e-1) vp	on (note-2)	1.00 1.2 1.0 0.990 967 513	pc/h pc/h		
Free-Flow Speed from Field Measurement: Field measured speed, SFM Observed volume, Vf Estimated Free-Flow Speed: Base free-flow speed, BFFS Adj. for lane and shoulder width, fLS Adj. for access points, fA				mi/h veh/h mi/h mi/h mi/h		
Free-flow speed, FFS			51.2	mi/h		
Adjustment for no-pass: Average travel speed,		np	0.6 43.1	mi/h mi/h		

Percent Time-Spent-Following						
Grade adjustment factor, fG	1.00					
PCE for trucks, ET	1.1					
PCE for RVs, ER	1.0					
Heavy-vehicle adjustment factor, fHV	0.995					
Two-way flow rate, (note-1) vp	963	pc/h				
Highest directional split proportion (note-2)	510					
Base percent time-spent-following, BPTSF	57.1	90				
Adj.for directional distribution and no-passing zones, fd/np	3.6					
Percent time-spent-following, PTSF	60.7	%				
Level of Service and Other Performance Measur	ces					
Level of service, LOS	D					
Volume to capacity ratio, v/c	0.30					
Peak 15-min vehicle-miles of travel, VMT15	1197	veh-mi				
Peak-hour vehicle-miles of travel, VMT60	3975	veh-mi				
Peak 15-min total travel time, TT15	27.8	veh-h				

Notes:

- 1. If $vp \ge 3200 \text{ pc/h}$, terminate analysis-the LOS is F. 2. If highest directional split $vp \ge 1700 \text{ pc/h}$, terminate analysis-the LOS is F.

Lane Group EBT EBR WBL WBT NBL NBR Lane Configurations † † † † †
·
Volume (vph) 96 376 451 105 459 382
Ideal Flow (vphpl) 1900 1900 1900 1900 1900
Storage Length (ft) 530 530 0 400
Storage Lanes 1 1 1 1
Taper Length (ft) 100 100 100 100
Satd. Flow (prot) 1759 1583 1770 1681 1770 1583
Flt Permitted 0.950 0.950
Satd. Flow (perm) 1759 1583 1770 1681 1770 1583
Right Turn on Red Yes Yes
Satd. Flow (RTOR) 409 415
Link Speed (mph) 55 55 30
Link Distance (ft) 6000 1100 1000
Travel Time (s) 74.4 13.6 22.7
Peak Hour Factor 0.88 0.92 0.92 0.80 0.92 0.92
Heavy Vehicles (%) 8% 2% 2% 13% 2% 2%
Shared Lane Traffic (%)
Lane Group Flow (vph) 109 409 490 131 499 415
Turn Type Perm Prot Free
Protected Phases 4 3 8 2
Permitted Phases 4 Free
Detector Phase 4 4 3 8 2
Switch Phase
Minimum Initial (s) 4.0 4.0 4.0 4.0 4.0
Minimum Split (s) 22.0 22.0 10.0 10.0 22.0
Total Split (s) 31.0 31.0 29.0 60.0 30.0 0.0
Total Split (%) 34.4% 34.4% 32.2% 66.7% 33.3% 0.0%
Yellow Time (s) 5.0 5.0 5.0 5.0 5.0
\(\frac{1}{2}\)
, ()
()
Lead/Lag Lag Lag Lead
Lead-Lag Optimize?
Recall Mode None None None Min
Act Effet Green (s) 10.8 10.8 23.1 39.8 24.1 75.9
Actuated g/C Ratio 0.14 0.14 0.30 0.52 0.32 1.00
v/c Ratio 0.44 0.71 0.91 0.15 0.89 0.26
Control Delay 35.0 10.8 50.8 9.6 46.4 0.4
Queue Delay 0.0 0.0 0.0 0.0 0.0 0.0
Total Delay 35.0 10.8 50.8 9.6 46.4 0.4
LOS C B D A D A
Approach Delay 15.9 42.1 25.5
Approach LOS B D C
Queue Length 50th (ft) 48 0 216 30 217 0



Base Capacity (vph) 581 797 538 1199 561 1583 Starvation Cap Reductn 0 0 0 0 0 Spillback Cap Reductn 0 0 0 0 0 0 Storage Cap Reductn 0 0 0 0 0 0 Reduced v/c Ratio 0.19 0.51 0.89 0.26 0.91 0.11

Intersection Summary

Area Type: Other

Cycle Length: 90

Actuated Cycle Length: 75.9

Natural Cycle: 90

Control Type: Actuated-Uncoordinated

Maximum v/c Ratio: 0.91

Intersection Signal Delay: 28.1 Intersection LOS: C
Intersection Capacity Utilization 67.1% ICU Level of Service C

Analysis Period (min) 15

95th percentile volume exceeds capacity, queue may be longer.

Queue shown is maximum after two cycles.

Splits and Phases: 3: Mamalahoa Hwy & Main Access



Single Lane Roundabout Analysis

Source: Roundabouts in the United States NCHRP 572, Chapter 6 Interpretation, Appraisal, and Applications p. 108

Project: Kahuku Village

Intersection: Mamalahoa Highway and Main Access Road

Prepared By: The Traffic Management Consultant Peak Hour: 2030 PM Peak Hour With Project

Approach	Movement	V (vph)	PHF	T	ET	v (pch)	c	v _c	v/c	d	d_{+5}	d _{adj}	LOS
	U-Turn	0	0.92	0%	2.0	0							
Eastbound	Left-Turn	0	0.92	0%	2.0	0	679	510	0.19	6.5	0.9	7.5	Α
Eastooulid	Through	96	0.88	8%	2.0	127	0/9	310	0.19	0.5	0.9	7.5	A
Rig	Right-Turn *	376	0.92	2%	2.0	0							
	U-Turn	0	0.92	0%	2.0	0			1.01		5.0	61.0	
Westbound	Left-Turn	451	0.92	2%	2.0	510	671 521	521		55.9			F
Westboulid	Through	105	0.80	13%	2.0	165		321					Г
	Right-Turn	0	0.92	0%	2.0	0							
	U-Turn	0	0.92	0%	2.2	0		127	0.52	7.5	2.6	10.1	
Northbound	Left-Turn	459	0.92	2%	2.2	521	995						В
Northbound	Through	0	0.92	2%	2.2	0	993	127	0.32				В
	Right-Turn *	382	0.92	0%	2.2	0							
	U-Turn	0	0.92	0%	2.2	0					0.0	10.5	
Southbound	Left-Turn	0	0.92	0%	2.2	0	342	1196	0.00	10.5			В
Soumbound	Through	0	0.92	0%	2.2	0	342						
	Right-Turn	0	0.92	0%	2.2	0							

^{*} Separate Lane

Source: Roundabouts in the United States NCHRP 572, Chapter 6 Interpretation,

$$d_{adj} = 3600/c \ +900 \ * \ T \ * \ (v/c \ -1 \ + \ \sqrt{\left((v/c \ -1)^2 + ((3600/c) \ * \ v/c)/(450 \ * \ T)\right)}) \ + \ 5 \ * \ v/c$$

where, d_{adj} = average control delay (sec/veh)

c = entry capacity in passenger car units per hour (pch) = $1130 * \exp(-0.0010 * v_c)$

 $v_c = conflicting flow (pch)$

T = time period (1 for 60-min, 0.25 for 15-min)

v = traffic flow (pch)

HCS+: Two-Lane Highways Release 5.4

Two-Way Two-Lane Highway	Segment A	nalysis		
Analyst RSO Agency/Co. Traffic Management Co. Date Performed 7/11/2011 Analysis Time Period PM Peak Hour Highway Mamalahoa Highway From/To Kahuku Ranch Rd to Co. Jurisdiction State of Hawaii Analysis Year 2030 With Project Description Kahuku Villages				
Input Dat	.a			
Segment length 5.0 mi % Recreation Recreation type Level % No-pass Grade: Length mi Access properties of the segment type with the segment type the segment typ	ar factor, and buse tional vesing zone ooints/mi	s hicles	0.90 4 0 10 7	% % % /mi
Two-way hourly volume, V 1035 veh/h Directional split 54 / 46 %				
Average Travel S	speed			
Grade adjustment factor, fG PCE for trucks, ET PCE for RVs, ER Heavy-vehicle adjustment factor, Two-way flow rate, (note-1) vp Highest directional split proportion (note-2)	1.00 1.2 1.0 0.992 1159	pc/h pc/h		
Free-Flow Speed from Field Measurement: Field measured speed, SFM Observed volume, Vf Estimated Free-Flow Speed: Base free-flow speed, BFFS Adj. for lane and shoulder width, fLS Adj. for access points, fA	- - 55.0 0.0 1.8	mi/h veh/h mi/h mi/h mi/h		
Free-flow speed, FFS	53.3	mi/h		
Adjustment for no-passing zones, fnp Average travel speed, ATS	0.4 43.8	mi/h mi/h		

Percent Time-Spent-Following		
Grade adjustment factor, fG	1.00	
PCE for trucks, ET	1.1	
PCE for RVs, ER	1.0	
Heavy-vehicle adjustment factor, fHV	0.996	
Two-way flow rate, (note-1) vp	1155	pc/h
Highest directional split proportion (note-2)	624	-
Base percent time-spent-following, BPTSF	63.8	%
Adj.for directional distribution and no-passing zones, fd/np	2.8	
Percent time-spent-following, PTSF	66.6	ଖ
Level of Service and Other Performance Measur	ces	
Level of service, LOS	D	
Volume to capacity ratio, v/c	0.36	
Peak 15-min vehicle-miles of travel, VMT15	1438	veh-mi
Peak-hour vehicle-miles of travel, VMT60	5175	veh-mi
Peak 15-min total travel time, TT15	32.8	veh-h

Notes:

- 1. If $vp \ge 3200 \text{ pc/h}$, terminate analysis-the LOS is F.
- 2. If highest directional split vp >= 1700 pc/h, terminate analysis-the LOS is F.

HCS+: Two-Lane Highways Release 5.4

Two	-Way Two-Lan	e Highway Se	egment A	nalysis		
Analyst Agency/Co. Date Performed Analysis Time Period Highway From/To Jurisdiction Analysis Year Description Kahuku Vi	7/11/2011 PM Peak Horn Mamalahoa I Hookena Ber State of Hr 2030 With	Highway ach Rd 101.(awaii				
		Input Data				
	8.0 ft 2.0 ft 5.0 mi Eevel mi %	% Trucks a % Recreati % No-passi Access poi	and buse onal ve ng zone	s hicles	0.92 3 0 50	% % /mi
		e Travel Spe	and			
Grade adjustment factor PCE for trucks, ET PCE for RVs, ER Heavy-vehicle adjustment Two-way flow rate, (not Highest directional sp	ent factor,		1.00 1.1 1.0 0.997 1579	pc/h pc/h		
Free-Flow Speed from F Field measured speed, Observed volume, Vf Estimated Free-Flow Sp Base free-flow speed, Adj. for lane and show Adj. for access points	- - 55.0 2.6 2.5	mi/h veh/h mi/h mi/h mi/h				
Free-flow speed, FFS			49.9	mi/h		
Adjustment for no-pass Average travel speed,		np	1.0 36.7	mi/h mi/h		

Percent Time-Spent-Following						
Grade adjustment factor, fG	1.00					
PCE for trucks, ET	1.0					
PCE for RVs, ER	1.0					
Heavy-vehicle adjustment factor, fHV	1.000					
Two-way flow rate, (note-1) vp	1574	pc/h				
Highest directional split proportion (note-2)	897	_				
Base percent time-spent-following, BPTSF	74.9	ଚ				
Adj.for directional distribution and no-passing zones, fd/np	5.4					
Percent time-spent-following, PTSF	80.3	%				
Level of Service and Other Performance Measu	res					
Level of service, LOS	E					
Volume to capacity ratio, v/c	0.49					
Peak 15-min vehicle-miles of travel, VMT15	1967	veh-mi				
Peak-hour vehicle-miles of travel, VMT60	7240	veh-mi				
Peak 15-min total travel time, TT15	53.6	veh-h				
Volume to capacity ratio, v/c Peak 15-min vehicle-miles of travel, VMT15 Peak-hour vehicle-miles of travel, VMT60	0.49 1967 7240	veh-mi				

- 1. If $vp \ge 3200 \text{ pc/h}$, terminate analysis-the LOS is F. 2. If highest directional split $vp \ge 1700 \text{ pc/h}$, terminate analysis-the LOS is F.

HCS+: Two-Lane Highways Release 5.4

Two-	Way Two-Lane	Highway Se	gment A	nalysis		
Analyst Agency/Co. Date Performed Analysis Time Period Highway From/To Jurisdiction Analysis Year Description Kahuku Vil	Mamalahoa H Kapalapala State of Ha 2030 With P	r ighway Ranch Rd 46 waii				
		Input Data_				
	evel mi %	% Trucks a % Recreati % No-passi Access poi	nd buses onal vel	s hicles	0.94 6 0 10 5	% % % /mi
Directional split						
	Average	Travel Spe	ed			
Grade adjustment factor PCE for trucks, ET PCE for RVs, ER Heavy-vehicle adjustment Two-way flow rate, (note Highest directional spl	et factor,	n (note-2)	1.00 1.2 1.0 0.988 1082 573	pc/h pc/h		
Free-Flow Speed from Fi Field measured speed, S Observed volume, Vf Estimated Free-Flow Spe Base free-flow speed, E Adj. for lane and shoul Adj. for access points,	- - 55.0 2.6 1.3	mi/h veh/h mi/h mi/h mi/h				
Free-flow speed, FFS			51.2	mi/h		
Adjustment for no-passi Average travel speed, A	0.5 42.3	mi/h mi/h				

Percent Time-Spent-Following						
1.00						
1.1						
1.0						
0.994						
1076	pc/h					
570						
61.2	%					
3.2						
64.3	%					
ces						
D						
0.34						
1336	veh-mi					
5025	veh-mi					
31.6	veh-h					
	1.1 1.0 0.994 1076 570 61.2 3.2 64.3 Ces					

Notes:

- 1. If $vp \ge 3200 \text{ pc/h}$, terminate analysis-the LOS is F.
- 2. If highest directional split vp >= 1700 pc/h, terminate analysis-the LOS is F.

APPENDIX G 11.11.11 In In In 11.11.11 Inthe th TRAFFIC NOISE STUDY In 11.11.11 In In In In In In 11.11.11 In In In 11.11.11

11.11.11

la la la la la la la la la

11/11/11

TRAFFIC NOISE STUDY FOR KAHUKU VILLAGE HAWAII, HAWAII

Prepared for:

PBR HAWAII & ASSOCIATES, INC.

Prepared by:

Y. EBISU & ASSOCIATES 1126 12th Avenue, Room 305 Honolulu, Hawaii 96816

TABLE OF CONTENTS

<u>CHAPTE</u>	<u>CHAPTER TITLE</u>	PAGE NO.
	List of Figures List of Tables	ii iii
I.	SUMMARY	1
11.	PURPOSE	3
Ш.	NOISE DESCRIPTORS AND THEIR RELATIONSHIP TO LAND USE COMPATIBILITY	4
IV.	GENERAL STUDY METHODOLOGY	10
V.	EXISTING NOISE ENVIRONMENT	15
VI.	FUTURE NOISE ENVIRONMENT	18
VII.	DISCUSSION OF PROJECT RELATED NOISE IMPACTS AND POSSIBLE NOISE MITIGATION MEASURES	21
APPEND	ICES:	
Α	REFERENCES	25
В	EXCERPTS FROM EPA'S ACOUSTIC TERMINOLOGY GUIDE	26
С	SUMMARY OF BASE YEAR AND FUTURE YEAR TRAFFIC VOLUMES	29

LIST OF FIGURES

NUMBER	FIGURE TITLE	PAGE NO
1	PROJECT LOCATION MAP	2
2	LAND USE COMPATIBILITY WITH YEARLY DAY-NIGHT AVERAGE SOUND LEVEL AT A SITE FOR BUILDINGS AS COMMONLY CONSTRUCTED	7
3	NOISE MEASUREMENT LOCATIONS IN PROJECT ENVIRONS	11
4	HOURLY VARIATIONS OF TRAFFIC NOISE AT 50 FT SETBACK DISTANCE FROM THE CENTERLINE OF MAMALAHOA HIGHWAY BETWEEN PRINCE KUHIO DR. AND 78 MILEPOST AT END OF MEDIAN (OCT. 16, 2006)	14
5	ANTICIPATED RANGE OF CONSTRUCTION NOISE LEVELS VS. DISTANCE	23
6	AVAILABLE WORK HOURS UNDER DOH PERMIT PROCEDURES FOR CONSTRUCTION NOISE	24

LIST OF TABLES

<u>NUMBER</u>	TABLE TITLE	PAGE NO.
1	EXTERIOR NOISE EXPOSURE CLASSIFICATION (RESIDENTIAL LAND USE)	5
2	EFFECTS OF NOISE ON PEOPLE (RESIDENTIAL LAN USES ONLY)	D 6
3	TRAFFIC AND BACKGROUND NOISE MEASUREMENT RESULTS	12
4A	EXISTING (CY 2010) TRAFFIC VOLUMES AND NOISE LEVELS ALONG VARIOUS ROADWAY SECTIONS (AM PEAK HOUR)	16
4B	EXISTING (CY 2010) TRAFFIC VOLUMES AND NOISE LEVELS ALONG VARIOUS ROADWAY SECTIONS (PM PEAK HOUR)	16
5	YEAR 2010 AND 2030 DISTANCES TO 65 AND 70 DNL CONTOURS	17
6A	FUTURE (CY 2030) TRAFFIC VOLUMES AND NOISE LEVELS ALONG VARIOUS ROADWAY SECTIONS (AM PEAK HOUR, WITH PROJECT)	19
6B	FUTURE (CY 2030) TRAFFIC VOLUMES AND NOISE LEVELS ALONG VARIOUS ROADWAY SECTIONS (PM PEAK HOUR, WITH PROJECT)	19
7A	CALCULATIONS OF PROJECT AND NON-PROJECT TRAFFIC NOISE CONTRIBUTIONS (CY 2030, AM PEAK HOUR)	20
7B	CALCULATIONS OF PROJECT AND NON-PROJECT TRAFFIC NOISE CONTRIBUTIONS (CY 2030, AM PEAK HOUR)	
	,	

CHAPTER I. SUMMARY

The existing and future traffic noise levels in the vicinity of the proposed Kahuku Village Project on the Island of Hawaii were evaluated for their potential impact on present and future noise sensitive areas. Figure 1 depicts the location of the project site. The future traffic noise levels along the primary access roadways to the project were calculated for the year 2030.

Along the existing Mamalahoa Highway, traffic noise levels are expected to increase by 6.4 to 6.6 DNL between CY 2010 and CY 2030 as a result of both project and non-project traffic. Along the sections of Mamalahoa Highway west and east of the project, traffic noise levels are predicted to increase by 1.5 DNL as a result of non-project traffic. Traffic noise level increases due to project traffic are predicted to be 4.9 DNL along Mamalahoa Highway. The future increases in traffic noise levels are expected to be controlled by project traffic along Mamalahoa Highway as well as along the Entrance Road to the project site.

Existing residences are located along the section of Mamalahoa Highway west of the project site. Because they are all located beyond 118 feet from the centerline of highway, future traffic noise levels at existing residences along Mamalahoa Highway should not exceed the FHA/HUD standard of 65 DNL at project build-out by CY 2030. For this reason traffic noise mitigation measures should not be required at these existing residences in conjunction with this project.

Future traffic noise levels along the project's Entrance Road are predicted to be relatively high at project build out by 2030. Because the lands along the Entrance Road are undeveloped, adverse noise impacts are not expected along the Entrance Road between the proposed Kahuku Village and Mamalahoa Highway.

Within the proposed Kahuku Village, traffic noise mitigation measures should be considered due to the relatively high traffic volumes which are anticipated along the project's Entrance Road. These mitigation measures may include the use of adequate buffer (or set back) distances, the use of sound attenuating walls and/or berms, and the use of closure and air conditioning.

Unavoidable, but temporary, noise impacts may occur during the construction of the proposed project. Because construction activities are predicted to be audible at the neighboring properties to the northwest, the quality of the acoustic environment may be degraded to unacceptable levels during periods of construction. Mitigation measures to reduce construction noise to inaudible levels will not be practical in all cases. For this reason, the use of quiet equipment and construction curfew periods as required under the State Department of Health noise regulations are recommended to minimize construction noise impacts.

CHAPTER I. SUMMARY

The existing and future traffic noise levels in the vicinity of the proposed Kahuku Village Project on the Island of Hawaii were evaluated for their potential impact on present and future noise sensitive areas. Figure 1 depicts the location of the project site. The future traffic noise levels along the primary access roadways to the project were calculated for the year 2030.

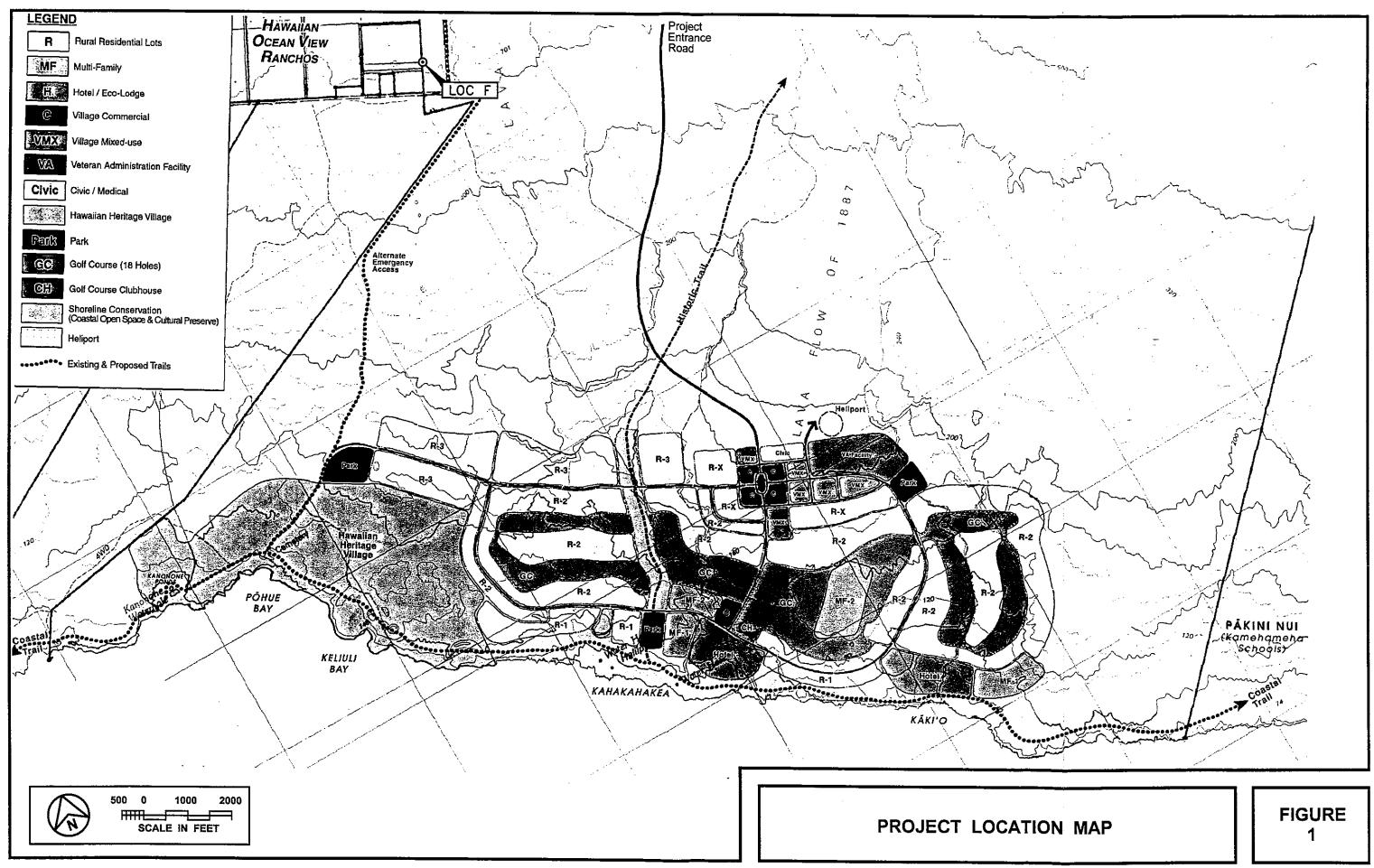
Along the existing Mamalahoa Highway, traffic noise levels are expected to increase by 6.4 to 6.6 DNL between CY 2010 and CY 2030 as a result of both project and non-project traffic. Along the sections of Mamalahoa Highway west and east of the project, traffic noise levels are predicted to increase by 1.5 DNL as a result of non-project traffic. Traffic noise level increases due to project traffic are predicted to be 4.9 DNL along Mamalahoa Highway. The future increases in traffic noise levels are expected to be controlled by project traffic along Mamalahoa Highway as well as along the Entrance Road to the project site.

Existing residences are located along the section of Mamalahoa Highway west of the project site. Because they are all located beyond 118 feet from the centerline of highway, future traffic noise levels at existing residences along Mamalahoa Highway should not exceed the FHA/HUD standard of 65 DNL at project build-out by CY 2030. For this reason traffic noise mitigation measures should not be required at these existing residences in conjunction with this project.

Future traffic noise levels along the project's Entrance Road are predicted to be relatively high at project build out by 2030. Because the lands along the Entrance Road are undeveloped, adverse noise impacts are not expected along the Entrance Road between the proposed Kahuku Village and Mamalahoa Highway.

Within the proposed Kahuku Village, traffic noise mitigation measures should be considered due to the relatively high traffic volumes which are anticipated along the project's Entrance Road. These mitigation measures may include the use of adequate buffer (or set back) distances, the use of sound attenuating walls and/or berms, and the use of closure and air conditioning.

Unavoidable, but temporary, noise impacts may occur during the construction of the proposed project. Because construction activities are predicted to be audible at the neighboring properties to the northwest, the quality of the acoustic environment may be degraded to unacceptable levels during periods of construction. Mitigation measures to reduce construction noise to inaudible levels will not be practical in all cases. For this reason, the use of quiet equipment and construction curfew periods as required under the State Department of Health noise regulations are recommended to minimize construction noise impacts.



Page 2

CHAPTER II. PURPOSE

The objectives of this study were to describe the existing and future noise environment in the environs of the proposed Kahuku Village on the island of Hawaii. Traffic noise level increases and impacts associated with the proposed development were to be determined within the project site as well as along the public roadways expected to service the project traffic. A specific objective was to determine the future traffic noise level increases associated with both project and non-project traffic, and the potential noise impacts associated with these increases. Assessments of possible impacts from short term construction noise at the project site were also included in the noise study objectives. Recommendations for minimizing these noise impacts were also to be provided as required.

CHAPTER III. NOISE DESCRIPTORS AND THEIR RELATIONSHIP TO LAND USE COMPATIBILITY

The noise descriptor currently used by federal agencies to assess environmental noise is the Day-Night Average Sound Level (DNL or Ldn). This descriptor incorporates a 24-hour average of instantaneous A-Weighted sound levels as read on a standard Sound Level Meter. The maximum A-Weighted sound level occurring while a noise source such as a heavy truck or aircraft is moving past a listener (i.e., the maximum sound level from a "single event") is referred to as the "Lmax value". The mathematical product (or integral) of the instantaneous sound level times the duration of the event is known as the "Sound Exposure Level", or Lse, which is analogous to the energy of the time-varying sound levels associated with a single event.

The DNL values represent the average noise during a typical day of the year. DNL exposure levels of 55 or less are typical of quiet rural or suburban areas. DNL exposure levels of 55 to 65 are typical of urbanized areas with medium to high levels of activity and street traffic. DNL exposure levels above 65 are representative of densely developed urban areas and areas fronting high volume roadways.

By definition, the minimum averaging period for the DNL descriptor is 24 hours. Additionally, sound levels which occur during the nighttime hours of 10:00 PM to 7:00 AM are increased by 10 decibels (dB) prior to computing the 24-hour average by the DNL descriptor. Because of the averaging used, DNL values in urbanized areas typically range between 50 and 75 DNL. In comparison, the typical range of intermittent noise events may have maximum Sound Level Meter readings between 75 and 105 dBA. A more complete list of noise descriptors is provided in Appendix B to this report. In Appendix B, the Ldn descriptor symbol is used in place of the DNL descriptor symbol.

Table 1, extracted from Reference 1, categorizes the various DNL levels of outdoor noise exposure with severity classifications. Table 2, also extracted from Reference 1, presents the general effects of noise on people in residential use situations. Figure 2, extracted from Reference 2, presents suggested land use compatibility guidelines for residential and nonresidential land uses. A general consensus among federal agencies has developed whereby residential housing development is considered acceptable in areas where exterior noise does not exceed 65 DNL. This value of 65 DNL is used as a federal regulatory threshold for determining the necessity for special noise abatement measures when applications for federal funding assistance are made.

As a general rule, noise levels of 55 DNL or less occur in rural areas, or in areas which are removed from high volume roadways. In urbanized areas which are shielded from high volume streets, DNL levels generally range from 55 to 65 DNL, and are usually controlled by motor vehicle traffic noise. Residences which front major roadways are generally exposed to levels of 65 DNL, and as high as 75 DNL when the

TABLE 1

EXTERIOR NOISE EXPOSURE CLASSIFICATION (RESIDENTIAL LAND USE)

NOISE EXPOSURE CLASS			FEDERAL (1) STANDARD
Minimal Exposure	Not Exceeding 55 DNL	Not Exceeding 55 Leq	Unconditionally Acceptable
Moderate Exposure	Above 55 DNL But Not Above 65 DNL	Above 55 Leq But Not Above 65 Leq	Acceptable(2)
Significant Exposure	Above 65 DNL But Not Above 75 DNL	Above 65 Leq But Not Above 75 Leq	Normally Unacceptable
Severe Exposure	Above 75 DNL	Above 75 Leq	Unacceptable

Notes: (1) Federal Housing Administration, Veterans Administration, Department of Defense, and Department of Transportation.

(2) FHWA uses the Leq instead of the Ldn descriptor. For planning purposes, both are equivalent if: (a) heavy trucks do not exceed 10 percent of total traffic flow in vehicles per 24 hours, and (b) traffic between 10:00 PM and 7:00 AM does not exceed 15 percent of average daily traffic flow in vehicles per 24 hours. The noise mitigation threshold used by FHWA for residences is 67 Leq.

TABLE 2

EFFECTS OF NOISE ON PEOPLE (Residential Land Uses Only)

General Community Attitude Towards Area			Noise is likely to be the most important of all adverse aspects of the community environment.	Noise is one of the most important adverse aspects of the community environment.	Noise is one of the important adverse aspects of the community environment.	Noise may be considered an adverse aspect of the community environment.	Noise considered no more important than various other environmental factors.
	Average	Community Reaction	Very Severe	Severe	Significant	Moderate	Slight
Annoyance ²		% of Population ₃ Highly Annoyed	37%	25%	15%	%6	4%
Speech Interference	Outdoor	Distance in Meters for 95% Sentence Intelligibility	0.5	6.0	1.5	2.0	3.5
Speech Interferen	Indoor	%Sentence Intelligibility	%86	%66	100%	100%	100%
Hearing		Qualitative Description	May Begin to Occur	Will Not Likely Occur	Will Not Occur	WIII Not Occur	Will Not Occur
EFFECTS ¹		DAY-NIGHT AVERAGE SOUND LEVEL IN DECIBELS	75 and above	70	65	09	55 and below

- 1. "Speech Interference" data are drawn from the following tables in EPA's "Levels:Document": Table 3, Fig. D-1, Fig. D-2, Fig. D-3. All other data from National Academy of Science 1977 report "Guidelines for Preparing Environmental Impact Statements on Noise, Report of Working Group 69 on Evaluation of Environmental Impact of Noise."
- 2. Depends on attitudes and other factors.
- The percentages of people reporting annoyance to lesser extents are higher in each case. An unknown small percentage of people will report being "highly annoyed" even in the
- quietest surroundings. One reason is the difficulty all people have in integrating annoyance over a very long time.
- 4. Attitudes or other non-acoustic factors can modify this. Noise at low levels can still be an important problem, particularly when it intrudes into a quiet environment.
- NOTE: Research implicates noise as a factor producing stress-related health effects such as heart disease, high-blood pressure and stroke, ulcers and other digestive disorders. The relationships between noise and these effects, however, have not as yet been quantified.

LAND USE	ADJUSTED YEARLY DAY-NIGHT AVERAGE SOUND LEVEL (DNL) IN DECIBELS 60 60 70 80 9
Residential — Single Family, Extensive Outdoor Use	
Residential — Multiple Family, Moderate Outdoor Use	
Residential — Multi—Story Limited Outdoor Use	
Hotels, Motels Transient Lodging	
School Classrooms, Libraries, Religious Facilities	
Hospitals, Clinics, Nursing Homes, Health Related Facilities	
Auditoriums, Concert Halls	
Music Shells	
Sports Arenas, Outdoor Spectator Sports	
Neighborhood Parks	
Playgrounds, Golf courses, Riding Stables, Water Rec., Cemeteries	
Office Buildings, Personal Services, Business and Professional	
Commercial — Retail, Movie Theaters, Restaurants	
Commercial — Wholesale, Some Retail, Ind., Mfg., Utilities	
Livestock Farming, Animal Breeding	
Agriculture (Except Livestock)	
Compatible	Marginally Compatible
With Insulation per Section A.4	Incompatible

LAND USE COMPATIBILITY WITH YEARLY AVERAGE DAY-NIGHT AVERAGE SOUND LEVEL (DNL) AT A SITE FOR BUILDINGS AS COMMONLY CONSTRUCTED.

(Source: American National Standards Institute S12.9—1998/Part 5)

FIGURE 2

roadway is a high speed freeway. Due to noise shielding effects from intervening structures, interior lots are usually exposed to 3 to 10 DNL lower noise levels than the front lots which are not shielded from the traffic noise.

For the purposes of determining noise acceptability for funding assistance from federal agencies, an exterior noise level of 65 DNL or lower is considered acceptable. These federal agencies include the Federal Aviation Administration (FAA), Department of Defense (DOD); Federal Housing Administration, Housing and Urban Development (FHA/HUD), and Veterans Administration (VA). This standard is applied nationally (see Reference 3), including Hawaii.

Because of our open-living conditions, the predominant use of naturally ventilated dwellings, and the relatively low exterior-to-interior sound attenuation afforded by these naturally ventilated structures, an exterior noise level of 65 DNL does not eliminate all risks of noise impacts. Because of these factors, a lower level of 55 DNL is considered as the "Unconditionally Acceptable" (or "Near-Zero Risk") level of exterior noise (see Reference 4). For typical, naturally ventilated structures in Hawaii, an exterior noise level of 55 DNL results in an interior level of approximately 45 DNL, which is considered to be the "Unconditionally Acceptable" (or "Near-Zero Risk") level of interior noise. However, after considering the cost and feasibility of applying the lower level of 55 DNL, government agencies such as FHA/HUD and VA have selected 65 DNL as a more appropriate regulatory standard.

For commercial, industrial, and other non-noise sensitive land uses, exterior noise levels as high as 75 DNL are generally considered acceptable. Exceptions to this occur when naturally ventilated office and other commercial establishments are exposed to exterior levels which exceed 65 DNL.

In the State of Hawaii, the State Department of Health (DOH) regulates noise from on-site activities. State DOH noise regulations are expressed in maximum allowable property line noise limits rather than DNL (see Reference 5). The noise limits apply on all islands of the State, including the island of Hawaii. Although they are not directly comparable to noise criteria expressed in DNL, State DOH noise limits for preservation/residential, apartment/commercial, and agricultural/industrial lands equate to approximately 55, 60, and 76 DNL, respectively.

Because the proposed project site is located on lands planned for single family and multifamily residential, and resort uses, various DOH noise limits may be applicable along the lot boundary lines or receptor locations for any stationary machinery, or equipment related to commercial or construction activities. These property line limits are 60 dBA and 50 dBA during the daytime and nighttime periods, respectively, for resort lots. For multifamily or apartment use, the State DOH limits are also 60 dBA and 50 dBA during the daytime and nighttime periods, respectively. For single family residential and public facility uses, the State DOH limits are 55 dBA and 45 dBA during the daytime and nighttime periods, respectively. These noise limits cannot be exceeded for

more than 2 minutes in any 20-minute time period under the State DOH noise regulations. The State DOH noise regulations do not apply to aircraft or motor vehicles.

CHAPTER IV. GENERAL STUDY METHODOLOGY

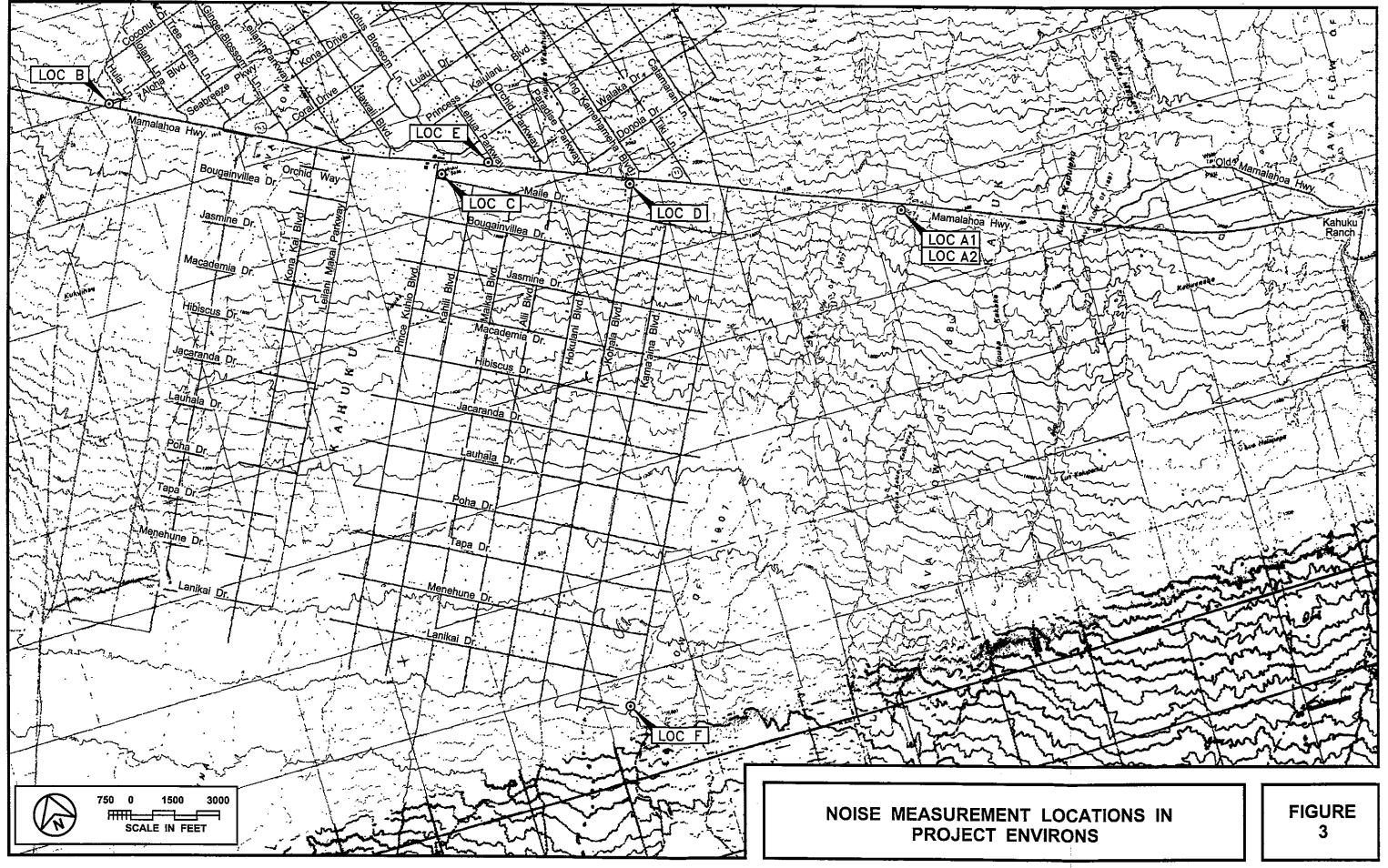
Existing traffic and background ambient noise levels were measured at seven locations in the project environs to provide a basis for developing the traffic noise levels along Mamalahoa Highway, which is the primary roadway which will service the proposed development. The measurements were also used for determining the existing background ambient noise levels in the project area.

The locations of the measurement sites are shown in Figure 3. Noise measurements were performed in December 2010 and March 2011. The traffic noise measurement results, and their comparisons with computer model predictions of existing traffic noise levels are summarized in Table 3. The results of the traffic noise measurements were compared with calculations of existing traffic noise levels to validate the computer model used.

Traffic noise calculations for the existing conditions as well as noise predictions for the future conditions with and without the project were performed using the Federal Highway Administration (FHWA) Noise Prediction Model, Version 2.5 (Reference 6). Traffic data entered into the noise prediction model were: hourly traffic volumes, average vehicle speeds, estimates of traffic mix, and loose soil propagation loss factor. The traffic assignments for the project (Reference 7) and Hawaii State Department of Transportation counts on Mamalahoa Highway (References 8 through 10) were the primary sources of data inputs to the model. For existing and future traffic, it was assumed that the average noise levels, or Leq(h), during the PM peak hour were 1.2 dB less than the 24-hour DNL along Mamalahoa Highway and the project's Entrance Road. This assumption was based on computations of both the hourly Leq and the 24-hour DNL of traffic noise along Mamalahoa Highway (see Figure 4).

Traffic noise calculations for both the existing and future conditions in the project environs along Mamalahoa Highway and along the project's Entrance Road were developed for ground level receptors without the benefit of shielding effects. Traffic assignments with and without the project were obtained from the project's traffic impact analysis report (Reference 7). The forecasted increases in traffic noise levels over existing levels were calculated for scenarios with and without the project. Areas with potential adverse noise impacts resulting from the project were identified. The relative contributions of non-project and project related traffic to the total noise levels were also calculated, and an evaluation was made of possible traffic noise impacts resulting from the project.

Along the proposed project's Entrance Road, calculations of future traffic noise levels at project build out in CY 2030 were made. The setback distances to the 65 and 70 DNL traffic noise contours were also determined using the future traffic volumes contained in Reference 7. General recommendations for traffic noise mitigation measures were also provided to minimize risks of traffic noise impacts on future occupants of Kahuku Village.



Page 11

TABLE 3
TRAFFIC AND BACKGROUND NOISE MEASUREMENT RESULTS

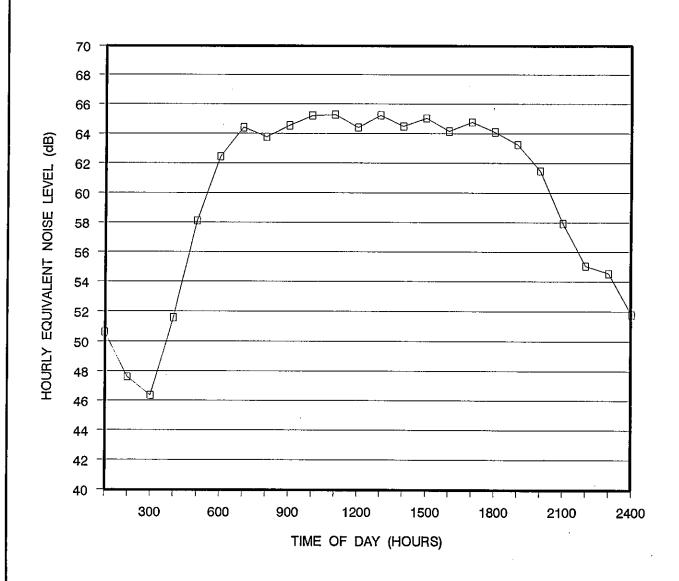
Predicted Leg (dB)	62.0	56.5	58.5	53.8	55.3	56.3
Measured <u>Leg (dB)</u>	61.6	53.8	56.7	54.9	54.0	55.8
olume H.TRUCK	S,	ω	4	ω	7	ဖ
ly Traffic Volume <u>M.TRUCK</u> <u>H.TRUCK</u>	0	0	ဖ	И	7	7
Hour AUTO	100	100	210	316	222	188
Ave. Speed Hourly Traffic Volume (MPH) AUTO M.TRUCK	09	09	58	. 55	09	09
Time of Day (HRS)	0648 TO 0748	0648 TO 0748	0907 TO 0937	0954 TO 1024	1039 TO 1109	1257 TO 1329
LOCATION	A1. 50 FT from centerline of Mamalahoa Highway (3/28/11)	A2. 100 FT from centerline of Mamalahoa Highway (3/28/11)	B. 122 FT from centerline of Mamalahoa Highway (3/28/11)	C. 370 FT from centerline of Mamalahoa Highway (3/28/11)	D. 258 FT from centerlineof Mamalahoa Highway(3/28/11)	E. 138 FT from centerline of Mamalahoa Highway(3/28/11)

TABLE 3 (CONTINUED)
TRAFFIC AND BACKGROUND NOISE MEASUREMENT RESULTS

	LOCATION	Time of Day (HRS)	Time of Day Ave. Speed Hourly Traffic Volume (HRS) (MPH) AUTO M.TRUCK H.TRUCK	Hou <u>AUTO</u>	Hourly Traffic Volume AUTO M.TRUCK H.TRUCK	olume H.TRUCK	Measured Leg (dB)	Predicted Leg (dB)
⋖	A1. 50 FT from centerline of Mamalahoa Highway (3/28/11)	1549 TO 1649	09	216	/-	ო -	63.6	64.2
∢	A2. 100 FT from centerline of Mamalahoa Highway (3/28/11)	1549 TO 1649	09	216	~	ო	58.9	58.7
Щ Page 12	F. At east end of last road and at south end of Kamaaina Blvd. (12/12/10)	1508 TO 1530	N/A	N/A	N/A	N/A	22.0	N/A

FIGURE 4

HOURLY VARIATIONS OF TRAFFIC NOISE AT 50 FT SETBACK DISTANCE FROM THE CENTERLINE OF MAMALAHOA HIGHWAY BETWEEN PRINCE KUHIO DR. AND 78 MILEPOST AT END OF MEDIAN (OCT. 16, 2006)



☐ 50 FT from Roadway Centerline (66.0 DNL)

CHAPTER V. EXISTING NOISE ENVIRONMENT

The existing traffic noise levels in the project environs vary from levels of approximately 66 DNL along the Mamalahoa Highway Rights-of-Way, to less than 40 DNL at the interior locations of the project site which are removed from the highway and coastline. Traffic noise levels along Mamalahoa Highway are approximately 66 DNL at 50 feet setback distance from the highway centerline. Traffic noise levels decrease to approximately 55 DNL at 186 feet setback distance from the highway centerline.

Appendix C contains the existing traffic volumes on Mamalahoa Highway near the project's proposed Entrance Road. Calculations of existing traffic noise levels during the AM and PM peak traffic hours using the traffic volumes contained in Appendix C are presented in Tables 4A and 4B. The hourly Leq (or Equivalent Sound Level) contribution from each roadway section in the project environs was calculated for comparison with forecasted traffic noise levels with and without the project. The existing setback distances from the roadways' centerlines to their associated 65 and 70 DNL contours were also calculated as shown in Table 5. The contour line setback distances do not take into account noise shielding effects or the additive contributions of traffic noise from intersecting street sections. Based on the results of Table 5, it was concluded that the existing 65 DNL traffic noise contour is located at approximately 55 feet from the centerline of Mamalahoa Highway.

At setback distances of 100 feet from the Mamalahoa Highway centerline, existing traffic noise levels are approximately 60 DNL. Because the existing residences located along Mamalahoa Highway and west of the project site are typically set back at least 100 feet or greater distances from the highway centerline, existing traffic noise levels at these existing residences closest to the highway are typically less than 60 DNL.

At setback distances of 186 feet from the Mamalahoa Highway centerline, existing traffic noise levels are less than 55 DNL, and present minimal risk of adverse noise impacts. At the locations in the project area which are removed from Mamalahoa Highway or the shoreline (such as at Location F), local traffic noise, maintenance equipment, dog barking, and the natural sounds of birds and winds in foliage are the dominant noise sources. Between motor vehicle or maintenance equipment noise events, background ambient noise levels can drop to a range of 15 to 20 dBA. The minimum background ambient noise levels at these interior locations are controlled by distant traffic, the sounds of birds, and wind noise. At locations near the shoreline, the sounds of surf become the dominant background noise source, with background noise levels in the order of 50 to 60 dBA.

TABLE 4A

EXISTING (CY 2010) TRAFFIC VOLUMES AND NOISE LEVELS ALONG VARIOUS ROADWAY SECTIONS (AM PEAK HOUR)

	SPEED	TOTAL	****** V	OLUMES (VI	PH) *******	*		
LOCATION	<u>(MPH)</u>	<u>VPH</u>	AUTOS	M TRUCKS	<u>H TRUCKS</u>	<u>50' Leq</u>	<u>100' Leq</u>	150' Leq
Mamalahoa Hwy. West of Project Entrance Road	60	183	174	0	9	64.4	58.9	55.6
Mamalahoa Hwy. East of Project Entrance Road	60	183	174	0	9	64.4	58.9	55.6
Proposed Project Entrance Road (Open Areas)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Proposed Project Entrance Road (Developed Areas)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Notes

- 1. Traffic mix along Mamalahoa Highway was assumed to consist of 95.19% automobiles, 0.01% medium trucks, and 4.80% heavy trucks and buses.
- 2. Loose Soil ground attenuation factor was assumed.

TABLE 4B

EXISTING (CY 2010) TRAFFIC VOLUMES AND NOISE LEVELS ALONG VARIOUS ROADWAY SECTIONS (PM PEAK HOUR)

	SPEED	TOTAL	****** V	OLUMES (VI	PH) *******	•		
<u>LOCATION</u>	<u>(MPH)</u>	<u>VPH</u>	<u>AUTOS</u>	M TRUCKS	H TRUCKS	<u>50' Leq</u>	100' Leq	150' Leq
Mamalahoa Hwy. West of Project Entrance Road	60	231	227	1	3	64.6	58.9	55.4
Mamalahoa Hwy. East of Project Entrance Road	60	231	227	1	3	64.6	58.9	55.4
Proposed Project Entrance Road (Open Areas)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Proposed Project Entrance Road (Developed Areas)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Notes:

- 1. Traffic mix along Mamalahoa Highway was assumed to consist of 98.10% automobiles, 0.50% medium trucks, and 1.40% heavy trucks and buses.
- 2. Loose Soil ground attenuation factor was assumed.

TABLE 5
YEAR 2010 AND 2030 DISTANCES TO 65 AND 70 DNL CONTOURS

	65 DNL SE	TBACK (FT)	70 DNL SE	TBACK (FT)
STREET SECTION	CY 2010	CY 2030	<u>CY 2010</u>	CY 2030
Mamalahoa Hwy. West of Project Entrance Road	55	118	30	65
Mamalahoa Hwy. East of Project Entrance Road	55	118	30	65
Proposed Project Entrance Road (Open Areas)	N/A	132	N/A	72
Proposed Project Entrance Road (Developed Areas)	N/A	98	N/A	53

Notes:

- (1) All setback distances are from the roadways' centerlines.
- (2) See Tables 4A, 4B, 6A, and 6B for traffic volume, speed, and mix assumptions.
- (3) Setback distances are for unobstructed line-of-sight conditions.
- (4) DNL assumed to be 1.2 dB greater than PM peak hour Leq(h) along all roadways.

CHAPTER VI. FUTURE NOISE ENVIRONMENT

Traffic Noise. Predictions of future traffic noise levels were made using the traffic volume assignments of Reference 7 for CY 2030 with and without the proposed project. Appendix C presents the future traffic assignments from Reference 7 for CY 2030 with and without the proposed project. The future assignments of project plus non-project traffic on the roadway sections which would service the project are shown in Tables 6A and 6B for the AM and PM peak hours of traffic, respectively. Also shown in Tables 6A and 6B are the predicted future traffic noise levels at 50, 100, and 150 feet setback distances from the centerlines of the roadways servicing the project.

Tables 7A and 7B present the predicted increases in traffic noise levels by CY 2030 with and without the proposed project for the AM and PM peak hours, respectively, and as measured by the Leq descriptor system. As indicated in Tables 7A and 7B, by CY 2030 and following complete project build-out, traffic noise levels on Mamalahoa Highway in the areas fronting the project are predicted to increase by 6.4 to 6.6 Leq as a result of both project and non-project traffic. The increase in traffic noise DNL values along Mamalahoa Highway from CY 2010 to 2030 is predicted to be 6.4 DNL. This range of increases in traffic noise levels from 6.4 to 6.6 Leq or 6.4 DNL is considered to be large, and reflects the growth in forecasted project related traffic in the project environs by CY 2030, from relatively low Base Year levels in CY 2010. Without the project, increases in traffic noise levels by CY 2030 are expected to be relatively small at 1.5 Leq or DNL, with traffic noise levels essentially similar to present levels.

Table 5 summarizes the predicted increases in the future setback distances to the 65 and 70 DNL traffic noise contour lines along Mamalahoa Highway in the project environs and attributable to both project plus non-project traffic in CY 2030. The setback distances in Table 5 do not include the beneficial effects of noise shielding from terrain features and highway cuts, or the detrimental effects of additive contributions of noise from intersecting streets. As indicated in Table 5, the setback distance to the 65 DNL contour are predicted to be 118 feet from the centerline of Mamalahoa Highway following project build-out in CY 2030.

The planned Kahuku Village is located at the makai (south) section of the project's Entrance Road (see Figure 1). The lands between Mamalahoa Highway and the planned Kahuku Village are anticipated to be vacant in the 2030 planning period. Along the proposed project Entrance Road, posted vehicle speeds of 45 and 35 miles per hour were assumed along the undeveloped (or open) and developed sections of the Entrance Road, respectively. For noise modeling purposes, average vehicle speeds of 55 and 45 miles per hour were used for the undeveloped (or open) and developed sections of the Entrance Road, respectively. Setback distances to the 65 DNL contour are predicted to be approximately 132 feet and 98 feet from the centerline of the Entrance Road along the undeveloped and developed sections, respectively.

TABLE 6A

FUTURE (CY 2030) TRAFFIC VOLUMES AND NOISE LEVELS ALONG VARIOUS ROADWAY SECTIONS (AM PEAK HOUR, WITH PROJECT)

	SPEED	TOTAL	******* V	OLUMES (VI	PH) *******	*		
<u>LOCATION</u>	<u>(MPH)</u>	<u>VPH</u>	<u>AUTOS</u>	M TRUCKS	H TRUCKS	<u>50' Leq</u>	<u>100' Leq</u>	150' Leq
M								
Mamalahoa Hwy. West of Project Entrance Road	60	831	791	0	40	71.0	65.4	62.1
Mamalahoa Hwy. East of Project Entrance Road	60	820	781	0	39	71.0	65.4	62.0
Proposed Project Entrance Road (Open Areas)	55	915	897	5	13	69.4	63.7	60.3
Proposed Project Entrance Road (Developed Areas)	45	915	897	5	13	66.8	61.2	57.9

Notes

- 1. Traffic mix along Mamalahoa Highway was assumed to consist of 95.19% automobiles, 0.01% medium trucks, and 4.8% heavy trucks and buses.
- 2. Traffic mix along Entrance Road was assumed to consist of 98.10% automobiles, 0.50% medium trucks, and 1.40% heavy trucks and buses.
- 3. Loose Soil ground attenuation factor was assumed.

TABLE 6B

FUTURE (CY 2030) TRAFFIC VOLUMES AND NOISE LEVELS ALONG VARIOUS ROADWAY SECTIONS (PM PEAK HOUR, WITH PROJECT)

	SPEED	TOTAL	****** V	OLUMES (VI	PH) *******	*		
LOCATION	<u>(MPH)</u>	<u>VPH</u>	<u>AUTOS</u>	M TRUCKS	<u>H TRUCKS</u>	<u>50' Leq</u>	<u>100' Leq</u>	<u>150' Leq</u>
Mamalahoa Hwy. West of Project Entrance Road	60	989	970	5	. 14	71.0	65.2	61.8
Mamalahoa Hwy. East of Project Entrance Road	60	987	968	5	14	71.0	65.2	61.8
Proposed Project Entrance Road (Open Areas)	55	1,596	1,566	8	22	71.8	66.1	62.7
Proposed Project Entrance Road (Developed Areas)	45	1,596	1,566	8	22	69.2	63.6	60.3

Notes:

- Traffic mix along Mamalahoa Highway was assumed to consist of 98.10% automobiles, 0.50% medium trucks, and 1.40% heavy trucks and buses.
- 2. Traffic mix along Entrance Road was assumed to consist of 98.10% automobiles, 0.50% medium trucks, and 1.40% heavy trucks and buses.
- 3. Loose Soil ground attenuation factor was assumed.

TABLE 7A

CALCULATIONS OF PROJECT AND NON-PROJECT TRAFFIC NOISE CONTRIBUTIONS (CY 2030) (AM PEAK HOUR)

STREET SECTION	NOISE LEVEL (DB) NON-PROJECT TRAFFIC	INCREASE DUE TO: PROJECT TRAFFIC
Mamalahoa Hwy. West of Project Entrance Road	1.5	5.1
Mamalahoa Hwy. East of Project Entrance Road	1.5	5.1
Proposed Project Entrance Road (Open Areas)	N/A	69.4
Proposed Project Entrance Road (Developed Areas)	N/A	66.8

TABLE 7B

CALCULATIONS OF PROJECT AND NON-PROJECT TRAFFIC NOISE CONTRIBUTIONS (CY 2030) (PM PEAK HOUR)

STREET SECTION	NOISE LEVEL (DB) NON-PROJECT TRAFFIC	INCREASE DUE TO: PROJECT TRAFFIC
Mamalahoa Hwy. West of Project Entrance Road	1.5	4.9
Mamalahoa Hwy. East of Project Entrance Road	1.5	4.9
Proposed Project Entrance Road (Open Areas)	N/A	71.8
Proposed Project Entrance Road (Developed Areas)	N/A	69.2

VII. DISCUSSION OF PROJECT RELATED NOISE IMPACTS AND POSSIBLE NOISE MITIGATION MEASURES

<u>Traffic Noise At Existing Residences</u>. The increases in traffic noise levels attributable to the project from the present to CY 2030 are predicted to be 4.9 DNL along Mamalahoa Highway, where traffic noise levels are expected to remain above 65 DNL along the highway Rights-of-Way. These increases in traffic noise levels along Mamalahoa Highway which are attributable to the project are considered to be large, and are higher than the traffic noise increase of 1.5 DNL expected as a result of non-project traffic.

The project lands which front Mamalahoa Highway are currently vacant, as are the lands on the mauka (north) and east sides of the project site. Residential and commercial developments are located along Mamalahoa Highway west of the project site. The lands along the highway Rights-of-Way and within 118 feet of the highway centerline are generally vacant west of the project site except for commercial structures. Existing residences west of the project site are located beyond 118 feet from the highway centerline, At setback distances of 118 feet from the highway centerline, CY 2030 traffic noise levels are not expected to exceed the FHA/HUD standard of 65 DNL.

In summary, the traffic forecasts for CY 2030 conditions indicate that future traffic noise levels with the project should not exceed the FHA/HUD acceptability threshold of 65 DNL at existing residences in the project environs. For this reason, traffic noise mitigation measures should not be required at these existing residences.

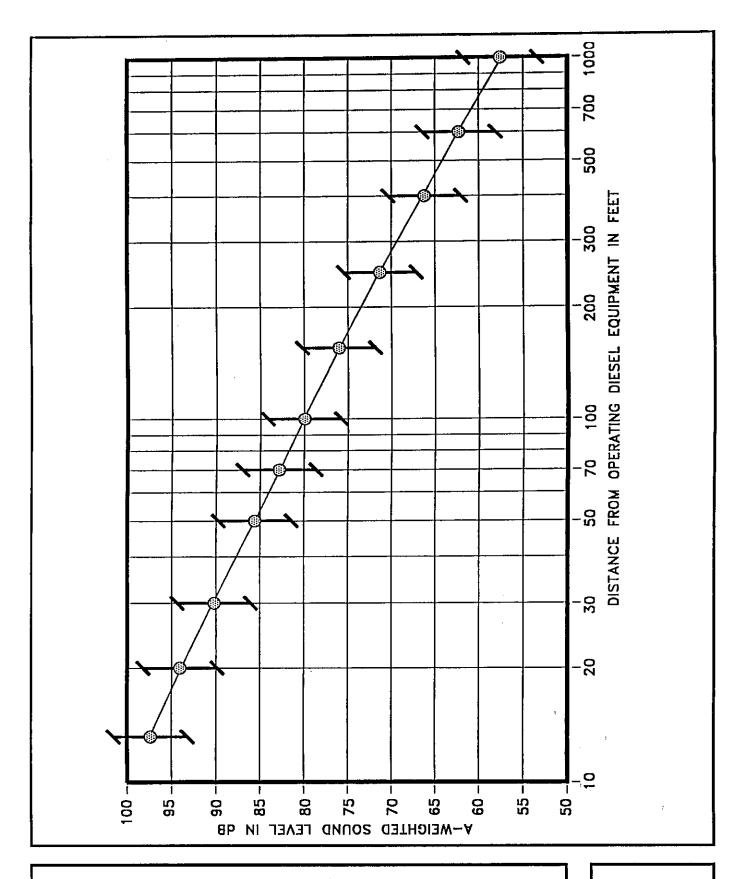
Traffic Noise At Future Project Residences. Future Kahuku Village residences are planned along the makai (south) sections of the project's Entrance Road. At the Mamalahoa Highway end of the Entrance Road, the setback distance to the 65 DNL contour is predicted to be 132 feet at an average vehicle speed of 55 miles per hour. At the Kahuku Village end of the Entrance Road, where average vehicle speeds are expected to be lower at 45 miles per hour, and the setback distance to the 65 DNL contour is predicted to be 98 feet. Because the existing background noise levels in the area planned for Kahuku Village are very low and less than 55 DNL, it is suggested that maximum practical setback distances be provided between the project's entrance and interior roadways and noise sensitive developments such as residences, learning centers, and hotel units.

The construction of minimum 6 foot high sound attenuation walls and/or berms at planned residences or other noise sensitive uses which front the high volume roadways is also recommended if adequate buffer space is not available along the high volume roadways. The exact height and length of the sound attenuation wall will need to be determined after the lot, house pad, and grading plans become available. Where both adequate setback distance or the addition of sound attenuating walls and/or berms are not feasible, the use of closure and air conditioning of the noise sensitive structures is the remaining noise mitigation measure which could be applied.

It should be noted that the "Minimal Exposure, Unconditionally Acceptable" noise exposure level is 55 DNL. Where future noise sensitive structures are predicted to be exposed to traffic noise levels greater than 55 DNL, there is some risk of occupant dissatisfaction due to future traffic noise levels at these future noise sensitive structures. A noise exposure level of 55 DNL is significantly less than the FHA/HUD standard of 65 DNL, so mitigation of noise at levels between 65 and 55 DNL is voluntary rather than mandatory.

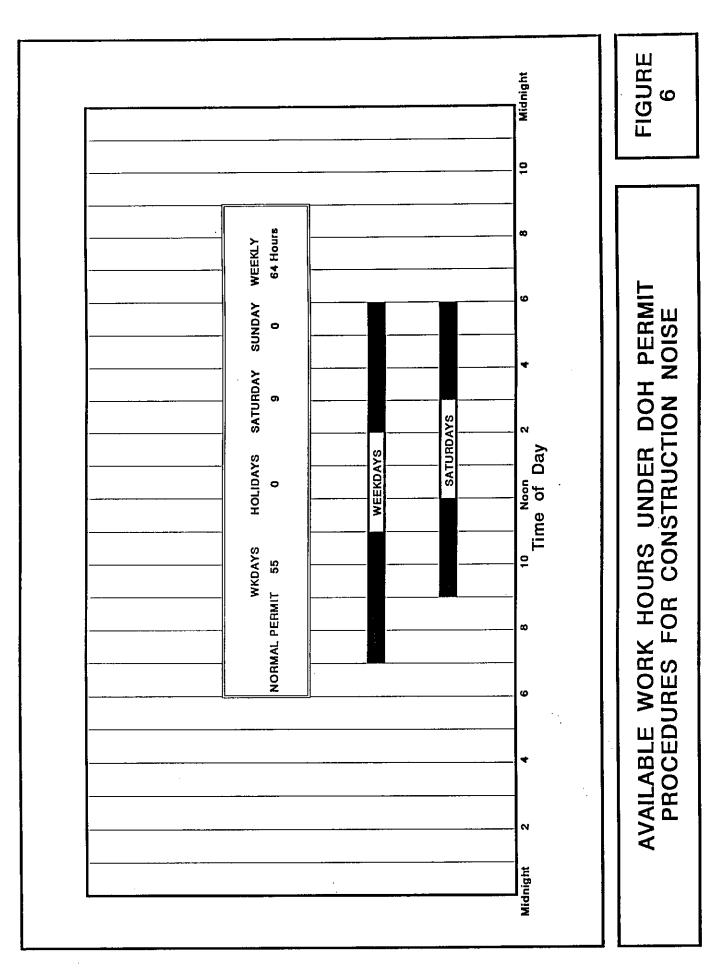
Construction Noise. Audible construction noise will probably be unavoidable during the entire project construction period. The total time period for construction is unknown, but it is anticipated that the actual work will be moving from one location on the project site to another during that period. Actual length of exposure to construction noise at any receptor location will probably be less than the total construction period for the entire project. Typical levels of noise from construction activity (excluding pile driving activity) are shown in Figure 5. The noise sensitive properties which are predicted to experience the highest noise levels during construction activities on the project site are the existing residences near Location F (see Figure 3) which are northwest of the planned Kahuku Village. Adverse impacts from construction noise are not expected to be in the "public health and welfare" category due to the temporary nature of the work and due to the administrative controls available for its regulation. Instead, these impacts will probably be limited to the temporary degradation of the quality of the acoustic environment in the vicinity of the project site.

Mitigation of construction noise to inaudible levels will not be practical in all cases due to the intensity of construction noise sources (80 to 90+ dBA at 50 feet distance), due to the exterior nature of the work (grading and earth moving, trenching, concrete pouring, hammering, etc.), and due to the very low background noise levels of of 22 dBA measured at Location F. The use of properly muffled construction equipment should be required on the job site. The incorporation of State Department of Health construction noise limits and curfew times, which are applicable on the island of Hawaii (Reference 5), is another noise mitigation measure which can be applied to this project. Figure 6 depicts the normally permitted hours of construction for normal construction noise as well as the curfew periods for construction noise. Noisy construction activities are not allowed on Sundays and holidays under the DOH permit procedures.



ANTICIPATED RANGE OF CONSTRUCTION NOISE LEVELS VS. DISTANCE

FIGURE 5



Page 24

APPENDIX A. REFERENCES

- (1) "Guidelines for Considering Noise in Land Use Planning and Control;" Federal Interagency Committee on Urban Noise; June 1980.
- (2) American National Standard, "Sound Level Descriptors for Determination of Compatible Land Use," ANSI S12.9-1998/ Part 5; Acoustical Society of America.
- (3) "Environmental Criteria and Standards, Noise Abatement and Control, 24 CFR, Part 51, Subpart B;" U.S. Department of Housing and Urban Development; July 12, 1979.
- (4) "Information on Levels of Environmental Noise Requisite to Protect the Public Health and Welfare with an Adequate Margin of Safety;" U.S. Environmental Protection Agency; EPA 550/9-74- 004; March 1974.
- (5) "Title 11, Administrative Rules, Chapter 46, Community Noise Control;" Hawaii State Department of Health; September 23, 1996.
- (6) "FHWA Highway Traffic Noise Model User's Guide;" FHWA-PD-96-009, Federal Highway Administration; Washington, D.C.; January 1998 and Version 2.5 Upgrade (April 14, 2004).
- (7) Draft Traffic Impact Analysis Report for the Proposed Kahuku Village Project; The Traffic Management Consultant; March 2011.
- (8) 24-Hour Traffic Counts, Station B71001107663, Mamalahoa Highway Between Prince Kuhio Drive and 78 Milepost At End of Median; State Department of Transportation; October 16, 2006.
- (9) 24-Hour Traffic Counts, Station B71001107663, Mamalahoa Highway Between Prince Kuhio Drive and 78 Milepost At End of Median; State Department of Transportation; October 17, 2006.
- (10) 24-Hour Vehicle Type Classification Counts, Station B71001107663, Mamalahoa Highway Between Prince Kuhio Drive and 78 Milepost At End of Median; State Department of Transportation; October 16-17, 2006.

APPENDIX B

EXCERPTS FROM EPA'S ACOUSTIC TERMINOLOGY GUIDE

Descriptor Symbol Usage

The recommended symbols for the commonly used acoustic descriptors based on A-weighting are contained in Table I. As most acoustic criteria and standards used by EPA are derived from the A-weighted sound level, almost all descriptor symbol usage guidance is contained in Table I.

Since acoustic nomenclature includes weighting networks other than "A" and measurements other than pressure, an expansion of Table I was developed (Table II). The group adopted the ANSI descriptor-symbol scheme which is structured into three stages. The first stage indicates that the descriptor is a level (i.e., based upon the logarithm of a ratio), the second stage indicates the type of quantity (power, pressure, or sound exposure), and the third stage indicates the weighting network (A, B, C, D, E....). If no weighting network is specified, "A" weighting is understood. Exceptions are the A-weighted sound level and the A-weighted peak sound level which require that the "A" be specified. For convenience in those situations in which an A-weighted descriptor is being compared to that of another weighting, the alternative column in Table II permits the inclusion of the "A". For example, a report on blast noise might wish to contrast the LCdn with the LAdn.

Although not included in the tables, it is also recommended that "Lpn" and "LepN" be used as symbols for perceived noise levels and effective perceived noise levels, respectively.

It is recommended that in their initial use within a report, such terms be written in full, rather than abbreviated. An example of preferred usage is as follows:

The A-weighted sound level (LA) was measured before and after the installation of acoustical treatment. The measured LA values were 85 and 75 dB respectively.

<u>Descriptor Nomenclature</u>

With regard to energy averaging over time, the term "average" should be discouraged in favor of the term "equivalent". Hence, Leq, is designated the "equivalent sound level". For Ld, Ln, and Ldn, "equivalent" need not be stated since the concept of day, night, or day-night averaging is by definition understood. Therefore, the designations are "day sound level", "night sound level", and "day-night sound level", respectively.

The peak sound level is the logarithmic ratio of peak sound pressure to a reference pressure and not the maximum root mean square pressure. While the latter is the maximum sound pressure level, it is often incorrectly labelled peak. In that sound level meters have "peak" settings, this distinction is most important.

"Background ambient" should be used in lieu of "background", "ambient", "residual", or "indigenous" to describe the level characteristics of the general background noise due to the contribution of many unidentifiable noise sources near and far.

With regard to units, it is recommended that the unit decibel (abbreviated dB) be used without modification. Hence, DBA, PNdB, and EPNdB are not to be used. Examples of this preferred usage are: the Perceived Noise Level (Lpn was found to be 75 dB. Lpn = 75 dB). This decision was based upon the recommendation of the National Bureau of Standards, and the policies of ANSI and the Acoustical Society of America, all of which disallow any modification of bel except for prefixes indicating its multiples or submultiples (e.g., deci).

Noise Impact

In discussing noise impact, it is recommended that "Level Weighted Population" (LWP) replace "Equivalent Noise Impact" (ENI). The term "Relative Change of Impact" (RCI) shall be used for comparing the relative differences in LWP between two alternatives.

Further, when appropriate, "Noise Impact Index" (NII) and "Population Weighed Loss of Hearing" (PHL) shall be used consistent with CHABA Working Group 69 Report <u>Guidelines for Preparing Environmental Impact</u> Statements (1977).

APPENDIX B (CONTINUED)

TABLE I A-WEIGHTED RECOMMENDED DESCRIPTOR LIST

	<u>TERM</u>	SYMBOL
1.	A-Weighted Sound Level	LA
2.	A-Weighted Sound Power Level	LWA
3.	Maximum A-Weighted Sound Level	L _{max}
4.	Peak A-Weighted Sound Level	L _{Apk}
5.	Level Exceeded x% of the Time	Lx
6.	Equivalent Sound Level	L _{eq}
7.	Equivalent Sound Level over Time (T) (1)	L _{eq(T)}
8.	Day Sound Level	L _d
9.	Night Sound Level	L _n
10.	Day-Night Sound Level	L _{dn}
11.	Yearly Day-Night Sound Level	L _{dn(Y)}
12.	Sound Exposure Level	L _{SE}

(1) Unless otherwise specified, time is in hours (e.g. the hourly equivalent level is $L_{eq(1)}$). Time may be specified in non-quantitative terms (e.g., could be specified a $L_{eq(WASH)}$ to mean the washing cycle noise for a washing machine).

SOURCE: EPA ACOUSTIC TERMINOLOGY GUIDE, BNA 8-14-78,

APPENDIX B (CONTINUED)

TABLE II RECOMMENDED DESCRIPTOR LIST

	TERM A-WE	EIGHTING	ALTERNATIVE ⁽¹ A-WEIGHTING	OTHER ⁽²⁾ WEIGHTING	UNWEIGHTED
1.	Sound (Pressure) ⁽³⁾ Level	LA	L _{pA}	L _B , L _{pB}	Lр
2. 3.	Sound Power Level Max. Sound Level	L _{WA}	١.	L _{WB}	L _W . L _{may}
4.	Peak Sound (Pressure) Level	L _{Apk}	^L Amax	L _{Bpk}	^L pmax ^L pk
5.	Level Exceeded x% of the Time	r ^x	^L Ax	L _{Bx}	L _{px}
6.	Equivalent Sound Level	L _{eq}	L _{Aeq}	L _{Beq}	L _{peq}
7.	Equivalent Sound Level (4) Over Time(T)	Leq(T)	L _{Aeq(T)}	L _{Beq(T)}	Lpeq(T)
8.	Day Sound Level	Ld	L _{Ad}	L _{Bd}	^L pd
9.	Night Sound Level	Ln	LAn	L _{Bn}	^L pn
10.	Day-Night Sound Level	Ldn	L _{Adn}	L _{Bdn}	^L pdn
11.	Yearly Day-Night Sound Level	L _{dn(Y)}	L _{Adn(Y)}	^L Bdn(Y)	Lpdn(Y)
12.	Sound Exposure Level	L _S	L _{SA}	L _{SB} `	L _{Sp}
13.	Energy Average Value Over (Non-Time Domain) Set of Observations	L _{eq(e)}	L Aeq(e)	L _{Beq(e)}	L peq(e)
14.	Level Exceeded x% of the Total Set of (Non-Time Domain) Observations	L _x (e)	^L Ax(e)	L _{Bx(e)}	L _{px(e)}
15.	Average L _x Value	r _x	L _{Ax}	L _{Bx}	L _{px}

^{(1) &}quot;Alternative" symbols may be used to assure clarity or consistency.

⁽²⁾ Only B-weighting shown. Applies also to C,D,E,.....weighting.

⁽³⁾ The term "pressure" is used only for the unweighted level.

⁽⁴⁾ Unless otherwise specified, time is in hours (e.g., the hourly equivalent level is Leq(1). Time may be specified in non-quantitative terms (e.g., could be specified as Leq(WASH) to mean the washing cycle noise for a washing machine.

APPENDIX C

SUMMARY OF BASE YEAR AND FUTURE YEAR TRAFFIC VOLUMES

ROADWAY LANES	**** CY 2 AM VPH	2010 ***** PM VPH	CY 2030 (AM VPH	NO BUILD) PM VPH	CY 2030 AM VPH) (BUILD) PM VPH
Mamalahoa Hwy West of Access Road (EB)	102	104	143	145	469	447
Mamalahoa Hwy West of Access Road (WB)	81	127	113	178	362	542
Two-Way	183	231	256	323	831	989
Mamalahoa Hwy East of Access Road (EB)	102	104	143	145	415	456
Mamalahoa Hwy East of Access Road (WB)	81	127	113	178	405	531
Two-Way	183	231	256	323	820	987
Kahuku Village Access Road (NB)	N/A	N/A	N/A	N/A	409	808
Kahuku Village Access Road (SB)	N/A	N/A	N/A	N/A	506	788
Two-Way	N/A	N/A	N/A	N/A	915	1,596

APPENDIX H In In In 11.11.11 AIR QUALITY STUDY In 11.11.11 11.11.11 In In In In In In 11.11.11 11.11.11 11.11.11 In In In

AIR QUALITY STUDY FOR THE PROPOSED KAHUKU VILLAGE PROJECT

KAU DISTRICT, HAWAII

Prepared for:

Nani Kahuku Aina, LLC

July 2011



P.O. BOX 1808 * KAILUA-KONA, HAWAII 96745 * TELEPHONE (808) 329-1627 * FAX (808) 331-8428 EMAIL: bdneal@kona.net

CONTENTS

S	ection		Page
	1.0	Summary	1
	2.0	Introduction	4
	3.0	Ambient Air Quality Standards	5
	4.0	Regional and Local Climatology	7
	5.0	Present Air Quality	11
	6.0	Short-Term Impacts of Project	16
	7.0	Long-Term Impacts of Project	19
	8.0	Conclusions and Recommendations	28
	Refere	ences	30

FIGURES

Figure

1 Project Location Map

TABLES

Table

- 1 Summary of State of Hawaii and National Ambient Air Quality Standards
- 2 Air Pollution Emissions Inventory for Island of Hawaii, 1993
- Annual Summaries of Sulfur Dioxide Measurements for Hawaii Island Monitoring Stations
- 4 Annual Summaries of Particulate Matter (PM2.5) Measurements for Hawaii Island Monitoring Stations

TABLES (cont.)

Table

- 5 Estimated Worst-Case 1-Hour Carbon Monoxide and Nitrogen Dioxide Concentrations Along Roadways Near Kahuku Village Project
- 6 Estimated Worst-Case 8-Hour Carbon Monoxide Concentrations Along Roadways Near Kahuku Village Project

1.0 SUMMARY

Nani Kahuku Aina, LLC is proposing to develop the Kahuku Village Project in the Kau District on the island of Hawaii. The proposed project will consist of a Hawaiian heritage center facility and a mixed-use residential and commercial village. This study evaluates existing air quality conditions in the project area and examines the potential short- and long-term air quality impacts that could occur as a result of construction and use of the proposed facilities. Mitigative measures are suggested to reduce any potential air quality impacts where possible and appropriate.

Both federal and state standards have been established to maintain ambient air quality. At the present time, seven parameters are regulated including: particulate matter, sulfur dioxide, hydrogen sulfide, nitrogen dioxide, carbon monoxide, ozone and lead. Hawaii air quality standards are comparable to the national standards, although in some cases the Hawaii standards are more stringent than the national standards, such as for carbon monoxide. For some other parameters, such as for particulate matter and sulfur dioxide, the national standards are more restrictive.

Regional and local climate together with the amount and type of human activity generally dictate the air quality of a given location. The climate of the project area is very much affected by its near coastal situation and by nearby mountains. Winds are predominantly trade winds from the northeast or east, but kona storms generate occasional strong winds from the south or southwest during winter. Temperatures in the project area are

generally very consistent and moderate with average daily temperatures at nearby Naalehu ranging from about 66°F to 79°F. The extreme minimum temperature recorded at Naalehu is 55°F, while the extreme maximum temperature is 90°F. Average annual rainfall in the area amounts to about 25 inches with much of the precipitation occurring during the winter months.

Except for natural volcanic emissions, there are very few sources of air pollution in the project area. The volcanic emissions (vog) are a significant factor, however. Air quality in the project area has been chronically impacted by volcanic emissions for many years since Kilauea Volcano resumed erupting in 1983. The vog-related air pollution consists mostly of sulfur dioxide gas and fine particulate matter. Air quality data that are available for the general area from the Hawaii Department of Health suggest that sulfur dioxide and fine particulate matter concentrations may sometimes exceed state and/or national air quality standards at the project site.

If the proposed project is given the necessary approvals to proceed, it may be inevitable that some short—and/or long-term impacts on air quality will occur either directly or indirectly as a consequence of project construction and use. Short—term impacts from fugitive dust will likely occur during project construction phases. To a lesser extent, exhaust emissions from stationary and mobile construction equipment, from the disruption of traffic, and from workers' vehicles may also affect air quality during periods of construction. State air pollution control regulations require that there be no visible fugitive dust emissions at the property line. Hence, an effective dust control plan must be implemented

to ensure compliance with state regulations. Fugitive dust emissions can be controlled to a large extent by watering of active work areas, using wind screens, keeping adjacent paved roads clean, and by covering of open-bodied trucks. Other dust control measures could include limiting the area that can be disturbed at any given time and/or mulching or chemically stabilizing inactive areas that have been worked. Paving and landscaping of project areas early in the construction schedule will also reduce dust emissions. Monitoring dust at the project boundary during the period of construction could be considered as a means to evaluate the effectiveness of the project dust control program. Exhaust emissions can be mitigated by moving construction equipment and workers to and from the project site during off-peak traffic hours.

To assess the potential long-term impact of emissions from project-related motor vehicle traffic operating on roadways in the project area after construction is completed, a computerized air quality modeling study was undertaken. The air quality modeling study estimated current worst-case concentrations of carbon monoxide and nitrogen dioxide in the project vicinity and predicted future levels both with and without the proposed project. During worst-case conditions, model results indicated that present 1-hour and 8-hour worst-case carbon monoxide and nitrogen dioxide concentrations are well within both the state and the national ambient air quality standards. In the year 2030 without the project, worst-case carbon monoxide concentrations were predicted to remain unchanged while nitrogen dioxide concentrations would decrease (improve). With the project in the 2030. worst-case carbon monoxide concentrations were projected to increase but remain well within standards. dioxide concentrations would also increase but remain

relatively low levels and well within standards. Due to the small impact the project is expected to have, implementing mitigation measures for long-term traffic-related air quality impacts is probably unnecessary and unwarranted.

2.0 INTRODUCTION

Nani Kahuku Aina, LLC is proposing to develop the Kahuku Village Project located in the Kau District on the island of Hawaii (see Figure 1 for project location). The project site is situated on 16,457 acres between the Hawaiian Ocean View Ranchos to the west, the Damon Trust Lands and Kamehameha Schools property to the east, Mamalahoa Highway to the north and the Pacific Ocean to the south. The project includes the construction of the Hawaiian Heritage Center and a mixed-use residential and commercial village. Hawaiian Heritage Center facilities will include a visitor's classrooms, meeting space, laboratories, dormitory caretaker's residence, comfort stations housing, a campgrounds. The mixed-use village will include 1,050 single- and multi-family residential units, 200,000 square feet of retailcommercial space, an 18-hole golf course, two 250-room hotels, a civic center, a Veterans Administration Facility and parks. main access to the development is proposed as an at-grade intersection on Mamalahoa Highway about 5 miles west of South Point Road. Development of the project would occur in phases and be completed by 2030.

The purpose of this study is to describe existing air quality in the project area and to assess the potential short— and long-term direct and indirect air quality impacts that could result from construction and use of the proposed facilities as planned. Measures to mitigate project impacts are suggested where possible and appropriate.

3.0 AMBIENT AIR QUALITY STANDARDS

Ambient concentrations of air pollution are regulated by both national and state ambient air quality standards (AAQS). National AAQS are specified in Section 40, Part 50 of the Code of Federal Regulations (CFR), while State of Hawaii AAQS are defined in Chapter 11-59 of the Hawaii Administrative Rules. summarizes both the national and the state AAQS that are specified in the cited documents. As indicated in the table, national and state AAQS have been established for particulate matter, sulfur dioxide, nitrogen dioxide, carbon monoxide, ozone and The state has also set a standard for hydrogen sulfide. National AAQS are stated in terms of both primary and secondary standards for most of the regulated air pollutants. primary standards are designed to protect the public health with an "adequate margin of safety". National secondary standards, on the other hand, define levels of air quality necessary to protect the public welfare from "any known or anticipated adverse effects of a pollutant". Secondary public welfare impacts may include such effects as decreased visibility, diminished comfort levels, or other potential injury to the natural or man-made environment, e.g., soiling of materials, damage to vegetation or other economic damage. In contrast to the national AAQS, Hawaii State AAQS are given in terms of a single standard that is designed "to protect public health and welfare and to prevent the significant deterioration of air quality".

Each of the regulated air pollutants has the potential to create or exacerbate some form of adverse health effect or to produce environmental degradation when present in sufficiently high concentration for prolonged periods of time. The AAQS specify a maximum allowable concentration for a given air pollutant for one or more averaging times to prevent harmful effects. Averaging times vary from one hour to one year depending on the pollutant and type of exposure necessary to cause adverse effects. In the case of the short-term (i.e., 1- to 24-hour) AAQS, both national and state standards allow a specified number of exceedances each year.

The Hawaii AAQS are in some cases considerably more stringent than the comparable national AAQS. In particular, the Hawaii 1-hour AAQS for carbon monoxide is four times more stringent than the comparable national limit. On the other hand, the current Hawaii AAQS for sulfur dioxide are probably less stringent than the national standards. During the early part of 2010, the national primary annual and 24-hour standards for sulfur dioxide were revoked in favor of a new national 1-hour standard which is considered to be more stringent than the Hawaii short-term standards. The Hawaii AAQS for sulfur dioxide have not yet been updated to bring them in line with the national standards.

In 1993, the state revised its particulate standards to follow those set by the federal government. During 1997, the federal government again revised its standards for particulate, but the new standards were challenged in federal court. A Supreme Court ruling was issued during February 2001, and as a result, the new standards for particulate were finally implemented during 2005.

To date, the Hawaii Department of Health has not updated the state particulate standards.

In September 2001, the state vacated the state 1-hour standard for ozone and an 8-hour standard was adopted that was the same as the national standard. During 2008, the national standard for ozone was again revised and made more stringent. The Hawaii standard for ozone has not yet been amended to follow the national standard.

During the latter part of 2008, EPA revised the standard for lead making the standard more stringent. So far, the Hawaii Department of Health has not revised the corresponding state standard for lead.

During early 2010, a national 1-hour primary standard for nitrogen dioxide was implemented. To date, Hawaii has not promulgated a 1-hour standard for nitrogen dioxide, but the Hawaii annual standard for this pollutant is more stringent than the national annual standard.

4.0 REGIONAL AND LOCAL CLIMATOLOGY

Regional and local climatology significantly affect the air quality of a given location. Wind, temperature, atmospheric turbulence, mixing height and rainfall all influence air quality. Although the climate of Hawaii is relatively moderate throughout most of the state, significant differences in these parameters may occur from one location to another. Most differences in regional

and local climates within the state are caused by the mountainous topography.

The site of the proposed project is located along the southern coast of the island of Hawaii. The topography of Hawaii Island is dominated by the great volcanic masses of Mauna Loa (13,653 feet), Mauna Kea (13,796 feet), and of Hualalai, the Kohala Mountains and Kilauea. The island consists entirely of the slopes of these mountains and of the broad saddles between them. Mauna Loa and Kilauea, located on the southern half of the island, are still active volcanoes. The project site is located on the lower southwestern slope of Mauna Loa.

Hawaii lies well within the belt of northeasterly trade winds generated by the semi-permanent Pacific high pressure cell to the north and east. Areas along the eastern coasts of the islands are particularly affected by the trade winds and are usually well-ventilated nearly year round. Although the project site is situated along the southern coast of Hawaii Island, the nearby high mountains of Mauna Loa and to a lesser extent Kilauea modify the trade wind influence. The nearest long-term wind data available for the project area are collected at the Hilo Airport located about 65 miles to the northeast. These data are probably only semi-representative of the project area. Mean annual wind speed at the Hilo Airport is about 8 mph, which is lower than many windward locations in the state, and wind directions are bimodal showing either a northeast or southwest preference [1]. Northeast trade winds typically occur during the daytime, while winds from the southwest typically occur during the nighttime due to cold air drainage from the mountains. Winds from the south or southwest also occur occasionally in association with winter

storms. Due to the high terrain of Mauna Loa, winds at the project site can be expected to be mostly easterly trade winds during the day. When the trade winds shift toward the north, winds at the project site may be substantially blocked by Mauna Loa. During the night, mountain drainage winds from the north probably often occur.

Air pollution emissions from motor vehicles, the formation of photochemical smog and smoke plume rise all depend in part on air temperature. Colder temperatures tend to result in higher of contaminants from automobiles concentrations of photochemical smog and ground-level concentrations of air pollution from stack sources. In Hawaii, the annual and daily variation of temperature depends to a large degree on elevation above sea level, distance inland and exposure to the trade winds. Average temperatures at locations near sea level generally are warmer than those at higher elevations. exposed to the trade winds tend to have the least temperature variation, while inland and leeward areas often have the most. At nearby Naalehu, average annual daily minimum and maximum temperatures are 66°F and 79°F, respectively. The minimum temperature on record is 55°F, and the extreme maximum is 90°F [2]. Due to the lower elevation, temperatures in the project area can be expected to be a few degrees warmer.

Small scale, random motions in the atmosphere (turbulence) cause air pollutants to be dispersed as a function of distance or time from the point of emission. Turbulence is caused by both mechanical and thermal forces in the atmosphere. It is often measured and described in terms of Pasquill-Gifford stability class.

Stability class 1 is the most turbulent and class 6 the least. Thus, air pollution dissipates the best during stability class 1 conditions and the worst when stability class 6 prevails. In the project area, stability classes 5 or 6 probably often occur, developing during clear, calm nighttime or early morning hours when temperature inversions form due to radiation cooling or to drainage flow from the mountainous interior of the island. Stability classes 1 through 4 occur during the daytime, depending mainly on the amount of cloud cover and incoming solar radiation and the onset and extent of sea breeze conditions.

Mixing height is defined as the height above the surface through which relatively vigorous vertical mixing occurs. Low mixing heights can result in high ground-level air pollution concentrations because contaminants emitted from or near the surface can become trapped within the mixing layer. In Hawaii, minimum mixing heights tend to be high because of mechanical mixing caused by the trade winds and because of the temperature moderating effect of the surrounding ocean. Low mixing heights may sometimes occur, however, at inland locations and even at times along coastal areas early in the morning following a clear, cool, windless night. Coastal areas also may experience low mixing levels during sea breeze conditions when cooler ocean air rushes in over warmer land. Mixing heights in Hawaii typically are above 3000 feet (1000 meters).

Rainfall can have a beneficial affect on the air quality of an area in that it helps to suppress fugitive dust emissions, and it also may "washout" gaseous contaminants that are water soluble. Rainfall in Hawaii is highly variable depending on elevation and

on location with respect to the trade wind. Annual rainfall in the project area is usually sparse. At nearby South Point, normal annual rainfall is about 25 inches [2]. Winter months generally are the wettest. Rainfall at the project site can be expected to be similar.

5.0 PRESENT AIR QUALITY

Present air quality in the project area is mostly affected by air pollutants from vehicular, agricultural and/or natural sources. Table 2 presents an air pollutant emission summary for the island of Hawaii for calendar year 1993. While these emission estimates have become somewhat dated and current emission levels probably somewhat higher, the proportional relationships likely still about the same. The emission rates shown in the table pertain to manmade emissions only, i.e., emissions from natural sources are not included. As suggested in the table, much of the manmade particulate emissions on Hawaii originate from area sources, such as the mineral products industry and agriculture. Manmade sulfur oxides are emitted almost exclusively by point sources, such as power plants and other fuel-burning industries. Nitrogen oxides emissions emanate predominantly from area sources (mostly motor vehicle traffic), although industrial point sources contribute a significant share. The majority of carbon monoxide emissions occur from area sources (motor vehicle traffic), while hydrocarbons are emitted mainly from point sources. In the Kau District where the project is located, there are relatively few manmade sources of air pollution.

Hawaii Island is unique from the other islands in the state in terms of the natural volcanic air pollution emissions that occur.

Volcanic emissions frequently plague the project area. This is especially so since the latest eruption phase of the Kilauea Volcano began in 1983. Air pollution emissions from the Hawaiian volcanoes consist primarily of sulfur dioxide. After entering the atmosphere, these sulfur dioxide emissions are carried away by the wind and either washed out as acid rain or gradually transformed into particulate sulfates or acid aerosols. Emissions from Kilauea are vented to the atmosphere relatively close by (about 40 miles northeast of the project site), and the prevailing wind patterns tend to carry the emissions toward the project area much of the time. Because of this, relatively high concentrations of sulfur dioxide may potentially occur at the project site and volcanic haze (vog) can impact the area.

Since the closure of the sugar mill at nearby Pahala, the nearest major industrial sources of air pollution in the project vicinity are Hawaii Electric Light Company power plants located in Keaau and Hilo, but these sources are very distant. Air pollution emissions from these sources consist mostly of sulfur dioxide and oxides of nitrogen. Hydrogen sulfide emissions are also emitted from Puna Geothermal Venture's geothermal power plant located about 60 miles to the northeast.

Mamalahoa Highway, which passes through the project area, is the region's only major arterial roadway. Emissions of carbon monoxide, nitrogen oxides, hydrocarbons and other contaminants will occur from motor vehicles traversing this roadway, but the volume of traffic is relatively light. Any impacts are probably very small.

The State Department of Health (DOH) operates a network of air quality monitoring stations at various locations around the state. On the island of Hawaii, specialized monitoring stations related to the vog have been established during the past few years. are located at Hilo, Kona, Mountain View, Pahala and Puna. monitoring station was also established in nearby Ocean View during 2010, but data from this station have not yet been reported in summary format. Monitoring stations also exist at Volcanoes National Park, but these stations are not operated by DOH and the data are not readily available in summary format. Sulfur dioxide and fine particulate are monitored at the stations located in Hilo, Kona, Mountain View and Pahala, while the Puna station measures sulfur dioxide and hydrogen sulfide. Table 3 summarizes the sulfur dioxide data for the five-year period from 2005 to 2009. As indicated in the table, the stations nearest to the volcanic source, Pahala and Mountain View, recorded the highest concentrations, and Pahala was impacted the most due to its prevailing downwind location. Measurements of sulfur dioxide concentrations at the Pahala station (which was established during 2007) were frequently elevated during the 2007-2009 monitoring period, especially during 2008 when 25 exceedances of the 3-hour standard were reported and 39 exceedances of the 24-hour standard were measured. The highest annual second-highest 3-hour and 24hour concentrations (which are most relevant to the standards) for these three years were 0.963 ppm and 0.311 ppm, respectively; these concentrations are about twice the applicable standards. Annual average concentrations at Pahala ranged from 0.020 to 0.070 ppm. This also is about twice the state and national standard.

Sulfur dioxide was monitored at Mountain View beginning the latter part of 2007. Concentrations exceeded the 3-hour standard once each during 2008 and 2009 and the 24-hour standard once during

2008 and twice during 2009. The highest annual second-highest 3-hour and 24-hour concentrations were 0.416 ppm and 0.183 ppm, respectively. While the applicable 3-hour concentration met the standard, the relevant 24-hour concentration was about 31 percent over the standard. Annual concentrations at Mountain View were relatively low, ranging from about 0.005 to 0.007 ppm and well within the standard.

Sulfur dioxide concentrations at the Hilo monitoring station during 2005-2009 were significantly elevated at times, particularly on occasion during 2008. The 3-hour concentration exceeded the standard once during 2008 with a concentration of 0.740 ppm, while the second-highest concentration was 0.455 ppm and within the standard of 0.500 ppm. The annual maximum 24-hour concentration reached 0.144 ppm during 2008, which is considered equal to but not exceeding the standard of 0.14 ppm. Annual highest second-highest 24-hour concentrations were 0.085 ppm or less. Annual concentrations were relatively low at 0.005 ppm or less.

Sulfur dioxide concentrations at the Kona and Puna monitoring stations were somewhat elevated at times during the monitoring period, but concentrations were lower than the other stations. Maximum 3-hour and 24-hour concentrations generally less than about 50% of the standards. Maximum annual concentrations were also well within the standard at these locations.

As indicated above, fine particulate matter concentrations are also measured at Hilo, Kona, Mountain View and Pahala. The instrumentation to make these measurements was installed early in

2008. As indicated in Table 4, the highest annual 24-hour concentration of fine particulate matter occurred during 2009 at Mountain View with a value of 80 $\mu\text{g/m}^3$, which is more than twice the national standard. All of the stations except for Hilo reported several exceedances of the 24-hour standard during this monitoring period. Annual average concentrations were highest at Kona, reflecting its more distant location from the volcanic source and the probable conversion of volcanic sulfur dioxide gas to fine particulate matter with time and travel distance from Kilauea. Annual concentrations at Kona exceed the national standard, while other locations were within the annual standard.

In general, volcanic-related sulfur dioxide concentrations can be expected to decrease with distance from the source as the gas disperses and undergoes chemical conversion processes in the At longer distances, such as at Kona, the sulfur atmosphere. dioxide will be substantially dispersed and transformed into fine particulate matter that is ever present and results in higher long-term average concentrations. The data collected and reported at the special purpose Hawaii Island voq monitoring stations tends to support this. Because the project site is at an intermediate location between Pahala and Kona, it can be expected that vogrelated sulfur dioxide concentrations in the project area will be lower than Pahala but higher than Kona. On the other hand, longterm fine particulate concentrations are likely higher than Pahala Based on the information available, it but lower than Kona. appears probable that air quality in the project area will meet the current state standards for sulfur dioxide. However, the federal government revised its sulfur dioxide standards during 2010, and the new federal standard is considered to be more stringent than the state standards. Although summary data pertaining to the new federal standard have not yet been reported,

it appears doubtful that sulfur dioxide concentration levels in the Kau area will meet the national 1-hour standard.

Like many other locations on Hawaii Island, the standards for fine particulate matter may be exceeded in the project area. This assumes, of course, that the same level of volcanic activity that has persisted for the past several years continues.

At this time, there are no reported measurements of lead, ozone, nitrogen dioxide or carbon monoxide in the project vicinity or anywhere on the island. These are primarily motor vehicle related air pollutants. Lead, ozone and nitrogen dioxide typically are regional scale problems. Concentrations of lead and nitrogen dioxide generally have not been found to exceed AAQS elsewhere in Ozone concentrations, on the other hand, have been found to exceed the state standard at times at Sand Island on Carbon monoxide air pollution typically is a microscale problem caused by congested motor vehicular traffic. In traffic congested areas such as urban Honolulu, carbon monoxide concentrations have been found to occasionally exceed the state AAQS. Concentrations of carbon monoxide and nitrogen dioxide in the project area are estimated later in this study based on computer modeling of motor vehicle emissions.

6.0 SHORT-TERM IMPACTS OF PROJECT

Short-term direct and indirect impacts on air quality could potentially occur due to project construction. For a project of this nature, there are two potential types of air pollution emissions that could directly result in short-term air quality

impacts during project construction: (1) fugitive dust from vehicle movement and soil excavation; and (2) exhaust emissions from on-site construction equipment. Indirectly, there also impacts from slow-moving construction short-term equipment traveling to and from the project site, temporary increase in local traffic caused by construction workers, and from the disruption of normal traffic flow caused by roadway lane closures.

Fugitive dust emissions may arise from the grading and dirt-moving activities associated with site clearing and preparation work. The emission rate for fugitive dust emissions from construction activities is difficult to estimate accurately. This is because of its elusive nature of emission and because the potential for its generation varies greatly depending upon the type of soil at the construction site, the amount and type of dirt-disturbing activity taking place, the moisture content of exposed soil in work areas, and the wind speed. The EPA [3] has provided a rough estimate for uncontrolled fugitive dust emissions construction activity of 1.2 tons per acre per month under conditions of "medium" activity, moderate soil silt content (30%), and precipitation/evaporation (P/E) index of 50. Uncontrolled fugitive dust emissions at the project site would likely be somewhere near that level, depending on the amount of rainfall that occurs. In any case, State of Hawaii Air Pollution Control Regulations [4] prohibit visible emissions of fugitive dust from construction activities at the property line. Thus, an effective dust control plan for the project construction phase is essential.

Adequate fugitive dust control can usually be accomplished by the establishment of a frequent watering program to keep bare-dirt

surfaces in construction areas from becoming significant sources In dust-prone or dust-sensitive areas, other control measures such as limiting the area that can be disturbed at any given time, applying chemical soil stabilizers, mulching and/or using wind screens may be necessary. Control regulations further stipulate that open-bodied trucks be covered at all times when in motion if they are transporting materials that could be blown away. Haul trucks tracking dirt onto paved streets from unpaved areas is often a significant source of dust in construction areas. Some means to alleviate this problem, such as road cleaning or tire washing, may be appropriate. Paving of parking areas and/or establishment of landscaping as early in the construction schedule as possible can also lower the potential for fugitive dust emissions. Monitoring dust at the project boundaries could be considered to quantify and document the effectiveness of dust control measures.

On-site mobile and stationary construction equipment also will emit air pollutants from engine exhausts. The largest of this equipment is usually diesel-powered. Nitrogen oxides emissions from diesel engines can be relatively high compared to gasoline-powered equipment, but the annual standard for nitrogen dioxide is not likely to be violated by short-term construction equipment emissions. Also, the new short-term (1-hour) standard for nitrogen dioxide is based on a three-year average; thus it is unlikely that relatively short-term construction emissions would exceed the standard. Carbon monoxide emissions from diesel engines are low and should be relatively insignificant compared to vehicular emissions on nearby roadways.

Project construction activities will also likely obstruct the normal flow of traffic at times to such an extent that overall vehicular emissions in the project area will temporarily increase. The only means to alleviate this problem will be to attempt to keep roadways open during peak traffic hours and to move heavy construction equipment and workers to and from construction areas during periods of low traffic volume. Thus, most potential short-term air quality impacts from project construction can be mitigated.

7.0 LONG-TERM IMPACTS OF PROJECT

After construction is completed, use of the proposed roadway improvements by motor vehicle traffic could potentially cause long-term impacts on ambient air quality in the project area. Motor vehicles with gasoline-powered engines are significant sources of carbon monoxide. They also emit nitrogen oxides and other contaminates.

Federal air pollution control regulations require that new motor vehicles be equipped with emission control devices that reduce emissions significantly compared to a few years ago. In 1990, the President signed into law the Clean Air Act Amendments. This legislation required further emission reductions, which have been phased in since 1994. More recently, additional restrictions were signed into law during the Clinton administration, and these began to take effect during the next decade. The added restrictions on emissions from new motor vehicles will lower average emissions each year as older vehicles leave the state's roadways and are retired. It is estimated that carbon monoxide emissions, for example, will go down by an average of about 25 to 30 percent per

vehicle during the next 20 years due to the replacement of older vehicles with newer models. Nitrogen oxides emissions are expected to drop even more.

To evaluate the potential long-term ambient air quality impact of motor vehicle traffic using the proposed new roadway facilities, computerized emission and atmospheric dispersion models can be used to estimate ambient carbon monoxide and nitrogen dioxide concentrations along roadways within the project area. For this project, three scenarios were selected for the air quality modeling study: (1) year 2011 with present conditions, (2) year 2030 without the project, and (3) year 2030 with the project. To begin the modeling study of the three scenarios, critical receptor areas in the vicinity of the project were identified for analysis. Generally speaking, roadway intersections are the primary concern because of traffic congestion and because of the increase in vehicular emissions associated with traffic queuing. For this study, only the project access road intersection with Mamalahoa Highway was identified for analysis.

The traffic impact report for the project [5] describes the existing and projected future traffic conditions and laneage configurations of the study intersection in detail. In performing the air quality impact analysis, it was assumed that all recommended traffic mitigation measures would be implemented.

The main objective of the modeling study was to estimate maximum 1-hour average carbon monoxide and nitrogen dioxide concentrations for each of the three scenarios studied. To evaluate the significance of the estimated concentrations, a comparison of the

predicted values for each scenario can be made. Comparison of the estimated values to the national and state AAQS was also used to provide another measure of significance.

Maximum air pollution concentrations typically coincide with peak traffic periods. The traffic impact assessment report evaluated morning and afternoon peak traffic periods. These same periods were evaluated in the air quality impact assessment.

The EPA computer model MOBILE6.2 [6] was used to calculate vehicular carbon monoxide and nitrogen oxides emissions for each year studied. One of the key inputs to MOBILE6.2 is vehicle mix. Unless very detailed information is available, national average values are typically assumed, which is what was used for the present study. Based on national average vehicle mix figures, the present vehicle mix in the project area was estimated to be 35.4% light-duty gasoline-powered automobiles, 51.7% light-duty gasoline-powered trucks and vans, 3.6% heavy-duty gasoline-powered vehicles, 0.2% light-duty diesel-powered vehicles, 8.6% heavy-duty diesel-powered trucks and buses, and 0.5% motorcycles. For the future scenarios studied, the vehicle mix was estimated to change slightly with fewer light-duty gasoline-powered automobiles and more light-duty gasoline-powered trucks and vans.

Ambient temperatures of 59 and 68 degrees F were used for morning and afternoon peak-hour emission computations, respectively. These are conservative assumptions since morning/afternoon ambient temperatures will generally be warmer than this, and carbon monoxide and nitrogen dioxide emission estimates given by

MOBILE6.2 generally have an inverse relationship to the ambient temperature.

Unlike carbon monoxide which is emitted directly by motor vehicles and remains relatively stable in the atmosphere, motor vehicles generally do not emit nitrogen dioxide directly. Rather, nitric oxide is formed in the combustion process and emitted from the engine exhaust. As it disperses into the atmosphere, it interacts primarily with ozone to form nitrogen dioxide. For the purposes of this analysis, it was conservatively assumed that the nitrogen oxides emission estimates given by MOBILE6.2 are 100 percent nitric oxide and that 10 percent of the nitric oxide converts rapidly to nitrogen dioxide in the short distance it travels from the point of emission to nearby receptors.

After computing vehicular carbon monoxide and nitrogen dioxide emissions through the use of MOBILE6.2, these data were then input to an atmospheric dispersion model. EPA air quality modeling guidelines [7] currently recommend that the computer model CAL3QHC [8] be used to assess carbon monoxide concentrations at roadway intersections, or in areas where its use has previously been established, CALINE4 [9] may be used. few years ago, CALINE4 was used extensively in Hawaii to assess air quality impacts at roadway intersections. In December 1997, the California Department of Transportation recommended that the intersection mode of CALINE4 no longer be used because it was thought the model had become outdated. Studies have shown that CALINE4 may tend to over-predict maximum concentrations in some situations. Therefore, CAL3QHC was used for the analysis.

CAL3QHC was developed for the U.S. EPA to simulate vehicular movement, vehicle queuing and atmospheric dispersion of vehicular emissions near roadway intersections. It is designed to predict average pollutant concentrations 1-hour near intersections based on input traffic and emission data, roadway/receptor geometry and meteorological conditions.

Although CAL3QHC is intended primarily for use in assessing atmospheric dispersion near signalized roadway intersections, it can also be used to evaluate unsignalized intersections. This is accomplished by manually estimating queue lengths and then applying the same techniques used by the model for signalized intersections. In the future with the project, in accordance with the traffic report, the study intersection was assumed to be signalized.

Input peak-hour traffic data were obtained from the traffic study cited previously. This included vehicle approach volumes, saturation capacity estimates, intersection laneage and signal timings (where applicable). All emission factors that were input to CAL3QHC for free-flow traffic on roadways were obtained from MOBILE6.2 based on assumed free-flow vehicle speeds corresponding to the posted or design speed limits.

Model roadways were set up to reflect roadway geometry, physical dimensions and operating characteristics. Concentrations predicted by air quality models generally are not considered valid within the roadway-mixing zone. The roadway-mixing zone is usually taken to include 3 meters on either side of the traveled

portion of the roadway and the turbulent area within 10 meters of a cross street. Model receptor sites were thus located at the edges of the mixing zones near all intersections that were studied for all three scenarios. This implies that pedestrian sidewalks either already exist or are assumed to exist in the future. All receptor heights were placed at 1.8 meters above ground to simulate levels within the normal human breathing zone.

Input meteorological conditions for this study were defined to provide "worst-case" results. One of the key meteorological inputs is atmospheric stability category. For these analyses, atmospheric stability category 6 was assumed for the morning cases, while atmospheric stability category 4 was assumed for the afternoon cases. These are the most conservative stability categories that are generally used for estimating worst-case pollutant dispersion within rural or suburban areas for these periods. A surface roughness length of 10 cm (indicative of a smooth surface) and a mixing height of 1000 meters were used in all cases. Worst-case wind conditions were defined as a wind speed of 1 meter per second with a wind direction resulting in the highest predicted concentration. Concentration estimates were calculated at wind directions of every 5 degrees.

Existing background concentrations of carbon monoxide and nitrogen dioxide in the project vicinity are believed to be at low levels. Thus, background contributions from sources or roadways not directly considered in the analysis were accounted for by adding background concentrations of 0.5 ppm of carbon monoxide and 0.002 ppm of nitrogen dioxide to all predicted concentrations for 2011. Although increased traffic is expected to occur within the project area within the next several years with

or without the project, background carbon monoxide concentrations may not change significantly since individual emissions from motor vehicles are forecast to decrease with time. Hence, background values for 2011 were assumed to persist for the future scenarios studied.

Predicted Worst-Case 1-Hour Concentrations

Table 5 summarizes the final results of the modeling study in the form of the estimated worst-case 1-hour morning and afternoon ambient carbon monoxide and nitrogen dioxide concentrations. These results can be compared directly to the state and the national AAQS. Estimated worst-case concentrations are presented in the table for three scenarios: year 2011 with existing traffic, year 2030 without the project and year 2030 with the project. The locations of these estimated worst-case 1-hour concentrations all occurred at or very near the indicated intersections.

As indicated in the table, the highest estimated 1-hour carbon monoxide concentration within the project vicinity for the present (2011) case was 0.9 ppm. This was projected to occur during the morning peak traffic hour along Mamalahoa Highway. The highest 1-hour nitrogen dioxide concentration also occurred during the morning with a value of 0.006 ppm. The predicted worst-case concentrations for the 2011 scenario were well within both the national and the state standards.

In the year 2030 without the proposed project, the highest worst-case 1-hour carbon monoxide concentration along Mamalahoa Highway in the vicinity of the project was predicted to continue to occur

during the morning peak traffic hour with a value of 0.9 ppm. Compared to the existing case, both morning and afternoon carbon monoxide concentrations remained unchanged. Worst-case nitrogen dioxide concentrations were estimated to be the same during both morning and afternoon peak traffic periods and to decrease compared to the existing case. Estimated worst-case concentrations of nitrogen dioxide remained well within the state and national standards.

Predicted 1-hour worst-case concentrations for the 2030 with project scenario increased compared to the without project case due to the assumed construction and use of the project access road. A predicted worst-case 1-hour carbon monoxide concentration of 2.8 ppm occurred during the morning near the intersection of Mamalahoa Highway. A predicted worst-case 1-hour nitrogen dioxide concentration of 0.009 ppm also occurred during the morning at this location. Although these concentrations are higher compared to the without project scenario, the concentrations are well within the standards.

Predicted Worst-Case 8-Hour Carbon Monoxide Concentrations

Worst-case 8-hour carbon monoxide concentrations were estimated by multiplying the worst-case 1-hour values by a persistence factor of 0.5. This accounts for two factors: (1) traffic volumes averaged over eight hours are lower than peak 1-hour values, and (2) meteorological conditions are more variable (and hence more favorable for dispersion) over an 8-hour period than they are for a single hour. Based on monitoring data, 1-hour to 8-hour persistence factors for most locations generally vary from 0.4 to 0.8 with 0.6 being the most typical. One study based on modeling [10]

concluded that 1-hour to 8-hour persistence factors could typically be expected to range from 0.4 to 0.5. EPA guidelines [11] recommend using a value of 0.7 unless a locally derived persistence factor is available. Recent monitoring data for locations on Oahu reported by the Department of Health [12] suggest that this factor may range between about 0.2 and 0.7 depending on location and traffic variability. Considering the location of the project and the traffic pattern for the area, a 1-hour to 8-hour persistence factor of 0.5 will likely yield reasonable estimates of worst-case 8-hour concentrations.

The resulting estimated worst-case 8-hour concentrations are indicated in Table 6. For the 2011 scenario, the estimated worst-case 8-hour carbon monoxide concentration at the single location studied (Mamalahoa Highway at the location of the project access road) was 0.4 ppm. The estimated worst-case concentration for the existing case was well within both the state standard of 4.4 ppm and the national limit of 9 ppm. For the year 2030 without project scenario, the worst-case concentration remained the same at 0.4 ppm. For the 2030 with project scenario, the worst-case concentration increased to 1.4 ppm due to the assumed construction and use of the project access road intersection but remained well within both the national and the state AAQS.

Conservativeness of Estimates

The results of this study reflect several assumptions that were made concerning both traffic movement and worst-case meteorological conditions. One such assumption concerning worst-case meteorological conditions is that a wind speed of 1 meter per second with a steady direction for 1 hour will occur. A steady

wind of 1 meter per second blowing from a single direction for an hour is extremely unlikely and may occur only once a year or less. With wind speeds of 2 meters per second, for example, computed carbon monoxide concentrations would be only about half the values given above. The 8-hour estimates are also conservative in that it is unlikely that anyone would occupy the assumed receptor sites (within 3 m of the roadways) for a period of 8 hours.

8.0 CONCLUSIONS AND RECOMMENDATIONS

Assuming that Kilauea Volcano continues to emit sulfur dioxide at the rates it has for the past several years, the available data suggest that sulfur dioxide concentrations at the project site will likely meet the current state air quality standards, but it appears probable that concentration levels will exceed the new and more stringent federal 1-hour standard at times. Concentrations of fine particulate matter will also likely exceed federal standards during vog episodes.

The major potential short-term air quality impact of the project will occur from the emission of fugitive dust during construction phases. Uncontrolled fugitive dust emissions from construction activities are estimated to amount to about 1.2 tons per acre per month, depending on rainfall. To control dust, active work areas and any temporary unpaved work roads should be watered at least twice daily on days without rainfall. Use of wind screens and/or limiting the area that is disturbed at any given time will also help to contain fugitive dust emissions. Wind erosion of inactive areas of the site that have been disturbed could be controlled by mulching or by the use of chemical soil stabilizers. Dirt-hauling trucks should be covered when traveling on roadways to prevent

windage. A routine road cleaning and/or tire washing program will also help to reduce fugitive dust emissions that may occur as a result of trucks tracking dirt onto paved roadways in the project area. Establishment of landscaping early in the construction schedule will also help to control dust. Monitoring dust at the project boundary during the period of construction could be considered as a means to evaluate the effectiveness of the project dust control program and to adjust the program if necessary.

During construction phases, emissions from engine exhausts (primarily consisting of carbon monoxide and nitrogen oxides) will also occur both from on-site construction equipment and from vehicles used by construction workers and from trucks traveling to and from the project. Increased vehicular emissions due to disruption of traffic by construction equipment and/or commuting construction workers can be alleviated by moving equipment and personnel to the site during off-peak traffic hours.

After the proposed project is completed, any long-term impacts on air quality in the project area due to emissions from project-related motor vehicle traffic should be negligible. Worst-case concentrations of carbon monoxide and nitrogen dioxide should remain well within both the state and the national ambient air quality standards. Implementing any air quality mitigation measures for long-term traffic-related impacts is probably unnecessary and unwarranted.

REFERENCES

- 1. "Local Climatological Data, Annual Summary With Comparative Data, Hilo, Hawaii, 1993", U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Environmental Data Service, National Climatic Center, Asheville, NC.
- 2. "Climatic Summary of the United States, Supplement for 1951 through 1960, Hawaii and Pacific", U.S. Department of Commerce, Weather Bureau, Washington, D.C., 1965.
- 3. Compilation of Air Pollutant Emission Factors, Volume I: Stationary Point and Area Sources, Fifth Edition, AP-42, U.S. Environmental Protection Agency, Research Triangle Park, NC, January 1995.
- 4. State of Hawaii. Hawaii Administrative Rules, Chapter 11-60, Air Pollution Control.
- 5. Traffic Management Consultant, Inc., <u>Traffic Impact Analysis</u> Report for the Proposed Kahuku Village, Draft, March 2011.
- 6. User's Guide to MOBILE6.2, Mobile Source Emission Factor Model, U.S. Environmental Protection Agency, Office of Transportation and Air Quality, Assessment and Standards Division, Ann Arbor, Michigan, January 2002.
- 7. Guideline on Air Quality Models (Revised), Including Supplements A and B, EPA-450/2-78-027R, U.S. Environmental Protection Agency, Research Triangle Park, NC, July 1986.
- 8. User's Guide to CAL3QHC Version 2.0: A Modeling Methodology for Predicting Pollutant Concentrations Near Roadway Intersections, U.S. Environmental Protection Agency, November 1992.
- 9. CALINE4 A Dispersion Model for Predicting Air Pollutant Concentrations Near Roadways, FHWA/CA/TL-84/15, California State Department of Transportation, November 1984 with June 1989 Revisions.
- 10. "Persistence Factors for Mobile Source (Roadway) Carbon Monoxide Modeling", C. David Cooper, <u>Journal of the Air & Waste Management Association</u>, Volume 39, Number 5, May 1989.
- 11. <u>Guideline for Modeling Carbon Monoxide from Roadway Intersections</u>, U.S. Environmental Protection Agency, EPA-454/R-92-005, November 1992.

12. <u>Annual Summaries, Hawaii Air Quality Data, 2005-2009</u>, State of Hawaii Department of Health.



Table 1
SUMMARY OF STATE OF HAWAII AND NATIONAL AMBIENT AIR QUALITY STANDARDS

		Averaging	Maximum A	llowable Con	centration
Pollutant	Units	Time	National Primary	National Secondary	State of Hawaii
Particulate Matter	μ g/m ³	Annual	_	_	50
(<10 microns)		24 Hours	150ª	150ª	150 ^b
Particulate Matter	μ g/m 3	Annual	15°	15°	_
(<2.5 microns)	·	24 Hours	35 ^d	35 ^d	_
Sulfur Dioxide	ppm	Annual			0.03
		24 Hours	_	_	0.14 ^b
		3 Hours	_	0.5 ^b	0.5 ^b
		1 Hour	0.075 ^e	_	_
Nitrogen Dioxide	ppm	Annual	0.053	0.053	0.04
		1 Hour	0.100 ^f		_
Carbon Monoxide	ppm	8 Hours	9 ^b	-	4.4 ^b
		1 Hour	35 ^b	_	9 ^b
Ozone	ppm	8 Hours	0.075 ^g	0.075 ^g	0.08 ^g
Lead	μ g/m 3	3 Months	0.15 ^h	0.15 ^h	_
	, -	Quarter	1.5 ⁱ	1.5 ⁱ	1.5 ⁱ
Hydrogen Sulfide	ppm	1 Hour	-	-	35 ^b

 $^{^{\}mbox{\scriptsize a}}$ Not to be exceeded more than once per year on average over three years.

 $^{^{\}mbox{\scriptsize b}}_{\mbox{\scriptsize Not}}$ to be exceeded more than once per year.

 $^{^{\}mbox{\scriptsize C}}$ Three-year average of the weighted annual arithmetic mean.

 $[\]overset{\text{d}}{\text{98th}}$ percentile value of the 24-hour concentrations averaged over three years.

e Three-year average of annual fourth-highest daily 1-hour maximum.

 $[\]overset{\text{f}}{\text{98th}}$ percentile value of the daily 1-hour maximum averaged over three years.

 $^{{\}rm g}_{\rm Three-year}$ average of annual fourth-highest daily 8-hour maximum.

h Rolling 3-month average.

i Quarterly average.

Table 2

AIR POLLUTION EMISSIONS INVENTORY FOR ISLAND OF HAWAII, 1993

Air Pollutant	Point Sources (tons/year)	Area Sources (tons/year)	Total (tons/year)
Particulate	30,311	9,157	39,468
Sulfur Oxides	9,345	nil	9,345
Nitrogen Oxides	4,054	8,858	12,912
Carbon Monoxide	3,357	23,934	27,291
Hydrocarbons	1,477	203	1,680

Source: Final Report, "Review, Revise and Update of the Hawaii Emissions Inventory Systems for the State of Hawaii", prepared for Hawaii Department of Health by J.L. Shoemaker & Associates, Inc., 1996

Table 3

ANNUAL SUMMARIES OF SULFUR DIOXIDE MEASUREMENTS FOR HAWAII ISLAND MONITORING STATIONS

Location / Parameter	2005	2006	2007	2008	2009
location / Farameter	2003	2000	2007	2000	2003
Hilo					
3-Hour Averaging Period:					
No. of Samples	2856	2630	2597	2450	2449
Highest Concentration (ppm)	0.282	0.173	0.210	0.740	0.364
2 nd Highest Concentration (ppm)	0.215	0.156	0.173	0.455	0.329
No. of State AAQS Exceedances	0	0	0	1	0
24-Hour Averaging Period:					
No. of Samples	362	331	347	359	358
Highest Concentration (ppm)	0.097	0.062	0.064	0.144	0.102
2 nd Highest Concentration (ppm)	0.049	0.037	0.062	0.080	0.085
No. of State AAQS Exceedances	0	0	0	0	0
Annual Average Concentration (ppm)	0.004	0.003	0.004	0.005	0.005
Kona	1	1	1	1	1
3-Hour Averaging Period:					
No. of Samples	2341	2697	2756	2445	2560
Highest Concentration (ppm)	0.032	0.046	0.034	0.124	0.130
2 nd Highest Concentration (ppm)	0.032	0.035	0.025	0.112	0.111
No. of State AAQS Exceedances	0	0	0	0	0
24-Hour Averaging Period:					
No. of Samples	296	341	343	353	365
Highest Concentration (ppm)	0.018	0.012	0.011	0.054	0.045
2 nd Highest Concentration (ppm)	0.016	0.011	0.011	0.038	0.042
No. of State AAQS Exceedances	0	0	0	0	0
Annual Average Concentration (ppm)	0.005	0.004	0.004	0.009	0.004
Mountain View	I				
3-Hour Averaging Period:					
No. of Samples	_	-	192	2446	2576
Highest Concentration (ppm)	=	-	0.188	0.700	0.597
2 nd Highest Concentration (ppm)	_	-	0.139	0.375	0.416
No. of State AAQS Exceedances	_	-	0	1	1
24-Hour Averaging Period:					
No. of Samples	_	-	27	354	361
Highest Concentration (ppm)	_	-	0.072	0.159	0.217
2 nd Highest Concentration (ppm)	_	-	0.050	0.105	0.183
No. of State AAQS Exceedances	_		0	1	2
Annual Average Concentration (ppm)	_	_	0.008	0.005	0.007

Table 3 (cont.)

ANNUAL SUMMARIES OF SULFUR DIOXIDE MEASUREMENTS FOR HAWAII ISLAND MONITORING STATIONS

Location / Parameter	2005	2006	2007	2008	2009
Pahala					
				T	
3-Hour Averaging Period:					
No. of Samples	-	-	1051	2621	2628
Highest Concentration (ppm)	-	-	0.167	1.000	0.726
2 nd Highest Concentration (ppm)	-	_	0.155	0.963	0.685
No. of State AAQS Exceedances	=	-	0	25	7
24-Hour Averaging Period:					
No. of Samples	-	-	133	365	365
Highest Concentration (ppm)	-	-	0.067	0.311	0.290
2 nd Highest Concentration (ppm)	-	-	0.056	0.311	0.215
No. of State AAQS Exceedances	-	-	0	39	18
Annual Average Concentration (ppm)	-	-	0.020	0.070	0.065
Puna	1		ı	·	
3-Hour Averaging Period:					
No. of Samples	2266	2431	2406	2420	2477
Highest Concentration (ppm)	0.193	0.025	0.072	0.036	0.218
2 nd Highest Concentration (ppm)	0.049	0.022	0.061	0.012	0.116
No. of State AAQS Exceedances	0	0	0	0	0
24-Hour Averaging Period:					
No. of Samples	317	360	353	355	345
Highest Concentration (ppm)	0.037	0.009	0.022	0.009	0.073
2 nd Highest Concentration (ppm)	0.012	0.007	0.021	0.004	0.032
No. of State AAQS Exceedances	0	0	0	0	0
Annual Average Concentration (ppm)	0.001	0.002	0.002	0.002	0.002

Source: State of Hawaii Department of Health, "Annual Summaries, Hawaii Air Quality Data, 2005 - 2009"

Table 4

ANNUAL SUMMARIES OF PARTICULATE MATTER (PM2.5) MEASUREMENTS FOR HAWAII ISLAND MONITORING STATIONS

Location / Parameter	2005	2006	2007	2008	2009
Hilo					
24-Hour Averaging Period:			T	T	1
No. of Samples	_	_	_	245	356
Highest Concentration (ug/m3)			_	35	36
98 th Percentile Concentration (ug/m3)	_	_	_	2.4	26
No. of AAOS Exceedances		_	_	0	1
			_	-	
Annual Average Concentration (ug/m3)	_	-	_	5	6
Kona			1	1	1
24-Hour Averaging Period:					
No. of Samples	_	_	_	292	352
Highest Concentration (ug/m3)	_	=	-	44	61
98 th Percentile Concentration (ug/m3)	-	-	-	37	37
No. of AAQS Exceedances	_	-	-	10	8
Annual Average Concentration (ug/m3)	_	_	_	21	16
Mountain View					
24-Hour Averaging Period:					
No. of Samples	_	_	-	256	360
Highest Concentration (ug/m3)	-	=	-	51	80
98 th Percentile Concentration (ug/m3)	-	-	-	40	39
No. of AAQS Exceedances	-	-	-	7	9
Annual Average Concentration (ug/m3)	_	=	-	5	9
Pahala			L	L	
24-Hour Averaging Period:					
No. of Samples	-	-	-	257	365
Highest Concentration (ug/m3)	-	-	-	76	51
98 th Percentile Concentration (ug/m3)	-	_	-	45	29
No. of AAQS Exceedances	=	=	-	14	4
Annual Average Concentration (ug/m3)	_	_	_	15	10

Source: State of Hawaii Department of Health, "Annual Summaries, Hawaii Air Quality Data, 2005 - 2009"

Table 5

ESTIMATED WORST-CASE 1-HOUR CARBON MONOXIDE AND NITROGEN DIOXIDE CONCENTRATIONS
ALONG ROADWAYS NEAR KAHUKU VILLAGE PROJECT (parts per million)

	Year/Scenario						
Roadway	2011/Present		2030/Without Project		2030/With Project		
Intersection	AM	PM	AM	PM	AM	PM	
	Carbon Monoxide						
Mamalahoa Highway at Project Access Road ^a	0.9	0.7	0.9 0.7		2.8	2.2	
	Nitrogen Dioxide						
Mamalahoa Highway at Project Access Road ^a	0.006	0.005	0.003	0.003	0.009	0.007	

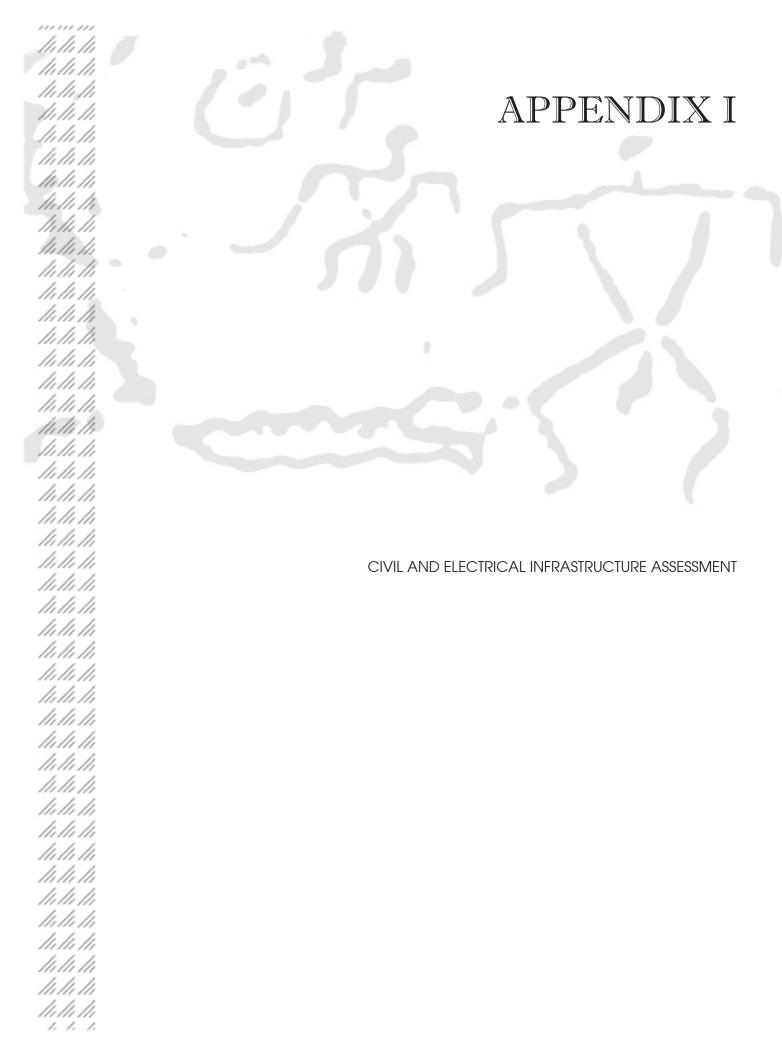
^aProject access road assumed to exist with project only.

Table 6

ESTIMATED WORST-CASE 8-HOUR CARBON MONOXIDE CONCENTRATIONS ALONG ROADWAYS NEAR KAHUKU VILLAGE PROJECT (parts per million)

	Year/Scenario						
Roadway Intersection	2011/Present	2030/Without Project	2030/With Project				
Mamalahoa Highway at Project Access Road ^a	0.4	0.4	1.4				

 $^{{}^{\}mathrm{a}}\mathrm{Project}$ access road assumed to exist with project only.



KAHUKUVILLAGE

CIVIL AND ELECTRICAL INFRASTRUCTURE ASSESSMENT

TMK (3) 9-2-001: 072 Kahuku Ahupua'a, Ka'ū District, Island and County of Hawai'i, Hawai'i

July 18, 2011

Prepared for: Nani Kahuku 'Āina, LLC 99-1324 Koaha Place Aiea, Hawai'i 96701

Chapter 1 – Introduction	1
1.1 PROJECT DESCRIPTION	1
1.1.1 EXISTING USES	1
1.1.2 PROPOSED USE	1
Chapter 2 – Roadways	4
2.1 EXISTING CONDITIONS	4
2.2 PROPOSED INFRASTRUCTURE	4
2.2.1 HIGHWAY IMPROVEMENTS	4
2.2.2 ONSITE ROADWAYS	5
Chapter 3 – GRADING AND EROSION CONTROL	6
3.1 EXISTING CONDITIONS	6
3.1.1 CLIMATE	6
3.1.2 TOPOGRAPHY AND GEOLOGY	6
3.1.3 SOILS	6
3.1.4 GRADING	7
3.1.5 EROSION CONTROL	7
Chapter 4 – DRAINAGE	9
4.1 EXISTING CONDITIONS	9
4.1.1 FLOODING AND TSUNAMI HAZARDS	9
4.1.2 MARINE WATER QUALITY	9
4.1.3 EXISTING DRAINAGE INFRASTRUCTURE	10
4.1.4 EXISTING HYDROLOGY	10
4.2 DEVELOPED CONDITIONS	11
4.2.1 COUNTY OF HAWAII DRAINAGE STANDARDS	11
4.2.2 PROPOSED DRAINAGE INFRASTRUCTURE	11
4.2.3 BEST MANAGEMENT PRACTICES BMPS	13
Chapter 5 – WATER	14
5.1 EXISTING CONDITIONS	14
5.2 WATER DEMAND	14
5.3 PROPOSED WATER SUPPLY SYSTEM	15
5.3.1 REVERSE OSMOSIS PROCESS	16
5.3.2 PROPOSED WATER SUPPLY DISTRIBUTION	17
5.3.3 PHASING	18
Chapter 6 – WASTEWATER	20

6.1 EXISTING CONDITIONS	20
6.2 POTENTIAL SYSTEM REQUIREMENTS AND CONSIDERATIONS	20
6.3 WASTEWATER FLOW PROJECTIONS	21
6.4 PROPOSED WASTEWATER SYSTEM	21
6.4.1 WASTEWATER TREATMENT	21
6.4.2 EFFLUENT DISPOSAL	22
6.4.3 WASTEWATER REUSE	23
6.4.4 SLUDGE HANDLING	24
Chapter 7 – SOLID WASTE	25
7.1 EXISTING CONDITIONS	25
7.2 WASTE GENERATION	25
Chapter 8 – POWER AND COMMUNICATIONS	27
8.1 EXISTING CONDITIONS	27
8.2 ELECTRICAL AND TELECOMMUNICATIONS DEMAND	27
8.3 PROPOSED ELECTRICAL AND TELECOMMUNICATIONS SYSTEMS	28
8.3.1 ELECTRICAL	28
8.3.2 TELECOMMUNICATIONS	28
8.3.3 INFRASTRUCTURE IMPROVEMENTS	29
8.3.4 ROADWAY LIGHTING	29
Chapter 9 – ORDER OF MAGNITUDE COSTS	30

LIST OF TABLES

Table 1.1, Kahuku Village Land Use Summary	2
Table 1.2, Kahuku Village Land Use Summary by Phase	
Table 4.1, Existing State Department of Transportation Culverts	
Table 4.2, Runoff Estimates	11
Table 5.1, Potable Water Average Daily Demand Estimate, MGD	
Table 5.2, Non-Potable Water Average Daily Demand Estimate, MGD	12
Table 6.1, Wastewater Flow Projections, MGD	17
Table 7.1, Solid Waste Generation, tons/year	21
Table 8.1, Electrical Demand and Telephone Line Requirements	22
Table 9.1, Order of Magnitude Costs, in thousands	24

LIST OF FIGURES

Figure 1, Location Map

Figure 2, Tax Map

Figure 3, Aerial Photograph

Figure 4, Conceptual Masterplan

Figure 5, Phasing Plan

Figure 6, Road Concept Plan

Figure 7, Soils Map

Figure 8, Mean Annual Rainfall

Figure 9, Water Concept Plan

Figure 10, Irrigation Concept Plan

Figure 11, Sewer Concept Plan

Figure 12, Electrical Transmission Plan

Figure 13, Alternate Electrical Transmission Plan

Figure 14, Electrical Plan

Figure 15, Communication Plan

Figure 16, Elec/Comm Ducting Plan

APPENDICES

Water and Sewer Demand Calculations Electrical and Telephone Use Summary

ABBREVIATIONS AND ACRONYMS

CWDA Critical Wastewater Disposal Area
CZM Hawai'i Coastal Zone Management
CZMA Coastal Zone Management Act

DBEDT State of Hawai'i Department of Business Economic Development and Tourism

DHHL State of Hawai'i Department of Hawaiian Homelands

DLNR State of Hawai'i Department of Land and Natural Resources

DOH State of Hawai'i Department of Health
DWS County Department of Water Supply
EIS Environmental Impact Statement

EISPN Environmental Impact Statement Preparation Notice

FAA Federal Aviation Administration

FEMA Federal Emergency Management Agency

FIRM Flood Insurance Rate Map
HAR Hawai'i Administrative Rules

HCC Hawai'i County Code

HELCO Hawai'i Electric Light Company, Inc.
HOVE Hawaiian Ocean View Estates
HOVR Hawaiian Ocean View Ranchos

HRS Hawai'i Revised Statutes

HTCO Hawaiian Telcom

kV Kilovolt

Mgd Million gallons per day

MP Milepost

Msl mean sea level

NEPA National Environmental Policy Act NGPC Notice of General Permit Coverage

NKA Nani Kahuku 'Āina, LLC

NOAA National Oceanic and Atmospheric Administration
NPDES National Pollutant Discharge Elimination Systems

NRCS U.S. Department of Agriculture Natural Resources Conservation Services

NWS National Weather Service

OEQC Office of Environmental Quality Control

OTWC Oceanic Time Warner Cable

ppm parts per million ROW Right-of-Way

SHPD State Historic Preservation Division

SMA Special Management Area
TIAR Traffic Impact Analysis Report

TWT TW Telecom

UHM University of Hawai'i at Manoa
USGS United States Geological Survey
WWTP Wastewater Treatment Plant

Chapter 1 – Introduction

1.1 PROJECT DESCRIPTION

The Kahuku Village project is located near south point on the Big Island in the Kaʻū District, County of Hawaiʻi (see Figure 1, Location Map). The proposed 1,975 acre project footprint encompasses only a small portion of the 16,456.547 acre property, TMK (3) 9-2-001: 072. The property extends from the Māmalahoa Highway makai to the coast, between Hawaiian Ocean View Ranchos to the northwest and a large parcel owned by Kamehameha Schools to the southeast (see Figure 2, Tax Map). The property's 5-mile coastline includes the Kanonohe anchialine ponds, Pōhue Bay, Keliuli Bay, Kahakahakea, Hāli'ipalala, and Kāki'o (see Figure 3, Aerial Photograph).

1.1.1 EXISTING USES

The property is undeveloped and consists primarily of pāhoehoe and 'a'ā lava with kipuka on the mauka portion of the property. Historically the area was used for ranching, but not for crops. Its current use is limited to recreational and scientific activities.

The majority of the property surrounding the project site is also undeveloped. There are two existing subdivisions located on the northwest side of the property including the Hawaiian Ocean View Ranchos and Hawaiian Ocean View Estates. These properties were subdivided in the 1950s and 1960s, but have only been partly built out with very limited infrastructure. The Kahuku Ranch property mauka of the Mamalahoa Highway was recently purchased by the Federal government to expand the Hawaii Volcanoes National Park. The large properties east of the project owned by S.M. Damon Trust, M. Mallick, and Kamehameha Schools are also undeveloped.

1.1.2 PROPOSED USE

The Kakuku Village project will include a wide variety of land uses including; residential, commercial, mixed use, visitor accommodations, golf course, community services, park, conservation, cultural, scientific research and education. The project is comprised of two primary components; the Hawaiian Heritage Center and the Mixed-Use Village. The Mixed-Use Village will include a central Village Green located on the mauka side of the development at the end of the main access roadway, which will be surrounded by commercial, mixed use, civic, public parks and a Veteran's Administration medical facility. Along the shoreline, two hotels, multi-family residential, and oceanfront single family properties are planned. A golf course and variety of single family and multifamily residential lots will connect the Village Green to the shoreline hotels.

The other primary component of the project is the Hawaiian Heritage Center which will comprise of a number of different, scientific research, education, cultural and preservation uses surrounding Pohue Bay and Keliuli Bay. The Hawaiian Heritage Center will perpetuate and expand on the current cultural, educational and research activities onsite. The Hawaiian Heritage Center could include a wide variety of uses including; fishing village, learning village, hula mound, amphitheater, heritage institute, visitor center, marine science lab, camp sites and eco-lodges, archeological and cultural preserves and conservation areas.

The vast majority of the property will be untouched and will remain undeveloped. Approximately 88% of the property's 16,457 acres will remain undeveloped which equates to 14,482 acres. In addition, of the 1,975 acres within the project footprint, 356 acres will be designated as preserve area.

An extensive network of trails through the open space areas both within the project footprint and in the undeveloped portions of the property will connect the mauka and makai areas as well as provide lateral shoreline access through the project site. The open space areas, particularly along the shoreline, have significant natural, cultural and archeological resources and much of the area will be designated as Special Resource Management Area, Shoreline Conservation, Parks, and Cultural Preserve. See Figure 4 - Conceptual Masterplan.

The proposed land use areas and units are summarized in the table below and do not include any of the open space areas described above.

Table 1.1 - Kahuku Village Land Use Summary

Land Use	Acres	Units
Visitor Accommodations		
Hotel	75	500
Residential	-	
R-X: Single Family (15,000 sf)	55	135
R-1: Oceanfront / Preserve Lots (1+ acres)	84	60
R-2: Golf Estates (1.5 - 2 acres)	483	291
R-3: Estates (2+ acres)	180	75
MF-1: Oceanfront Condo / Fractional	40	140
MF-2: Golf Villas (4-5 du/acre)	50	180
Community Parks	40	-
VMX: Village Mixed-use*		169
Mixed-Use Village		
Commercial	24	-
Village Green	2	-
VMX: Village Mixed-use*	38	-
Civic	9	-
VA Facility	45	-
Amenities/Support		
WWTP/Maintenance Facilities	20	-
18-hole Golf Course and Clubhouse	330	-
Hawaiian Heritage Center		
Heritage Institute	20	-
Eco-Lodge	20	100
Camp Sites	5	-
Fishing Village	10	-
Learning Village	75	100
Amphitheater	2	-
Visitors Center	5	-
Marine Science Laboratory	5	-
Cultural Preserve	356	-
Maintenance Facilities	2	
TOTA	AL 1,975	1,750

^{* -} VMX mixed use acreage is included as commercial land use and the mixed use residential units are included in the residential land use.

The project will be developed in four phases starting in 2016 and ending in 2027. The majority of the project will be developed in Phases 2 and 3. The land use areas and unit counts are shown by phase in the table below. See Figure, 5 – Phasing Plan.

Table 1.2 – Kahuku Village Land Use Summary by Phase

Land Use	-	ise 1 -2018	Pha 2019	se 2 -2021	Phas 2022-		Pha 2025	se 4 -2027	То	tal
	Units	Acres	Units	Acres	Units	Acres	Units	Acres	Units	Acres
Visitor Accommodations	-	-	250	37	250	38	-	-	500	75
Residential	76	88	281	278	635	456	58	110	1050	932
Mixed Use Village	-	4	-	10	-	90	-	14	-	118
Amenities/Support	-	10	-	330	-	10	-	-	-	350
Hawaiian Heritage Center	200	500	-	-	-	-	-	-	200	500
Total	276	602	531	655	885	594	58	124	1,750	1,975

Chapter 2 – Roadways

2.1 EXISTING CONDITIONS

The property is currently accessed off of Mamalahoa Highway along its 4-mile long frontage between mileposts (MP) 71 and 76. The Mamalahoa Highway, also known as the Hawaii Belt Road, is the only public roadway connection around the southern tip of the island connecting the Kaʻū district to the South Kona and Puna district. The highway provides access to Kailua-Kona and the Kona International Airport (56 miles away) to the North, and access to Naalehu and beyond to Hilo (76 miles away) to the south. This primary arterial highway is a two way, two lane paved Class I limited access state highway within a 100 foot right of way with paved shoulders and guardrails. The speed limit fronting the property is 55 mph.

State Department of Transportation (DOT) staff confirmed that there are no mapped access restrictions along the highway frontage. Along the 4 mile frontage there are several existing unpaved 4-wheel drive access points to the property. The majority of users currently access the property and Pohue Bay off of Mamalahoa Highway using a 4-wheel drive road between MP 76 and 75 near Hawaiian Ocean View Ranchos. This access is through a shared access and utility easement in favor of TMK (3) 9-2-001: 075 and 076 along the property boundary with Hawaii Ocean View Ranchos.

In addition to the above access there is also a scenic point turnout near MP 75, an existing access and gate near MP 74, and two more existing access points between MP 73 and 74 which appear to lead to the kipuka on the makai side of the road. There is also an existing paved driveway access point at the existing intersection with the old Mamalahoa Highway near MP 73.

2.2 PROPOSED INFRASTRUCTURE

2.2.1 HIGHWAY IMPROVEMENTS

A Traffic Impact Analysis Report (TIAR) prepared by The Traffic Management Consultant includes analysis of the existing and proposed traffic patterns at the project site. The TIAR also provides recommendations for transportation infrastructure improvements to accommodate the project including a new at-grade intersection off of the Mamalahoa Highway near MP 74 approximately one mile east of Hawaiian Ocean View Ranchos.

The traffic analysis in the TIAR evaluated traffic flows for each phase of the project and provides recommendations for roadway improvements at the intersection of Mamalahoa Highway and the project entry roadway. Recommended improvements by phase are as follows:

Phases 1 and 2 (2016 to 2021)

- Stop controlled channelized intersection with Mamalahoa Highway
- Separate left turn and right turn lanes on mauka bound main access road
- Exclusive left turn lane on westbound Mamalahoa Highway with deceleration length
- Exclusive right turn lane on eastbound Mamalahoa Highway
- Right turn acceleration lane from main access road to eastbound Mamalahoa Highway
- Two-lane, two-way main access road from Mamalahoa Highway to the mixed use village

Phase 3 (2022 to 2024)

- Signalization of intersection at Mamalahoa Highway with exclusive left turn phase from westbound Mamalahoa Highway
- Extension of exclusive left turn lane on westbound Mamalahoa Highway
- Extension of exclusive right turn lane on mauka bound main access road

Phase 4 (2025 to 2027)

No additional improvements are recommended for Phase 4.

The main access road is proposed to be stop controlled up to the end of Phase 2 (2023). Traffic signalization may be required by Phase 3 (2024), and a traffic signal warrant analysis should be conducted prior to design and construction of the signalized intersection.

2.2.2 ONSITE ROADWAYS

All roadways within the property will be privately owned and maintained and designed to conform to AASHTO standards. Pavement design recommendations will be determined by a geotechnical engineer during design.

The approximately 6 mile long main access road to the project site will extend from the intersection at Mamalahoa Highway to the Mixed-Use Village. From there, secondary roadways will provide looped connectivity to the hotels, residential areas, golf course and Hawaiian Heritage Center. Additional minor roadways will loop through residential areas to provide access to the main loop. See Figure 6, Road Concept Plan.

A secondary emergency access road will be provided to allow emergency access from the development to the existing roadway system within the Hawaiian Ocean View Ranchos. The roadway will be a 20 foot wide unpaved gravel road with shoulders. The roadway will generally follow the existing 4 wheel drive roadways used to access the site.

Roadways surrounding the Village Green within the Mixed-Use Village will have curb and sidewalks due to the more urban and pedestrian nature of the village center with parking on one or both sides of the road. All other roadways within the Mixed-Use Village will have unpaved shoulders and roadside swales.

A system of pedestrian and bicycle paths will allow connectivity throughout the development. Within the Mixed-Use Village, paths will generally parallel the roadways. Paths that connect to the residential areas, the hotels and to the golf course will have meandering independent alignments and may or may not be parallel to a roadway. Minor roadways and roadways that are not anticipated to have non-vehicular traffic or low volumes of traffic will not have sidewalks or paths.

The proposed roadway system is shown on Figure 6. All roadways will typically be two-lane two-way asphalt concrete paved roads with shoulders with the exception of the curb and gutter and sidewalks within the village core. There are three classifications of roadways shown on Figure 6 including a primary roadway which includes the main entry road from Mamalahoa Highway all the way to the coastline. The secondary roadways will include the main loop road through the development, and the minor roadways would include all other roadways within the development. Many of the minor roads within the residential areas will be built out as each residential pad is developed.

Chapter 3 – GRADING AND EROSION CONTROL

3.1 EXISTING CONDITIONS

3.1.1 CLIMATE

The project site is located on the leeward side of Maunaloa with the predominant trade winds coming from a north easterly direction. As a result, the rainfall pattern is relatively dry with slightly higher rainfall in the winter. The average annual rainfall along the coastline is approximately 30 inches and increases up to approximately 40 inches along the highway as elevation increases.

3.1.2 TOPOGRAPHY AND GEOLOGY

The project site is located on the southwest flank of Mauna Loa below the Southwest Rift Zone. Mauna Loa is considered an active volcano and the majority of the site is covered with pāhoehoe and 'a'ā lava flows from both historic and prehistoric flows as recent as 1907. Because of the frequency of lava flows and location of the project site, the entire property is within USGS Lava Hazard Zone 2.

The property generally slopes in the makai direction from the Mamalahoa Highway to the shoreline from an elevation of approximately 2000 feet msl to sea level within an approximate distance of 6 miles. The average slope across the site is approximately 6% with some areas in excess of 20%.

3.1.3 SOILS

The NRCS Soil Survey shows that the project site consists primarily of pāhoehoe (rLW) and 'a'ā lava flows (rLV) with kipuka on the mauka side of the property. Vegetation within the kipuka is sparse with some ohia in the higher elevation kipuka closer to South Point. Along the shoreline, and near the bays, also consists of cinder land (rCL) and small beach (BH) areas. (See Figure 7. Soils Map). The following are NRCS descriptions for soil types found within the project site.

Lava Flows, pāhoehoe (rLW) - This soil has a billowy, glassy surface that is relatively smooth. In some areas, the surface is rough and broken and there are hummocks and pressure domes. The soil has no cover and is typically bare of vegetation, except for mosses and lichens. In the areas of higher rainfall, however, scattered 'ōhi'a trees, ohelo berry, and a'ali'i have gained a foothold in cracks and crevices. Some flat slabs are used as facings on buildings and fireplaces. The NRCS Land Capability Grouping, rates soil types according to eight levels, ranging from the highest classification level, I, to the lowest level, VIII. The capability classification, an indicator of suitability of soil for field crop cultivation, for this soil is VIIIs, non-irrigated, meaning the soils and landforms have limitations that preclude their use for commercial plants and restrict their use to recreation, wildlife or water supply or aesthetic purposes. The subclass is "s," meaning the soil is limited because it is shallow, droughty, or stony.

<u>Lava Flows, 'a'ā (rLV)</u> – This soil is rough and broken, consisting of a mass of clinkery, hard, glassy, sharp pieces piled in tumbled heaps. There is practically no soil covering and it is typically bare of vegetation, except for mosses, lichens, ferns and a few small 'ōhi'a trees. In areas of high rainfall, it contributes substantially to the underground water supply and is used for watershed. The capability classification is VIIIs, non-irrigated. Class VIII soils and landforms have limitations that preclude their use for commercial plants and restrict their use to recreation,

wildlife or water supply or aesthetic purposes. The subclass is "s," meaning the soil is limited because it is shallow, droughty or stony.

<u>Cinder Land, (rCL)</u> - Cinder land (rCL) consists of areas of bedded magmatic ejecta associated with cinder cones. It is a mixture of cinders, pumice, and ash. These materials are black, red, yellow, brown, or variegated in color. They have jagged edges and a glassy appearance and show little or no evidence of soil development. Although Cinder land commonly supports some vegetation, it has no value for grazing, because of its loose nature and poor trafficability. It is used for wildlife habitat and recreational areas. The capability classification is VIIIs, non-irrigated. Class VIII soils and landforms have limitations that preclude their use for commercial plants and restrict their use to recreation, wildlife or water supply or aesthetic purposes. The subclass is "s," meaning the soil is limited because it is shallow, droughty, or stony.

<u>Beaches (BH)</u> – These are long, narrow, sloping areas of sand and gravel along the coastline, typically used for recreation and are sometimes covered by waves during storms or high tide. The sand and gravel vary in color, ranging from yellowish or white sand, formed in coral and sea shells, black sand, formed in lava rocks and green sand formed in olivine. The capability classification is VIIIw, non-irrigated. Class VIII soils and landforms have limitations that preclude its use for commercial plants and restrict their use to recreation, wildlife or water supply or aesthetic purposes. The subclass is "w," meaning that water in or on the soil interferes with plant growth or cultivation and in some instances the wetness can be corrected by artificial drainage.

3.1.4 GRADING

The existing ground surface within the project site is primarily covered by 'a'ā lava flows with some pāhoehoe and cinder land near the shoreline. The lava rock surface is very rough and uneven with the existing landforms unchanged from their original creation by volcanic lava flows as recent as 1907. Due to the minimal rainfall and permeability of the lava rock, the existing ground surface has not eroded and there are no existing drainage ways through the property.

The proposed development and final grades shall closely follow the existing topography to minimize earthwork activities. Earthwork activities will include; roadway excavation and embankment, rough grade and landscaping of the golf courses, utility installation and access roads, and site grading for the commercial, industrial, residential, educational and visitor accommodations.

Due to the predominance of lava flows on site, the earthwork activities may include blasting and pneumatic hammering to excavate lava rock and rock crushing operations to produce aggregate material for use during construction. Import of soil will be required for all areas that will be landscaped, primarily the golf course, due to the lack of available topsoil on site.

3.1.5 EROSION CONTROL

The nearshore waters off the property are classified as "AA" by the State Department of Health. According to DOH Water Quality Standards, "It is the objective of class AA waters that these waters 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 source or actions" (HAR §11-54-03(c)(1)). To the extent practicable, the wilderness character of these areas shall be protected. Therefore, storm runoff will be prevented from entering into the ocean through the application of permanent and construction Best Management Practices (BMPs).

Soil erosion and sediment control BMPs will be implemented to minimize and control erosion of soils and dust during construction. BMPs are pollution control measures, applied to nonpoint sources, on-site or off-site, to control erosion and the transport of sediments and other pollutants which have an adverse impact on waters of the state. Construction BMPs are temporary measures installed before construction commences and removed after construction completion. Potential construction BMPs include but are not limited to gravel entrance, water trucks, dust screen, silt fence, retention basins, diversion berm/ditches, and grading procedures that follow Hawaii County Code Chapter 10 – Erosion and Sediment Control.

Unlike construction BMPs, permanent BMPs are designed to remain part of the project features after the site grading operation is completed. The permanent BMPs are intended to reduce storm water pollution typically associated with the increased impervious surfaces. Permanent BMPs will consist of the golf course sumps and low lying areas, landscaping, lava swales and sumps, and injection wells. Increase in runoff rates resulting from the development will be mitigated by infiltrating excess runoff into the ground and the implementation of BMPs. As a result, the proposed project is not expected to create an adverse impact to the near shore waters.

Chapter 4 – DRAINAGE

4.1 EXISTING CONDITIONS

4.1.1 FLOODING AND TSUNAMI HAZARDS

Based on the Federal Emergency Management Agency (FEMA) Flood Insurance Rate Maps (2004) the project site is located in minimal tsunami inundation area and in Flood Zone X (an area of undetermined flood hazard). According to staff at FEMA, Flood maps/studies are being updated to incorporate coastal studies (Upolu Point to Cape Kumukahi). Revised preliminary maps to be distributed in mid 2011 and scheduled to become effective late in 2012.

Tsunami Studies of the area were analyzed by Sea Engineering in its July 1987 report entitled "Coastal Engineering Planning and Design Considerations for the Hawaiian Riviera Resort, Kahuku, Kau, Hawaii." Sea Engineering determined that the tsunami inundation will extend approximately 425 to 445 feet inland and will vary in elevation from 9.5 to 12 feet above mean sea level (MSL). A shoreline conservation area stretching 500 to 1000 feet from the coast will be established for the project, in which development will be not allowed, therefore the project will not extend into the tsunami inundation zone.

4.1.2 MARINE WATER QUALITY

The nearshore waters off the Property are classified as "AA" by the State DOH and are not listed in the Clean Water Act §303(d) list (impaired waters bodies that do not meet State Water Quality Standards). According to DOH Water Quality Standards, "It is the objective of class AA waters that these waters 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 source or actions" (HAR §11-54-03(c)(1)). Discharges into "AA" Marine waters do not qualify for coverage under NPDES General Permit, therefore any storm water discharges into the nearshore waters off the property require a NPDES Individual Permit.

In West Hawai'i groundwater resources and the nearshore marine environment are inextricably connected because groundwater enters the ocean from numerous points along the coast. This is a result of many subsurface pathways through porous lava for groundwater to reach the ocean.

The property is subject to the State DOH Underground Injection Control (UIC) regulations (HAR Chapter 11-23) which govern the location, construction and operation of injection wells in an effort to protect the quality of Underground Sources of Drinking Water (USDW). The delineation between the USDW and aquifers that are exempted from being used as USDW are shown on the DOH UIC Maps. The UIC line through the property parallels the coastline and is shown on Figure 6. The majority of the project site is on the makai side of the UIC line and is within an exempted aquifer. Any injection wells used for disposal of stormwater runoff will require a permit from the Department of Health.

Assessment on the Potential Impact on Water Resources of the Proposed Kahuku Village Project in the Kau District of the Island of Hawaii dated May 2011 has been prepared by Tom Nance Water Resource Engineering.

Assessment of the Marine and Anchialine Pool Environments, Kahuku Villages, Ka'u, Hawaii dated May 2011 has been prepared by Marine Research Consultants, Inc.

"The entire Kahuku Villages project site consists of unweathered a'a and pahoehoe lava flows which are devoid of any significant ash, soil or vegetative cover. The predominance of porous lavas and lack of soil results in topography of extremely high permeability. Surface runoff as a continuous flow over any significant distance, even in the most extreme rainfall events, does not occur. However, all such runoff would be directed into undeveloped open space or coveyed to subsurface disposal in dry wells or seepage pits, ultimately becoming ground water recharge. As a result, there would be no surface runoff discharging directly into the ocean at the shoreline from the project site after it is developed. For this reason, there will be no effects to the marine environment as a result of direct surface runoff."

4.1.3 EXISTING DRAINAGE INFRASTRUCTURE

The State Department of Transportation maintains the only drainage infrastructure within the project vicinity. Based on available record drawings, the drainage infrastructure, which was constructed in the 70s, consists of six 24-inch culverts crossing Mamalahoa Highway (refer to Table 4.1).

Runoff through the culverts are expected to be minimal due to the high permeability of the 'a'ā and pāhoehoe lava fields on both sides of the highway and the absence of natural drainage ways within the boundaries of the subject property. The culverts were likely installed to allow passage of localized drainage at low points along the highway. There are no drainage calculations or drainage reports on file with the State Department of Transportation.

Table 4.1 – Existing State Department of Transportation Culverts

Mile	6			
Post	Station	Size	Length	Construction Plans
71.1	699+75	24-inch	52-feet	1976 Approved Kahuku Towards Kona Highway Improvements
71.8	741+21	24-inch	68-feet	1975 Approved Hawaii Belt Road Kahuku to Papa
72.7	786+00	24-inch	78-feet	1975 Approved Hawaii Belt Road Kahuku to Papa
73.6	833+50	24-inch	78-feet	1975 Approved Kahuku Towards Kona Highway Improvements
74.2	868+00	24-inch	56-feet	1975 Approved Kahuku Towards Kona Highway Improvements
74.7	890+00	24-inch	75-feet	1975 Approved Kahuku Towards Kona Highway Improvements

4.1.4 EXISTING HYDROLOGY

According to the Hawaii County General Plan, the area consists of moderate slopes, extremely permeable soils, and relatively young lava flows. Median annual rainfall of the Kau region varies from less than 20 inches at South Point to 75 inches at the 5,000-ft elevation (refer to Figure 8, Mean Annual Rainfall). Drainage area for the developed area of the project is approximately 70.1 square miles determined from USGS Quadrangles, which is part of the larger 155.59 square mile Kauna Watershed. The top of the drainage area is at Puu O KeoKeo (elevation 6,875-feet) located on Mauna Loa's South West Rift Zone. The drainage area includes large portions of the existing Hawaiian Ocean View Estates and Hawaiian Ocean View Ranchos subdivisions.

Due to lack of substantial rainfall and high permeability of the natural ground surface across the property and on the upland slopes mauka of the Property, surface runoff generally does not

occur even during the most intense rainfalls. As a result, no natural gulches or waterways have been created on the property. At present, the annual rainfall that occurs on the property percolates to the underlying groundwater or is evaporated or transpired into the atmosphere, therefore no significant surface runoff occurs.

4.2 DEVELOPED CONDITIONS

4.2.1 COUNTY OF HAWAII DRAINAGE STANDARDS

The proposed drainage systems hydrologic criteria will be in accordance with County of Hawaii Standards with the exception of applying NOAA Atlas 14 Volume 4 Version 2.1 in lieu of Plates 1 and 2 (Intensity of 1-hr Rainfall for 10 and 50 year Return Periods). Plates 1 and 2 of the drainage standards are based on the U.S. Department of Commence Technical Paper 43, Rainfall Frequency Atlas of the Hawaiian Islands (TP-43) published in 1962. The isopluvial (rainfall intensity) maps in NOAA Atlas 14 Volume 4 Version 2.1 are the result of interpolation of frequency estimates of a larger sample of rain stations with longer years of record than TP-43. Hence NOAA Atlas 14 Volume 4 Version 2.1 portrays a more accurate representation of the rainfall intensity than the current County of Hawaii Drainage Standards.

For drainage areas of 100 acres or less, the County of Hawaii Drainage Standards stipulates that the drainage system be designed for a return periods of 10-years or 50-years. Due to potential sumps in the developed area, the 50-year return period will be applied to the residential, mixed-use, commercial, industrial, and visitor accommodation areas. To determine the runoff quantity for these areas, the rational method will be used. The rational method is based on the drainage area, runoff coefficient (ground cover conditions), and the rainfall intensity for duration equal to the time of concentration. For drainage areas greater than 100 acres, the County of Hawaii uses Plates 6 and 6A in the drainage standards where peak discharge is a function of the drainage area (runoff zone).

As discussed in the previous section, generally no existing surface runoff occurs due to the porous lava and the topography. However, an increase in runoff is anticipated with the replacement of porous lava with top soil, vegetation and impervious surfaces.

4.2.2 PROPOSED DRAINAGE INFRASTRUCTURE

Due to relatively high permeability of the lava fields mauka of the project site, pre-developed offsite runoff onto the project site will be negligible. In the post-developed condition, stormwater runoff within the project site will be generated from replacement of porous lava with top soil, vegetation and impervious surfaces. The increase in runoff will be mitigated by detaining, retaining and infiltrating runoff into the ground. Since it is assumed that there is minimal or no pre-developed runoff, 100% of the post-developed runoff will be used for drainage system sizing.

Due to the site characteristics, the location of the property and the proposed masterplan, the project is well suited to implementation of Low Impact Development (LID) strategies. LID is a stormwater management strategy that promotes conservation of existing natural features and use of localized small-scale stormwater systems in an effort to mimic the natural hydrologic patterns while minimizing the installation of stormwater infrastructure. LID practices and stormwater systems that can be incorporated into the project include the following:

- Minimize impervious area, use permeable surfaces where possible including permeable sidewalk and roadway/driveway paving
- Plan site around existing site features retain and incorporate natural topography

- Minimize grading and disturbed area maximize existing undisturbed lava fields
- Narrow roads and minimize driveway lengths/widths, use wheel strips and shared driveways
- Provide connected bike and pedestrian pathways
- · Locate sidewalks on one side of street
- Plant trees especially large canopy, plant in well thought out locations
- Use source control of stormwater for pollutant control and groundwater recharge
- Mimimize conventional infrastructure including: curb and gutter, piping and drain inlets
- Utilize the lava rock onsite lava sumps, lava swales, lava trenches, shallow drywells, drainage injection wells, detention and retention basins.

In areas with high density (commercial, industrial, civic, and multi-family residential) within the mixed use village core, conventional stormwater infrastructure will be implemented including curb, gutter, drain inlets and drain pipes. The piped drainage system will be conveyed into a drainage injection well, retention/detention basin or another type of detention/infiltration system. The piped drainage systems will be limited to the core of the mixed use village. Outside of the core of the mixed use village in areas of lower density, the stormwater runoff will be conveyed using natural lava swales or grassed swales and conveyed through localized infiltration practices such as lava sumps and lava trenches. Other infiltration practices using shallow drywells, drainage injection wells and detention/retention basins will be utilized where necessary.

Overflow routes for excess runoff from developed areas shall be directed to low points in either the golf course or other undeveloped areas within the project limits. These low lying areas will act as detention/retention areas and will serve as the ultimate disposal point of stormwater runoff. There are no existing or proposed stormwater outfalls to the ocean.

During design, a Drainage Masterplan will be developed that incorporates the stormwater management strategies listed above to establish the project drainage concept and to provide design criteria for the phased development of the project. The Drainage Masterplan will be based on detailed topographic survey and proposed mass grading of the project site and will include; LID stormwater strategies, infiltration and stormwater system sizing criteria, detention/retention analysis, flood analysis, and drainage system schematics and plans.

The implementation of LID stormwater strategies, will allow management of runoff at the source and sizing of stormwater facilities will be site specific varying depending on land use. In addition, 100% of post developed runoff will be infiltrated onsite, so there will not be a conventional backbone piped stormwater conveyance to a discharge point. Therefore, stormwater runoff peak flows by per acre of land use have been estimated in Table 4.2. This provides a general estimate of total peak flow for the project.

Table 4.2 – Stormwater Runoff Peak Flow Estimates

Intensity of 1 hr Rainfall (Tm=10 years) i(10) = 1.85 in/hr NOAA Atlas 14 Volume 4 Version 2.1 Intensity of 1 hr Rainfall (Tm=50 years) i(50) = 2.45 in/hr NOAA Atlas 14 Volume 4 Version 2.1

Land Use	Area (Acres)		С	Tc (Min)	I		Acre fs)	Total	Q ₅₀ (cfs)
		Exist	Developed			Exist	Developed	Exist	Developed
Hotel	75	0.10	0.60	15	4.4	0.44	2.64	33	198
Residential	842	0.10	0.40	15	4.4	0.44	1.76	370	1,482
Multi-Family	90	0.10	0.50	15	4.4	0.44	2.20	40	198
Mixed-Use Village	118	0.10	0.70	15	4.4	0.44	3.08	52	363
WWTP	20	0.10	0.60	15	4.4	0.44	2.64	9	53
Golf Course	330		e 6 and 6A Drainage S			2	.00	6	660
Hawaiian Heritage Center*	144*	0.10	0.40	15	4.4	0.44	1.76	63	253

^{* - 356} acres of cultural preserve is not included.

4.2.3 BEST MANAGEMENT PRACTICES BMPS

Increase in runoff rates resulting from the development will be mitigated by infiltrating excess runoff into the ground and the implementation of BMPs. As a result, the proposed project is not expected to create adverse impacts to the near shore waters.

Temporary and permanent BMPs will be implemented for the project as described in section 3.1.5 Erosion Control.

Chapter 5 – WATER

5.1 EXISTING CONDITIONS

The project site is located in the Manuka Aquifer System Area, which is within the SW Maunaloa Aquifer Sector Area on the southwest slope of Mauna Loa from Kealakekua to South Point (Hawaii Water Plan August 2009). Due to high permeability of the ground surfaces with the Manuka aquifer, combined with the relatively dry rainfall patterns on the leeward side of the island, there are no surface water resources on or near the project site. Any surface water runoff that does occur is intermittent. Water sources available to the project site are from groundwater sources only.

A Groundwater Assessment prepared by Tom Nance Water Resources Engineering provides an assessment of the quantity and quality of groundwater available at the project site and identifies potential impacts to groundwater as a result of the project. Given the geologic conditions of the area and water quality testing, there is groundwater within a brackish basal lens underlying the property near the shoreline. It is expected that salinity of the groundwater will decrease in the mauka direction.

It is not anticipated that high level groundwater with low salinity would be available to the project site. A Time Domain Electromagnetic Study (TDEM) conducted by Blackhawk was performed in August 2008 to assess the geophysical characteristics of the subsurface hydrogeologic formations near the project site. The study could not confirm existence of high level potable water at the project site. It is very likely that only brackish and saltwater is available at site.

There are no public or private water systems serving property. However, there are several existing private wells in the general area including one in Hawaiian Ocean View Ranchos (HOVR), wells, and tanks located on Kahuku Ranch. There is also a Department of Water Supply water service area for South Point with well and reservoir located at intersection of Mamalahoa Highway and South Point Road. The County also recently installed an exploratory well in Hawaiian Ocean View Estates (HOVE) to supply a potable water fill station on Mamalahoa highway in HOVE, scheduled for completion in September 2011.

Per the Tom Nance Water Resources Engineering Assessment, "Due to the relatively dry and limited areal extent of the upgradient watershed, the flow of groundwater beneath the site is quite modest. Potable quality groundwater in limited quantities is only available near to or above Mamalahoa Highway from wells that would be 2000 feet deep and five miles from the project site."

5.2 WATER DEMAND

Water demand estimates for both potable and non-potable uses were performed using domestic and irrigation usage rates characteristic of similar developments along the Kona coast and are summarized in Tables 5.1 and 5.2 below. These demand estimates are cumulative, and detailed demand calculations are included in the appendix. Potable water will be used primarily for domestic purposes with limited irrigation use in areas not served by a non-potable irrigation system. Non-potable water will supplied by brackish wells and recycled R-1 water from the treatment plant for irrigation of the development including the golf course and common areas.

Table 5.1 – Potable Water Average Daily Demand Estimate, MGD

	Phase 1	Phases 1 & 2	Phases 1, 2 & 3	Phases 1, 2, 3 & 4
Land Use	2016-2018	2019-2021	2022-2024	2025-2027
Resort	0.000	0.075	0.150	0.150
Residential	0.078	0.232	0.482	0.524
Commercial	0.004	0.014	0.180	0.198
Amenities/Support	0.006	0.028	0.034	0.034
Hawaiian Heritage	0.070	0.070	0.070	0.070
Total	0.158	0.419	0.916	0.976

Table 5.2 – Non-Potable Water Average Daily Demand Estimate, MGD

	Phase 1	Phases 1 & 2	Phases 1, 2 & 3	Phases 1, 2, 3 & 4
Land Use	2016-2018	2019-2021	2022-2024	2025-2027
Resort	0.000	0.125	0.250	0.250
Residential	0.005	0.135	0.352	0.388
Commercial	0.004	0.014	0.104	0.118
Amenities/Support	0.045	0.673	0.693	0.693
Hawaiian Heritage	0.094	0.094	0.094	0.094
Total	0.148	1.041	1.493	1.543

5.3 PROPOSED WATER SUPPLY SYSTEM

Due to the limited water resources within the project vicinity and the lack of a public or private water supply within reasonable distance to the project, brackish and salt water are the only source of water available at the project site. As a result, desalination of the brackish and/or salt water is required to provide potable water to meet demand. Depending on salinity, the brackish water may be suitable for non-potable use such as irrigation without desalination. It is anticipated that the desalination system would be primarily for the production of potable water to meet domestic demands with limited irrigation use. Brackish water and recycled wastewater will be used to meet non-potable demands.

If an alternate potable groundwater source becomes available offsite, it could be utilized at a later date. Other alternatives include desalination of ocean water either on land or offshore.

There are many different processes available to desalinate brackish water and salt water. Typically these processes can be fit into two categories, thermal desalination and membrane desalination. Thermal desalination uses heat to vaporize source water and then condense water vapor to produce freshwater. Variations of thermal desalination processes include multistage flash, multiple effect distillation, and vapor compression. Membrane desalination uses a filtration process to separate dissolved solids from source water to produce freshwater. Variations of filtration processes include electrodialysis, electrodialysis reversal, nanofiltration and reverse osmosis.

Due to energy requirements required to vaporize water, the thermal processes are not recommended for this project. Similarly, the electrical energy required for electrodialysis is also significant due to the electric current required to drive the membrane filtration. The RO processes use water pressure to drive membrane filtration. This pressure is obtained mechanically by pumping and does also require significant energy. However, with improvements to membrane technology and energy recovery devices over the past decade, RO is generally the most economical option. It is also a process already in use for brackish and salt water desalination along the Kona coast. In addition, the reverse osmosis process is also the preferred process given the water quality, water quantity, as well as operation, maintenance, and installation costs.

5.3.1 REVERSE OSMOSIS PROCESS

The RO process uses a semi-permeable membrane to remove dissolved solids including salt in brackish and seawater. The process requires a pressure differential to drive water through a membrane, which is permeable to water, leaving a concentrated brine solution behind. A typical RO process includes the following steps.

- Feed water intake
- Pre-treatment
- Desalination
- Post-treatment water conditioning
- Disposal of waste products

FEED WATER INTAKE

Since the available water resources on site are from groundwater, the feedwater supply for the RO system will come from brackish and salt water (saline) wells drilled into the groundwater lens below the site. The raw water supply wells would be designed to draw water exclusively from beneath the brackish basal lens.

PRE-TREATMENT

Pre-treatment of the feed water is required to remove dissolved solids and organics to increase the efficiency and life of the RO system by minimizing fouling, scaling and degradation of the membrane. It allows optimization of product water flow and quality and recovery rates. Various types of pretreatment can be implemented depending on the quality of the feed water and may include; silica removal, chlorination/dechlorination, coagulation/flocculation, clarification, media filtration, ph adjustments, or antiscalants.

DESALINATION

After pre-treatment the feed water is pumped through the RO membranes where it is split into a permeate stream of desalinated water and a concentrate stream of saline by product. Depending on the quality and quantity of the feed water, the RO configuration may have multiple stages or passes which gradually desalinate the water to the desired salinity and dissolved solids level.

POST-TREATMENT

After RO is completed, the product water will be conditioned to adjust pH levels and for disinfection. After post-treatment the final product water is pumped to the storage reservoir and available for consumption as potable water. The resulting product water recovery rate from a salt water source is approximately 40% of the feed water supply.

DISPOSAL OF WASTE PRODUCTS

The RO process results in the production of several waste by products that require disposal. The largest waste product by volume is the concentrated brine by product, which for salt water desalination is approximately 60% of the feed water supply. In addition to the brine, there is also waste by products resulting from the pre-treatment of the feed water and from backwash and cleaning of the membranes.

Concentrate disposal options typically include the following: discharge to surface waters, wastewater treatment, and subsurface injection/infiltration or ocean discharge. Due to the quality of the marine water resources and lack of surface water discharge points, the concentrate will be disposed of using injection wells to be located on the makai side of the UIC line.

The RO disposal wells would be designed to deliver the concentrate deeper into the saline groundwater zone that the raw water supply wells would draw from, thereby eliminating the possibility of recirculation of the concentrate back to the supply wells.

The property is subject to the State DOH Underground Injection Control (UIC) regulations (HAR Chapter 11-23) which govern the location, construction, and operation of injection wells in an effort to protect the quality of Underground Sources of Drinking Water (USDW). The delineation between the USDW and aquifers that are exempt from being used as USDW are determined by the DOH (refer to Figure 6). The project site is generally on the makai side of the UIC line and is within an exempted aquifer.

Other process waste products typically require some form of treatment prior to final disposal to either the wastewater system or subsurface injection/infiltration. Similar to the brine disposal, subsurface discharge will likely require UIC permits.

5.3.2 PROPOSED WATER SUPPLY DISTRIBUTION

The proposed water system including both potable and non-potable systems will be privately owned and maintained. Use of the water system will be metered to individual users and the system will be privately operated and maintained. The proposed water and irrigation systems are shown on Figure 9, Water Concept Plan and Figure 10, Irrigation Concept Plan.

POTABLE SYSTEM

The potable water will be supplied by three salt water (saline) wells and one backup well located along the entry road at elevation 330 feet MSL. Each well will be approximately 600 feet deep spaced 200 feet apart and will pump at a maximum rate of 1,000 gpm each. The salt water will be pumped to a RO treatment plant with three separate treatment trains with one backup at a maximum flow rate of 400 gpm each. Following desalination, the potable water will be stored in a reservoir at elevation 340 which will service the project the site by gravity flow in one pressure zone.

The RO concentrate leaving the RO plant will gravity flow to two gravity injection wells, 600 feet deep spaced at 100 feet apart and arrayed parallel to the coast line makai of the Underground Injection Control line near the Mixed Use Village. A 12-inch main will deliver the concentrate from RO plant to injection wells along the entry road. The disposal wells are shown on Figure 9 and include two additional disposal wells for the wastewater system.

A transmission main will deliver potable water from the reservoir to the project site with looped system of distribution mains following the looped roadways throughout the project site. The distribution mains will provide both domestic and fire protection water demand including water meters, backflow preventers and fire hydrants. The system will be designed to the County's Department of Water Supply standards. In remote areas with low irrigation demand, the potable main will be used for irrigation.

NON-POTABLE SYSTEM

The non-potable water will be supplied by six brackish wells located along the entry road at elevation 1,000 feet MSL. The wells will be arrayed parallel to the coastline spaced 1,500 feet apart. Each well will be approximately 1,000 feet deep and will pump at a maximum rate 300 gpm each. The non-potable water will be stored in two reservoirs located at elevation 360 feet MSL. The reservoirs will service the project the site by gravity flow in one pressure zone. A 2.0 MG reservoir will provide storage of brackish water for irrigation of the entire development except for the golf course. A second 3.0 MG reservoir will provide storage of brackish and recycled R-1 wastewater for irrigation of the golf course (refer to Figure 10, Irrigation Concept Plan).

The non-potable system will be sized to meet the maximum irrigation demand using brackish water as the primary source of water. As recycled R-1 wastewater effluent from the treatment plan becomes available, it will be used to supplement irrigation demand with mixing to occur in the golf course irrigation system. Recycled R-1 effluent will be pumped from the wastewater treatment plant (WWTP) into the golf course system with storage of R-1 and brackish in the 3.0 MG irrigation reservoir.

Separate transmission mains will deliver non-potable water from each reservoir to the project site. The 2.0 MG reservoir will connect to a looped system of distribution mains following the main roadways throughout the project site and will provide irrigation water to all areas except some of the single family residential lots. Water usage will be metered to each property or end user and the system will be operated and maintained by a private water and sewer company. The 3.0 MG reservoir will connect directly to the golf course and will provide both brackish and recycled R-1 wastewater for irrigation use.

Alternative locations for irrigation reservoirs within the golf course and/or a R-1 irrigation reservoir near the WWTP will be considered during design depending on project phasing, construction costs and operation and maintenance requirements.

5.3.3 PHASING

The project water supply development will be phased over 10 years. During the initial Phase 1, the non-potable water demand is small. Therefore both potable and non-potable water demand would be supplied from the RO treatment plant.

During Phase 2 of the project, the non-potable water demand significantly increases which would then be supplied by construction of the brackish wells and the non-potable irrigation system. The initial non-potable use from the RO treatment plant could then be switched over to potable usage.

The phasing of the potable and non-potable water systems including any temporary facilities or connections will be evaluated during the design phase. Design of the system will be highly dependent on actual groundwater yield and salinity levels including construction costs and operation and maintenance of the facilities.

Chapter 6 – WASTEWATER

6.1 EXISTING CONDITIONS

There are no existing private or public wastewater treatment facilities on or near project site. Wastewater treatment in the project vicinity is typically done using Individual Wastewater Systems including cesspools, seepage pits and septic tanks and drainfields.

Portions of the property are designated as Critical Wastewater Disposal Areas (CWDA) by the State DOH governed under the Hawaii Administrative Rules (HAR) Chapter 11-62, Appendix E.. The CWDA line crosses through the property in two locations, near the shoreline parallel to the coastline and also on the makai side of the Mamalahoa Highway parallel to the highway (refer to Fugure 6). The project site is located in a CWDA with no exceptions, and DOH may impose more stringent requirements including higher effluent standards and limitations on effluent disposal.

The property is also subject to the State DOH Underground Injection Control (UIC) regulations (HAR Chapter 11-23) which govern the location, construction and operation of injection wells in an effort to protect the quality of Underground Sources of Drinking Water (USDW). The delineation between the USDW and aquifers that are exempt from being used as USDW are shown on the DOH UIC Maps. The UIC line through the property parallels the coastline and is shown on Figure 6. The project site is generally on the makai side of the UIC line and is within an exempted aquifer.

6.2 POTENTIAL SYSTEM REQUIREMENTS AND CONSIDERATIONS

Since the project site will not be served by a municipal sewer collection system, a new on-site wastewater treatment and disposal system must be constructed as part of the proposed development. The wastewater system will be privately operated and maintained.

The DOH regulates wastewater treatment systems and allows two options of wastewater treatment works for the proposed site (HAR Chapter 11-62):

- Centralized wastewater treatment plant (WWTP)
- Individual wastewater systems (IWS)

An IWS is defined by DOH regulations as an onsite wastewater treatment system that receives and disposes of no more than 1,000 GPD of wastewater. A centralized WWTP is a system that collects, treats and disposes of wastewater from multiple sources with design flows greater than 1,000 GPD. Due to the size of the proposed development centralized WWTPs are required. However, for remote areas within the project area, such as the Hawaiian Heritage Center and Eco-Lodges, IWSs will be evaluated as an alternative during design after consultation and approval of DOH.

Additional considerations/requirements for a centralized WWTP include:

- Allows for potential reuse of the treated R-1 or R-2 effluent, subject to the Guidelines for Treatment and Use of Recycled Water, May 15, 2002.
- WWTP designed for peak flows with a 100% back up component
- WWTP operated and maintained by a certified treatment plant operator

- WWTP subject to stringent regulatory requirements in terms of monitoring, recordkeeping, and reporting of continuous flow measurement, spills, overflows, etc.
- Due to location within a CWDA and the proximity to Class AA marine waters, higher effluent standards may apply

6.3 WASTEWATER FLOW PROJECTIONS

The wastewater flow projections for the project are based on land use areas, unit counts and estimated population using demand rates from the State HAR Chapter 11-62, Appendix F and the City and County, Division of Wastewater Management, *Design Standards of the Department of Wastewater Management*, Volume 1. The flow rate estimates in the table below factor in both wet and dry inflow and infiltration and peak flow factors and include a peak flow factor of 5. The flow projections below are cumulative, and detailed wastewater flow projections are included in the appendix.

Table 6.1 - Wastewater Flow Projections, MGD

Land Use		Phase 1 016-201			ases 1 8 2019-202			ses 1, 2 022-202	•	Phases 1, 2, 3 & 4 2025-2027			
	Ave	Max	Peak	Ave	Max	Peak	Ave	Max	Peak	Ave	Max	Peak	
Resort	0.000	0.000	0.000	0.054	0.254	0.300	0.108	0.508	0.602	0.108	0.508	0.602	
Residential	0.026	0.123	0.233	0.114	0.546	1.004	0.268	1.281	2.310	0.282	1.344	2.510	
Commercial	0.014	0.065	0.070	0.048	0.227	0.244	0.245	1.183	1.313	0.282	1.359	1.506	
Amenities/Support	0.0002	0.001	0.014	0.015	0.063	0.080	0.015	0.065	0.093	0.015	0.065	0.093	
Hawaiian Heritage	0.054	0.233	0.413	0.054	0.233	0.413	0.054	0.233	0.413	0.054	0.233	0.413	
Total	0.094	0.422	0.730	0.285	1.323	2.041	0.690	3.270	4.731	0.741	3.509	5.124	

6.4 PROPOSED WASTEWATER SYSTEM

The proposed wastewater systems within the project will be privately owned and maintained and will be comprised of a collection system of gravity and force mains, pump stations, one wastewater treatment plant, an irrigation reservoir for treated effluent, and injection wells with capacity for 100% backup for effluent disposal. In order to supplement irrigation demand, the wastewater will be treated to R-1 quality and stored in the irrigation reservoir for golf course irrigation.

The wastewater collection system will consist of gravity sewer mains to be located within roadways where grade allows. Due to proposed location of WWTP and topography of site, the gravity mains will flow to pump stations and force mains will pump to the WWTP. Treated effluent from the WWTP will be disposed of into the ground initially until wastewater flows are large enough with predictable quality and volume to allow treatment of the effluent to R-1 standards. At which time, treated effluent will be discharged to an irrigation reservoir which will supply R-1 water for non-potable use on the golf course. Conceptual layout of the proposed wastewater system is shown on Figure 11, Sewer Concept Plan.

6.4.1 WASTEWATER TREATMENT

To minimize cost and size of plant and to allow for phasing of the project, private package modular plants are well suited to the project. There are several types that could be utilized for the project that will satisfy these requirements including the need for effluent reuse, nutrient removal, and variable flows. Treatment systems that use an enhanced activated sludge process including Sequence Batch Reactors, Membrane Bio Reactor, and other biomass and biofilm treatment systems, have been used by similar projects in West Hawaii and are

recommended for the project. For land uses such as industrial, medical and scientific uses that generate high volume or high strength waste water, on-site pretreatment prior to discharge to the wastewater system may be required.

The specific components of the proposed WWTP will be determined during the design phase of the project. However, a typical biological treatment process is outlined below:

- Influent screening Raw wastewater influent is processed through a screening and degritting facility to remove trash and debris. The screening unit will be enclosed in building and/or installed with odor control unit to minimize odors and for pest control
- Equalization Depending on wastewater flow variations, tanks are typically placed ahead of the treatment process to equalize flows. Equalization tanks will be sized based on the anticipated variation of influent flow rates.
- Biological Treatment Treatment of the wastewater is typically done using some form of anoxic and aerobic biologic reactors. The actual configuration of the reactors is dependent on the specific treatment process.
- Sludge digesters and dewatering unit The waste sludge that is removed during biological treatment is typically dewatered and disposed of offsite.
- Tertiary Treatment Treated effluent from primary and secondary treatment must be further treated to produce a water quality suitable for reuse. This may require removal of nutrients.
- Disinfection Filtration, ultra violet or chemical disinfection is required to eliminate pathogens in treated effluent prior to reuse.

6.4.2 EFFLUENT DISPOSAL

Treated wastewater effluent leaving the treatment plant must be disposed of. There are several options available for disposal of effluent:

- Infiltration injection wells, seepage pits, disposal trenches, ponds
- Discharge to ocean, stream
- Reuse non-potable irrigation

Due to environmental concerns and economic constraints, direct discharge to the ocean is not proposed. Effluent disposal for the project will be achieved by infiltration and reuse for non-potable irrigation. During initial phases of the project, the wastewater flow rates may not be consistent enough to warrant production of R-1 recycled water. As a result, infiltration of effluent will be the primary disposal method until the WWTP is generating enough effluent to justify the production of R-1 recycled water. At such time, R-1 effluent will be stored in the irrigation reservoir and gravity fed to the golf course for irrigation use.

Treated wastewater effluent is regulated by HAR Chapter 11-62, which requires the following:

- Effluent disposal systems shall be designed to peak flows
- Effluent disposal systems shall have a 100% backup component
- The WWTP shall be operated and maintained by a certified treatment plant operator and effluent disposal shall conform to monitoring, recordkeeping, and reporting of continuous flow measurement, and overflows requirements.

6.4.3 WASTEWATER REUSE

Wastewater reuse systems are comprised of treatment and disposal components that work in partnership on a continual supply and demand basis. The treatment system typically includes a series of physical, chemical, and biological processes in which wastewater is treated to a quality that makes it suitable for one or more beneficial uses and the subsequent supply of recycled water. In Hawaii, there has been growing demand for use of this precious non-potable resource for landscape and golf course irrigation. In addition to the economical benefit, reuse can offer a practical and environmentally-friendly means of wastewater disposal from treatment systems.

The treatment and use of recycled water in Hawaii is regulated by the Department of Health. Chapter 11-62 HAR presents statutory requirements for wastewater effluent and recycled water quality as well as effluent monitoring and reporting. Moreover, no recycled water systems can be constructed, used, or modified without written approval by the Director of the Department of Health. The regulations also refer to the "Guidelines for the Treatment and Use of Recycled Water" (dated May 15, 2002), which summarizes suitable uses for different categories of recycled water – R-1, R-2, and R-3.

According Table 3-1 of the Guidelines, the use of recycled water at golf courses, residential, parks and educational facilities require a R-1 water quality for above ground spray irrigation. This precaution stems from potential health risks surrounding public exposure. Effluent limits for R-1 water are essentially the same as municipal tertiary treated wastewater and require significant reduction in viral and bacterial pathogens using disinfection of the wastewater effluent. It is possible that R-2 water quality could be produced and used for subsurface irrigation depending on land use.

Effluent reuse system – the proposed recycled water system will consist of a storage component which will provide a minimum of 2 days of storage. Effluent from the WWTP will be pumped into the golf course irrigation system which includes a 3.0 MG reservoir. The reservoir will store brackish irrigation water and treated effluent. The non-potable water in the reservoir will then be gravity fed to the golf course for irrigation use.

At full build out, R-1 production will be used to offset irrigation demand, but it will not completely meet the demand. It is anticipated that the R-1 production at full buildout would only supply only about half of the golf course irrigation demand. The estimated storage requirement for 2 days of recycled water usage will be approximately 0.5 MG to be included in the 3.0 MG reservoir serving the golf course (refer to Figure 10).

Effluent disposal backup system – As required by the regulations, the effluent disposal system shall have a 100% backup component. Since ocean discharge is not being considered, subsurface disposal is the other primary alternative. Effluent disposal options for the backup system include the following:

- Injection wells, seepage pits
- Pond
- Absorption trenches/leach fields

Due to the quality of the marine water resources and lack of surface water discharge points, the effluent will be disposed of using injection wells to be located on the makai side of the UIC line. Treated effluent leaving the WWTP will gravity flow to two gravity injection wells. These wells will be drilled to a depth of 600 feet and spaced at 100 feet arrayed parallel to the coast line makai of the Underground Injection Control line near the Mixed Use Village. The effluent

disposal system will connect with the RO brine concentrate disposal system and deliver effluent and brine concentrate to a series of injection wells near the mixed use village. A total of four disposal wells are shown on Figure 9 and Figure 11. A minimum of two disposal wells are required for the wastewater system. Additional wells will be installed if necessary.

As mentioned previously, the property is subject to the State DOH Underground Injection Control (UIC) regulations (HAR Chapter 11-23) which govern the location, construction and operation of injection wells in an effort to protect the quality of Underground Sources of Drinking Water (USDW). The delineation between the USDW and aquifers that are exempted from being used as USDW are shown on the DOH UIC Maps. The UIC line through the property parallels the coastline and is shown on Figure 11. The project site is generally on the makai side of the UIC line and is within an exempted aquifer. Any wells for disposal of effluent will require a permit from the Department of Health.

6.4.4 SLUDGE HANDLING

The WWTP will include an on-site sludge handling facility required including a holding tank and dewatering facility with additional capacity for storage. Dewatered sludge will be disposed of at a County landfill or through an alternative means such as feedstock for a biomass facility or a land application.

Chapter 7 - SOLID WASTE

7.1 EXISTING CONDITIONS

The County of Hawaii currently operates a network of 21 recycling and transfer stations and two landfills. Since the County does not have curbside pickup, residents and private collection companies collect solid waste and transport it any one of the transfer stations. The County transports waste from the transfer stations to either the South Hilo Sanitary Landfill or the West Hawaii Sanitary Landfill in Puuanahulu.

In December 2009, the County completed its Integrated Resources and Solid Waste Management Plan (IRSWMP), which evaluates the County's existing waste management practices and programs and provides options and recommendations for both short term and long term implementation of the proposed improvements to the County's waste management system. Recommendations include programmatic improvements to reduce, reuse and recyle waste, and infrastructure improvements to upgrade, repair and reconstruct transfer stations and landfills. The IRSWMP specifically identifies a proposed new transfer station to be located in Ocean View which is in close proximity to the project property. Development of the transfer station is programmed to occur within the next few years.

The Kahuku Villages project site is located between two existing transfer stations, one in Milolii and the other in Waiohinu. The Waiohinu transfer station is approximately 7 miles along Mamalahoa to the property and another 6 miles down to the project site. The proposed transfer station to be located in Ocean View would be much closer.

7.2 WASTE GENERATION

The IRSWMP includes a waste stream assessment and historic waste generation rates for the County on a per capita basis. For the fiscal year 07-08, the County of Hawaii waste generation rate was 9.4 pounds/capita/day using resident population. When transient population is added using the State of Hawaii de facto population, the waste generation rate drops to 8.3 pounds/capita/day. This rate is much higher than the 2009 US EPA waste generation rate of 4.34 pounds/capita/day which does not include construction and demolition debris. Due to the transient nature of the development, the diversity of land use types, and the 10 year phasing plan, the County waste generation rate is probably conservative. The County de facto waste generation rate 8.3 pounds/capita/day was used to estimate the total annual waste generation is in the table below.

Table 7.1 – Solid Waste Generation, tons/year

Population Segment	Pha 2016	se 1 -2018		s 1 & 2 -2021		1, 2 & 3 -2024	Phases 1, 2, 3 & 4 2025-2027		
	Capita	Solid Waste	Capita	Solid Waste	Capita	Solid Waste	Capita	Solid Waste	
Transient Hotel/Tentalows	154	233	364	551	888	1,345	1,122	1,700	
Residential Households	138	209	728	1,103	2,240	3,393	2,378	3,602	
Total	292	442	1,092	1,654	3,128	4,738	3,500	5,302	

Population estimates above were obtained from Table 1.0 in the Kahuku Village Commercial Market Assessment Retail Demand Analysis. Since the County's waste generation rate is based on population, only the permanent residential and transient overnight guests are included

in the estimate above. Temporary visitors such as recreational uses, sightseers, golfers, day use visitors, are not included in the population count.

Chapter 8 – POWER AND COMMUNICATIONS

Prepared by Ron Ho and Associates, Inc.

8.1 EXISTING CONDITIONS

As State Public Utility Commission (PUC) regulated public utilities, HELCO. and HTCO. are responsible for the development of off-site facilities that meet island-wide needs, such as power generating plants and power and signal transmission lines, and facilities that serve regional needs of the Kau District. Presently, the nearest existing off-site facilities that could possibly serve this development are HELCO's Kapua Substation or HELCO's South Point Substation and HTCO's Naalehu central office. Oceanic Time Warner Cable (OTWC) is a State Department of Commerce and Consumer Affairs cable television franchisee that is the sole land-line provider of cable television service to Hawaii Island. Although not a PUC regulated utility, OTWC's off-site facility construction policy is to provide such facilities where the anticipated revenue from the prospective service connections warrants the expenditure. HTCO has a similar policy with regard to new developments. TWT is a PUC-registered telecommunications provider but is franchised through the Department of Commerce and Consumer Affairs. HTCO, TWT and OTWC all offer broadband and telephone services.

An existing wind energy facility, Kamaoa Wind Farm, is located on a parcel adjacent to the Nani Kahuku Aina, LLC property. Some of the electricity generated by this facility is fed into HELCO's system through a 69 kV transmission line that is connected to HELCO's line on Mamalahoa Highway and paid for through a purchase power agreement with HELCO. Typical for large alternate energy producers, an interconnection study, which gauges the impact of the alternate energy in-feed on HELCO's system, was required prior to consummation of the purchase power agreement.

8.2 ELECTRICAL AND TELECOMMUNICATIONS DEMAND

The projected electrical demand and telephone line requirements are summarized in Table 8.1.

Table 8.1 – Electrical Demand and Telephone Line Requirements

Electric and Comm. Master Plan	Electric Demand (kiloVolt-Amperes kVA)	Telephone Lines
Phase 1	4,742	396
Phases 1 & 2	12,704	1,136
Phases 1 through 3	27,554	2,145
Phases 1 through 4	31,394	2,292

The electrical demand figures for residential, commercial and other land uses are based planning figures used by HELCO planning personnel for system capacity planning. For commercial, resort and other land uses, the acreage assigned that land use is multiplied by an electrical demand rate per acre characteristic of that land use. The telephone line figures for residential, commercial and other land uses are based on quantities used by HTCO planning personnel in anticipating their cable provisioning requirements. It should be noted that the telephone line requirement figures represent the quantity of copper, twisted pair lines that would normally provision a development of this size. Should the telecommunication service provider elect to provision the development with fiber optic service to the premises, the quantity of telephone lines would be substantially reduced as fiber optic cable would allow for delivery of telephone, video and broadband service via the same cable.

8.3 PROPOSED ELECTRICAL AND TELECOMMUNICATIONS SYSTEMS

8.3.1 ELECTRICAL

Distributed power within the development will be required for the residential, commercial and resort facilities as well as utility infrastructure i.e. desalination plant, wastewater treatment facilities, water and sewer pumping stations, etc. Because of their importance for health and safety, the latter require firm power sources, and in most cases, emergency power generation as a back-up power source. It should be noted that communities and businesses have also become accustomed to having power available on a constant and an instantaneous basis.

There appear to be two alternatives for provision of electrical power to the development, utility power and alternate energy with back-up generation. Although subject to natural forces, utility power is generally considered firm power. The alternate energy source, in this case a windfarm, relies upon the observations of sustained wind velocities taken during the planning stages of the facility development to deliver a relatively steady source of power. Nevertheless, a windfarm would generally be considered as an intermittent source. In order to mitigate those periods when the wind turbines are not delivering power, either a power storage facility or a power generation facility, such as a biomass or biodiesel generator is required. Because of their limited running time, emergency generator installations, used as backup power sources for critical infrastructure, are normally exempted from clean air permitting requirements. Biomass or biodiesel generators, which would probably be constantly running in parallel with the wind turbines as "soft or spinning" back-up, may be required to obtain some form of clean air permit although, these types of facilities would probably not have the same restrictions as fossil-fuel run generators. It appears, therefore, that the preferred alternative would be utility power.

HAWAII ELECTRIC LIGHT CO

During previous discussions, HELCO indicated that their South Point Substation has some capacity to serve the early portions of the development, however the off-site 12.47 kV distribution lines would need to be reconductored in order to provide this service. These off-site 12.47 kV distribution lines are jointly routed along with the HELCO's 69 kV transmission line on Mamalahoa Highway. An overhead or underground line extension would need to be constructed along an accessible route to connect the development with HELCO's off-site facilities along Mamalahoa Highway. The preferred alignment, as discussed with HELCO, is indicated on Figure 12. A possible alternate routing for the 69 kV transmission line, indicated on Figure 13, would be to extend a 69 kV line from the radial feed to the Kamaoa Wind Farm. It should be noted that this alternate routing would require access easements from Kamehameha Schools whereas easements for the preferred alignment could be granted to HELCO by the Developer. It should further be noted that the alternate routing would require the approval of HELCO and also, possibly, an interconnection study to determine whether the intermittent nature of the power input from the windfarm would have an impact on the proposed substation.

8.3.2 TELECOMMUNICATIONS

Telecommunications service to the development may be extended from the existing overhead facilities along Mamalahoa Highway via the existing overhead lines in the Hawaiian Ocean View Ranchos subdivision or along the alignment of the proposed HELCO 69 kV transmission line from Mamalahoa Highway. If OTWC or TWT extend their facilities to the development, either company could provide telephone service to the development as both companies have cable infrastructure sharing agreements. Currently OTWC has the capability to provide telephone,

video and broadband services. HTCO and TWT provide telephone and broadband service but do not currently have the ability to provide video service.

In lieu of extending overhead or underground telecommunications facilities from the existing facilities along Mamalahoa Highway, a satellite downlink, operated by a private telecommunications company could be sited near the development. This facility would act as the main distribution point for the telephone, cable television and broadband communication systems. The optimal site for this facility would be determined by the private vendor.

8.3.3 INFRASTRUCTURE IMPROVEMENTS

The proposed electric and communications infrastructure would be developed in accordance with the specifications and standards of HELCO, and the selected telecommunications service provider. The design and construction of the proposed onsite, underground electric and communications systems would meet or exceed the County's minimum requirements for roadway dedication.

The onsite electric and communications infrastructure would consist of concrete encased, PVC conduits, typically installed within a common trench and located, where feasible, under the roadway sidewalk/shoulder between the edge of pavement and the road right-of-way line. Manholes and handholes would be place periodically to serve as pulling points for the utilities and as parcel service points. The anticipated duct complement for most of the major roadways would consist of 4-5" and 2-4" conduits for HELCO and 5-4" conduits for telecommunications (4-4" conduits for HTCO and 1-4" conduit for OTWC). The anticipated duct complement for the Salt Water Well/HELCO Substation Access Road and Spine Road to the Resort Development is 6-5" conduits for HELCO and 7-4" conduits for telecommunications (6-4" conduits for HTCO and 1-4" conduit for OTWC). The number and size of conduits would vary based on the adjacent land usage with the typical minimum conduit complement being 2-4" conduits for HELCO and 3-4" conduit for telecommunications (2-4" conduits for HTCO and 1-4" conduit for OTWC) on local residential roadways. See Figures 14, 15 and 16 for alignments and anticipated complements.

8.3.4 ROADWAY LIGHTING

Pending the approval by the County of the new Outdoor Lighting Ordinance, use of Light Emitting Diode roadway luminaires may be required for roadway and outdoor area lighting applications unless these systems are time controlled to turn off at 11:00 PM (2300 HST). Since the development roadways will not be dedicated to the County, the Developer has the discretion whether or not to provide roadway lighting. In some resort developments, roadway lighting is provided at intersections while at other resort developments lighting is provided along all roadways maintained by the resort developer. If implemented, the roadway lighting system would be energized through metered electrical connections to HELCO secondary power sources situated along the Development roadways.

Chapter 9 – ORDER OF MAGNITUDE COSTS

Construction costs for the proposed civil infrastructure have been estimate and order of magnitude budgets are shown in the table below.

Table 9.1 – Order of Magnitude Costs, in thousands

Item	Phase 1	Phase 2	Phase 3	Phase 4	Total
ntem	2016-2018	2019-2021	2022-2024	2025-2027	TOTAL
Roadways and Grading	\$10,821	\$18,297	\$2,976	\$1,395	\$33,489
Water System	\$12,386	\$3,618	\$5,965	\$663	\$22,632
Sewer System	\$4,443	\$1,298	\$2,548	\$982	\$9,271
WWTP & Pump Stations	\$10,510	\$3,720	\$3,365	\$0	\$17,595
Drainage System	\$3,229	\$434	\$983	\$465	\$5,111
Irrigation System	0	\$13,639	\$2,046	\$506	\$16,191
Electrical/Communications	\$25,264	\$3,866	\$5,983	\$5,214	\$40,327
Highway Improvements	\$1,650	0	\$2,325	0	\$3,975
Const. Related Indirect.	\$770	\$170	\$770	\$170	\$1,880
Fees & Charges	\$17,000	\$5,200	\$4,800	\$2,800	\$29,800
Miscellaneous	\$516	\$516	0	0	\$1,032
Subtotal	\$86,589	\$50,758	\$31,761	\$12,195	\$181,303
Escalation	\$8,659	\$7,614	\$6,352	\$3,048	\$25,673
Total	\$95,248	\$58,372	\$38,113	\$15,243	\$206,976

Note – Infrastructure cost estimate provided by DJC Consulting.

REFERENCES

Belt Collins & Associates, *Hawaiian Riviera Resort, Kauhuku, Kau, Hawaii, Draft Environmental Impact Statement*, Prepared for Place Development Corporation and Hawaii Kau Aina Partnership, September 1987.

Sea Engineering Inc., Costal Engineering Planning and Design Considerations for the Hawaiian Riviera Resort, Kahuku, Kau, Hawaii, Prepared for Place Development Corporation and Hawaii Kau Aina Partnership, July 1987.

County of Hawaii, Department of Public Works, Storm Drainage Standard, October 1972.

County of Hawaii,

County of Hawaii, County of Hawaii General Plan, February 2005

County of Hawaii, Integrated Resources and Solid Waste Management Plan, 2009

County of Hawaii, Department of Water Supply, *Water Use and Development Plan Update, Hawaii Water Plan*, August 2010

County of Hawaii, Department of Water Supply, Water System Standards, 2002

City and County of Hawaii, Division of Wastewater Management, Design Standards of the Department of Wastewater Management, Volume 1, July 1993

State of Hawaii, Department of Health, 2006 State of Hawaii Quality Monitoring and Assessment Report: Integrated Report to the U.S. Environmental Protection Agency and The U.S. Congress Pursuant to Sections §303(D) and §305(B) Clean Water Act (P.L. 97-117), January 11, 2008.

State of Hawaii, Department of Land and Natural Resources, Commission on Water Resource Management, Surface-Water Hydrologic Units – A Management Tool for Instream Flow Standards, PR-2005-01, June 2005.

State of Hawaii, Department of Health, Hawaii Administrative Rules, Title 11, Chapter 62, Wastewater Systems, January 14, 2004.

State of Hawaii, Department of Health, Hawaii Administrative Rules, Title 11, Chapter 62, Appendix A, Individual and General Permit Standard Conditions, April 15, 1997.

State of Hawaii, Department of Health, Clean Water Branch,

State of Hawaii, Department of Health, Safe Drinking Water Branch, Hawaii Administrative Rules, Title 11, Chapter 23, Underground Injection Control, January 14, 2004.

State of Hawaii, Department of Health, Wastewater Branch, *Guidelines for the Treatment and Use of Recycled Water*, May 15, 2002

- U.S. Department of Agriculture, Soil Conservation Service, *Soil Survey for the Island of Hawaii, State of Hawaii*, December 1972
- U.S. Department of Commerce, Weather Bureau, *Technical Paper No. 43 Rainfall Frequency Atlas of the Hawaiian Islands for Areas to 200 Square Miles, Durations to 24 Hours, and Return Periods from 1 to 100 Years*, 1962
- U.S. Federal Emergency Management Agency, FIRM, Flood Insurance Rate Map, Hawaii County, Hawaii, Flood Insurance Map Number 155166IND0A, April 2, 2004.

U.S. Geological Survey, 7.5 Minute Topographic Maps Kahuku Ranch, HI 1995 Papa, HI 1995 Pohue Bay, HI 1995 Puu Hou, HI 1977 Puu O KeoKeo, HI 1995

U.S. National Oceanic and Atmospheric Administration, National Weather Service, *Precipitation Frequency Atlas of the United States*, NOAA Atlas 14, Volume 4, Version 2, 2009

US EPA, Municipal Solid Waste in the United States: 2009 Facts and Figures

Construction Plans Used

County of Hawaii Department of Public Works (Approved 5/76). Kahuku Towards Kona Highway Improvements, Priority No. 6, Job No. P-2129.

County of Hawaii Department of Public Works (Approved 2/75). Kahuku Towards Kona Highway Improvements, Job No. P-1957.

State of Hawaii Department of Transportation Highways Division (Approved 6/10/75). *Hawaii* Belt Road – Kahuku To Papa, Project No. 11E-01-75

Websites Used

State of Hawaii, Department of Business, Economic Development and Tourism Hawaii Statewide GIS Program http://hawaii.gov/dbedt/gis/

U.S. Department of Agriculture, Natural Resource Conservation Service Soil Data Mart http://soildatamart.nrcs.usda.gov/

U.S. National Oceanic and Atmospheric Administration, National Weather Service HDSC Precipitation Frequency Data Server http://hdsc.nws.noaa.gov/hdsc/pfds/hi/hi_pfds.html

PROJECT: Kahuku Village CLIENT: Nani Kahuku Aina LLC

SUBJECT: Potable Water, Irrigation Water and Sewer Demand JOB NO:

DATE:

2984-00 PHASE 1

05/01/11

KAHUKU VILLAGE - PHA	KAHUKU VILLAGE - PHASE 1 w													SEWER DEN	//AND			
															Design	Design		Design
						DOMESTIC	I	RRIGATION							Average	Maximum		Peak
USE	POTABLE DEMAND	IRRIGATION DEMAND	UNITS	ACRES	DENSITY	POTABLE	POTABLE	BRACKISH	R-1	UNITS	ACRES	CAPITA	RATE UNIT	Dry I/I	Daily, gpd	Daily, gpd	Wet I/I	Flow, gpd
VISITOR ACOMMODATIONS																		
Hotel	300 gpd/unit	500 gpd/unit	0	0	0.0	0		0		0	0	0	200 gpd/unit	0	0	0	0	0
		SUBTOTAL	0	0		0	0	0	0	0	0	0		0	0	0	0	0
RESIDENTIAL																		
R-X: Single Family	350 gpd/unit	750 gpd/unit	30	12.5	2.4	10,500	22,500			30	12.5	120	320 gpd/unit	600	10,200	48,600	15,625	64,225
R-1: Oceanfront Lots	350 gpd/unit	750 gpd/unit	28	39.5	0.7	9,800	21,000			28	39.5	112	320 gpd/unit	560	9,520	45,360	49,375	94,735
R-2: Golf Estates	350 gpd/unit	750 gpd/unit	7	11.0	0.6	2,450		5,250		7	11.0	28	320 gpd/unit	140	2,380	11,340	13,750	25,090
R-3: Estates	350 gpd/unit	750 gpd/unit	11	25.0	0.4	3,850	8,250			11	25.0	44	320 gpd/unit	220	3,740	17,820	31,250	49,070
MF-1: Oceanfront Condo	200 gpd/unit	300 gpd/unit	0	0.0	0.0	0	0			0	0.0	0	200 gpd/unit	0	0	0	0	0
MF-2: Golf Villas	300 gpd/unit	500 gpd/unit	0	0.0	0.0	0		0		0	0.0	0	320 gpd/unit	0	0	0	0	0
Community Parks	5gpp/ 200 people	50% AI @ 4,000 gpd/acre		0.0		0		0		0	0.0	0	5 gpd/person	0	0	0	0	0
		SUBTOTAL	76	88		26,600	51,750	5,250	0	76	88	304		1,520	25,840	123,120	110,000	233,120
COMMERCIAL																		
VMX: Village Mixed Use	2,000 gpd/acre	1,000 gpd/acre	0	0.0		0		0		0	0.0	0	300 gpd/unit	0	0	0	0	0
Village Green		1,000 gpd/acre		0.0				0		0	0.0	0	5 gpd/person	0	0	0	0	0
Commercial	1,000 gpd/acre	1,000 gpd/acre		4.0		4,000		4,000		0	4.0	160	80 gpd/person	800	13,600	64,800	5,000	69,800
Civic	1,000 gpd/acre	1,000 gpd/acre		0.0		0		0		0	0.0	0	80 gpd/person	0	0	0	0	0
VA Facility	2,000 gpd/acre	1,000 gpd/acre		0.0		0		0		0	0.0	0	250 gpd/person	0	0	0	0	0
		SUBTOTAL	0	4		4,000	0	4,000	0	0	4	160		800	13,600	64,800	5,000	69,800
AMENITIES/SUPPORT USES																		
18 hole GC	15,000 gallons	100 acres @6,000 gpd/acre	9	0		0		0		0	0							
Clubhouse	5 gpp/ 400 people	25% Al @4,000 gpd/acre		0		0		0		0	0	0	25 gpd/member	0	0	0	0	0
Maintenance Facility				5		5,000		5,000		0	5	5	20 gpd/person	25		525	6,250	6,775
WWTP				5		1,000		5,000		0	5	5	20 gpd/person	25	125	525	6,250	6,775
Main Road 1 Irrigation - 120		10,000 lf @2.5 gpd/ft						25,000										
Main Road 2 Irrigation - 60'		5,000 lf @1.0 gpd/ft						5,000										
Main Road 3 Irrigation - 60'	ROW	5,000 lf @1.0 gpd/ft						5,000										
		SUBTOTAL	0	10		6,000	0	45,000	0	0	10	10		50		1,050	12,500	13,550
TOTAL			76	102		36,600	51,750	54,250	0	76	102	474		2,370	39,690	188,970	127,500	316,470

IAWAIIAN HERITAGE	AREA				WATER DI	EMAND						,	SEWER DEN	IAND			
														Design	Design		Design
					DOMESTIC		IRRIGATION							Average	Maximum		Peak
USE	POTABLE DEMAND	IRRIGATION DEMAND	UNITS	ACRES	POTABLE	POTABLE	BRACKISH	R-1	UNITS	ACRES	CAPITA	RATE UNIT	Dry I/I	Daily, gpd	Daily, gpd	Wet I/I	Flow, gpd
Fishing Village	5gpp/ 200 people	20% Al @2,000 gpd/acre		10	1,000		4,000		0	10	200	5 gpd/person	1,000	2,000	6,000	12,500	18,500
Learning Village	100gpp/ 150 people	20% Al @2,000 gpd/acre	100	75	15,000		30,000		100	75	150	100 gpd/person	750	15,750	75,750	93,750	169,500
Amphitheater	5gpp/ 500 people	20% Al @2,000 gpd/acre		2	2,500		800		0	2	500	5 gpd/person	2,500	5,000	15,000	2,500	17,500
Heritage Institute	20gpp/ 100 workers	20% Al @2,000 gpd/acre		20	2,000		8,000		0	20	100	20 gpd/person	500	2,500	10,500	25,000	35,500
Visitors Center	5gpp/ 400 people	20% Al @2,000 gpd/acre		5	2,000		2,000		0	5	400	5 gpd/person	2,000	4,000	12,000	6,250	18,250
Marine Science Lab	20gpp/ 20 workers +	20% Al @2,000 gpd/acre		5	400		2,000		0	5	20	25 gpd/person	100	600	2,600	6,250	8,850
Camp Sites	50gpp/ 50 people			5	2,500		2,000		0	5	50	32 gpd/person	250	1,850	8,250	6,250	14,500
Eco-Lodge	300 gpd/unit	300 gpd/unit	100	20	30,000		30,000		100	20	400	200 gpd/unit	2,000	22,000	102,000	25,000	127,000
Maintenance Facility				2.0	15,000		15,000		0	2	10	20 gpd/person	50	250	1,050	2,500	3,550
		SUBTOTAL	200	144	70,400	0	93,800	0	200	144	1,830		9,150	53,950	233,150	180,000	413,150

				WATER D	EMAND						· ·	SEWER DEN	IAND			
													Design	Design		Design
				DOMESTIC		IRRIGATION							Average	Maximum		Peak
	UNI	S ACRE	S	POTABLE	POTABLE	BRACKISH	R-1	UNITS	ACRES	CAPITA		Dry I/I	Daily, gpd	Daily, gpd	Wet I/I	Flow, gpd
GRAND TOTALS - PHASE 1		76 2	16	107,000	51,750	148,050	0	276	246	2,304		11,520	93,640	422,120	307,500	729,620
	MAX DAILY DEMAND (1.5 for Pota	ble, 1.65 fc	r Irrigation)	160,500	85,388	244,283	0				POTENTIAL R-1 A	VAILABLE	74,912			

275,394

MAX DAILY DEMAND (1.5 for Potable, 1.65 for Irrigation) 160,500 85,388 244,283 12% Losses 19,260 179,760 10,247 29,314 0 TOTAL MDD + LOSSES
TOTAL POTABLE 95,634 273,596 0

TOTAL BRACKISH TOTAL WATER

273,596 548,990

- Preserve area of 356 acres excluded in HHA
- Water demand rates provided by Tom Nance Water Resources Engineering
 Sewer demand rates from Belt Collins Report

PROJECT: Kahuku Village CLIENT: Nani Kahuku Aina LLC

SUBJECT: Potable Water, Irrigation Water and Sewer Demand DATE: 05/01/11 JOB NO: 2984-00

PHASES 1 & 2

KAHUKU VILLAGE - PH	ASES 1 & 2		WATER DEMAND								S	EWER DEM	AND					
															Design	Design		Design
			1			DOMESTIC		IRRIGATION							Average	Maximum		Peak
USE	POTABLE DEMAND	IRRIGATION DEMAND	UNITS	ACRES	DENSITY	POTABLE	POTABLE	BRACKISH	R-1	UNITS	ACRES	CAPITA	RATE UNIT	Dry I/I	Daily, gpd	Daily, gpd	Wet I/I	Flow, gpd
VISITOR ACOMMODATIONS																		
Hotel	300 gpd/unit	500 gpd/unit	250	37	6.8	75,000		125,000		250	37	840	200 gpd/unit	4,200	54,200	254,200	46,250	300,450
		SUBTOTAL	250	37		75,000	0	125,000	0	250	37	840		4,200	54,200	254,200	46,250	300,450
RESIDENTIAL																		
R-X: Single Family	350 gpd/unit	750 gpd/unit	70	28.5	2.5	24,500	52,500			70	28.5	280	320 gpd/unit	1,400	23,800	113,400	35,625	149,025
R-1: Oceanfront Lots	350 gpd/unit	750 gpd/unit	28	39.5	0.7	9,800	21,000			28	39.5	112	320 gpd/unit	560	9,520	45,360	49,375	94,735
R-2: Golf Estates	350 gpd/unit	750 gpd/unit	117	170.5	0.7	40,950		87,750		117	170.5	468	320 gpd/unit	2,340	39,780	189,540	213,125	402,665
R-3: Estates	350 gpd/unit	750 gpd/unit	37	87.0	0.4	12,950	27,750			37	87.0	148	320 gpd/unit	740	12,580	59,940	108,750	168,690
MF-1: Oceanfront Condo	200 gpd/unit	300 gpd/unit	55	16.0	3.4	11,000	16,500			55	16.0	154	200 gpd/unit	770	11,770	55,770	20,000	75,770
MF-2: Golf Villas	300 gpd/unit	500 gpd/unit	50	14.0	3.6	15,000		25,000		50	14.0	140	320 gpd/unit	700	16,700	80,700	17,500	98,200
Community Parks	5gpp/ 200 people	50% AI @ 4,000 gpd/acre		11.0		500		22,000		0	11.0	28	5 gpd/person	140	280	840	13,750	14,590
		SUBTOTAL	357	367		114,700	117,750	134,750	0	357	367	1,330		6,650	114,430	545,550	458,125	1,003,675
COMMERCIAL																		
VMX: Village Mixed Use	2,000 gpd/acre	1,000 gpd/acre	0	0.0		0		0		0	0.0	0	300 gpd/unit	0	0	0	0	0
Village Green		1,000 gpd/acre		0.0				0		0	0.0	0	5 gpd/person	0	0	0	0	0
Commercial	1,000 gpd/acre	1,000 gpd/acre		14.0		14,000		14,000		0	14.0	560	80 gpd/person	2,800	47,600	226,800	17,500	244,300
Civic	1,000 gpd/acre	1,000 gpd/acre		0.0		0		0		0	0.0	0	80 gpd/person	0	0	0	0	0
VA Facility	2,000 gpd/acre	1,000 gpd/acre		0.0		0		0		0	0.0	0	250 gpd/person	0	0	0	0	0
		SUBTOTAL	0	14		14,000	0	14,000	0	0	14	560		2,800	47,600	226,800	17,500	244,300
AMENITIES/SUPPORT USES	3																	
18 hole GC	15,000 gallons	100 acres @6,000 gpd/acre	•	327		15,000		600,000		0	327							
Clubhouse	5 gpp/ 400 people	25% AI @4,000 gpd/acre		3		2,000		3,000		0	3	480	25 gpd/member	2,400	14,400	62,400	3,750	66,150
Maintenance Facility		-		5		10,000		10,000		0	5	5	20 gpd/person	25	125	525	6,250	6,775
WWTP				5		1,000		10,000		0	5	5	20 gpd/person	25	125	525	6,250	6,775
Main Road 1 Irrigation - 12	0' ROW	10,000 lf @2.5 gpd/ft						25,000										
Main Road 2 Irrigation - 60	' ROW	15,000 lf @1.0 gpd/ft						15,000										
Main Road 3 Irrigation - 60	' ROW	10,000 lf @1.0 gpd/ft				·		10,000										·
		SUBTOTAL	0	340		28,000	0	673,000	0	0	340	490		2,450	14,650	63,450	16,250	79,700
TOTAL	·	·	607	758		231,700	117,750	946,750	0	607	758	3,220		16,100	230,880	1,090,000	538,125	1,628,125

HAWAIIAN HERITAGE	AREA				WATER D	EMAND						S	SEWER DEN	IAND			
														Design	Design		Design
					DOMESTIC		IRRIGATION							Average	Maximum		Peak
USE	POTABLE DEMAND	IRRIGATION DEMAND	UNITS					UNITS	ACRES	CAPITA	RATE UNIT	Dry I/I	Daily, gpd	Daily, gpd	Wet I/I	Flow, gpd	
Fishing Village	5gpp/ 200 people	20% Al @2,000 gpd/acre		10	1,000		4,000		0	10	200	5 gpd/person	1,000	2,000	6,000	12,500	18,500
Learning Village	100gpp/ 150 people	20% AI @2,000 gpd/acre	100	75	15,000		30,000		100	75	150	100 gpd/person	750	15,750	75,750	93,750	169,500
Amphitheater	5gpp/ 500 people	20% AI @2,000 gpd/acre		2	2,500				0	2	500	5 gpd/person	2,500	5,000	15,000	2,500	17,500
Heritage Institute	20gpp/ 100 workers	20% AI @2,000 gpd/acre		20	2,000		8,000		0	20	100	20 gpd/person	500	2,500	10,500	25,000	35,500
Visitors Center	5gpp/ 400 people	20% Al @2,000 gpd/acre		5	2,000		2,000		0	5	400	5 gpd/person	2,000	4,000	12,000	6,250	18,250
Marine Science Lab	20gpp/ 20 workers +	20% Al @2,000 gpd/acre		5	400		2,000		0	5	20	25 gpd/person	100	600	2,600	6,250	8,850
Camp Sites	50gpp/ 50 people			5	2,500		2,000		0	5	50	32 gpd/person	250	1,850	8,250	6,250	14,500
Eco-Lodge	300 gpd/unit	300 gpd/unit	100	20	30,000				100	20	400	200 gpd/unit	2,000	22,000	102,000	25,000	127,000
Maintenance Facility			2.0 15,000 15,000				0	2	10	20 gpd/person	50	250	1,050	2,500	3,550		
		SUBTOTAL	200							144	1,830		9,150	53,950	233,150	180,000	413,150

				WATER D	EMAND						5	SEWER DEM	IAND			
													Design	Design		Design
				DOMESTIC		IRRIGATION							Average	Maximum		Peak
	UNITS	ACRES		POTABLE	POTABLE	BRACKISH	R-1	UNITS	ACRES	CAPITA		Dry I/I	Daily, gpd	Daily, gpd	Wet I/I	Flow, gpd
GRAND TOTALS - PHASES 1 & 2	807	902		302,100	117,750	1,040,550	0	807	902	5,050		25,250	284,830	1,323,150	718,125	2,041,275
MAX DAIL	rrigation)	453,150	194,288	1,716,908	0				POTENTIAL R-1 A	VAILABLE	227,864					

MAX DAILY DEMAND (1.5 for Potable, 1.65 for Irrigation) 12% Losses 453,150 54,378 194,288 23,315 1,716,908 0 206,029 0 TOTAL MDD + LOSSES 507,528 217,602 1,922,936 0 TOTAL POTABLE TOTAL BRACKISH 725,130 1,922,936

TOTAL WATER 2,648,066

- NOTES:
 1. Preserve area of 356 acres excluded in HHA
- Water demand rates provided by Tom Nance Water Resources Engineering
 Sewer demand rates from Belt Collins Report

Kahuku Village PROJECT: CLIENT: Nani Kahuku Aina LLC

SUBJECT: Potable Water, Irrigation Water and Sewer Demand DATE: 05/01/11 JOB NO: 2984-00

PHASES 1, 2 & 3

(AHUKU VILLAGE - PH	ASES 1, 2 & 3					WATER DE	MAND						S	EWER DEN	MAND			
															Design	Design		Design
					ſ	DOMESTIC		IRRIGATION							Average	Maximum		Peak
USE	POTABLE DEMAND	IRRIGATION DEMAND	UNITS	ACRES D	ENSITY	POTABLE	POTABLE	BRACKISH	R-1	UNITS	ACRES	CAPITA	RATE UNIT	Dry I/I	Daily, gpd	Daily, gpd	Wet I/I	Flow, gpd
ISITOR ACOMMODATIONS																		
Hotel	300 gpd/unit	500 gpd/unit	500	75	6.7	150,000		250,000		500	75	1,680	200 gpd/unit	8,400	108,400	508,400	93,750	602,15
		SUBTOTAL	500	75		150,000	0	250,000	0	500	75	1,680		8,400	108,400	508,400	93,750	602,15
ESIDENTIAL																		
R-X: Single Family	350 gpd/unit	750 gpd/unit	135	55.5	2.4	47,250	101,250			135	55.5	540	320 gpd/unit	2,700	45,900	218,700	69,375	288,07
R-1: Oceanfront Lots	350 gpd/unit	750 gpd/unit	60	84.0	0.7	21,000	45,000			60	84.0	240	320 gpd/unit	1,200	20,400	97,200	105,000	202,20
R-2: Golf Estates	350 gpd/unit	750 gpd/unit	291	483.0	0.6	101,850		218,250		291	483.0	1,164	320 gpd/unit	5,820	98,940	471,420	603,750	1,075,17
R-3: Estates	350 gpd/unit	750 gpd/unit	37	87.0	0.4	12,950	27,750			37	87.0	148	320 gpd/unit	740	12,580	59,940	108,750	168,69
MF-1: Oceanfront Condo	200 gpd/unit	300 gpd/unit	140	41.0	3.4	28,000	42,000			140	41.0	392	200 gpd/unit	1,960	29,960	141,960	51,250	193,21
MF-2: Golf Villas	300 gpd/unit	500 gpd/unit	180	50.0	3.6	54,000		90,000		180	50.0	504	320 gpd/unit	2,520	60,120	290,520	62,500	353,02
Community Parks	5gpp/ 200 people	50% AI @ 4,000 gpd/acre		22.0		1,000		44,000		0	22.0	56	5 gpd/person	280	560	1,680	27,500	29,18
		SUBTOTAL	843	823		266,050	216,000	352,250	0	843	823	3,044		15,220	268,460	1,281,420	1,028,125	2,309,54
OMMERCIAL																		
VMX: Village Mixed Use	2,000 gpd/acre	1,000 gpd/acre	149	33.0		66,000		33,000		149	33.0	596	300 gpd/unit	2,980	47,680	226,480	41,250	267,730
Village Green		1,000 gpd/acre		2.0				2,000		0	2.0	100	5 gpd/person	500	1,000	3,000	2,500	5,500
Commercial	1,000 gpd/acre	1,000 gpd/acre		24.0		24,000		24,000		0	24.0	960	80 gpd/person	4,800	81,600	388,800	30,000	418,80
Civic	1,000 gpd/acre	1,000 gpd/acre		0.0		0		0		0	0.0	0	80 gpd/person	0	0	0	0	
VA Facility	2,000 gpd/acre	1,000 gpd/acre		45.0		90,000		45,000		0	45.0	450	250 gpd/person	2,250	114,750	564,750	56,250	621,00
		SUBTOTAL	149	104		180,000	0	104,000	0	149	104	2,106		10,530	245,030	1,183,030	130,000	1,313,03
MENITIES/SUPPORT USES																		
18 hole GC	15,000 gallons	100 acres @6,000 gpd/acre	Э	327		15,000		600,000		0	327							
Clubhouse	5 gpp/ 400 people	25% AI @4,000 gpd/acre		3		2,000		3,000		0	3	480	25 gpd/member	2,400	14,400	62,400	3,750	66,15
Maintenance Facility				10		15,000		15,000		0	10	10	20 gpd/person	50	250	1,050	12,500	13,55
WWTP				10		2,000		10,000		0	10	10	20 gpd/person	50	250	1,050	12,500	13,55
Main Road 1 Irrigation - 120	O' ROW	10,000 lf @2.5 gpd/ft						25,000										
Main Road 2 Irrigation - 60'	ROW	25,000 lf @1.0 gpd/ft						25,000										
Main Road 3 Irrigation - 60'	ROW	15,000 lf @1.0 gpd/ft						15,000										
		SUBTOTAL	0	350		34,000	0	693,000	0	0	350	500		2,500	14,900	64,500	28,750	93,25
OTAL			1.492	1.352		630.050	216.000	1.399.250	0	1.492	1.352	7.330		36.650	636,790	3.037.350	1.280.625	4,317,97

AWAIIAN HERITAGE	AREA				WATER DI	EMAND							S	EWER DEN	IAND			
															Design	Design		Design
					DOMESTIC		IRRIGATION								Average	Maximum		Peak
USE	POTABLE DEMAND	IRRIGATION DEMAND	UNITS	ACRES				R-1	UNITS	ACRES	CAPITA	RATE	UNIT	Dry I/I	Daily, gpd	Daily, gpd	Wet I/I	Flow, gpd
Fishing Village	5gpp/ 200 people	20% Al @2,000 gpd/acre		10	1,000		4,000		0	10	200	5 gpc	d/person	1,000	2,000	6,000	12,500	18,50
Learning Village	100gpp/ 150 people	20% Al @2,000 gpd/acre	100	75	15,000		30,000		100	75	150	100 gpc	d/person	750	15,750	75,750	93,750	169,50
Amphitheater	5gpp/ 500 people	20% Al @2,000 gpd/acre		2	2,500		800		0	2	500	5 gpc	d/person	2,500	5,000	15,000	2,500	17,50
Heritage Institute	20gpp/ 100 workers	20% Al @2,000 gpd/acre		20	2,000		8,000		0	20	100	20 gpc	d/person	500	2,500	10,500	25,000	35,5
Visitors Center	5gpp/ 400 people	20% Al @2,000 gpd/acre		5	2,000		2,000		0	5	400	5 gpc	d/person	2,000	4,000	12,000	6,250	18,2
Marine Science Lab	20gpp/ 20 workers +	20% Al @2,000 gpd/acre		5	400		2,000		0	5	20	25 gpc	d/person	100	600	2,600	6,250	8,8
Camp Sites	50gpp/ 50 people			5	2,500		2,000		0	5	50	32 gpc	d/person	250	1,850	8,250	6,250	14,50
Eco-Lodge	300 gpd/unit	300 gpd/unit	100	20	30,000		30,000		100	20	400	200 gpc	d/unit	2,000	22,000	102,000	25,000	127,00
Maintenance Facility				2.0	15,000		15,000		0	2	10	20 gpc	d/person	50	250	1,050	2,500	3,5
•	SUBTO				70,400	0	93,800	0	200	144	1,830			9,150	53,950	233,150	180,000	413,15

				WATER DI	EMAND						Ş	SEWER DEM	IAND			
													Design	Design		Design
		DOMESTIC IRRIGATION											Average	Maximum		Peak
	UNITS	ACRES		POTABLE	POTABLE	BRACKISH	R-1	UNITS	ACRES	CAPITA		Dry I/I	Daily, gpd	Daily, gpd	Wet I/I	Flow, gpd
GRAND TOTALS - PHASES 1, 2 & 3	1,692	1,496		700,450	216,000	1,493,050	0	1,692	1,496	9,160		45,800	690,740	3,270,500	1,460,625	4,731,125
MAX DAILY DEMAND	.5 for Potable, 1.65 for Irrigation) 1,050,675 356,400 2,463,533 0						0				POTENTIAL R-1 A	VAILABLE	552,592	•		

MAX DAILY DEMAND (1.5 for Potable, 1.65 for Irrigation) 1,050,675 356,400 2,463,533 42,768 295,624 12% Losses 126,081 0 TOTAL MDD + LOSSES 1,176,756 399,168 2,759,156 0

TOTAL POTABLE 1,575,924 TOTAL BRACKISH TOTAL WATER

2,759,156 4,335,080

NOTES:

- 1. Preserve area of 356 acres excluded in HHA
- Water demand rates provided by Tom Nance Water Resources Engineering
 Sewer demand rates from Belt Collins Report

PROJECT: Kahuku Village

CLIENT: Nani Kahuku Aina LLC

SUBJECT: Potable Water, Irrigation Water and Sewer Demand

JOB NO: 2984-00 PHASES 1, 2, 3 & 4 - FULL BUILDOUT

05/01/11

DATE:

(AHUKU VILLAGE - PH	ASES 1,2, 3 & 4 - F	ULL BUILDOUT				WATER DE	MAND						S	EWER DEN	IAND			
															Design	Design		Design
						DOMESTIC		IRRIGATION							Average	Maximum		Peak
USE	POTABLE DEMAND	IRRIGATION DEMAND	UNITS	ACRES D	ENSITY	POTABLE	POTABLE	BRACKISH	R-1	UNITS	ACRES	CAPITA	RATE UNIT	Dry I/I	Daily, gpd	Daily, gpd	Wet I/I	Flow, gpd
ISITOR ACOMMODATIONS																		
Hotel	300 gpd/unit	500 gpd/unit	500	75	6.7	150,000		250,000		500	75	1,680	200 gpd/unit	8,400	108,400	508,400	93,750	602,150
		SUBTOTAL	500	75		150,000	0	250,000	0	500	75	1,680		8,400	108,400	508,400	93,750	602,150
RESIDENTIAL																		
R-X: Single Family	350 gpd/unit	750 gpd/unit	135	55.5	2.4	47,250	101,250			135	55.5	540	320 gpd/unit	2,700	45,900	218,700	69,375	288,07
R-1: Oceanfront Lots	350 gpd/unit	750 gpd/unit	60	84.0	0.7	21,000	45,000			60	84.0	240	320 gpd/unit	1,200	20,400	97,200	105,000	202,20
R-2: Golf Estates	350 gpd/unit	750 gpd/unit	291	483.0	0.6	101,850		218,250		291	483.0	1,164	320 gpd/unit	5,820	98,940	471,420	603,750	1,075,17
R-3: Estates	350 gpd/unit	750 gpd/unit	75	179.0	0.4	26,250	56,250			75	179.0	300	320 gpd/unit	1,500	25,500	121,500	223,750	345,25
MF-1: Oceanfront Condo	200 gpd/unit	300 gpd/unit	140	41.0	3.4	28,000	42,000			140	41.0	392	200 gpd/unit	1,960	29,960	141,960	51,250	193,210
MF-2: Golf Villas	300 gpd/unit	500 gpd/unit	180	50.0	3.6	54,000		90,000		180	50.0	504	320 gpd/unit	2,520	60,120	290,520	62,500	353,02
Community Parks	5gpp/ 200 people	50% Al @ 4,000 gpd/acre		40.0		1,000		80,000		0	40.0	100	5 gpd/person	500	1,000	3,000	50,000	53,00
		SUBTOTAL	881	933		279,350	244,500	388,250	0	881	933	3,240		16,200	281,820	1,344,300	1,165,625	2,509,92
OMMERCIAL																		
VMX: Village Mixed Use	2,000 gpd/acre	1,000 gpd/acre	169	37.5		75,000		37,500		169	37.5	676	300 gpd/unit	3,380	54,080	256,880	46,875	303,755
Village Green		1,000 gpd/acre		2.0				2,000		0	2.0	100	5 gpd/person	500	1,000	3,000	2,500	5,50
Commercial	1,000 gpd/acre	1,000 gpd/acre		24.0		24,000		24,000		0	24.0	960	80 gpd/person	4,800	81,600	388,800	30,000	418,80
Civic	1,000 gpd/acre	1,000 gpd/acre		9.0		9,000		9,000		0	9.0	360	80 gpd/person	1,800	30,600	145,800	11,250	157,05
VA Facility	2,000 gpd/acre	1,000 gpd/acre		45.0		90,000		45,000		0	45.0	450	250 gpd/person	2,250	114,750	564,750	56,250	621,000
		SUBTOTAL	169	118		198,000	0	117,500	0	169	118	2,546		12,730	282,030	1,359,230	146,875	1,506,10
MENITIES/SUPPORT USES											·		·					
18 hole GC	15,000 gallons	100 acres @6,000 gpd/acre	е	327		15,000		600,000		0	327							
Clubhouse	5 gpp/ 400 people	25% AI @4,000 gpd/acre		3		2,000		3,000		0	3	480	25 gpd/member	2,400	14,400	62,400	3,750	66,15
Maintenance Facility				10		15,000		15,000		0	10	10	20 gpd/person	50	250	1,050	12,500	13,55
WWTP				10		2,000	•	10,000		0	10	10	20 gpd/person	50	250	1,050	12,500	13,55
Main Road 1 Irrigation - 120	o' ROW	10,000 lf @2.5 gpd/ft						25,000										
Main Road 2 Irrigation - 60'		25,000 lf @1.0 gpd/ft						25,000										
Main Road 3 Irrigation - 60'	ROW	15,000 lf @1.0 gpd/ft						15,000										
		SUBTOTAL	0	350		34,000	0	693,000	0	0	350	500		2,500	14,900	64,500	28,750	93,25
OTAL		•	1,550	1,475		661,350	244,500	1,448,750	0	1,550	1,475	7,966		39,830	687,150	3,276,430	1,435,000	4,711,430

HAWAIIAN HERITAGE	AREA				WATER DI	MAND						;	SEWER DEN	IAND			
														Design	Design		Design
					DOMESTIC		IRRIGATION							Average	Maximum		Peak
USE	POTABLE DEMAND	IRRIGATION DEMAND	UNITS	ACRES	POTABLE	POTABLE	BRACKISH	R-1	UNITS	ACRES	CAPITA	RATE UNIT	Dry I/I	Daily, gpd	Daily, gpd	Wet I/I	Flow, gpd
Fishing Village	5gpp/ 200 people	20% AI @2,000 gpd/acre		10	1,000		4,000		0	10	200	5 gpd/person	1,000	2,000	6,000	12,500	18,500
Learning Village	100gpp/ 150 people	20% AI @2,000 gpd/acre	100	75	15,000		30,000		100	75	150	100 gpd/person	750	15,750		93,750	169,500
Amphitheater	5gpp/ 500 people	20% AI @2,000 gpd/acre		2	2,500		800		0	2	500	5 gpd/person	2,500	5,000	15,000	2,500	17,500
Heritage Institute	20gpp/ 100 workers	20% Al @2,000 gpd/acre		20	2,000		8,000		0	20	100	20 gpd/person	500	2,500	10,500	25,000	35,500
Visitors Center	5gpp/ 400 people	20% AI @2,000 gpd/acre		5	2,000		2,000		0	5	400	5 gpd/person	2,000	4,000	12,000	6,250	18,250
Marine Science Lab	20gpp/ 20 workers +	20% Al @2,000 gpd/acre		5	400		2,000		0	5	20	25 gpd/person	100	600	2,600	6,250	8,850
Camp Sites	50gpp/ 50 people			5	2,500		2,000		0	5	50	32 gpd/person	250	1,850	8,250	6,250	14,500
Eco-Lodge	300 gpd/unit	300 gpd/unit	100	20	30,000		30,000		100	20	400	200 gpd/unit	2,000	22,000	102,000	25,000	127,000
Maintenance Facility				2	15,000		15,000		0	2	10	20 gpd/person	50	250	1,050	2,500	3,550
•		SUBTOTAL	200	144	70,400	0	93,800	0	200	144	1,830		9,150	53,950	233,150	180,000	413,150

			WATER I	EMAND						· ·	SEWER DEN	MAND			
												Design	Design		Design
			DOMESTIC		IRRIGATION							Average	Maximum		Peak
	UNITS	ACRES	POTABLE	POTABLE	BRACKISH	R-1	UNITS	ACRES	CAPITA		Dry I/I	Daily, gpd	Daily, gpd	Wet I/I	Flow, gpd
GRAND TOTALS - PHASES 1, 2, 3 & 4 - FULL BUILDOUT	731,750	244,500	1,542,550	0	1,750	1,619	9,796		48,980	741,100	3,509,580	1,615,000	5,124,580		
MAX DAILY DEMAND (1.5 fo	ation) 1,097,625	403,425	2,545,208	0				POTENTIAL R-1 A	VAILABLE	592,880					

1,681,176

MAX DAILY DEMAND (1.5 for Potable, 1.65 for Irrigation) 403,425 2,545,208 1,097,625 305,425 12% Losses 131,715 48,411 0 TOTAL MDD + LOSSES 451,836 2,850,632 1,229,340 0

TOTAL POTABLE TOTAL BRACKISH TOTAL WATER

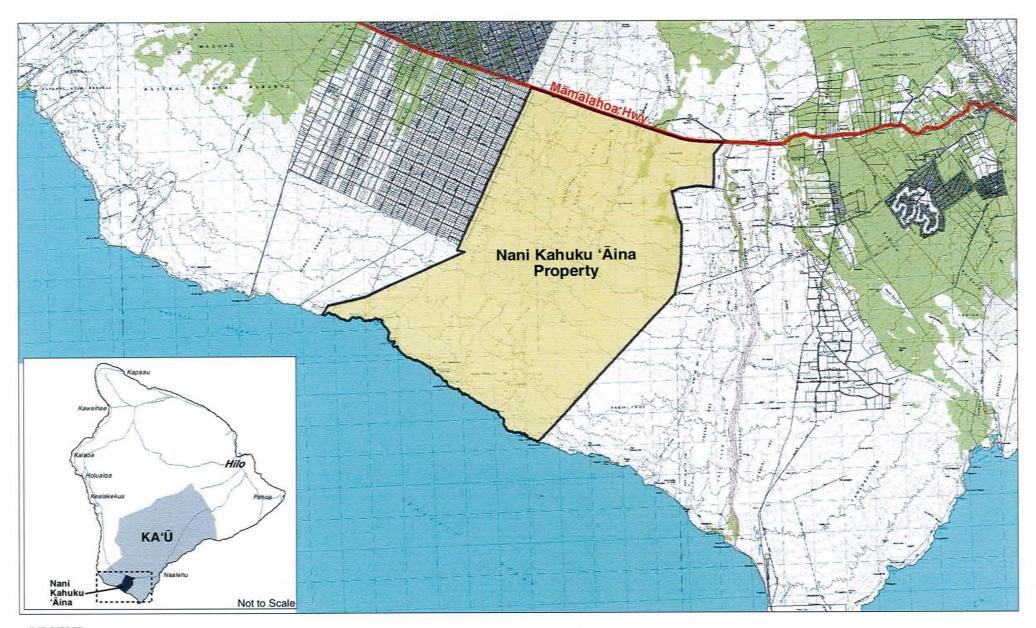
2,850,632 4,531,808

NOTES:

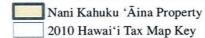
- 1. Preserve area of 356 acres excluded in HHA
- Water demand rates provided by Tom Nance Water Resources Engineering
 Sewer demand rates from Belt Collins Report

NANI KAHUKU VILLAGE CONCEPTUAL PLAN ELECTRIC AND TELEPHONE USE SUMMARY

	6-	and Diag				Electric						Те
KAHUKU VILLAGE		oncept Plan	kVA per	kVA per	Total kVA	Phase 1	Phase 2	Phase 3	Phase 4	Per Unit	Per Acre	Total
R-X: Single Family (10,000 sf)	Appr. Acres	Approximate units 135	Unit 7.5	Acre	1012.5					1.5		202.5
Phase 1		30	7.5	-	1012.5	225				1.5	-	202.5
Phase 2		40				223	300					
Phase 3		65						487.5				
R-1: Oceanfront/Preserve Lots (+ acre)	84	60	10	-	600					1.5	-	90
Phase 1 (Lot 32)		8				80						
Phase 1 (Lot 33)		20				200		220				
Phase 3 R-2: Golf Estates (1.5-2+ acres)	44.5 483	32 291	10	-	2910			320		1.5	_	436.5
Phase 1 (Lot 6)		7	10		2310	70				1.5		130.3
Phase 2 (Lot 9)		40					400					
Phase 2 (Lot 34)		55					550					
Phase 2 (Lot 36)		15					150					
Phase 3 (Lot 15)		30						300				
Phase 3 (Lot 25) Phase 3 (Lot 26)		23 16						230				
Phase 3 (Lot 26) Phase 3 (Lot 24)		80						160 800				
Phase 3 (Lot 24)		25						250				
R-3: Estates (2+ acres)	180	75	10	-	750					1.5	-	112.5
Phase 1		11				110						
Phase 2		26					260					
Phase 4 (lot 38)		20							200			
Phase 4 (lot 39) MF-1: Oceanfront/Condo	43 40	18 140	1.5	25	1310				180	1.5		210
Phase 2		55	1.5	25	1210		82.5			1.5	-	210
Phase 3		85					62.3	127.5				
MF-2: Golf Villas (4-5du/ac)	50	180	7.5	-	1350			127.0		1.5	-	270
Phase 2	14	50					375					
Phase 3		130						975				
VMX: Village Mixed-use	38	169	5	100	4645					-	10	380
Phase 3 (Lot 17)		40						1100				
Phase 3 (Lot 19) Phase 3 (Lot 18)		25 18						675 490				
Phase 3 (Lot 18)		30						800				
Phase 3 (Lot 22)		36						980				
Phase 4		20							550			
Visitor Accommodation Units	75	500	1.5	35	3375					-	5	375
Phase 2 (Lot 13)		250					1670					
Phase 3 (Lot 29)		250			2			1705			0.5	
Village Green Commercial	2 24	-	-	1 290	2 6960	2				-	0.5 10	240
Phase 1	4	_	-	230	0300	1160					10	240
Phase 2 (Lot 2)						1100	1160					
Phase 2 (Lot 11)							1740					
Phase 3 (Lot 3)	5							1450				
Phase 3 (Lot 4)								1450				
Civic	9 4 5	-	-	290	2610			2250	2610	-	10	90
VA Facility Community Park	45	-	-	50 1	2250 40			2250		-	2 0.1	90
Phase 2				•	70							
Phase 3												
Phase 4	18											
18 Hold Gold Course and Clubhouse	330	-	-	2	660		660			-	0.1	33
Hawaiian Heritage VIII (w/Eco-Lodge/Cabins)	482	100	-	5	2410	2410				-	0.5	241
Brackish Water Well Pumps (5 @ 125 HP) Phase 1	İ				650	260						
Phase 1						260	390					
Salt Water Well Pumps (4 @ 150 HP)	ĺ				600		330					
Phase 3	ĺ							300				
Phase 4	ĺ								300			
WWTP 0.5 MGD (2 Total) + Lift Station (2)	İ				450							
Phase 1						225	225					
Phase 2 Tahiri Windfarm Alternate Energy Offset	ĺ				-5000		225					
SUBTOTAL	1937	1650			-5000 27,484.50	4,742.00	7,962.50	14,850.00	3,840.00			2,775.50
JODIOTAL	1557	1000			_,,-050	7,7 72.00	2,302.30	1,000.00	3,0-0.00			_,,,,







Major Road

Figure 1 LOCATION MAP KAHUKU VILLAGE

Nani Kahuku 'Aina LLC
North Lineal Scale (in feet)
0 5,000 10,000 20,000



LEGEND

Nani Kahuku 'Āina Property

Figure 2
TAX MAP KEY

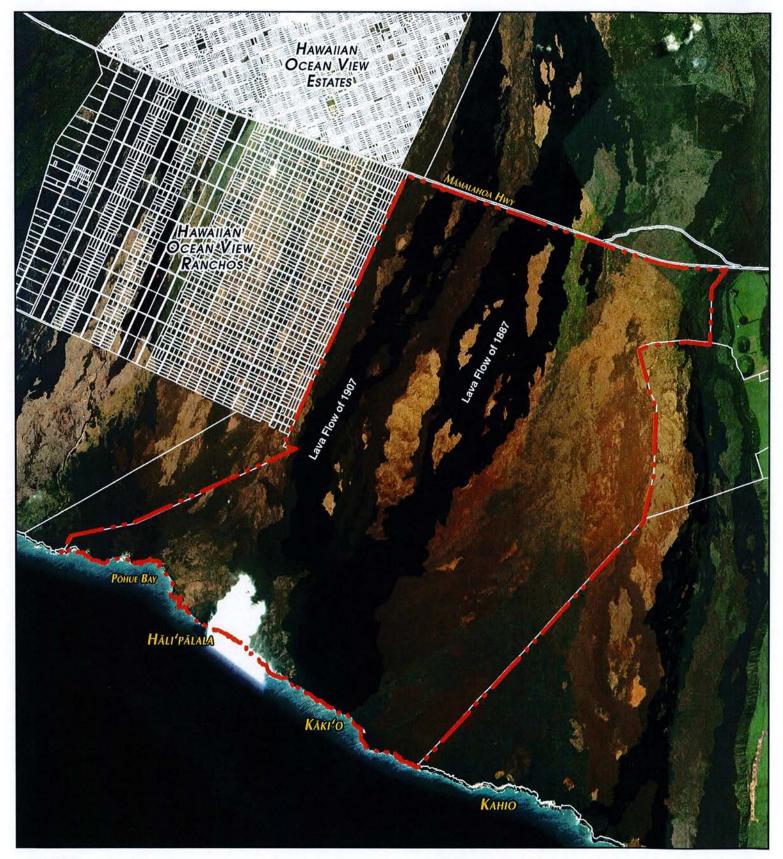
KAHUKU VILLAGF

lani Kahuku 'Āina, LLC

Ka'ū, Hawai'i



NOT TO SCALE



LEGEND

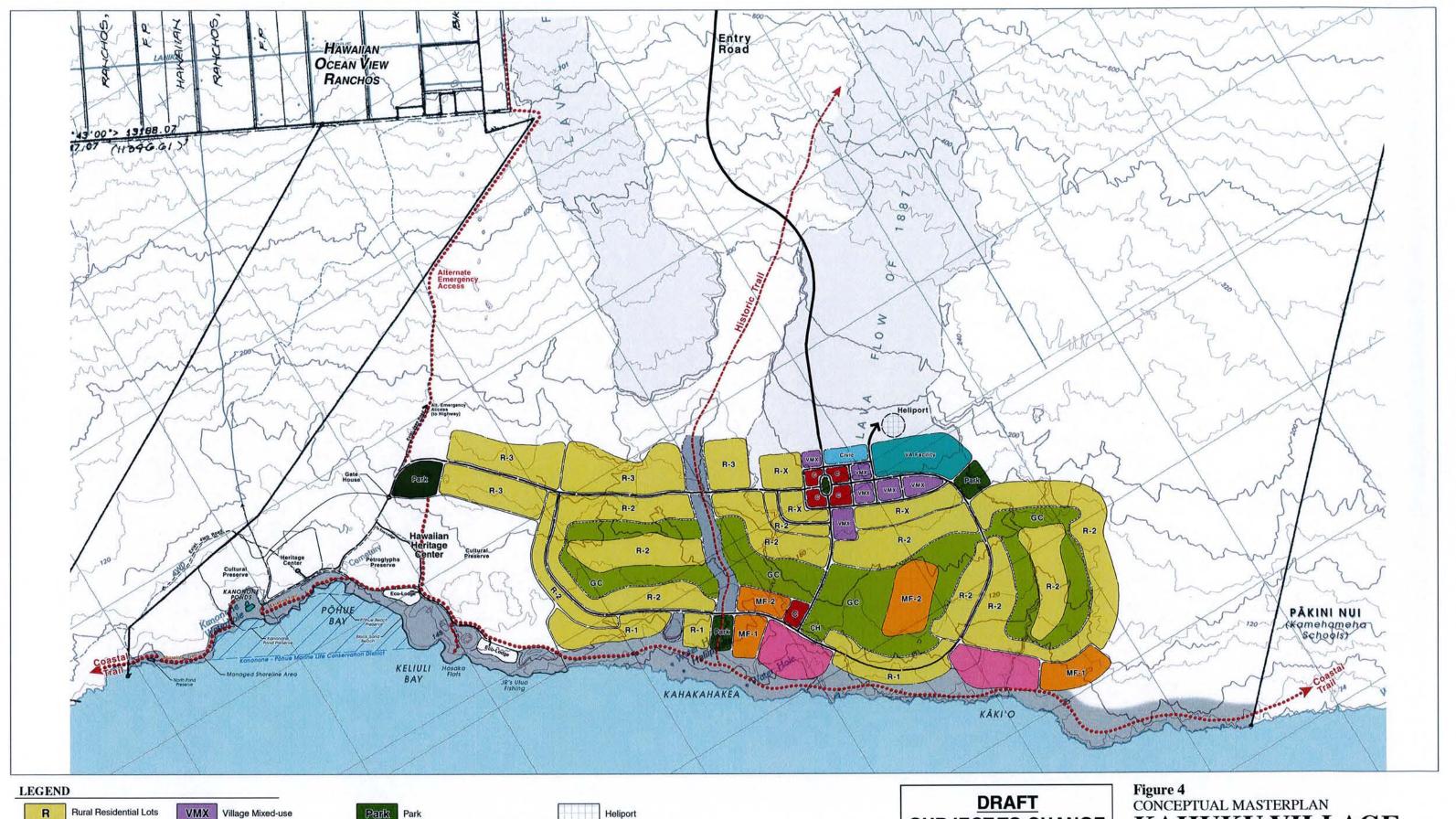
Nani Kahuku 'Āina Property

Figure 3
AERIAL PHOTOGRAPH

KAHUKU VILLAGE

Ka'ū, Hawai'i

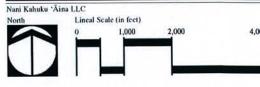
North Lineal Scale (in feet)
0 3,000 6,000 12,000



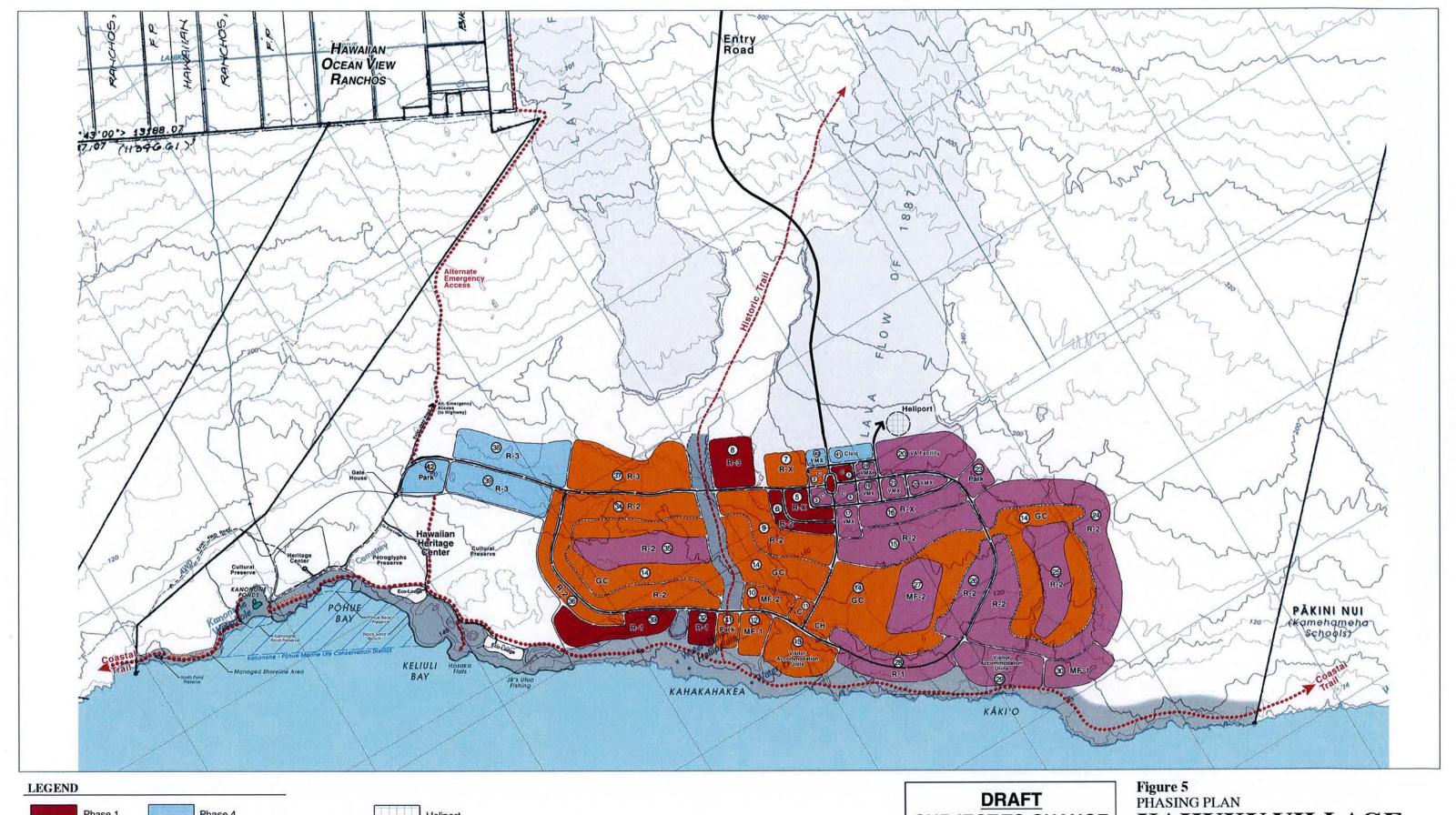


SUBJECT TO CHANGE

CONCEPTUAL MASTERPLAN KAHUKU VILLAGE



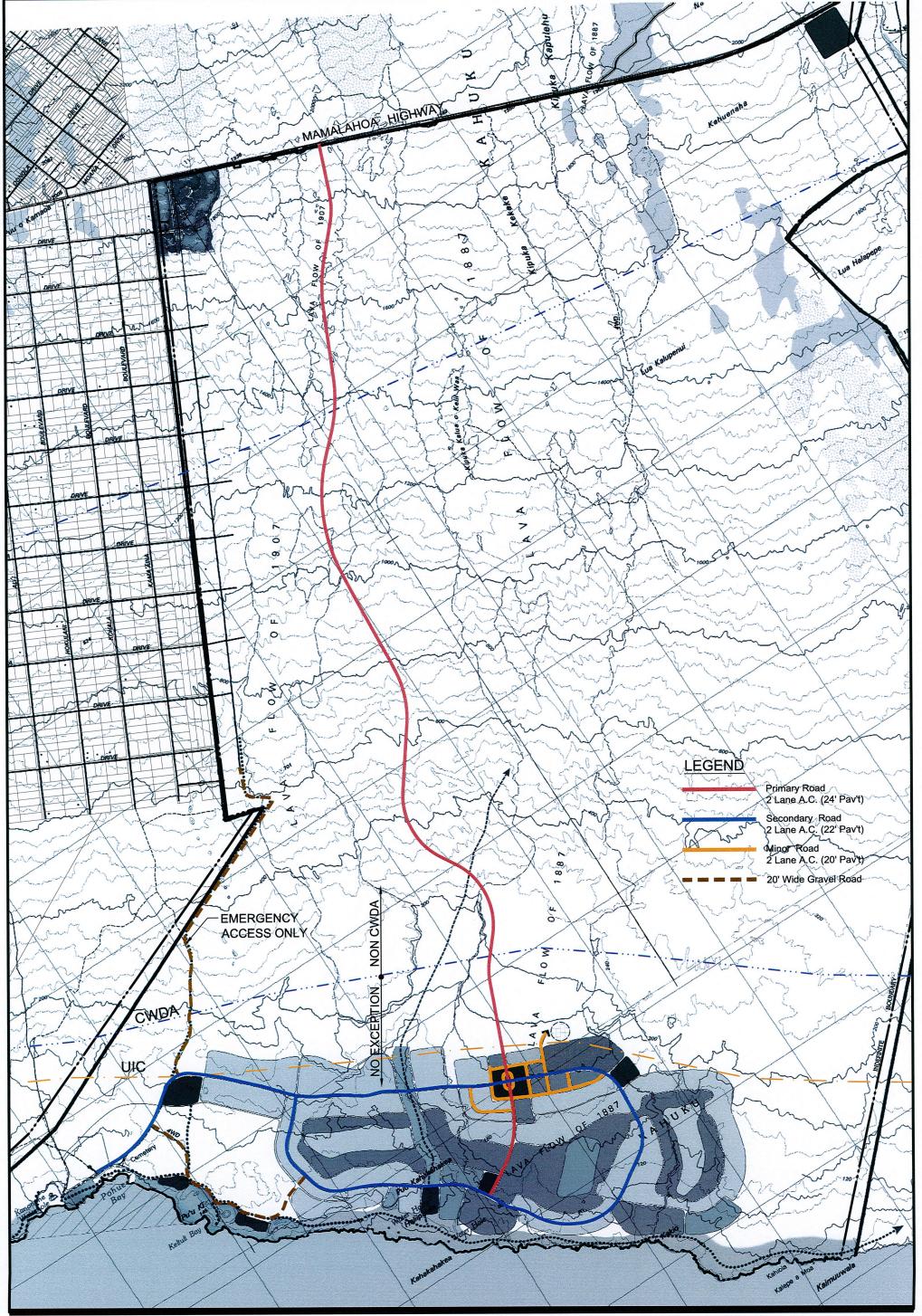
Source: PBR Hawaii Disclaimer: This graphic has been prepared for general planning purposes only





SUBJECT TO CHANGE

KAHUKU VILLAGE





201 Merchant Street, Suite 1900 Honolulu, Hawaii 96813 Telephone: (808) 521-0306 Fax: (808) 531-8018





KAHUKU VILLAGE FIGURE 6 - ROAD CONCEPT PLAN

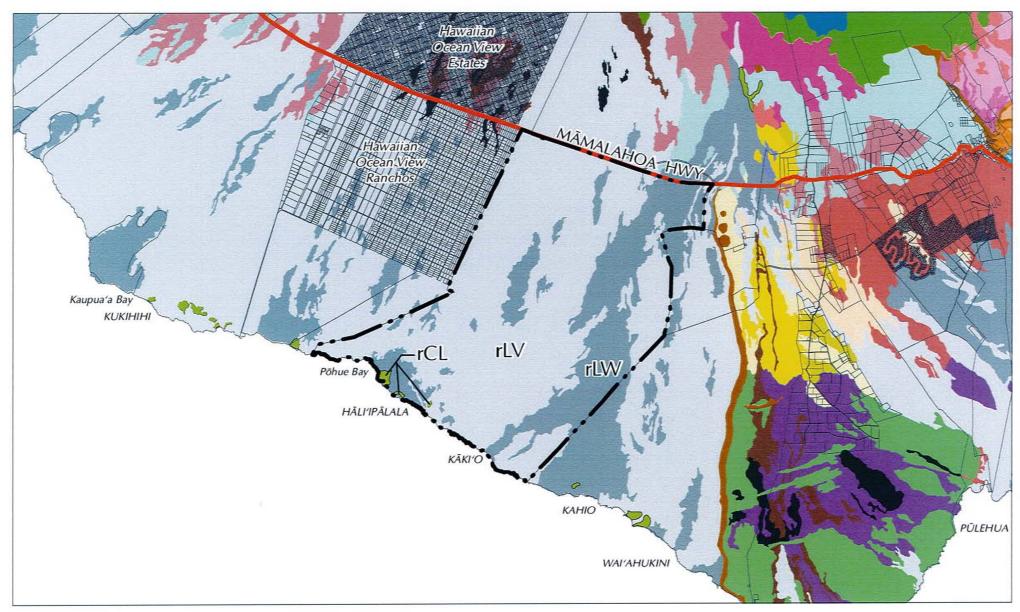
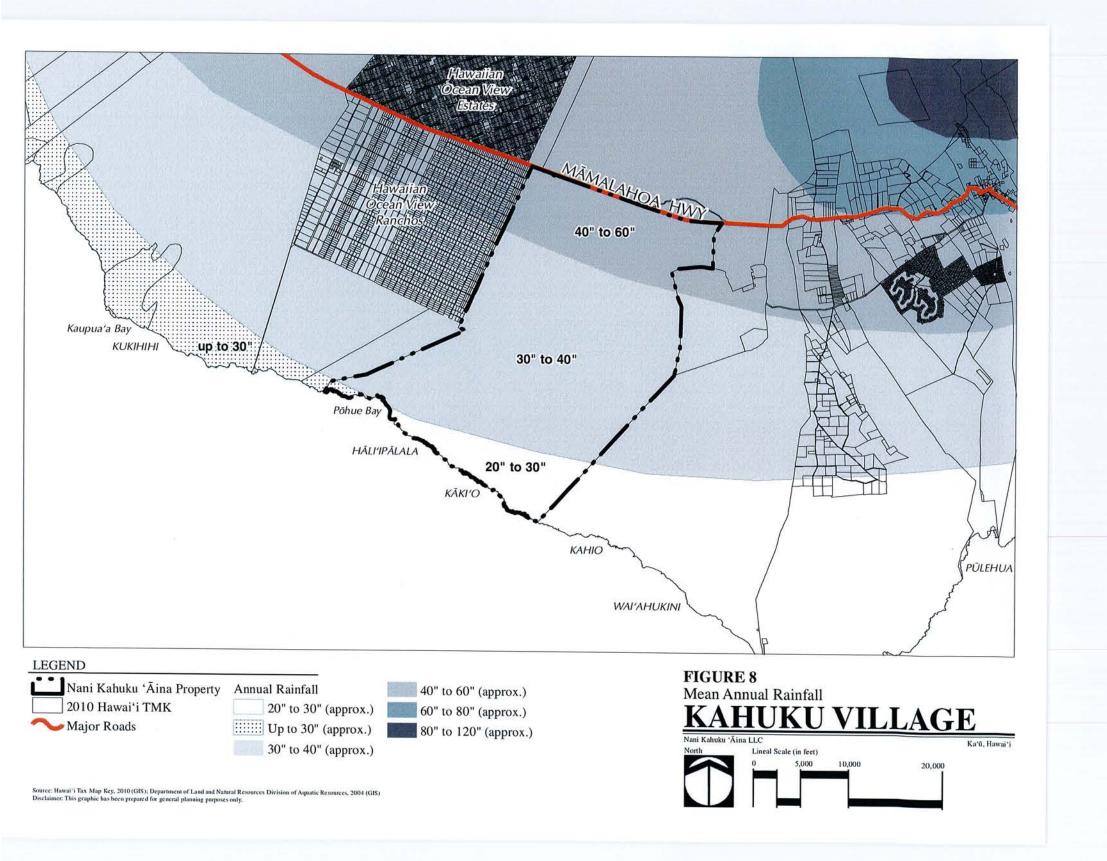


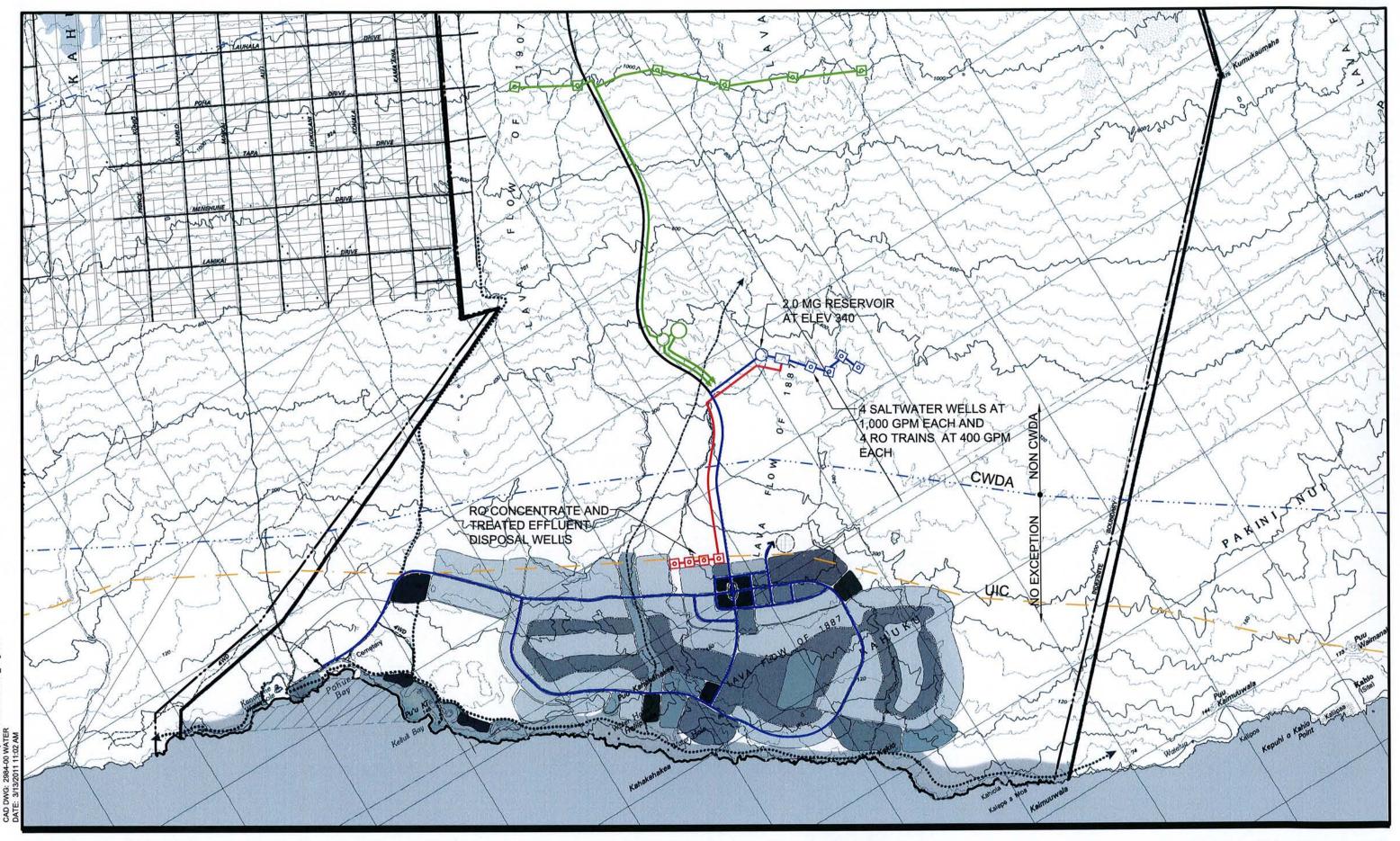


Figure 7
National Resource Conservation Service Soil Survey

KAHUKU VILLAGE

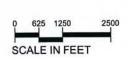
Nani Kahuku 'Āina LLC Ka'ū, Hawai'i



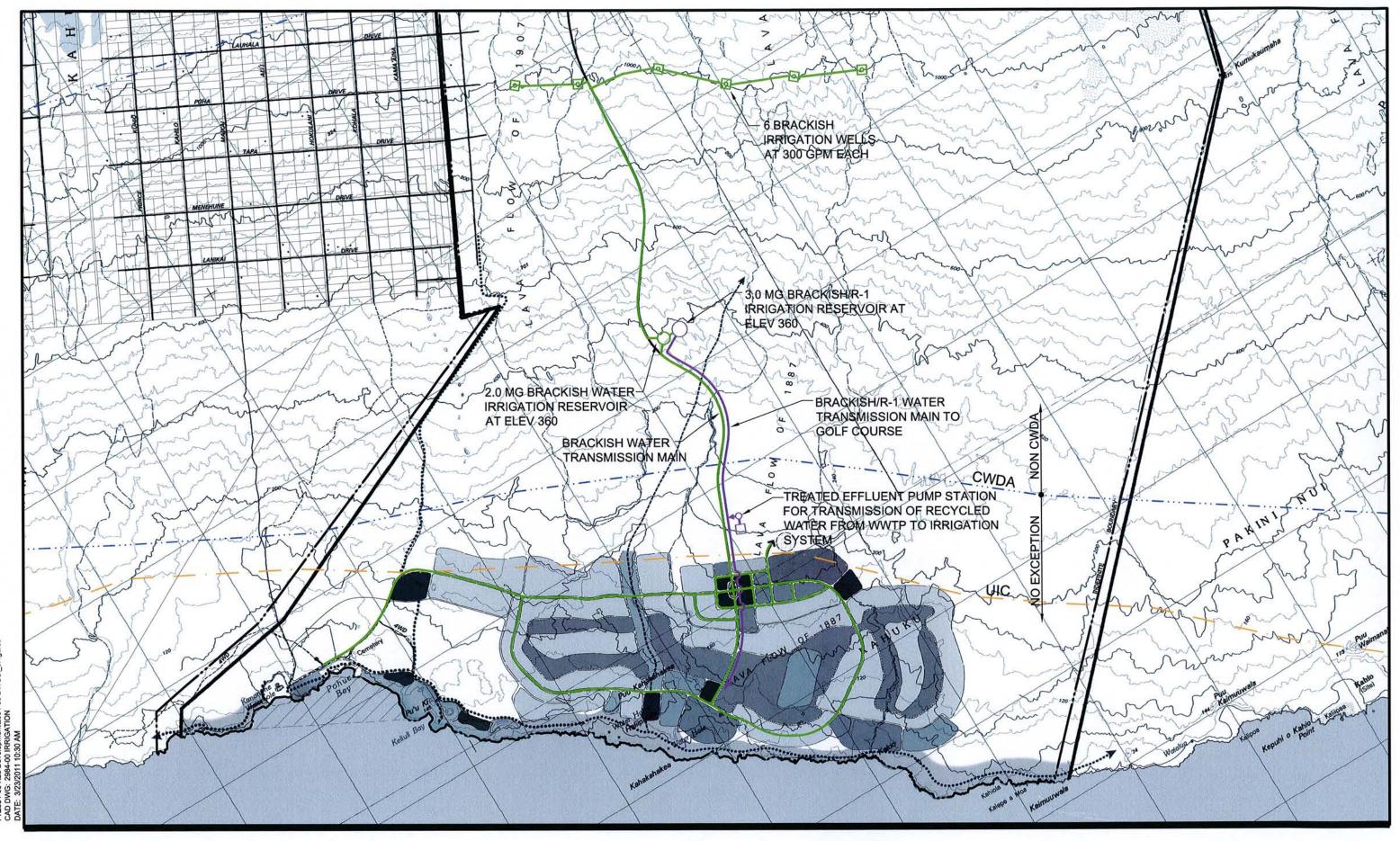






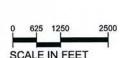


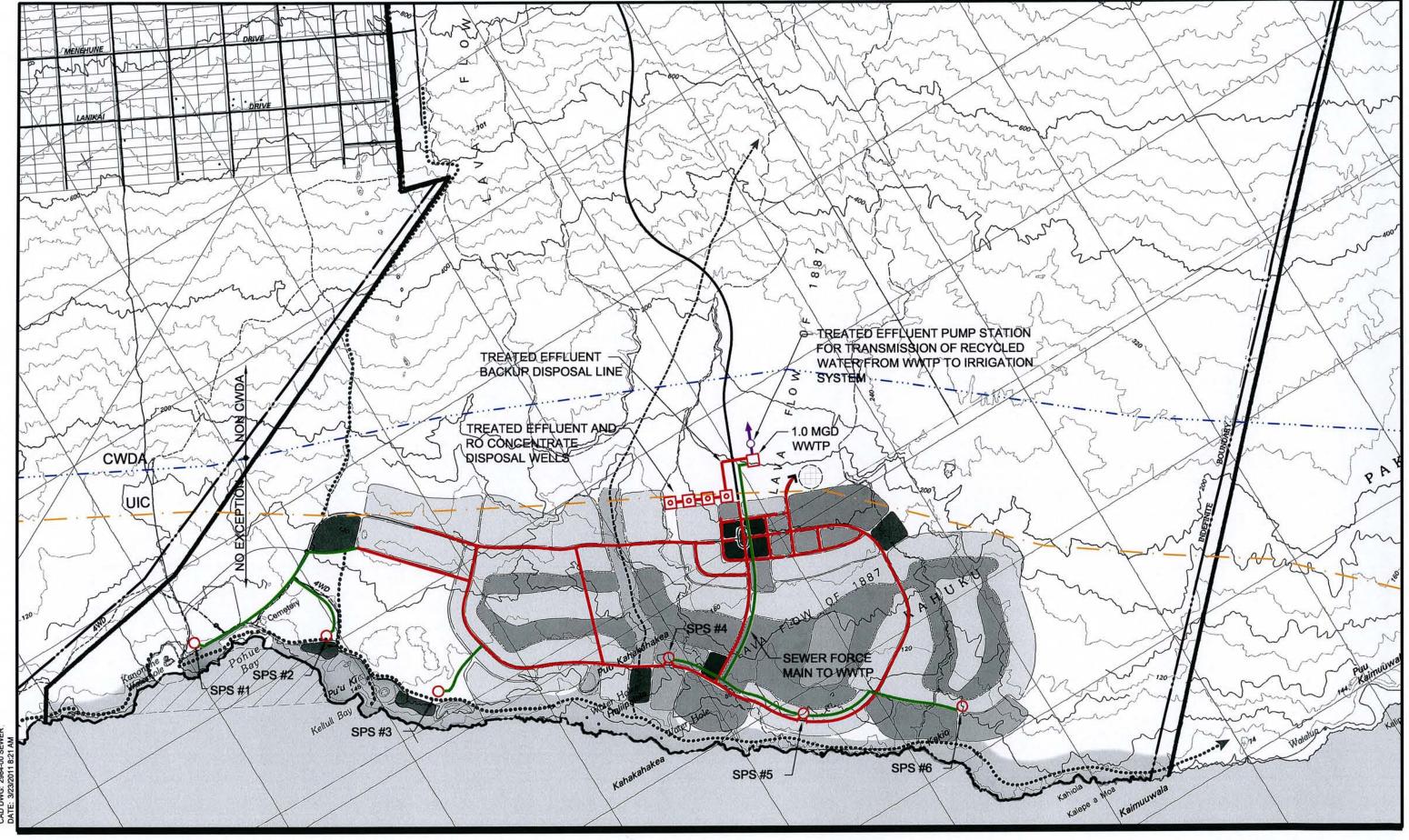
KAHUKU VILLAGE FIGURE 9 - WATER CONCEPT PLAN







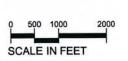




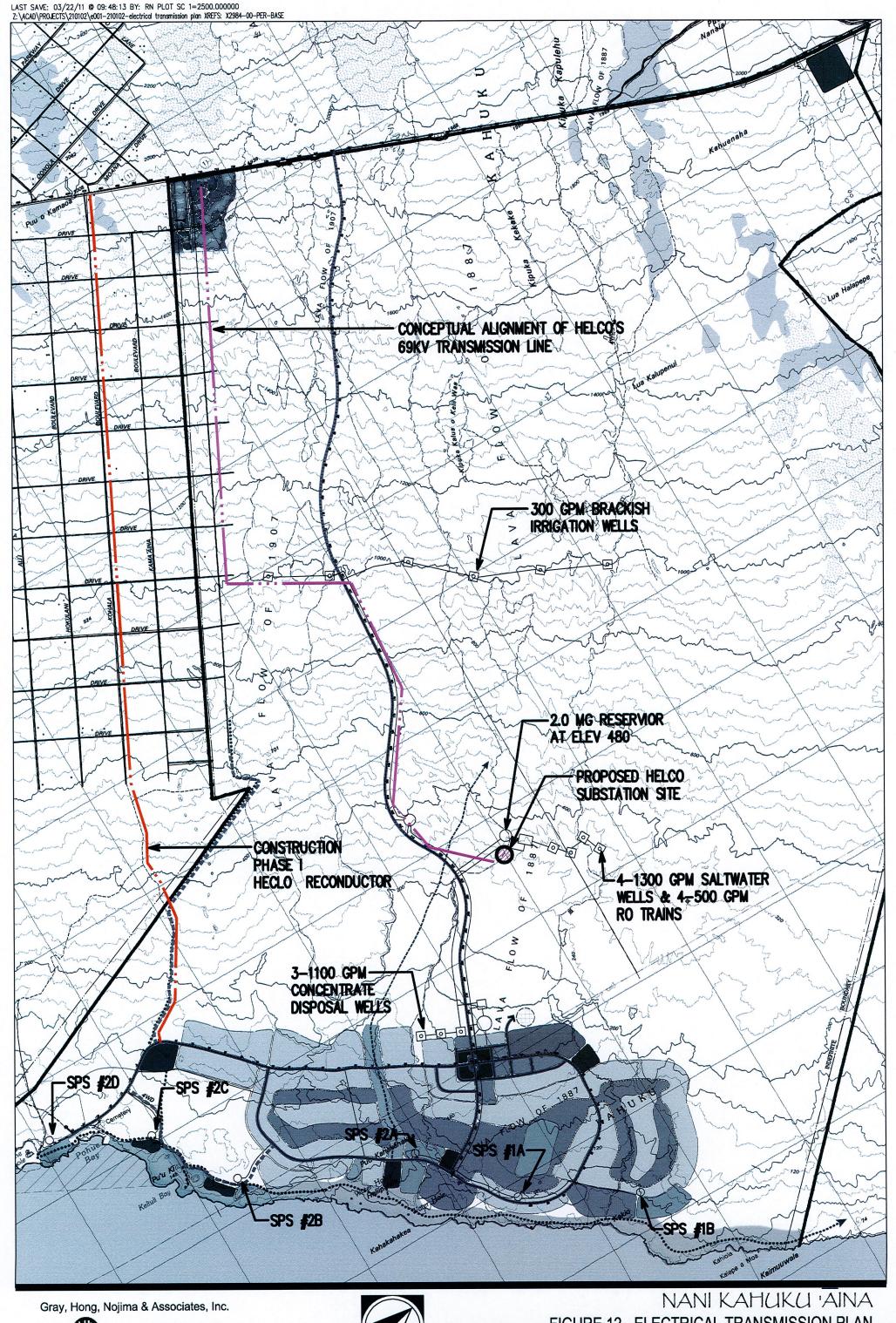


Honolulu, Hawaii 96813 Telephone: (808) 521-0306 CONSULTING ENGINEERS Fax: (808) 531-8018





KAHUKU VILLAGE FIGURE 11 - SEWER CONCEPT PLAN MARCH 23, 2011



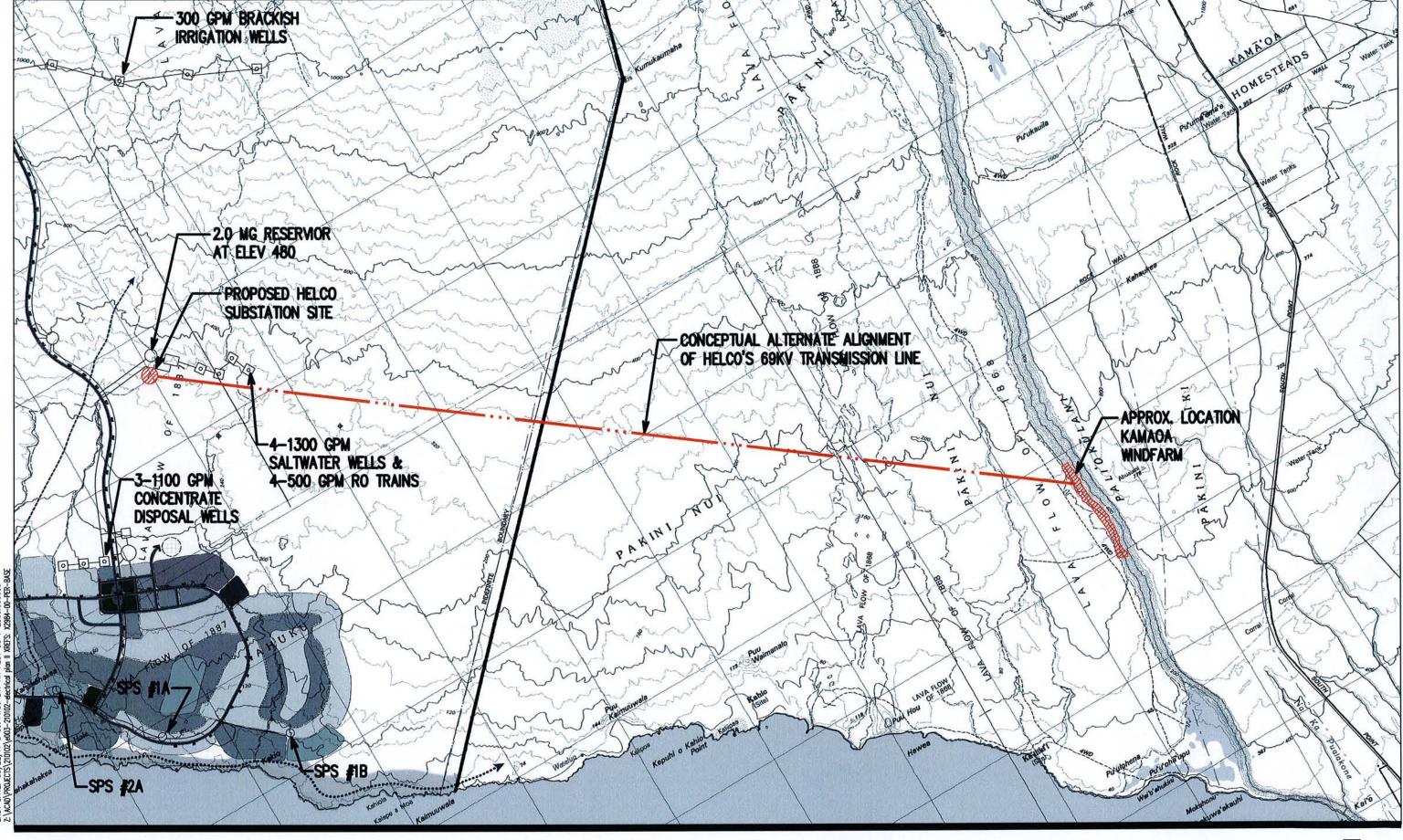


201 Merchant St, suite 1900 Honolulu, Hawaii 96813 Fax: (808) 531-8018 Telephone: (808) 521-0306



SCALE IN FEET

₂₅₀₀ FIGURE 12 - ELECTRICAL TRANSMISSION PLAN

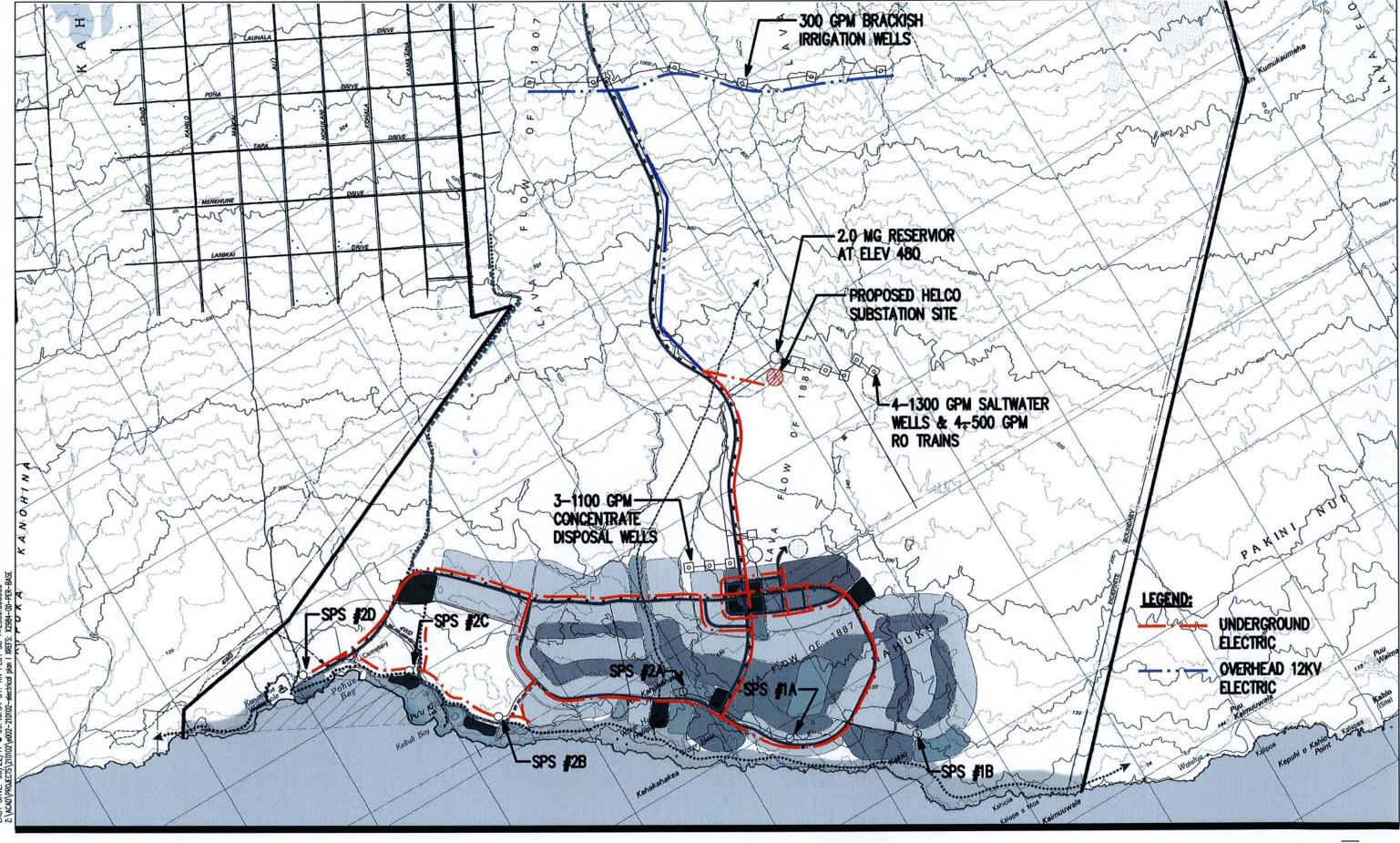




201 Merchant St, suite 1900 Honolulu, Hawaii 96813 Fax: (808) 531-8018 CONSULTING ENGINEERS Telephone: (808) 521-0306



NANI KAHUKU 'AINA FIGURE 13 - ALTERNATE ELECTRICAL TRANSMISSION PLAN

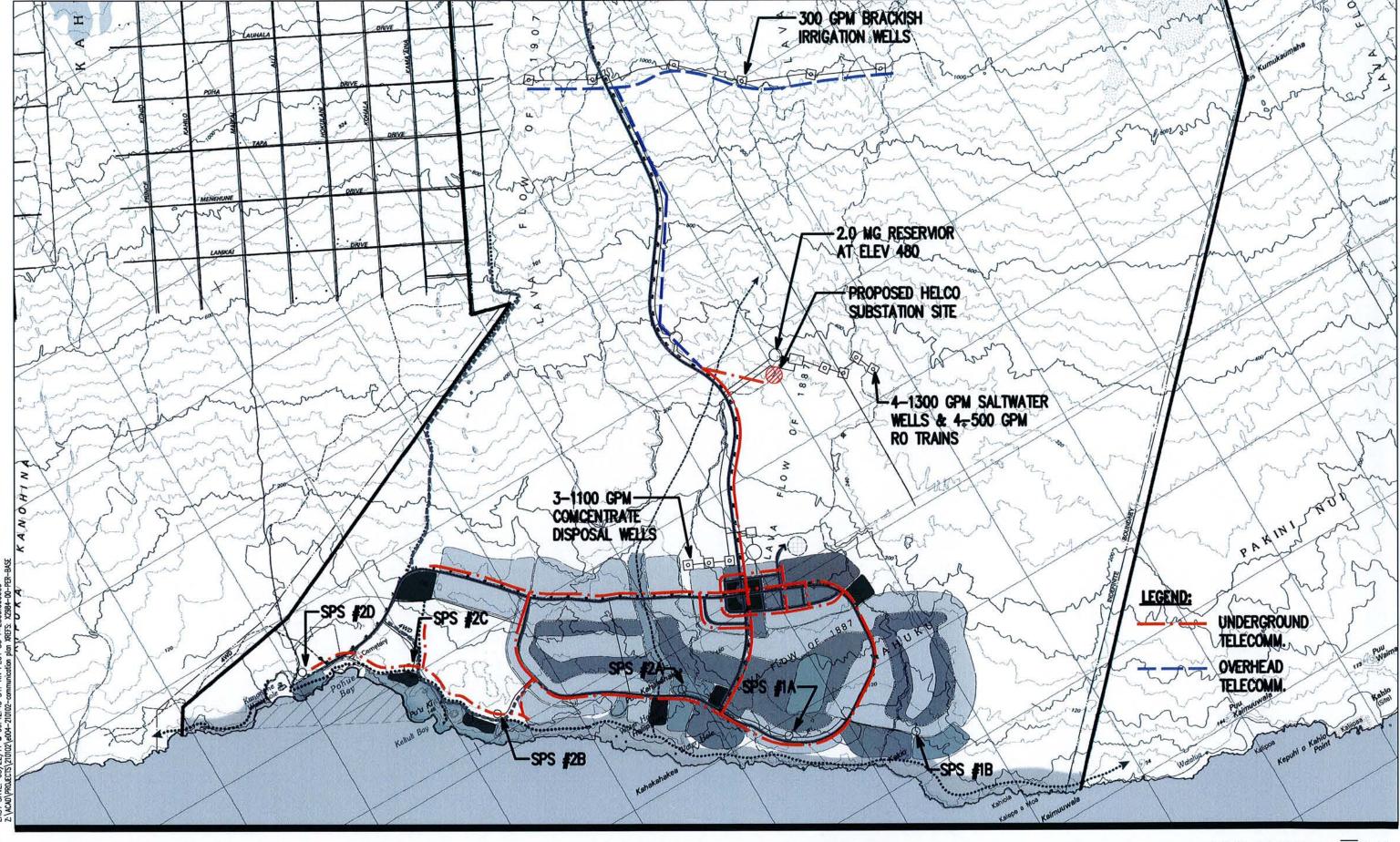




201 Merchant St, suite 1900 Honolulu, Hawaii 96813 Fax: (808) 531-8018 CONSULTING ENGINEERS Telephone: (808) 521-0306



NANI KAHUKU 'AINA FIGURE 14 - ELECTRICAL PLAN

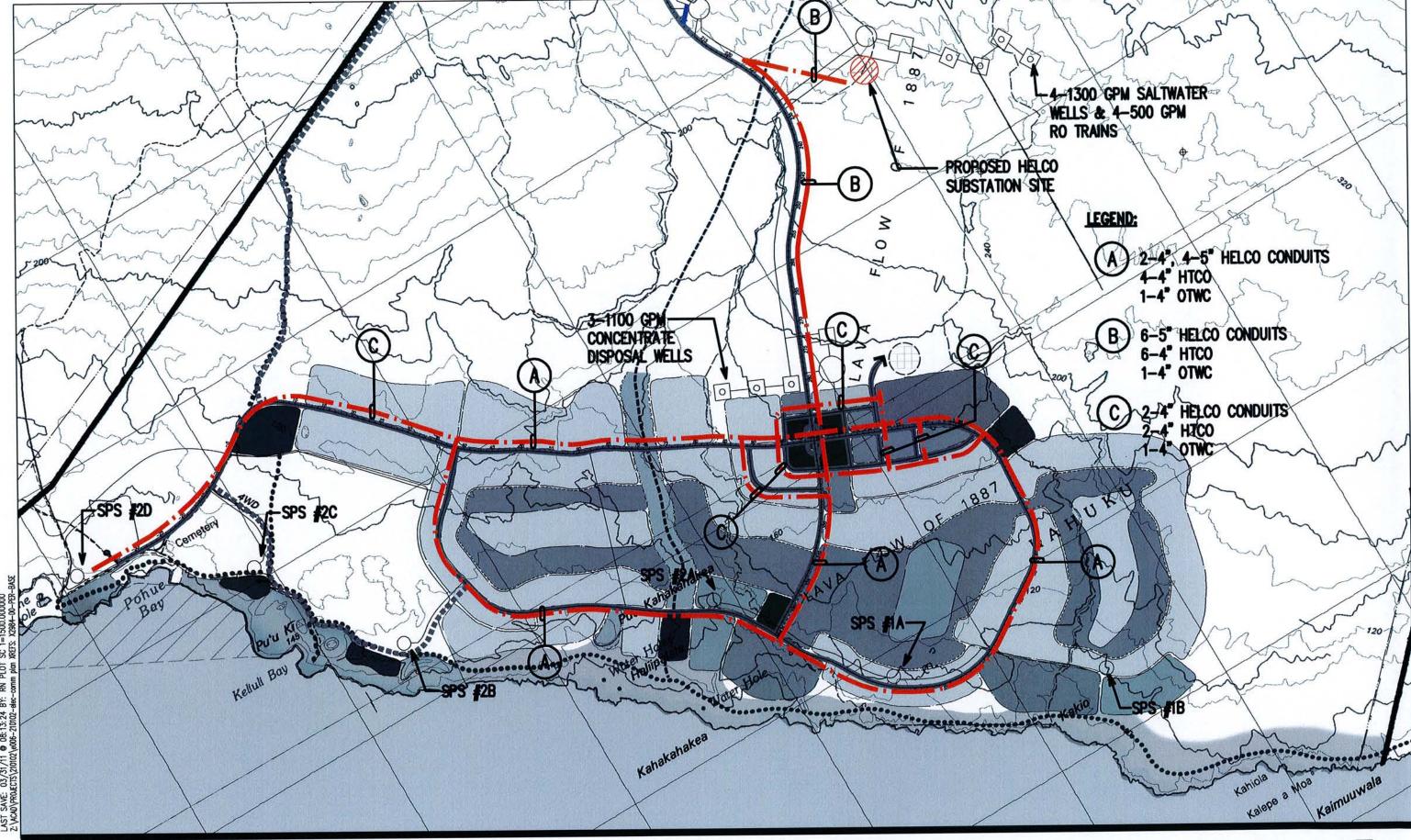




201 Merchant St, suite 1900 Honolulu, Hawaii 96813 Fax: (808) 531-8018 CONSULTING ENGINEERS Telephone: (808) 521-0306

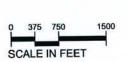


NANI KAHUKU 'AINA FIGURE 15 - COMMUNICATION PLAN



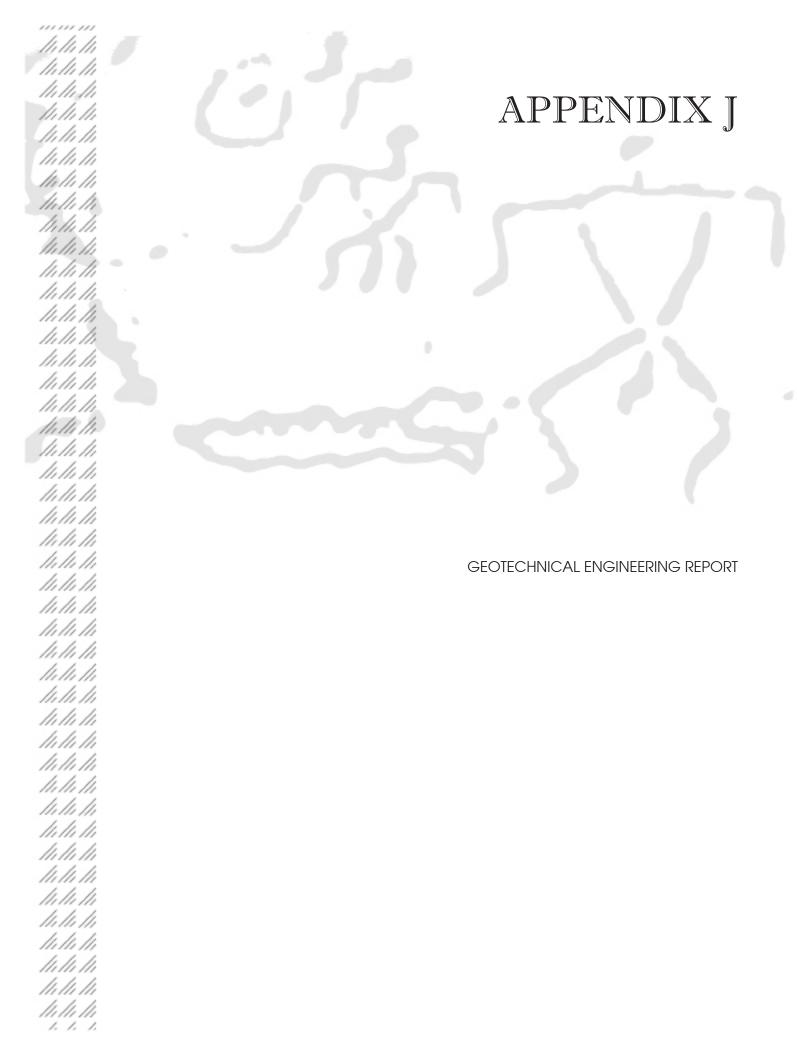






NANI KAHUKU 'AINA FIGURE 16 - ELEC/COMM DUCTING PLAN

MARCH 22, 2011





March 14, 2011 W.O. 6446-00

Mr. Valentine Peroff, Jr. Nani Kahuku Aina LLC 99-1324 Koaha Place Aiea, HI 96701

Geotechnical Engineering Consultation Kahuku Village Pohue Bay, District of Kau, Hawaii

Dear Mr. Peroff:

As requested, we submit this brief letter report providing geotechnical engineering consultation in support of the Environmental Impact Statement (EIS) for the Kahuku Village project.

Project Considerations

The proposed project is to the southeast of Hawaiian Ocean View Estates in the District of Kau on the Island of Hawaii. We understand a mixed-use community, including resort, residential, recreational and cultural developments, is planned at the site.

The project site encompasses an area of about 2,000 acres. Based on the information provided, a geological investigation was done for portions of the site by others in 1987

Purpose and Scope

The purpose of our geotechnical engineering consultation was to review the existing report prepared in 1987 by Dames and Moore, entitled "Geological Investigation, Proposed Hawaiian Riviera Resort, Ka'u, Hawaii, Hawaii, TMK 9-2-01: Portion 73" to determine if the findings and recommendations presented therein remain valid. We have provided a scope of work generally consisting of the following tasks and work efforts:

- 1. Review of the 1987 Dames and Moore report (the report).
- 2. Preparation of this brief letter report summarizing our work and presenting our findings and recommendations.
- 3. Coordination of our overall work on the project by our project engineer.

- 4. Quality assurance and client consultation by our principal engineer.
- 5. Miscellaneous work efforts such as word processing, clerical support, and reproductions.

Findings and Recommendations

Our review indicates that the report was the result of a reconnaissance type investigation. As such, the information is somewhat limited but the findings appear to be reasonable for the geologic setting and proposed development.

The recommendations are generally valid and representative of design and construction technology at the time of preparation. In the time since the preparation of the report, there has been some changes in standards that make the recommendations somewhat dated. In particular, the following findings and recommendations should be considered to be modified by this letter report:

- On page 12, Section 1.2.3, Seismic Hazards, the report references the Uniform Building Code and describes the site as being in Seismic Zone 3. The Uniform Building Code has been superseded by the International Building Code and sites are now classified based on subsurface materials and shear wave velocity.
- On page 19, Section 4.3, Recommended Resort Planning Guidelines to Mitigate Geological Hazards, the report again references and recommends the Uniform Building Code as the appropriate design standard. As previously discussed, the most current version of the International Building Code should be the governing standard.
- On page 19, Section 5.0, Suggested Future Studies, the report recommends the use of cross hole and refraction geophysical surveys. There are newer engineering geophysics techniques available now that may be more effective. Therefore, methods should not be limited to cross hole and refraction.

We do concur with Dames and Moore's recommendation that further study be undertaken for development of the site. It is our recommendation that such additional studies be conducted both as part of the master planning effort and as part of individual project design for the various elements of the development.

Closure

We appreciate the opportunity to assist you on this project. If you have questions or need additional information, please contact our office.

Respectfully submitted,

GEOLABS, INC.

Dayton E. Fraim, P.G., P.E.

Project Engineer/Geologist

Clayton S. Mimura, P.E.

President

CSM:DEF:as

(4 Copies to Addressee)

h:\6400Series\6446-00.df1

GEOLOGICAL INVESTIGATION
PROPOSED HAWAIIAN RIVIERA RESORT
KA'U, HAWAII, HAWAII
TMK: 9-2-01: Portion 72
FOR PALACE DEVELOPMENT CORPORATION AND
KA'U AINA PARTNERSHIP

DAMES & MOORE JOB NO. 15742-001-11

Dames & Moore



TABLE OF CONTENTS

1.0	INTRODUCTION	age 1
2.0	PURPOSE AND SCOPE OF WORK	2
3.0	GEOLOGICAL STUDY 3.1 ISLAND GEOLOGY 3.2 REGIONAL GEOLOGY 3.3 SITE GEOLOGY 3.3.1 Lava Flows 3.3.2 Shoreline Features	3 3 4 5
	3.4 ON-SITE GEOLOGICAL HAZARDS	9
	3.5 EXTERNAL GEOLOGICAL HAZARDS 3.5.1 Lava Flow Hazards 3.5.2 Seismic Hazards 3.5.3 Tsunami Hazards 3.5.4 Storm Wave Hazards 3.5.5 Miscellaneous Hazards	11
4.0	DISCUSSION AND RECOMMENDATIONS	15 15
	4.2 MARINA CONSTRUCTION	17 18
5.0	SUGGESTED FUTURE STUDIES	19
6.0	LIMITATIONS	20
	APPENDIX A - Definitions of Certain Geologic Terms APPENDIX B - Epicenter Locations in Hawaii and List of Earthquak	es

1.0 INTRODUCTION

This report presents the results of our geological investigation for the proposed Hawaiian Riviera Resort to be located west of South Point in Ka'u, Hawaii, Hawaii. The site is shown on the Location Map, Island of Hawaii, Plate 1.

It is our understanding that the resort site encompasses approximately 2,300 acres of oceanfront property and is a portion of a larger parcel. The property is located southwest of the Mamalahoa Highway. It extends from Humuhumu Point to the area east of Kahakahakea. The proposed site location and area of our study is shown as the shaded area on the Plot Plan, Plate 2.

The property is subdivided into two parcels. Palace Development

Corporation will develop the portion on the west end. The development will be

called the Hawaiian Palace Resort. The eastern portion will be developed by

Hawaii Ka'u Aina Partnership.

Helber, Hastert & Kimura, Planners, and Belt Collins & Associates, Inc., are preparing the Environmental Impact Statement for this project. We understand that the entire 3,200-acre project will consist of resort hotels, residential homes, a marina complex, golf courses, equestrian areas, an airfield, and a support community. Our study was focused on 2,300 acres of ocean front property as this is perceived as the area most susceptable to geological effects and hazards, and will therefore require the most planning. The proposed access roadway, airfield, and support community areas were not included in this geological investigation because their locations were not fully defined at the time of our study.

2.0 PURPOSE AND SCOPE OF WORK

The purpose of our investigation was to prepare a geological study of the area which would be included in the environmental impact statement. The geological investigation would consist of studying the history of the site, mapping the geological features at the resort site, drilling two probes at the proposed marina site, assessing the risk with regards to new lava flows and of ground movement due to earthquakes.

Our geological investigation consisted of the following scope of work:

- Conduct a literature study of the geological history of the site.
 Emphasis would be given for the proposed resort destination area.
- Conduct an air and land reconnaissance of the area to photograph and to map the lava features.
- Conduct a subsurface exploration at the proposed marina area by drilling two air track probe borings to explore the lava formation and stratification.
- 4. Conduct a risk assessment of the possibility of new lava flows entering into the area.
- 5. Conduct a risk assessment of future widening or movement of the existing cracks at the site.
- 6. Conduct an evaluation of known method of crushing the lava for landscaping and agricultural development.

This report presents the findings of our geological study and our recommended resort planning guidelines to mitigate on-site geological hazards. The Geological Study section is organized to present a brief overview of the geology of the Island of Hawaii, the regional geological features surrounding the resort site, followed by specific geological features and hazards identified by our study team.

The Discussion and Recommendations section is organized to present our ideas on how to utilize on-site materials as resources for construction and how to mitigate the unique as well as commonly-known geological hazards with a minimum of environmental impacts.

3.0 GEOLOGICAL STUDY

3.1 ISLAND GEOLOGY

The Island of Hawaii is the largest land mass in the Hawaiian chain and is also the youngest. It is formed by five volcanoes: Kohala, Hualalai, Mauna Kea, Mauna Loa, and Kilauea. At present, Mauna Loa and Kilauea are active. The other three are considered to be dormant.

A sixth volcano, Loihi Seamount, has recently been located off the southeast coast of Kilauea. The volcano locations are shown on Plate 1.

The shield of Mauna Loa has been built by eruptions along a southwest and a northeast rift zone which radiate out from the summit cauldera. The rift zones are shown on Plate 3. The southwest (SW) rift of Mauna Loa is about 60 miles (100 kilometers) long, including a submarine portion which extends to the base of the volcano.

Island volcanoes are constructed of lava flows characterized by very fluid lavas capable of spreading great distances from their vents. In Hawaii, two types of lava, pahoehoe and a'a, are identified based on contrasting surface features and flow behavior (Ref. 1). A'a flows are thicker and more viscous than pahoehoe lava. Hawaiian lava flows range from a few yards to more than 35 miles (56 kilometers) in length. The width of the flows varies from about

6 feet (2 meters) to 2.5 miles (4 kilometers). More descriptive definitions of a'a and pahoehoe lavas and other geologic terms used in this report are contained in Appendix A of this report.

3.2 REGIONAL GEOLOGY

The resort site is located along the seacoast of the southwest flank of Mauna Loa below the SW rift zone. Mauna Loa's summit is located 35 miles north of the site. The southwest flank of Mauna Loa is constructed of numerous pahoehoe and a'a lava flows. The geological region is bounded by the ocean, and the Kealakekua and Kahuku faults. The location of the faults is shown on the Regional Geological Structures Map, Plate 3.

The north-south trending Kahuku fault, which is located 6 miles (10 kilometers) southeast of the site, is located on the SW rift zone at South Point. The western side of the fault is down-dropped 600 feet (180 meters) relative to the eastern side, and forms a cliff at the sea coast. The fault can be traced inland for 11 miles (16 kilometers). The fault scarp gradually decreases in height until it disappears a short distance above Mamalahoa Highway (Highway 11 or the Belt Highway). This is due in part to infilling by younger lava flows. The fault extends beyond South Point at least 17.4 miles (29 kilometers) under the ocean.

The Kealakekua fault at Kealakekua Bay is located more than 31 miles (50 kilometers) from the site. This fault is observed to extend inland for approximately 5 miles (8 kilometers).

The slope of Hawaiian shield volcanoes is commonly at an angle of repose of 3 to 5 degrees or 10 percent. However, the ground slope in this geological region between the two faults is about 10 degrees or 18 percent.

Because the seaward flank of Mauna Loa is unbuttressed and sloped at a relatively steep angle, the repeated intrusion of magma into the SW rift zone often causes ground shifts on a regional scale. The inflation and deflation of the magma chamber in the rift zone causes gravitational tensional movement along the flank and causes the area between the two main faults to break into large regional slump blocks. These regional blocks are movable and have slumped downwards relative to each other. Recent geological investigation reports indicate that the slumping extends to the submarine region offshore (Refs. 2, 3). The location of the off-shore slump blocks are shown on Plate 3.

It should be noted that virtually all of the major slump blocks above sea level located between the two faults have been covered by lava flows

(Ref. 2). This suggests that regional block-faulting has not been active for decades or maybe centuries. Also, the resort site is located in subsidence zone 4, the lowest risk zone (Ref. 1).

3.3 SITE GEOLOGY

The proposed resort site extends along the shoreline for approximately

5 miles from Point Humuhumu to the area east of Kahakahakea. It extends from
the shoreline to an elevation of approximately +240 feet Mean Sea Level

(MSL). Topographically, the site has an average slope of 3 degrees or
approximately 5 to 6 percent. The slope of the area above the proposed resort
site is at approximately 10 degrees or 18 percent.

The site is covered by a'a and pahoehoe lava. Surface features of this site were determined by the characteristics of the prehistoric (pre-1789) and historic lavas of the Ka'u volcanic series of Mauna Loa.

3.3.1 Lava Flows

The majority of the lava flows on the site are prehistoric (pre-1789).

The western boundary of the proposed Hawaiian Palace site is located on a prehistoric a'a lava flow with an estimated age in the range of 800 to 1,000 years (Ref. 4). The pahoehoe lava that makes up the east portion of the Hawaiian Palace site and all of the land of the Ka'u Aina site (except the 1887 flow at the east boundary) range in age from 750 to greater than 1,500 years (Ref. 5).

There have been seven historic eruptions recorded along the southwest rift zone of Moana Loa. Two of these historic lava flows, 1887 and 1907, are located on or near the Ka'u Aina site. The lava flow of 1887 marks the eastern boundary of the resort site. In 1887, it was recorded that a vent opened approximately 12.5 miles from the site, at the +5,400 feet (1,700 meters) elevation on the southwest rift zone (Ref. 5). The vent was originally 4.5 miles (7.5 km) long but activity quickly localized to 2 vents, each about 1/2 mile (0.8 km) long. Due to the steepness of the terrain, the great volume of lava which erupted from the vents, and the relatively short distance to the sea, the flow reached the sea within one day. The eruption continued for 10 days.

The 1907 flow came from a vent at Elevation +5,800 feet (1,800 meters) that was active for 15 days. The a'a lava flow split into two lobes. The first lobe crossed the Mamalahoa Highway after one day, and the other crossed it after three days. Neither of the lobes of lava reached the sea. The location of the major flows and their estimated ages are shown on the Map of Relative Ages of Lava Flows, Plate 4.

A'a lava covers anywhere from 1/3 to 1/2 of the western portion of each of

the projects, and pahoehoe covers most of the eastern portions. A scaly pahoehoe lava was identified throughout much of the eastern portion of the site. The location of the lava flow types is shown in the Geologic Map, Plate 5.

The a'a flows at the site are typical in that they have a surface of crumbly clinker underlain by a massive core of hard, dense lava. Lava balls were observed along many flow margins, and two flow channels were located, one at each end of the site.

The pahoehoe flows have a smoother surface than the a'a flow. Numerous features characteristic of pahoehoe lava flows such as feeder channels, tumuli, and collapse features such as ponds, lava tubes, blisters and voids, were located on the site. No large lava tubes greater than 6 feet in diameter were located during the geological reconnaissance. Evidence of a large lava tube was observed, however, during the aerial reconnaissance in the kipuka above the proposed Hawaiian Palace Resort property. Many smaller lava tubes were located and were identified as caves.

Scaly pahoehoe appears to be transitional between pahoehoe and a'a. Its surface texture is more like that of a'a clinker. Many of the large collapse features, such as ponds, lava tubes, and blisters were associated with the scaly pahoehoe lava.

3.3.2 Shoreline Features

Other features observed at the site and shown on the Geologic Map are beaches, ground cracks, and brackish water ponds.

Several different types of beaches were identified. A white coralline sand beach is located at Pohue Bay. Black volcanic cinder sand beaches are located at the base of the littoral cones.

During the field reconnaissance, we observed that some of the shoreline areas (up to 200 feet inland) were covered with coarse to cobble-sized basaltic and coralline materials. We believe the presence of these loose surface materials is most likely the result of storm wave activity.

Several littoral cones are located east of Pohue Bay. They are aligned in two distinct rows. The row of younger cones is located along the shoreline. A second row of older littoral cones sits inland and marks the location of a former shoreline. The littoral cones are covered or surrounded by subsequent lava flows.

Large ground cracks were observed along portions of the shoreline at the resort site. These cracks were particularly obvious in the pahoehoe lava flows. The cracks tend to run in pairs, are about 2 feet wide and some have a vertical displacement on the oceanside portion of the crack of up to 2 feet. These cracks are estimated to be greater in depth than 25 feet as our geologist was able to push a 25-foot long measurement tape through the cracks. At the westernmost end of the proposed Hawaiian Palace site, it appears that the cracks may extend under a more recent a'a lava flow.

Brackish water or anchialine ponds were observed along the coastline of the property. Kanonone Water Hole and another large pond were located west of Pohue Bay. Several smaller ponds and two large ground cracks containing brackish water were located at the east end of the property. Seepage of fresh and brackish water was observed along the entire length of the coast. Beach rock, which forms at intertidal areas where fresh water is seeping, was observed on the eastern end of the Ka'u Aina site. In other portions of the shoreline, fresh water was observed floating at the surface of the salt water, particularly during low tide. This occurrence is commonly referred to as "gasoline water."

Sea cliffs are located along approximately 30 percent of the coastline.

The sea cliffs have an average height of 30 feet above sea level. Two large sea caves were observed shoreward of Puu Kahakahakea.

3.4 ON-SITE GEOLOGICAL HAZARDS

3.4.1 Ground Cracks

As stated in the Geology section, ground cracks are visible along portions of the coastal length of the property. They are generally located along the coastline but can also be found about 2,000 feet (610 meters) inland in the western portion.

The ground cracks are slightly arouate in shape and exhibit a pairing tendency. They averaged about 1.5 feet (0.4 meters) in width but several on both sides of the resort site were as much as 3 feet (0.8 meters) wide. A slight vertical off-set was noticed along most of the ground cracks. There were three major cracks which were offset vertically by about 2 feet (0.6 meters). The cracks are very deep, probably much deeper than 25 feet. Two ground cracks on the eastern part contained brackish water. Their length varied from 30 feet (9 meters) to 1,800 feet (550 meters) with an average length of about 1,300 feet (490 meters).

The exact causes of ground cracking at the site are still under investigation. However, the consensus of the geologists is that these cracks are related to the offshore regional slump blocks (discussed in Section 3.2), and the inflation and deflation of the volcano flanks.

Our current level of investigative effort has not yielded sufficient data to assess the age, rate of movement, and depth of these ground cracks. Based on our knowledge of the probable ages of the pre-historic a'a and pahoehoe

lava flows on the site, our best guess of the age of these ground cracks may be between 300 to 1,000 years old.

In 1976, U. S. Geologic Survey personnel began monitoring a geodetic control line from Na Puu a Pele located west of the site, to Puu Ki on the eastern end of the site (Plate 6). Within the last 11 years, the survey indicates that there has been little or no ground movement across this control line (Ref. 4).

The recordable movements were very small and well within the surveying accuracy tolerance limits. Ground cracks are rather unique geological features that should be considered in the resort planning. Engineering techniques are available and implementable to further quantify the physical characteristics of these cracks. Appropriate planning guidelines have been established in this report to mitigate the potential hazards posed by ground cracks.

3.4.2 Lava Tubes and Voids

Lava tubes and voids are commonly known geological hazards on all Hawaiian islands. Collapsed lava tubes are often identified by aligned circular depressions at the surface of pahoehoe flows. However, many times, there are no visible clues to the presence of lava tubes. Lava tubes and voids have been noticed in the central part of the kipuka on the proposed Hawaiian Palace Resort portion of the site and in the scaly pahoehoe and pahoehoe on the proposed Ka'u Aina property.

A Higher Hazard Lava Tube Area (Plate 5) was identified for the proposed Hawaiian Riviera Resort area because several large depressions with visible lava tube feeders and a collapsed lava tube were located. Very large aligned circular depressions were observed above the property line during the air

reconnaissance. Their size and alignment (suggesting a large lava tube) and the location of the depressions on the property determined the boundaries of this higher hazard area.

Two very large depressions with large visible feeder tubes, were located on the proposed Ka'u Aina site behind Puu Ki. These features were located within the proposed park area. If this area is to be developed, it should also be considered a Higher Hazard Lava Tube area.

Lava tubes and voids are commonly known in Hawaii, and the local construction industry has gained considerable knowledge on how to eliminate or mitigate these incidental hazards.

3.4.3 Tumuli

Tumuli are usually dome-shaped protrusions on the surface of pahoehoe flows. Some tumuli have a thin crust with a large void inside. Their geological hazards are similar to lava tubes and voids, and can be treated similarly. Sometimes, however, tumuli are infilled with solidified lava.

Tumuli can be found in the central part of the kipuka on the proposed Hawaiian Palace Resort part of the site, and in both the pahoehoe and scaly pahoehoe lavas of the proposed Ka'u Aina Resort part of the site.

3.5 EXTERNAL GEOLOGICAL HAZARDS

3.5.1 Lava Flow Hazards

Lava flow hazard in the Hawaiian Islands has recently been quantified on a proposed classification map based on lava-flow coverage of different areas during specific time periods (Ref. 1). The Island of Hawaii is divided into nine hazard zones, with Zone 1 having the highest lava flow risk and Zone 9 having the lowest risk. The proposed site is located in Zone 2. By

comparison, the primary population centers, Hilo and Kailua-Kona, are located in risk Zones 3 and 4, respectively.

Zone 2 is defined as, "several areas that are adjacent to and downslope from an active rift zone ... and therefore, subject to burial by lava flows of even small volume erupted in those rift zones" (Ref. 1). Long and voluminous lava flows have repeatedly entered Mauna Loa's Zone 2, covering about 5 percent of those areas since 1950 and about 20 percent within historical time. The classification of hazard zones is somewhat subjective and may change when new lava flows occur.

Given that two historic (1887 and 1907) a'a lava flows had reached the site and that there have been seven (7) historic eruptions recorded along the southwest rift zone of Mauna Loa, it is likely that there will be more eruptions along this rift in the future. The possibility of a lava flow entering this 5 mile-wide site exists. Accurate predictions of short-term probabilities of lava-flow coverage for this area are not yet feasible (Ref. 1).

Research and monitoring of lava flow occurance is continuing. Recent trends indicate that the SW rift zone eruptive vent locations have a tendency to move upslope (Ref. 2). If this trend continues, it would imply that future eruptive vents will be further away from the site. Therefore, the risk of on-site lava flows may decrease.

3.5.2 Seismic Hazards

The Island of Hawaii has been classified as seismic Zone 3 according to the Uniform Building Code (Ref. 6).

In Hawaii, the majority of earthquakes are the result of magma moving at shallow depth and seldom cause any damage. However, there are occasional

larger scale earthquakes that are associated with structural readjustment within the volcano that can cause property damage. A very large seismic event could cause the regional submarine slump block to move, which in turn may cause tsunami and may also cause the existing ground cracks at the site to move.

The most recent large earthquake to affect this area occurred along the Kealakekua fault in 1951, and had a magnitude of 6.2. A tabulation and a plot of all known large earthquakes between 1918 and 1985 near the Hawaiian Islands are presented in Appendix B.

Currently, there are strong motion detection devices installed in Hawaii to monitor volcanic and seismic activities. Scientists, however, are still not able to accurately forecast earthquake events.

Currently, state-of-the-art earthquake engineering is capable of quantifying seismic risk and providing structural design parameters for a specific site. Concrete and steel buildings can now be designed to provide adequate protection against collapse in case of large earthquakes.

3.5.3 Tsunami Hazards ·

Tsunamis are generated when a large mass of water is abruptly displaced. A tsunami that affects Hawaii may have been generated anywhere within the Pacific Basin including the immediate vicinity of Hawaii itself.

Locally-generated tsunamis are usually associated with a locally-occurring earthquake or a volcanic eruption.

The effects of locally-generated tsunami are similar to the effects of those generated within the Pacific Basin. Locally-generated tsunamis, however, are more dangerous because they give very little warning time for evacuation.

The most recent local tsunami occurred in 1975 and was generated in the Kalapana area by an earthquake of magnitude 7.2. This 1975 tsunami probably traveled past the shoreline of this site but there is no record of damage or of wave run-up heights.

The best safe guard against tsunami hazards is afforded by the National Weather Service Pacific Warning Center located in Ewa Beach, Oahu. It can identify an earthquake large enough to trigger a possible tsunami within a few minutes and with its strategically located tsunami sensing stations in the Pacific, can verify the occurrence of a tsunami in about half an hour.

3.5.4 Storm Wave Hazards

Storm waves are not a geologic hazard but are mentioned here because storm waves can dislodge large amounts of sea-bottom debris and throw it onto shore areas.

Large coral gravel deposited approximately 200 feet inland was observed along the shore at both ends of the site. This indicates that large storm waves can occur along the shoreline.

Appropriate shoreline protection and setback guidelines for either tsunami or storm wave runups are being developed separately by Sea Engineering Inc.

3.5.5 Miscellaneous Hazards

The site is located far enough away from the Mauna Loa vents so that other geological hazards such as ash fall, volcanic-gas emissions, and pyroclastic surges should not pose a great hazard to the site.

4.0 DISCUSSION AND RECOMMENDATIONS

4.1 ENGINEERING PROPERTIES OF GEOLOGIC FEATURES

4.1.1 Pahoehoe

Large portions of the site are covered with pahoehoe lava. Pahoehoe consists of massive, highly vesicular basalt. The nearsurface pahoehoe may be ripped with large bulldozers with great effort. This rock is probably more economically excavated by conventional drilling, blasting, and excavating techniques.

The excavated pahoehoe will come out as relatively large boulders which would have to be crushed in order to be used as fill. The crushing of boulders less than 12 inches can be done using large self-propelled sheepsfoot compactors such as a Caterpillar 825 or 835. Crushing using lighter equipment will be very difficult. The crushing of the material using sheepsfoot compactors will yield fairly coarse aggregate with little fines.

The boulders greater than 12 inches would have to be processed through a 7echanical crusher. The crushed rock will yield fairly well-graded material which can be used for structural fill and road way base course.

4.1.2 A a

The a'a flow creates a basalt consisting of layers of clinker which are large, highly vesicular gravel particles sandwiched between cores of massive, very low vesicular basalt. The clinker material can be easily crushed using a self-propelled sheepsfoot compactor, and this material yields well graded gravel. With great effort, the clinker can be crushed into sand-sized particles. However, the a'a core, which is very hard and massive, will have to be excavated using blasting techniques and will have to be crushed by mechanical crushers in order to create aggregate.

4.1.3 Lava Tubes and Voids

Within lava flows, generally pahoehoe, there are gas bubbles or lava tubes which may not be able to provide adequate support for buildings. A common technique to detect these voids has been to drill at each of the heavily loaded foundations. Once a lava tube or other void has been detected, several standard solutions for dealing with these features are available. The void may be grouted if small enough, or the foundation structure may be relocated to the bottom of the void. Voids which are very close to the surface can be collapsed using a very heavy weight dropped from a crane. This technique is called dynamic compaction and has been used for compaction of granular soils in other parts of the world. Dynamic compaction should be considered for this project as an economical ground improvement method.

Construction of buildings in lava tube and void areas is feasible.

Numerous successful examples can be readily identified in Kawaihae, Waikoloa,

Keahole, and Kailua-Kona.

4.1.4 Tumuli and Blisters

Tumuli often contain large volumes of solid basaltic rock but they may also contain a thin hard crust and a large void underneath. Solid tumuli may require extra blasting effort for removal, But they may also be considered as a resource for architectural masonry materials. Hollow tumuli and lava blisters can be treated in similar manner as lava tubes and voids.

4.1.5 Littoral Cones

Littoral cones or lithified ash deposits are generally loose and easily removable. They are a good source of fine-grained construction material, and good soil conditioner for golf course construction.

Because of the loose and compressible nature of the ash materials,

building foundations constructed on the ash could undergo excessive settlement. Accordingly, we recommend that no footings be placed on in-situ ash materials. The footings should be extended to sound rock or be placed on piles. Additional foundation investigation would be required for planning buildings in the littoral cone areas.

4.2 MARINA CONSTRUCTION

The proposed marina is located in pahoehoe lava. The location of the marina is shown on the Geologic Map, Plate 5. To study the subsurface conditions, two probes 35 feet deep were drilled with an air track drill rig from Isemoto Construction Co. The locations of the probes are shown on Plate 7. The probes indicated that the surface layer of pahoehoe lava was 25 to 35 feet deep. Probe 1, located near the ocean, encountered two voids 4 feet in height within a hard rock layer. In Probe 2, drilled inland, the encountered voids were no more than 1 foot in height. A clinker layer was encountered at 25 feet in Probe 2. The clinkers indicated that an a'a lava flow exists below the pahoehoe. The Log of Probes are shown on Plates 8.1 and 8.2.

The rock in the proposed marina can be excavated by drilling and blasting. The edges of the marina basin may be cut to near vertical. The side slopes surrounding the marina should be designed at a maximum slope of 1/2 Horizontal to 1 Vertical (1/2H:1V) or in accordance to architectural and civil engineering design requirements. Flatter-design slopes may be necessary if loose clinker is uncovered. Presplitting is recommended for creating relatively smooth-cut slopes.

Side slope planning should consider the existance of ground cracks.

Flatter slopes, set back, and benches may be required near the known ground cracks to maintain slope stability.

Additional borings and a more detailed investigation of the rock condition should be done after the marina location and surrounding grades are established. Material excavated during construction of the proposed marina can be used as fill for foundation pads or stockpiled at the proposed airport site for later use.

4.3 RECOMMENDED RESORT PLANNING GUIDELINES TO MITIGATE GEOLOGICAL HAZARDS

Ground Cracks - Ground cracks are the primary constraints on the site resort planning. These cracks do not pose any planning problem for the siting of the proposed marina.

For the siting of permanent habitable buildings, we recommend that:

- No building should straddle any crack,
- No building should be sited within 500 feet from the longitudinal extension of a crack.

Once the building size and column loads are known, then the horizontal setback distance from the ground cracks can best be determined. As a general rule, heavier buildings should have greater setback distance from crack edges.

These planning recommendations may be amended if the age and depth of cracks can be better defined by subsequent investigation studies.

Mat foundations are recommended for buildings that are near any known ground crack. Thick, coarse aggregate cushion fill is recommended under the mat foundations. Utility lines and roadways crossing the cracks will require special design details to tolerate any potential differential ground movement.

Lava Tubes - All building sites should have appropriate foundation investigation and probing to locate lava tubes and voids. Conventional foundation treatment can be implemented if any lava tube or void is found.

<u>Earthquakes</u> - Since this area is a high risk area for earthquakes, the buildings should be designed according to the Uniform Building Code, Seismic Zone 3 requirements. It may also be appropriate to conduct a seismicity evaluation at the design phase of the project to select a most appropriate seismic criteria for building design.

Lava Flows - There is no proven engineering technology which can be used to divert lava flows from entering a site. Recent experience in Iceland and in Hawaii has demonstrated that water sprayed on the advancing lava flow can sometimes alter the flow direction. Technologies for predicting earthquakes, volcanic eruptions, lava flows, and other known geological hazards are still at an early stage of development. Therefore, mitigation against these natural hazards are primarily dependent on early detection, early warning, and evacuation procedures offered by governmental agencies such as the Pacific Tsunami Warning Center and the Department of Civil Defense.

5.0 SUGGESTED FUTURE STUDIES

As part of the design and development of the proposed resort, we recommend that further geotechnical and geophysical studies be conducted to quantify the physical characteristics of the ground cracks. They would consist of cross hole geophysical investigations to determine the depth of the cracks, and the shear wave velocity of the rock. Core samples from the borings can be thin-sliced for mineral analysis. A refraction survey should be performed on the a'a lava flow adjacent to the cracks to determine if the cracks are continuous underneath the a'a flow.

We would also recommend an earthquake engineering study of the site. The purpose of this study would be to derive earthquake design response spectra for the structural design.

These additional studies should preferably be scheduled after the Master Plan for development is finalized, but before the design phase of the development.

6.0 LIMITATIONS

This report has been prepared for the use of Belt Collins & Associates for inclusion in an Environmental Impact Statement. This report has been done in accordance with generally accepted geological engineering procedures and no other warranty, expressed or implied, is made as to the professional advice included in this report. This report has been prepared for use by the Hawaiian Palace Development Corporation; Ka'u Aina Partnership; Belt Collins & Associates, Inc.; and Helber, Hastert & Kimura, Planners. It may not contain sufficient information for purposes of other parties or for other uses.

The following Plates and Appendices are attached:

Plate 1	- Location Map, Island of Hawaii
Plate 2	- Plot Plan, Proposed Hawaiian Riviera
Plate 3	 Regional Geological Structures Map
Plate 4	- Relative Ages of Lava Flows
Plate 5	- Geologic Map
Plate 6	- Map of USGS Geodetic Control Line
Plate 7	- Marina Map
Plates 8.1 and	8.2 - Logs of Probes, Probes 1 and 2
Appendix A	Geologic Definitions
	——————————————————————————————————————
Appendix B	- Seismic Events

Respectfully submitted,

DAMES & MOORE

A Professional Limited Partnership

S. K. Djou, P.E. Partner (Ltd.)

Michael A. Yamasaki

Associate

Patricia D. Lee

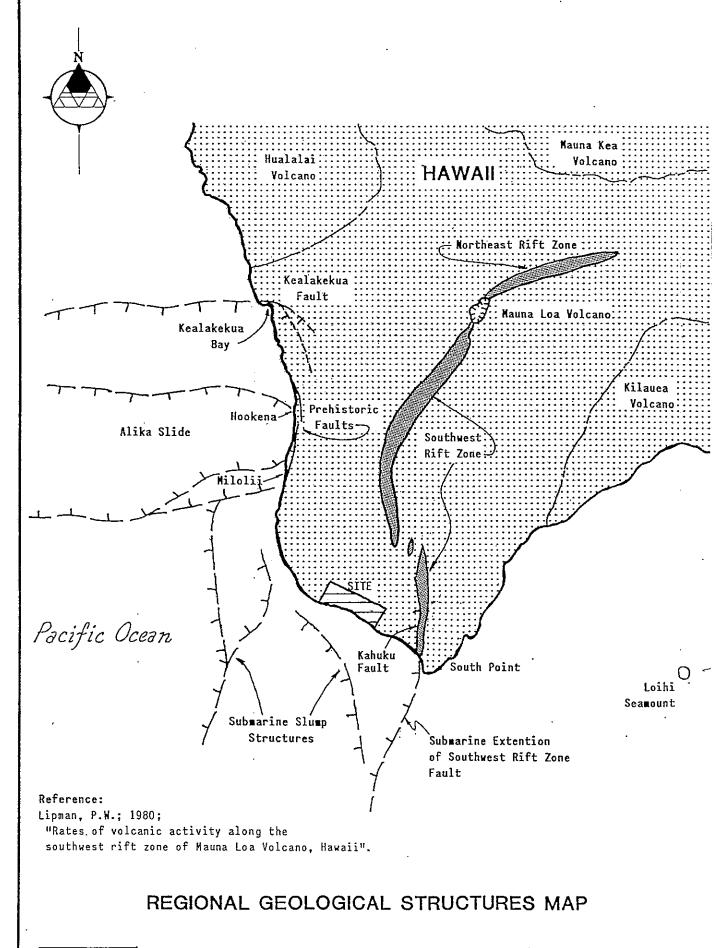
Geologist

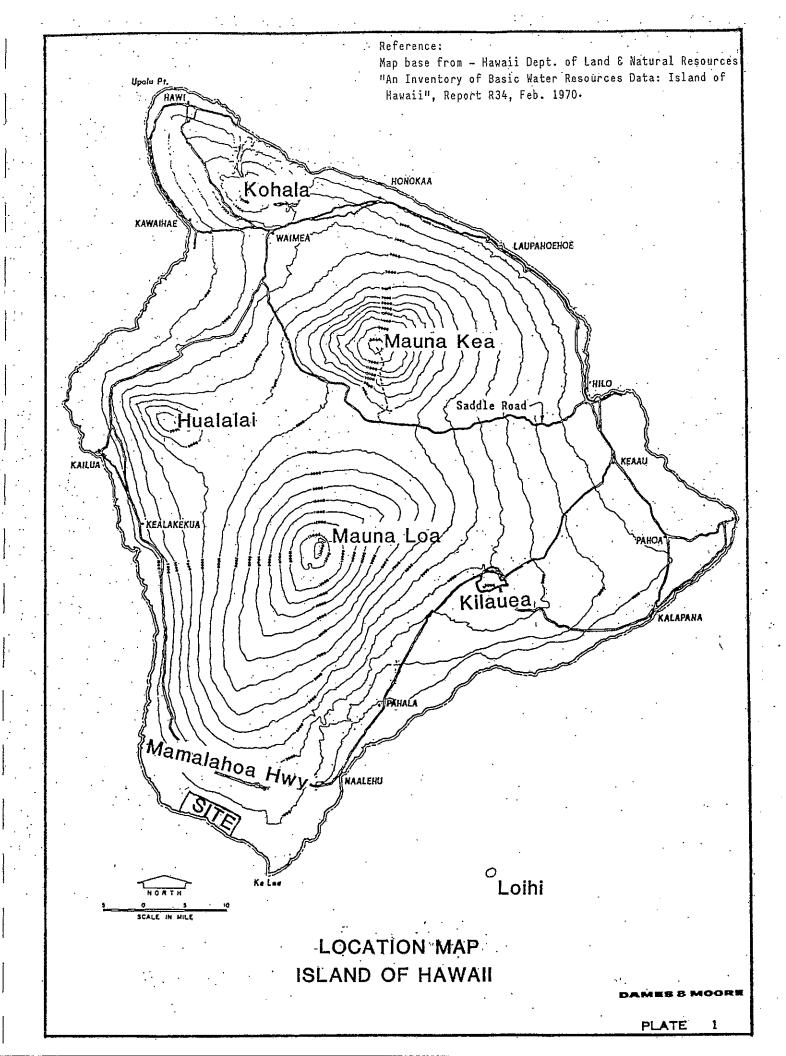
SKD/MAY/PDL:ob/mjo(4080A/323A:15742-001-11) (Six copies submitted)

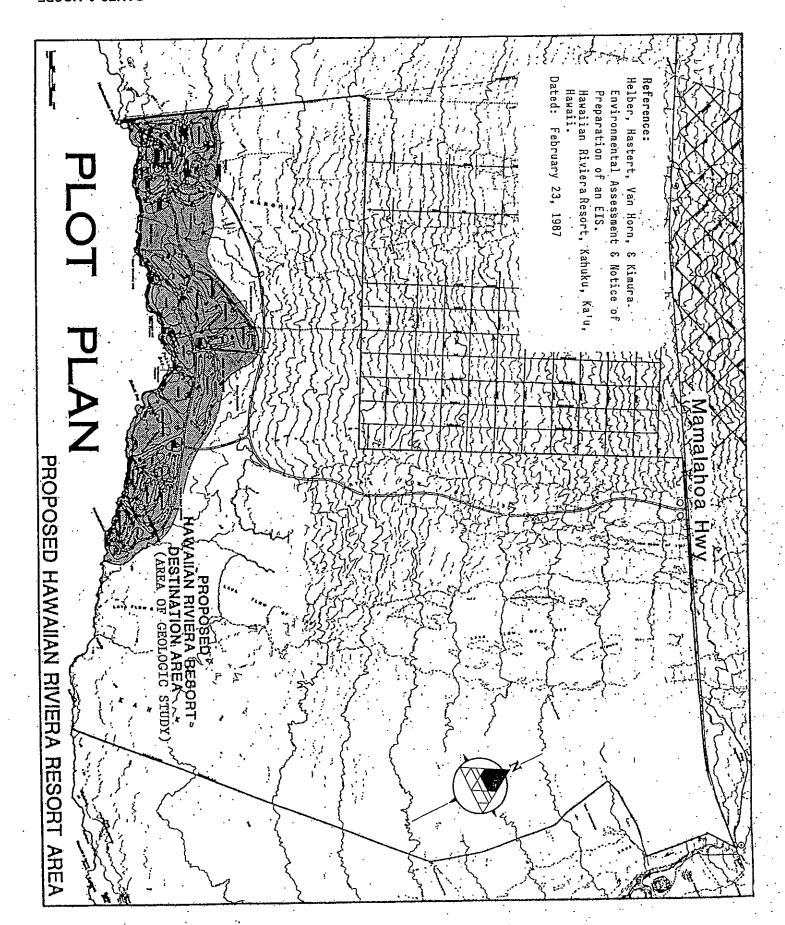
REFERENCES

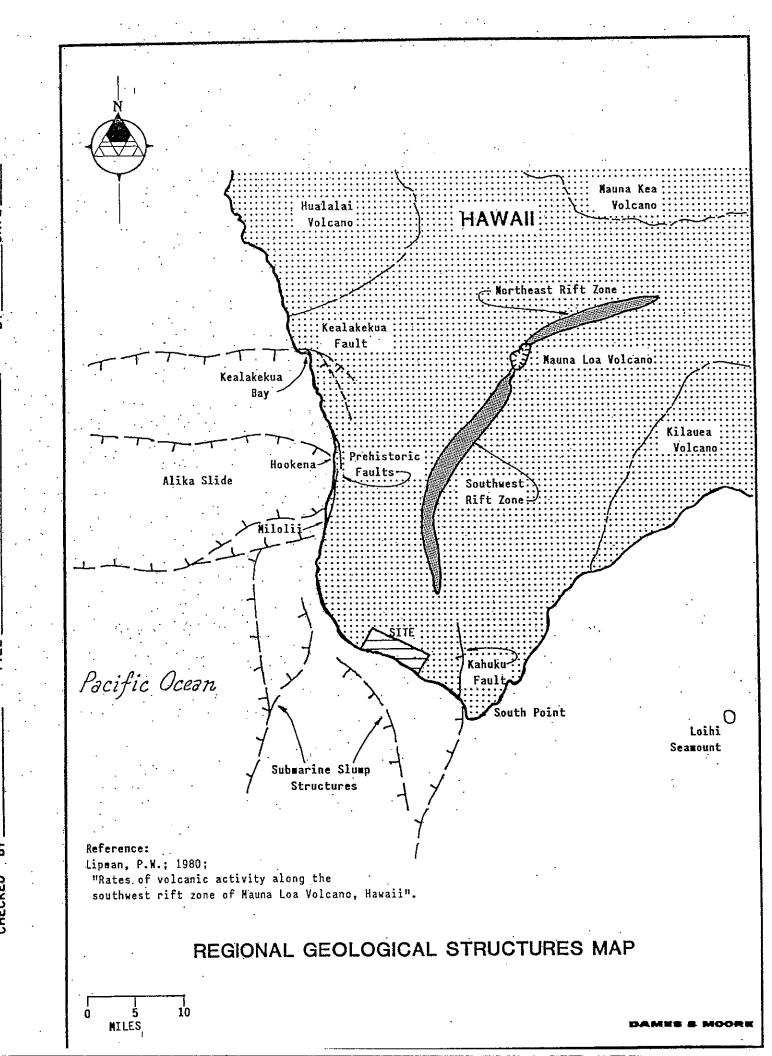
- Mullineaux, D. R., Peterson, D. W., and Crandell, D. R., 1987. "Volcanic Hazards in the Hawaiian Islands," USGS Professional Paper 1350, Chap. 22, pp. 599-622.
- Lipman, P. W., 1980A. "The Southwest Rift Zone of Mauna Loa: Implications for Structural Evolution of Hawaiian Volcanoes," <u>American Journal of</u> <u>Science</u>, Vol. 280-A, 1980, pp. 752-776.
- 3. MacDonald, G. A., Agatin, T. A., Peterson, F. L., 1983. <u>Volcanoes in the Sea</u>, University of Hawaii Press, Honolulu, 517 p.
- 4. Lockwood, J. P.,. 1987. Personal Communication.
- 5. Lipman, P. W., 1980B. "Rates of Volcanic Activity Along the Southwest Rift Zone of Mauna Loa, Hawaii," <u>Bull. Volcano.</u>, Vol. 43-4, 1980, pp. 703-725.
- 6. Uniform Building Code, 1982 Edition, p. 151.
- 7. Tilling, R. I., Koyanagi, R. Y., Lipman, P. W., Lockwood, J. P., Moore, J. G., and Swanson, D. W., 1976. "Earthquake and Related Catastrophic Events, Island of Hawaii, November 28, 1975: A Preliminary Report," USGS Circular 740, 33 p.

10.7 (KLY. 0-61)

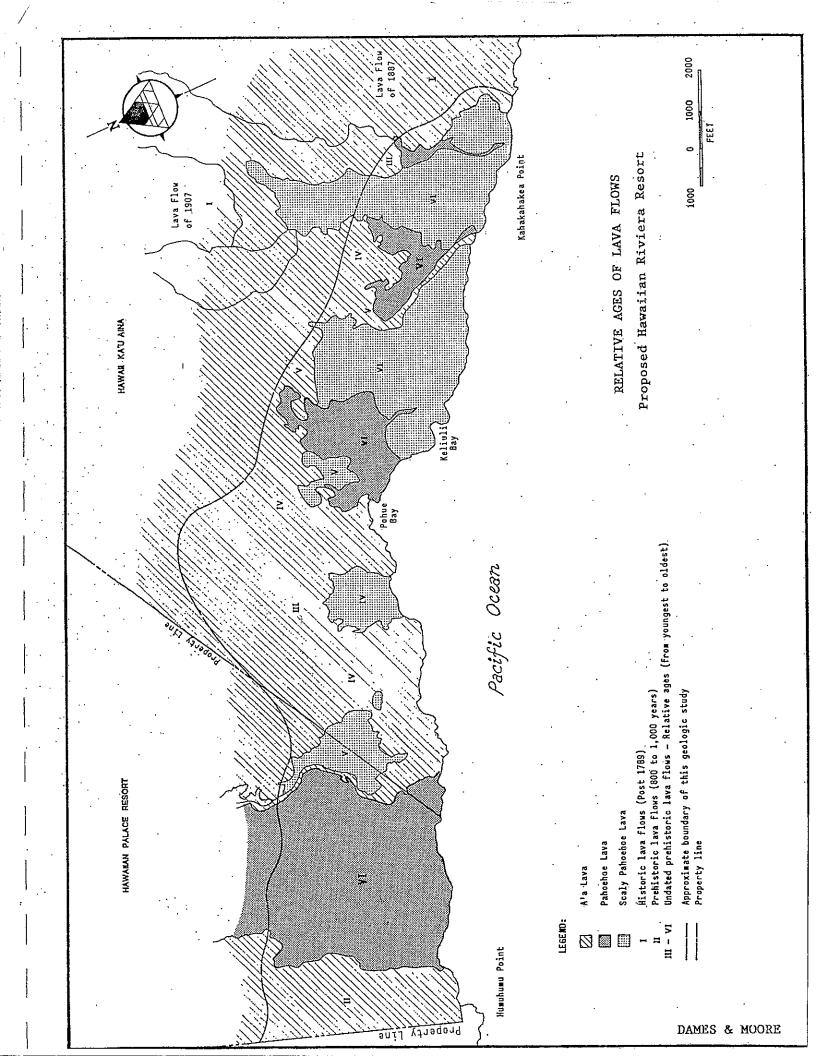


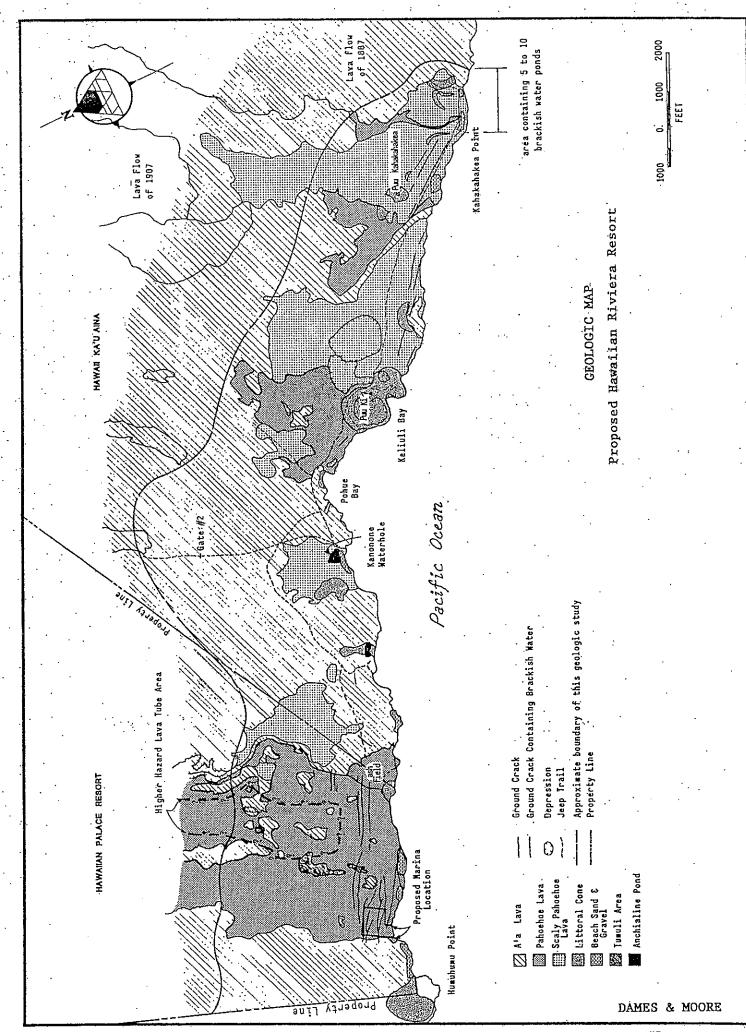


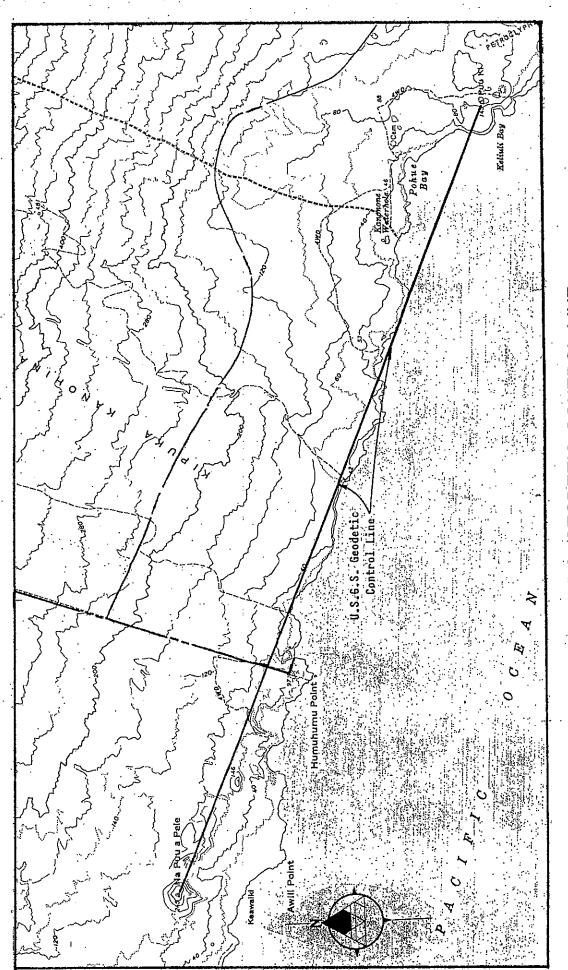




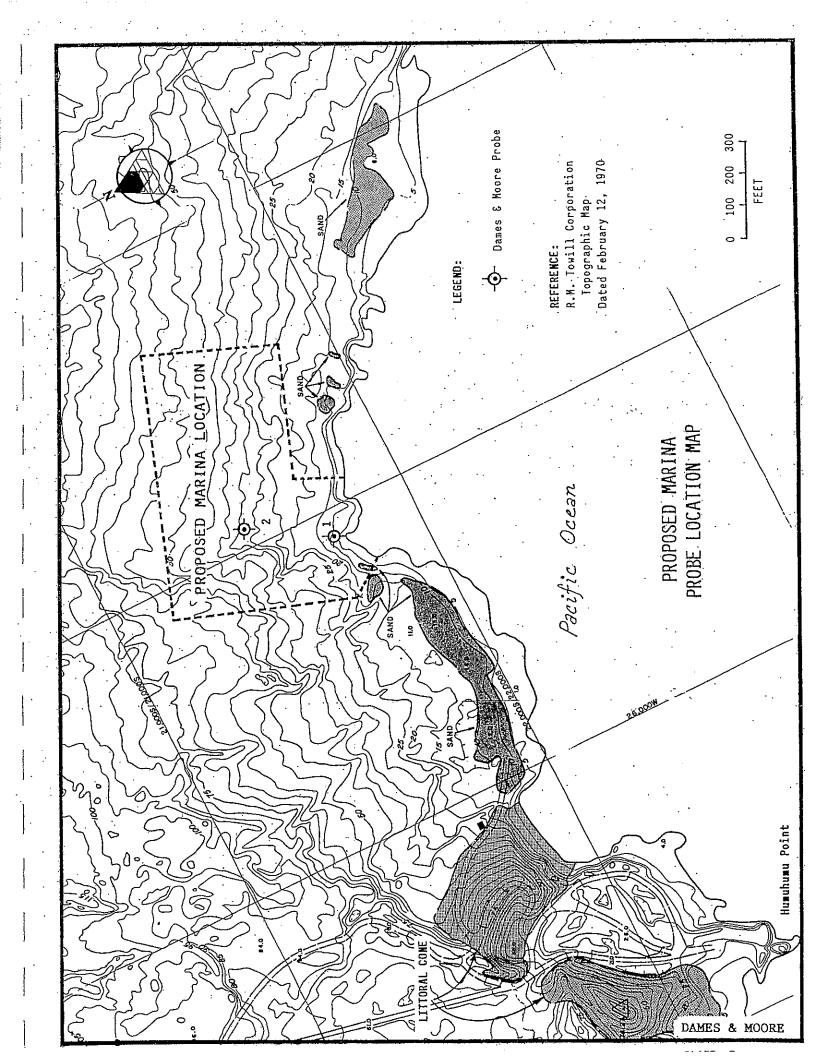
me VISroms



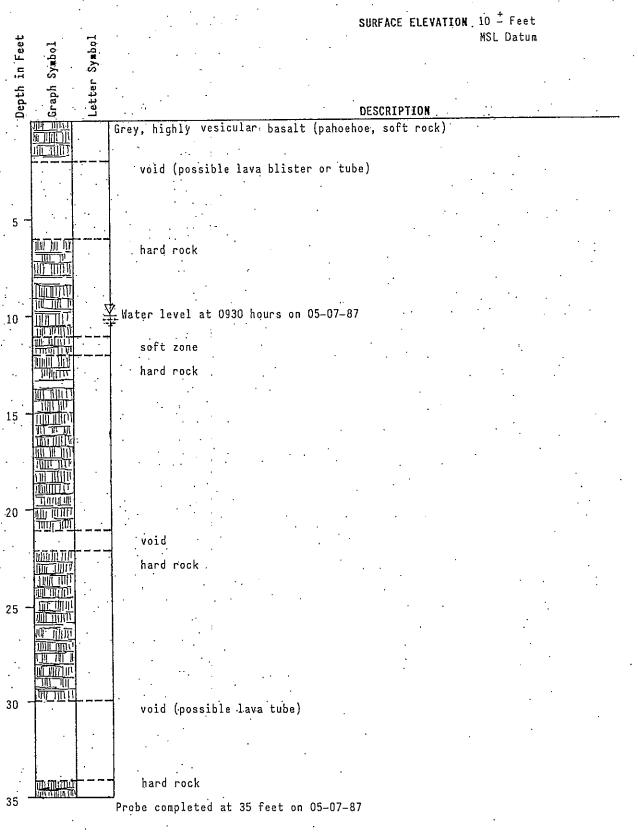




MAP OF U.S.G.S. GEODETIC CONTROL LINE

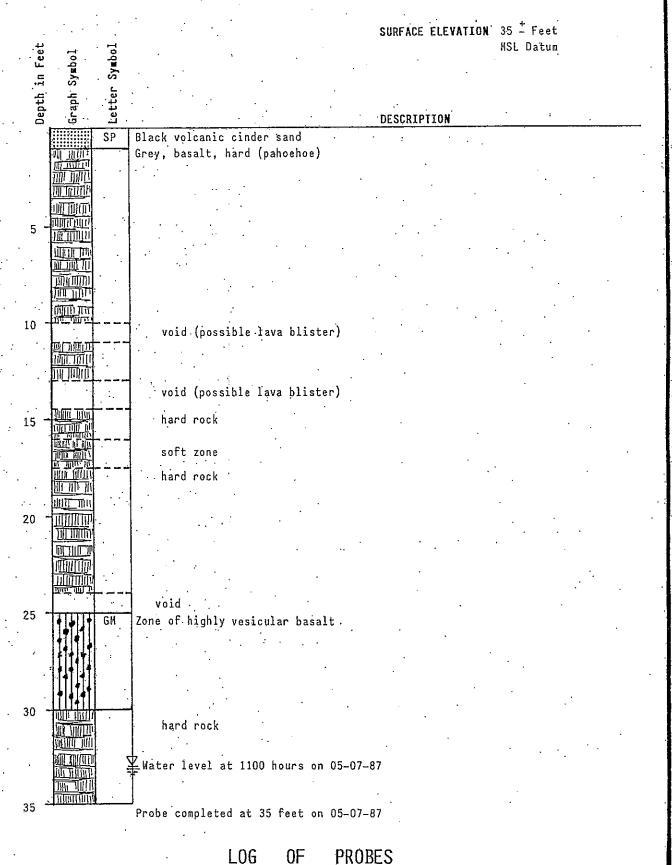






LOG OF PROBES

PROBE 2



DAMES & MOODE

APPENDIX A

GEOLOGIC DEFINITIONS

Definitions and explanation of the certain geologic terms used in this report are presented below. They have generally been taken from <u>Volcanoes in the Sea</u> (Ref. 3).

A'a - A'a lava has a higher viscosity than pahoehoe lava. Because of its high viscosity and the brittle nature of the cooled lava, the pasty a'a lava flows in a coarse clinker shell of its own making. This gives the flow a jagged morphology.

The massive pasty core is the active portion of the flow. Clinker is carried atop the flow, falls down the front of the flow front, and is buried by the overriding mass. The result is a dense interior layer between a clinkery top and bottom. Individual a'a flows are generally 6 to 24 feet thick, but locally they can be as thick as 60 feet.

Accretionary lava balls, ranging in size from a few inches to 3 yards or more, are common on a a flows, and are generally located towards the flow margins. They are formed when a fragment of solidified lava is rolled along and coated with the viscous liquid. They grow in size much like a snowball rolling down a hill in sticky snow.

<u>Pahoehoe</u> - Pahoehoe lava can be described as lava with a low viscosity. It is characterized by a relatively smooth, hummocky surface with tubes and cavities under the surface. Because of high gas content, the pahoehoe lavas are generally filled with numerous gas bubbles or vesicles. Smooth swells or blisters in the lava surface reflect larger gas pockets immediately beneath the surface.

Individual pahoehoe flows range in thickness from a few inches to as much as 9 feet. During the course of a single eruption, successive pahoehoe flows moving along the same path may build up thicknesses of many tens of feet.

Scaly Pahoehoe - Scaly pahoehoe lava appears to be a transitional lava between pahoehoe and a'a. It is usually found near the coastline in areas where the terrain has flattened out and flows have entered the sea. The crumpled, fractured texture is most likely a reflection of a cooler portion of the flow that is trapped between advancing material from the vent and material stalled by terrain change and rapid cooling. Many of the larger collapse or depression features, ponds, and lava tubes were associated with this lava type.

Tumuli - Tumuli (singular: tumulus) are nearly round to oval dome-shaped hills, which are occasionally found on the surface of pahoehoe flows. Commonly 9 to 18 feet high, they are often crowned with a gaping crevasse across the top of the dome in which the internal structure of the upper part of the flow is revealed. Tumuli are generally formed on a part of the flow that has been confined,

Appendix A Continuation

cooled slightly, then heaved up when the crust is pushed against stationary crust farther downstream. Sometimes the tumulus is hollow, but usually lava has run within and filled it.

Lava Blisters - Hollow toes of pahoehoe flows that were inflated by expansion of volcanic gas.

Lava Tubes - Pahoehoe lavas flow as lava rivers which quickly crust over and develop more or less continuous roofs. The lava stream then flows within a tunnel of its own making called a lava tube. Many smaller tubes branch off the main tubes, feeding the front and margins of the flow. At the end of the eruption, most of the lava may drain out of the main tubes leaving open tunnels which may be anywhere from a few feet to 40 feet in diameter.

Flow Channel - At the end of an eruption, the fluid lava may partly drain out of the central river of an a'a flow. A distinct channel or canyon is left which often acts as a channel for subsequent flows.

Littoral Cones - Where a'a flows enter the ocean, littoral cones, composed of lithified ash deposits, are constructed by violent explosions as the dense core of the flow encounters water. The cones, 30 to 70 feet high, may occur in pairs, one on each side of the a'a flow. Most cones have a steep seaward facing wall due to wave erosion. The internal structure of these cones is visible from the steep ocean side. Due to chemical weathering, the lithified ash deposits are often banded in colors that range from reds to browns and blacks. Grain size varies from fine sand to cobbles, takes the form of tuff, spatter and bombs, and can also be banded in appearance.

<u>Tsunamis</u> - Tsunamis, or seismic sea waves, are often associated with earthquakes and are generated when a large mass of water is abruptly displaced. Run-up distances are a function of local topography and volume of water. In Hawaii, the heights and distances reached by different tsunamis, or by the same tsunami on different islands, vary greatly. Heights varying between 3 and 45 feet have been recorded on the same island due to a single event.

APPENDIX B

SEISMIC EVENTS

There were 35 seismic events with magnitudes of 5 or greater occurring in the Hawaiian Islands between 1918 and 1985. The locations of the epicenters are shown on Plate Bl. Most of the earthquakes were located on or very near to the Island of Hawaii. The date, location, and magnitude of the epicenter are listed on the following pages, B2.1 through B2.8.

- 000 -

Attachments:

Plate B-1 - Epicenters in Hawaii Plate B-2.1 through 2.8 - List of Earthquakes

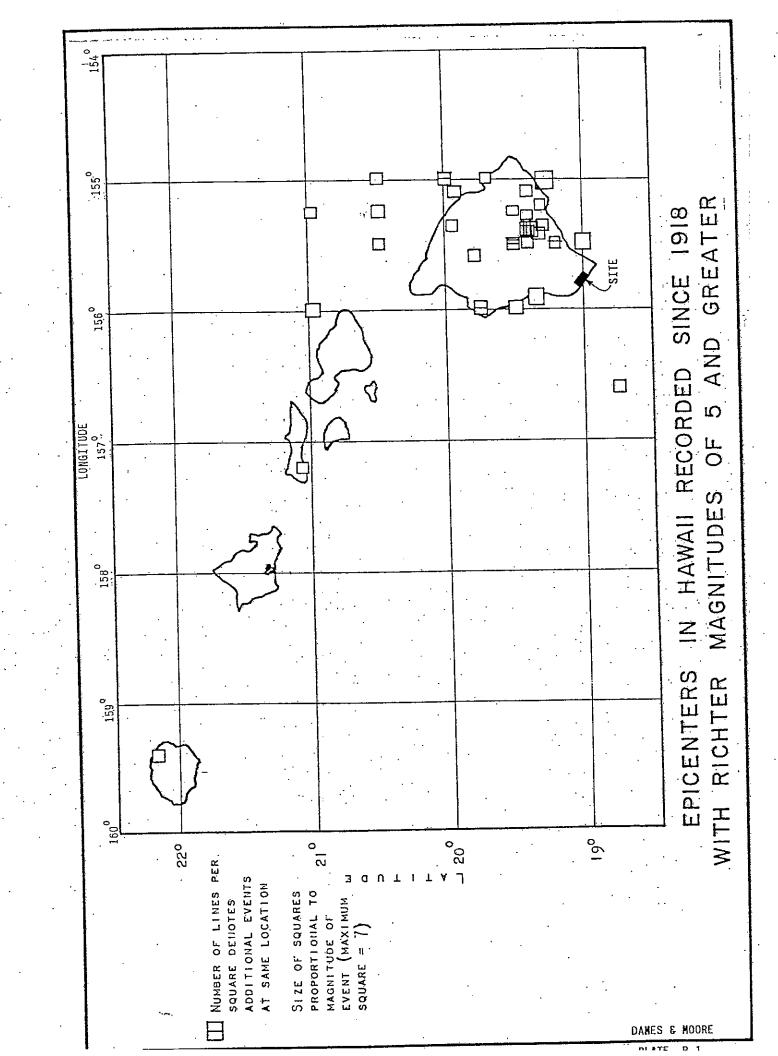


PLATE B-2

LIST OF FARTHQUAKES

		•	•		غ.
	DATE	LATITUDE	LONGITUDE	INTENSITY	MAGNITUDE
11011	00 1010	21.100	157.200	VII	•
	02 • 1918		159.400	VÎÎ	•
	14 1919	55.500		ĬV	
APR		19.420	155.270	VII	5.6
SEP		19.750	156.000	• •	
OCT	06 1929	19,750	156.000	VIT	6.5
FFR	6 1932	17.800	156.700	II	•
	14. 1932	19.280	155.220	•	4.0
JUL		19.420	155.270	IV	
	11 1933	19.000	158.000	111	4.0
	· · · · · · · · · · · · · · · · · · ·	19.700	155.000	VI .	•
DEC	02 1933	17.0111	[J] • ((U))	•	
MAY	10 • 1934	19.633	155.383	' V	
	02. 1935	19.418	155.283		
	28 1935	19.500	155.250	٧ .	5•6
	01 1935	19.366	155.651	. ^	
	1. 1935	19.635	155.434	V	
QCT	1 • 1935	19.000	[7 7 4 4 5 4	•	•
NOV	21 1935	19.516	155.518	. V	
	15 1936	19.400	155.250	V	
	23, 1938	21.000	156.000	VIII	6.7
	17. 1938	19.550	155.450	V .	
	15 1939	19.366	155•133	Α	
			155 266	v .	•
МДҮ		19.468	155.366	v	
	24 1939	19.416	155.233	V	
MAY	30 • 1939	19.500	156.833		
NUL	01. 1939	19.566	155.168	V	•
JUL	14 1939	19.318	155.116	٧	•
LIM	17. 1940	20.500	155.250	٧I	6.0
JUL		20.500	155.000		5.6
SEP		21.000	155.250	٧ - "	5.6 .
		19.500	155.500	. VII	6.0
			155.500	٧Ī	5.6
DEC	27 • 1944	19.500	1) 14) 0 (1		7 •
APR	10. 1949	26+000	175.000	ΙΙ	4.0
MAY	30 • 1950	19.500	156.000	VI	6.3
	14. 1950	20.000	155.500		4 • 0
DEC		19.500	155.500	•	4.0
DEC	•	19.500	155.500	•	. 4.0
4. 72 -			165 500	ΛΙ1.	6.5
	23, 1951	19.000	155.500	IX	6.9
	21 • 1951	19.750	156.000		U • 7
SEP		19.200	155.500	V,	
NOV		19.200	155.500	VI	
MAR	18 1952	19.125	155.033	V	

LIST OF EARTHQUAKES

	•	•		•
DATE	LATITUDE	LONGITUDE	INTENSITY	MAGNITUDE
APR 7. 1952	21.000	157.000	· V	
		155.483	VI	6.0
MAY 23, 1952	19.483	155.500	v	•
JUL 12: 1952	19.500		۸. ·	
JAN 10+ 1953	19,400	155.550	•	5.2
JAN 15. 1953	19.316	155.433	V	7.6
FEB 12 1953	19.283	155.450	IV	
MAR 30: 1954	20.000	155.000	•	6.0
MAR 30 • 1954	50.000 -	155.000	VII	6.5
	20.500	155.500	VI.	
JUL 3. 1954	•	155.000	ν	"'
APR 1. 1955	19.500	177.000		
AUG 7, 1955	20.500 .	155.500	ν	
AUG 14. 1955	19.500	155.500	V	
OCT 27, 1955	20.000	155.500	· V	
MAY 14. 1956	20.283	155.283	V	
OCT 16. 1956	.20.000	157.000	V	
			• • • • • • • • • • • • • • • • • • • •	. بنو
JUL 4, 1957	50.500	157.900	V	4.5
JUL 26 1957	20.250	156.250	•	4.6
AUG 10 1957	21.000	155.470	٠ .	4.2
AUG 11 • 1957	21.000	155.470		4.3
AUG 18. 1957	21.000	156.000	V	•
			•	
FEB 194 1958	19.350	155.150		4.5
OCT 22, 1958	19.201	155.316		4.3
OCT 23. 1958	19.201	155.316		4.3
FEB 19. 1959	19.350	155.150		4.0
MAR 07. 1959	19.733	155.200	•	4.0
				ה ר
MAR 09. 1959	19.833	155.633		3.5
MAR 12. 1959	20.016	155.416	•	4 • 0
JUN 03. 1959	20.916	. 156.166	•	3.3
JUN 26. 1959	19.220	156.370		4.2
JAN 15 1961	19.897	155.628		4.2
			, . ·	, 7
JAN 21. 1961	19,208	155.633		4.7
MAY 19. 1961	19.052	155.233		4.3
JUL 23+ 1961	19.400	155.283	. V	5. <u>1</u>
JUL 23+ 1961	19.400	155.283	· V ·	4.7
AUG 25. 1961	19.865	155.070		4.5
SEP 23+ 1961	19.400	155.100	V	4.1
SEP 25. 1961	19.400	155.100	V	5.9
SEP 25 1961	19.400	155.100	· V	4.1 .
	19.408	155.052	ĬV	4.0
- · · · · · · · · · · · · · · · · · · ·	19.797	155.838	•	4.0
MAR 10. 1962	120121	1234490	٠.	

LIST OF FARTHOUAKES

	•			
DATE	LATITUDE	LONGITUDE	INTENSITY	MAGNITUDE
MAR 24 1962	19.402	155.285	•	4.4
MAR 31 • 1962		155.918		4.5
APR 24, 1962	· ·	155.617		4.0
MAY 10 • 1962	19.402	155.285		4.3
JUN 14 1962	19,417	155.285		4.3
OUN THE TAUK	17#41/	133.603		7 • 3
JUN 27. 1962	19.400	155.417		6.1
JUN 28. 1962	19.800	155.600		5.7
JUL 14. 1962	19.740	155.637	•	4.0
JUL 23 • 1962	. 19•482	155.987		4.5
JUL 24: 1962	19.570	156.030	· .	4.9
AUG 18+ 1962	19.180	155.533		4.0
AUG 18, 1962		155.195	•	4.6
SEP 8 1962.		155.142	. •	4.1
NOV 22+ 1962	•	155.083		4.1
DEC 28. 1962	19.308	155.083	•	4.1
				,
DEC 31 • 1962	19.233	155.596	-	4.0
JAN 08. 1963	19.401	155 - 285		4 • 3
JAN 09. 1963	· ·	155.285		4.2
FER 17, 1963		156.870		4.1
MAR 24. 1963	19.750	155.563		4.5
JUN 6. 1963	19.198	155.551		4.2
AUG 26 1963		155.600	,	4.9
SEP 21 1963	19.200	155.500		4.8
OCT 23 1963	19.400	155.500		5•3
FEB 20 1964	20.700	155.830		4.3
JUN 04. 1964	19,447	155.280		4.0
JUN 8 1964		155.418		4.1
JUL 1 1964	19.313	155.115	· · · · · ·	4.5
JUL 17 • 1964	19.892	155.987	· .	4.5
AUG 13. 1964	19.500	155.400		4.1
AUG 26 • 1964	20.230	156.150		4.4
SEP 18 1964	19.315	155.115		4.9
OCT 11. 1964	18.750	156.617	•	5.5
DEC 03 1964	19.401	155.285	•	.4.7
DEC 03+ 1964	19.402	155.285	•	4.0
		A W T W SW TATE	•	. •
DEC 10 1964	19.308	155.203		5.0
FEB 13, 1965	18.750	155.267.		4.5
MAR 06 • 1965	19.250	155.222		4.0
MAR 22. 1965	19.222	155.538		4.6
JUL 22: 1965	19.335	155.510		4.3
			-	

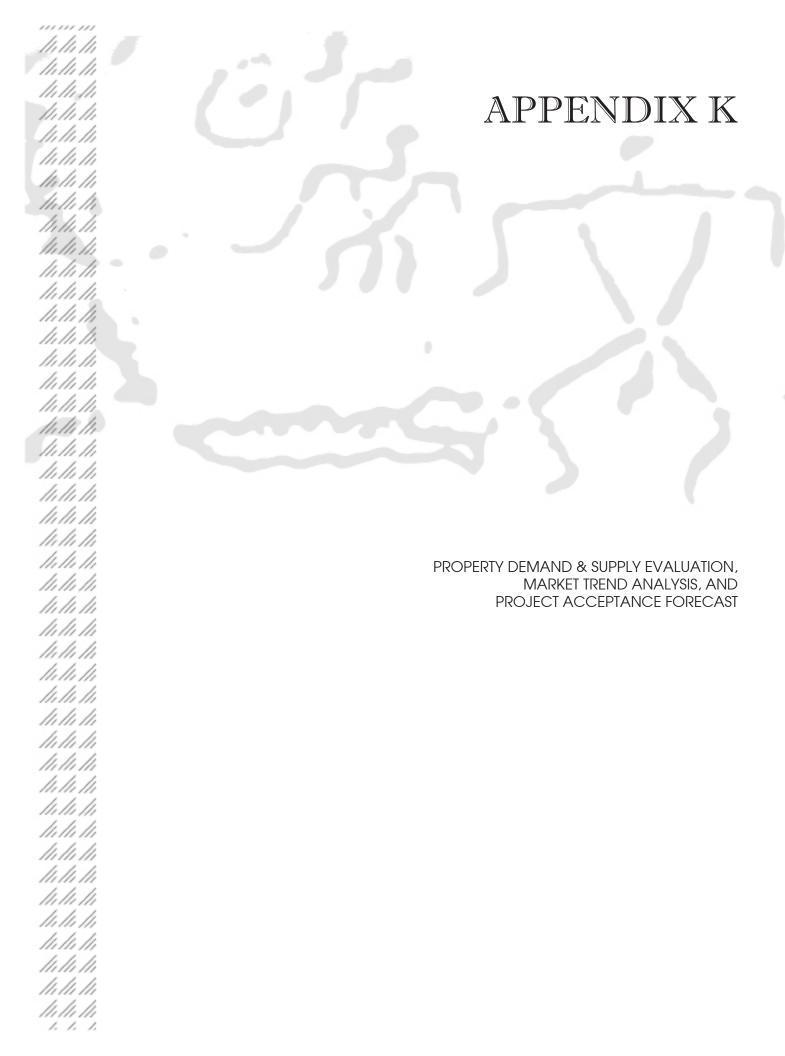
LIST OF FARTHQUAKES

DATE	LATITUDE	LONGITUDE	INTENSITY	MAGNITUDE
		155 200		4.3
DEC 26 1965	19.400	155.200	•	4.0
JAN 19. 1966	19.405	155.328		4.1
JAN 19, 1966	19.397	155.558		
MAR 01. 1966	19.412	155.453	• • •	4.0
MAR 14 1966	19.317	155.442		4 • 1
JUL 30 • 1966	19.417	155.420		4.3
SEP 05, 1966	19.353	155.437	. '	4.7
OCT 31 • 1966	19.320	155,467	,	4.0
NOV 05 1966	19.500	155.903	V -	<i>7</i> • • • • • • • • • • • • • • • • • • •
JAN 23, 1967	19.450	155.430		4.6
DAN ZUN 1700				
FEB 02 € 1967	19.362	155.092		4 • 6
MAR 24 1967	19.780	155.680		4.3
MAY 4. 1967	19.394	155.453		4.4
JUL 01 + 1967	19.500	155.300		4 • 2
JUL :5. 1967	19.383	155.435		4 • 1
				•
AUG 15 • 1967	19.967	155.384	•	4.0
SEP 8 1967	19.417	155.284		4 • 0
OCT 13. 1967	19.566	155.867		2.9
OCT 29: 1967	19.984	155.552		3.8
NOV 3 1967	19.990	156.700		4.0
34 1700			•	
FEB 22. 1968	19.250	156.320	•	4.5
MAR 31 1968		156.900		4.0
APR 28 1968	19.368	155.285		4.5
JUL 02 • 1968	•	155.817		3.4
AUG 01: 1968	19.333	155.102		4.0
AUG UI (700	7.20.23.1			
ΔUG 03. 1968	19.852	155.916		3.8
. AUG 05 1968	19.900	155.883		3.1
AUG 7. 1968	19.316	155.800		4.4
AUG 09. 1968	19.384	155.283		4.1
AUG 16. 1968	19.883	155.369		4 • 1
200 104 1300	1 / 2 / 11.5			
SEP 24 1968	20+167	155.801		4.1
NOV 18 1968		154.966	•	4.3
DEC 16+ 1968	19.319	155.200	•	4.7
JAN 1. 1969		157.870	•	4.7
FEB 10 1969	19.330	155.133	. •	4.5
			•	
FEB 22. 1969	19.434	156.525	•	3.9
MAR 05 1969	18.984	155.484		3.6
APR 9. 1969.		155.716		4.0
MAY 7. 1969	20.830	155.350		4.1
MAY 10 - 1969	19.366	155.069	•	4.9
		•		

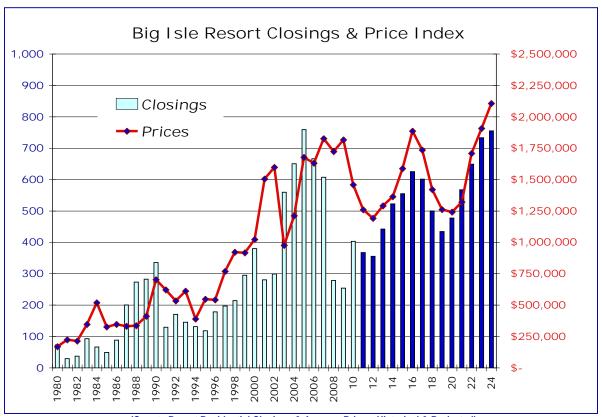
				•
DATE	LATITUDE	LONGITUDE	INTENSITY	MAGNITUDE
JUN 6. 1969	19.418	155.450		4.4
JUN 6, 1969	19.380	155,288		4.0
JUN 7 1969	19.267	155.183	•	. 4.0
JÜL 13. 1969	19.200	155.568		4.7
JUL 20 • 1969	19.385	155.902		3.6
AUG 07. 1969	19,685	156.035		3.5
SEP 3. 1969	19.330	- 155.420	•	4.3
OCT 11: 1969	20+333	155.050	÷ .	3.0.
OCT 14 1969	19.369	155.067	•	4.0
NOV 10 • 1969	19.168	155.501	V	4.5
NOV 24 1969	19.685	156.051		4.5
DEC 57. 1969		155+235		4 • 1
MAR 03 • 1970	20.069	155.651		4.0
MAR 18. 1970	19.368	155.050	II	4.1
MAR 30 • 1970	19.518	155.251		4.3
APR 12. 1970	19.369	155.417		4.3
APR 17. 1970	19.518	155.918	•	4 • 1
MAY 01 + 1970	20.052	155.883	•	3.7
MAY 10 . 1970	19.368	155.052		4,1
AUG 16, 1970	19,418	154.785		4.4
				, _
SEP 21; 1970	19.333	155.200		4.5 4.2
OCT 25 1970	19.300	155.234		4.9
OCT 25 1970		156.816 156.433		4.0
OCT 29 1970	19•517 20•084	155.834		4.3
NOV 13. 1970	∠u•064	T5∪¥u94	•	
NOV 18 • 1970	19*867	155.768		3.4
DEC 06: 1970	19.383	155.616		4.0
DEC 13. 1970	19.684	156-083		3.6
DEC 21 • 1970	20.200	155.235		3.0
MAR 31 • 1971	20.370	156.217		3.8
APR 26. 1971	19.392	155.283	V	4.4
MAY 14. 1971	19.900	156.267		3.7
AUG. 1. 1971	18.200	154.200	•	4.8
AUG 04 1971	20.100	155.800		4.0
AUG 16. 1971	19.367	155.283		4.5
FEB 29. 1972	19.283	156.533	•	4.9
MAR 27, 1972	21.150	156.250		3.8
SEP 5 1972	19.330	155.200		4•4
SEP 6. 1972	19.350	155 • 117		. 3.7
DEC 23. 1972	19.587	155.983		4.9
-	· · · · · · · · · · · · · · · · · · ·	•		-

LIST OF EARTHQUAKES

	•		•	•	•
• •	DATE	LATITUDE	LONGITUDE	INTENSITY	MAGNITUDE
	174416	L 471100L	29.11.7.701.1		
AUG	08 1974	19.470	155.670	III	
	08 1974	19.350	155.300	111	4.2
	12. 1974	19.370	155.430	III	
	18 1974	19.790	156.170	III.	
	21. 1974	19.550	155.950	III	
~00	, 1 • 1 / 1 -	* * * * * * * * * * * * * * * * * * * *			
ALIG	24. 1974	19.310	155.220	111	
	28 1974	19.333	155.210	ĪĪĪ	4 . A
	18. 1974	19.390	155.870	III	
	20. 1974.	19.780	155.530	.111	
	26. 1974	20.160	155.550	III	•
عدد	COA FAIR	7.9.100	1,5 (• 5,5		
ОСТ	15, 1974	19.420	155.490	III	4.0
	26 1974		155.190	ÎÏĪ	. • •
	30 • 1974		155.410	III	
	.31 • 1974	19.370	155.080	ĪĪĪ	4.0
		19.360	155.070	III	
UCI	31 • 1974	17.300	1,7,40,00	***	• .
NOU	09 1974	19.370	155.140	III	
			155.410	ÎII	4.1
	- · · · - ·	•	155.280	ĪIĪ	
	13. 1974	19.420	156.220	III	
	16 1974	19.190	155.317	III	3.9
NOV	22 1974	19.340	122.211		J • 1
		10 / 1/7	155 400	III	5•1
	30 • 1974	19.417	155.400 155.360	III	, 1
	30 • 1974	19.490	155.380	III	
	30 1974	19.440	155.440	III	4.3
-	08 1974		155.380	III	7.0
DEC	08 1974	19.420	עמנ ∙רכן.	111	
		10 (50	155 500	III	• • • • •
	11 • 1974		155.520	III	•
	11 • 1974		155,560	III	the second second
	12 1974		155.110	III	4.3
	15 • 1974	19.450	155.590		
DEC	16 1974	19.390	155.420	V	. 5.0
				T * *	• •
	16 1974	19.390	155.420	III	
•	16 1974		155.420	III	4.2
	21 1974	19.380	155.440	III	4.5
	25. 1974	19.320	. 155.283	III .	
DÉC	26 • 1974	19.220	155.290	III	. 4.3
				***	7. 1
	26. 1974	. 19.230	155.290	III	4 • 1 4 • 4
DEC		19.220.	155.300	III	~ • •
DEC		19.740	156.050	III	4 3
ÜEC		19.350	155.090	III	.4•2
DEC	30 • 1974	19.320	155.280	III	4 • 1
	4				



PROPERTY DEMAND & SUPPLY EVALUATION, MARKET TREND ANALYSIS AND PROJECT ACCEPTANCE FORECAST



(County Resort Residential Closings & Average Prices, Historical & Projected)

In Relation to

KAHUKU VILLAGE

A MASTER PLANNED COMMUNITY NEAR POHUE BAY, KA'U

Submitted to

Nani Kahuku Aina LLC

Ву

Ricky Cassiday

Honolulu, Hawaii,

TABLE OF CONTENTS

CHAPTERS

I. INTRODUCTION II. PROJECT DESCRIPTION & DEVELOPMENT PLAN III. TARGET MARKET, COMPETITIVE AREA AND COMMUNITY IV. COUNTY ECONOMIC CONTEXT AND REAL ESTATE MARKET V. COUNTY RESORT INDUSTRY AND RESORT RESIDENTIAL MARKET VI. RESORT RESIDENTIAL MARKET FORECAST VII. PRIMARY HOUSING MARKET FORECAST VIII. COMMERCIAL PROPERTY DEMAND PROJECTION IX. HOTEL PROPERTY DEMAND PROJECTION X. CONCLUDING REMARKS	PAGE 2 PAGE 4 PAGE 13 PAGE 25 PAGE 25 PAGE 42 PAGE 46 PAGE 48 PAGE 50 PAGE 51
APPENDIX	
ACCESSING THE VOG AND LAVA HAZARD AFFECTS MARKETABILITY AFFORDABLE HOUSING REQUIRMENT IMPACT OF KAHUKU VILLAGE ON THE REAL ESTATE MARKETS	PAGE 52 PAGE 54 PAGE 56
MAPS	
MAP 1: 1. MAP OF SUBJECT PROPERTY RELATIVE TO ISLAND MAP 2: PROPERTY LOCATION RELATIVE TO HIGHWAY & OCEAN, FROM SATELLITE MAP 3: LAND PLAN OVERVIEW MAP 4: LAND PLAN, MAKAI AREA MAP 5: LAND PLAN, HAWAIIAN HERITAGE CENTER LAYOUT	PAGE 1 PAGE 3 PAGE 4 PAGE 5 PAGE 8
TABLES	
TABLE 1: PROPOSED PROGRAM, CIVIC USE LANDS BY PROPERTY TYPE TABLE 2: PROPOSED PROGRAM, IN MIXED USE VILLAGE TABLE 3: PROPOSED PROGRAM, BY ACRES TABLE 4: DETAILED PROPOSED PROGRAM, BY ACRES TABLE 5: PROPOSED PROGRAM, BY RESIDENTIAL UNITS TABLE 6: DETAILED PROPOSED PROGRAM, BY RESIDENTIAL UNITS TABLE 7: PROPOSED PROGRAM, 2016-2018, BY RESIDENTIAL UNITS TABLE 8: PROPOSED PROGRAM, 2019-2021, BY RESIDENTIAL UNITS TABLE 9: AVERAGE PRICES, RESORT CONDOMINIUM UNITS TABLE 10: PROPOSED PROGRAM, 2022-2024, BY RESIDENTIAL UNITS TABLE 11: PROPOSED PROGRAM, 2025-2027, BY RESIDENTIAL UNITS TABLE 11: PROPOSED PROGRAM, 2025-2027, BY RESIDENTIAL UNITS TABLE 12: REAL GNPAGE GROWTH RATE PROJECTIONS 2011-2025 BY OECD TABLE 13: OVERALL RESORT MARKET TRENDS STATEWIDE TABLE 14: OVERALL RESORT MARKET TRENDS, 2010 1Q & 2Q ONLY TABLE 15: STATE OVERALL MARKET, CLOSINGS BY PRICE RANGE TABLE 16: STATE OVERALL MARKET, PERCENTAGE CHANGE OF CLOSINGS TABLE 17: CLOSING COUNTS BY ISLAND TABLE 18: OVERALL BIG ISLAND RESORT MARKET TRENDS TABLE 19: OVERALL BESORT MARKET TRENDS, 2010 1Q & 2Q ONLY TABLE 20: ALL RESORT SALES AND PRICE COMPARISONS, 2009 vs. 2010 TABLE 21: CONDO RESORT MARKET TRENDS, 2010 vs. 2009 TABLE 22: RESORT SINGLE FAMILY MARKET TREND 2010 vs. 2009 TABLE 23: SINGLE FAMILY MARKET TRENDS, RESALES TABLE 24: SINGLE FAMILY MARKET TRENDS, RESALES TABLE 25: SINGLE FAMILY MARKET TRENDS, NEW SALES TABLE 26: RESORT HOME SITE MARKET TREND 2010 vs. 2009	PAGE 4 PAGE 5 PAGE 6 PAGE 6 PAGE 6 PAGE 10 PAGE 11 PAGE 11 PAGE 12 PAGE 13 PAGE 28 PAGE 29 PAGE 30 PAGE 31 PAGE 31 PAGE 31 PAGE 34 PAGE 35 PAGE 37 PAGE 37 PAGE 39 PAGE 39 PAGE 39 PAGE 40 PAGE 41
TABLE 20: RESORT HOME SITE MARKET TREND 2010 VS. 2009 TABLE 27: AVERAGE PRICES FOR THE BIG ISLAND RESORT MARKET, 1996-2010 TABLE 28: FORECASTED RESORT RESIDENTIAL CLOSINGS STATEWIDE, 2010-2027	PAGE 41 PAGE 43 PAGE 44
,	

TABLE OF CONTENTS

TABLE 29: FORECASTED RESORT RESIDENTIAL CLOSINGS HAWAII ISLAND, 2013-27 TABLE 30: PROJECTED RESIDENTIAL CLOSINGS, 2016-2027 TABLE 31: FORECASTED RESIDENT POPULATION, 2007-2035 TABLE 32: FORECASTED RESIDENT POPULATION, 2007-2035 TABLE 33: FORECASTED DAILY RESIDENTIAL AND VISITOR POP, 2016-2027 TABLE 49: FORECASTED COMPOSITION OF DAILY POPULATION, 2016-2027 TABLE 50: FORECASTED RESORT RESIDENTIAL DEMOGRAPHICS, 2016-2027 TABLE 51: FORECASTED PRIMARY RESIDENTIAL DEMOGRAPHICS, 2016-2027 TABLE 52: FORECASTED RETAIL DEMAND ANALYSIS, 2016-2027 TABLE 53: HOTEL UNIT INVENTORY TABLE 54: HOTEL UNIT DELIVERY SCHEDULE TABLE 55: RESORT RESIDENTIAL RESALE ACTIVITY TABLE 56: RESALE CONDOMINIUM VALUES TABLE 57: HOUSING TYPE, UNIT DELIVERIES & AVERAGE PRICES, PER SCHED TABLE 58: UNIT DELIVERIES AND AFFORDABLE REQUIREMENTS TABLE 59: TOP PRICES ALLOWABLE PER AMI TARGET INCOME	PAGE 44 PAGE 45 PAGE 46 PAGE 47 PAGE 49 PAGE 49 PAGE 49 PAGE 50 PAGE 50 PAGE 52 PAGE 53 PAGE 54 PAGE 54 PAGE 54
CHARTS	
CHART 1: JOBS AND UNEMPLOYMENT CHART 2: ECONOMIC ACTIVITY: CONSUMER & BUSINESS CHART 3: BIG ISLAND VISITOR INDUSTRY TRENDS CHART 4: TREND IN JOB COUNT GROWTH CHART 5: WORKFORCE (POPULATION) VS. JOB GROWTH CHART 6: CONSTRUCTION INDUSTRY CHART 7: CLOSINGS VS. MORTGAGE RATES CHART 8: BIG ISLAND FM & SF CLOSINGS & PRICES CHART 9: DEVELOPER SHARE OF TOTAL MARKET CHART 10: SINGLE FAMILY PRICE TREND CHART 11: CONDOMINIUM PRICE TREND CHART 12: ALL PERMITS, M/F & S/F CHART 13: CONDO VS. SINGLE FAMILY MARKET SHARE CHART 14: HAWAII VISITOR ARRIVALS, STATEHOOD ONWARDS CHART 15: HOTEL OCCUPANCY BY ISLAND CHART 16: STATE HOTEL TREND ROOM RATES CHART 17: RESORT MARKET, 1979-2010, STATE CHART 18: TOTAL RESORT MARKET 1987-2010, QUARTERLY CHART 20: SALES GROWTH TRENDS, 1, 2 & 5 YEARS CHART 21: ANNUAL SALES BY ISLAND CHART 22: RESORT MARKET 1979-2010 CHART 23: TOTAL RESORT MARKET 1987-2010 CHART 23: TOTAL RESORT MARKET 1987-2010 CHART 23: TOTAL RESORT MARKET 1987-2010 CHART 24: TOTAL RESORT MARKET 1987-2010 CHART 23: TOTAL RESORT MARKET 1987-2010 CHART 24: TOTAL RESORT MARKET 1987-2010 CHART 24: TOTAL RESORT MARKET 1987-2010	PAGE 36
CHART 25: CONDO RESALE RESORT MARKET 1987-2010 CHART 26: RESORT CONDOMINIUM MARKET CHART 27: RESORT RESALE CONDOMINIUM MARKET CHART 28: SINGLE FAMILY RESORT MARKET CHART 29 HOME SITE RESORT MARKET	PAGE 36 PAGE 38 PAGE 38 PAGE 40 PAGE 41
CHART 30 CUMULATIVE HOUSING UNITS & GROSS REVENUES CHART 31: AVERAGE ANNUAL RESORT CLOSINGS VS KAHUKU	PAGE 42 PAGE 51

TABLE OF CONTENTS

I. INTRODUCTION II. PROJECT DESCRIPTION & DEVELOPMENT PLAN III. TARGET MARKET, COMPETITIVE AREA AND COMMUNITY IV. COUNTY ECONOMIC CONTEXT AND REAL ESTATE MARKET V. COUNTY RESORT INDUSTRY AND RESORT RESIDENTIAL MARKET VI. RESORT RESIDENTIAL MARKET FORECAST VII. PRIMARY HOUSING MARKET FORECAST VIII. COMMERCIAL PROPERTY DEMAND PROJECTION IX. HOTEL PROPERTY DEMAND PROJECTION X. CONCLUDING REMARKS	PAGE 2 PAGE 4 PAGE 13 PAGE 15 PAGE 25 PAGE 42 PAGE 46 PAGE 50 PAGE 51
APPENDIX ACCESSING THE VOG AND LAVA HAZARD AFFECTS MARKETABILITY AFFORDABLE HOUSING REQUIRMENT IMPACT OF KAHUKU VILLAGE ON THE REAL ESTATE MARKETS	PAGE 52 PAGE 52 PAGE 54 PAGE 56
MAPS	
MAP 1: 1. MAP OF SUBJECT PROPERTY RELATIVE TO ISLAND MAP 2: PROPERTY LOCATION RELATIVE TO HIGHWAY & OCEAN, FROM SATELLIT	PAGE 1 E
MAP 3: LAND PLAN OVERVIEW MAP 4: LAND PLAN, MAKAI AREA MAP 5: LAND PLAN, HAWAIIAN HERITAGE CENTER LAYOUT	PAGE 3 PAGE 4 PAGE 5 PAGE 8
TABLES	
TABLE 1: PROPOSED PROGRAM, CIVIC USE LANDS BY PROPERTY TYPE TABLE 2: PROPOSED PROGRAM, IN MIXED USE VILLAGE TABLE 3: PROPOSED PROGRAM, BY ACRES TABLE 4: DETAILED PROPOSED PROGRAM, BY ACRES TABLE 5: PROPOSED PROGRAM, BY RESIDENTIAL UNITS TABLE 6: DETAILED PROPOSED PROGRAM, BY RESIDENTIAL UNITS TABLE 7: PROPOSED PROGRAM, 2016-2018, BY RESIDENTIAL UNITS TABLE 8: PROPOSED PROGRAM, 2019-2021, BY RESIDENTIAL UNITS TABLE 9: AVERAGE PRICES, RESORT CONDOMINIUM UNITS TABLE 10: PROPOSED PROGRAM, 2022-2024, BY RESIDENTIAL UNITS TABLE 11: PROPOSED PROGRAM, 2022-2024, BY RESIDENTIAL UNITS TABLE 11: PROPOSED PROGRAM, 2025-2027, BY RESIDENTIAL UNITS TABLE 12: REAL GNPAGE GROWTH RATE PROJECTIONS 2011-2025 BY OECD TABLE 13: OVERALL RESORT MARKET TRENDS STATEWIDE TABLE 14: OVERALL RESORT MARKET TRENDS, 2010 1Q & 2Q ONLY TABLE 15: STATE OVERALL MARKET, CLOSINGS BY PRICE RANGE TABLE 16: STATE OVERALL MARKET, PERCENTAGE CHANGE OF CLOSINGS TABLE 17: CLOSING COUNTS BY ISLAND TABLE 18: OVERALL BIG ISLAND RESORT MARKET TRENDS TABLE 19: OVERALL BIG ISLAND RESORT MARKET TRENDS TABLE 20: ALL RESORT SALES AND PRICE COMPARISONS, 2009 vs. 2010 TABLE 20: ALL RESORT SALES AND PRICE COMPARISONS, 2009 vs. 2010 TABLE 22: RESORT SINGLE FAMILY MARKET TRENDS 2010 vs. 2009 TABLE 23: SINGLE FAMILY MARKET TRENDS, ALL SALES TABLE 24: SINGLE FAMILY MARKET TRENDS, NEW SALES TABLE 25: SINGLE FAMILY MARKET TRENDS, NEW SALES TABLE 26: RESORT HOME SITE MARKET TREND 2010 vs. 2009 TABLE 27: AVERAGE PRICES FOR THE BIG ISLAND RESORT MARKET, 1996-2010 TABLE 28: FORECASTED RESORT RESIDENTIAL CLOSINGS HAWAII ISLAND, 2013-	7 PAGE 44
TABLE 30: PROJECTED RESIDENTIAL CLOSINGS, 2016-2027	PAGE 44 PAGE 45

TABLE 31: FORECASTED RESIDENT POPULATION, 2007-2035 TABLE 32: FORECASTED RESIDENT POPULATION, 2007-2035 TABLE 33: FORECASTED DAILY RESIDENTIAL AND VISITOR POP, 2016-2027 TABLE 49: FORECASTED COMPOSITION OF DAILY POPULATION, 2016-2027 TABLE 50: FORECASTED RESORT RESIDENTIAL DEMOGRAPHICS, 2016-2027 TABLE 51: FORECASTED PRIMARY RESIDENTIAL DEMOGRAPHICS, 2016-2027	PAGE 46 PAGE 47 PAGE 48 PAGE 49 PAGE 49
TABLE 52: FORECASTED RETAIL DEMAND ANALYSIS, 2016-2027 TABLE 53: HOTEL UNIT INVENTORY	PAGE 49 PAGE 50
TABLE 54: HOTEL UNIT DELIVERY SCHEDULE	PAGE 50
TABLE 55: RESORT RESIDENTIAL RESALE ACTIVITY TABLE 56: RESALE CONDOMINIUM VALUES	PAGE 52 PAGE 53
TABLE 57: HOUSING TYPE, UNIT DELIVERIES & AVERAGE PRICES, PER SCHED	PAGE 54
TABLE 58: UNIT DELIVERIES AND AFFORDABLE REQUIREMENTS	PAGE 54
TABLE 59: TOP PRICES ALLOWABLE PER AMI TARGET INCOME	PAGE 55
CHART 1: JOBS AND UNEMPLOYMENT CHART 2: ECONOMIC ACTIVITY: CONSUMER & BUSINESS CHART 3: BIG ISLAND VISITOR INDUSTRY TRENDS CHART 4: TREND IN JOB COUNT GROWTH CHART 5: WORKFORCE (POPULATION) VS. JOB GROWTH CHART 6: CONSTRUCTION INDUSTRY CHART 7: CLOSINGS VS. MORTGAGE RATES CHART 8: BIG ISLAND FIM & SF CLOSINGS & PRICES CHART 9: DEVELOPER SHARE OF TOTAL MARKET CHART 10: SINGLE FAMILY PRICE TREND CHART 11: CONDOMINIUM PRICE TREND CHART 12: ALL PERMITS, M/F & S/F CHART 13: CONDO VS. SINGLE FAMILY MARKET SHARE CHART 14: HAWAII VISITOR ARRIVALS, STATEHOOD ONWARDS CHART 15: HOTEL OCCUPANCY BY ISLAND CHART 17: RESORT MARKET, 1979-2010, STATE CHART 18: TOTAL RESORT MARKET 1987-2010, QUARTERLY CHART 20: SALES GROWTH TRENDS, 1, 2 & 5 YEARS CHART 21: ANNUAL SALES BY ISLAND CHART 22: RESORT MARKET 1987-2010 CHART 23: TOTAL RESORT MARKET 1987-2010 CHART 23: TOTAL RESORT MARKET 1987-2010 CHART 24: TOTAL RESORT MARKET 1987-2010 CHART 25: CONDO RESALE RESORT MARKET 1987-2010 CHART 26: RESORT CONDOMINIUM MARKET CHART 27: RESORT RESALE CONDOMINIUM MARKET CHART 27: RESORT RESALE CONDOMINIUM MARKET CHART 27: RESORT RESALE CONDOMINIUM MARKET CHART 27: RESORT RESALE CONDOMINIUM MARKET CHART 28: SINGLE FAMILY RESORT MARKET	
CHART 1: JOBS AND UNEMPLOYMENT	PAGE 17
CHART 2: ECONOMIC ACTIVITY: CONSUMER & BUSINESS	PAGE 18
CHART 3: BIG ISLAND VISITOR INDUSTRY TRENDS	PAGE 18
CHART 4: TREND IN JUB COUNT GROWTH	PAGE 19
CHART 6: CONSTRUCTION INDUSTRY	PAGE 19
CHART 7: CLOSINGS VS. MORTGAGE RATES	PAGE 21
CHART 8: BIG ISLAND FM & SF CLOSINGS & PRICES	PAGE 21
CHART 9: DEVELOPER SHARE OF TOTAL MARKET	PAGE 22
CHART 10: SINGLE FAMILY PRICE TREND	PAGE 22
CHART 11: CONDOMINIUM PRICE TREND	PAGE 23
CHART 12: ALL PERMITS, M/F & S/F	PAGE 24
CHART 13: CONDO VS. SINGLE FAMILY MARKET SHARE	PAGE 24
CHART 14: HAWAII VISITOR ARRIVALS, STATEHOOD ONWARDS	PAGE 26
CHART 15: HOTEL OCCUPANCY BY ISLAND	PAGE 27
CHART 17: DECORT MARKET 4070 2040 CTATE	PAGE 27
CHART 17. RESURT MARKET, 1979-2010, STATE	PAGE 29
CHART 10. TOTAL RESORT WARRET 1907-2010, QUARTERLY CHART 10: SALES CROWTH TRENDS 1 2 & 5 VEARS	PAGE 30
CHART 20: SALES GROWTH TRENDS, 1, 2 & 3 TEARS	PAGE 32
CHART 21: ANNUAL SALES BY ISLAND	PAGE 33
CHART 22: RESORT MARKET 1979-2010	PAGE 34
CHART 23: TOTAL RESORT MARKET 1987-2010, QUARTERLY	PAGE 35
CHART 24: TOTAL RESALE RESORT MARKET 1987-2010	PAGE 36
CHART 25: CONDO RESALE RESORT MARKET 1987-2010	PAGE 36
CHART 26: RESORT CONDOMINIUM MARKET	PAGE 38
CHART 27: RESORT RESALE CONDOMINIUM MARKET	PAGE 38
CHART 28: SINGLE FAMILY RESORT MARKET	PAGE 40

PAGE 41

PAGE 42

PAGE 51

CHART 29 HOME SITE RESORT MARKET

CHART 30 CUMULATIVE HOUSING UNITS & GROSS REVENUES

CHART 31: AVERAGE ANNUAL RESORT CLOSINGS VS KAHUKU

I. Introduction

Nani Kahuku Aina LLC acquired the property (almost 17,000 acres, with 5 miles of shoreline) in August 2006 under the vision to develop it into an economic engine for the Ka'u area in a way that is respectful of the cultural and natural attributes of the land. The goal is to create an environmentally sustainable resort destination and neighborhood community that leaves 90% of the Property in open space, including all of the shoreline, which contains a productive hawksbill turtle nesting area, several pristine anchialine ponds and a 200+ acre petroglyph field.

Kapaau Pu'u O Umi Natural Area Kukuihaele Reserve Honokaa 1. . Waimea Paauilo 'Ö'ökala Laupahoehoe Waikoloa Hilo Forest Village Honomu Resv Waikii Paddock Peneekeo Game Papaikou Management Area Wainaku Hilo Upper Waiakea Holualoa Kailua Kona Keaau Hawaiian Forest Reserve Paradise Park Mauna Loa Kurtistown Kahaluu-Keauhou Forest Resv Hawaiian Hawaii Mountain Ainaloa Kealakekua Olaa Forest Beaches Park Reserves Pahoa Captain Fern Forest Leilan Kapapala Puna Estates Forest Reserve Volcano Forest Resv South Kona Forest Reserve Pahala Milolii Manuka State Park Naalehu

1. MAP OF SUBJECT PROPERTY RELATIVE TO ISLAND

The Data@Work is a market research firm that specializes in analyzing residential real estate markets for developers and lenders. We have been retained to perform a study analyzing the market for primary housing on the Big Island, relative to a planned resort development in Ka'u, on the southwest shore of the island. This study focuses on the historical, current, and projected market conditions and trends in accessing the ability of the resort project to sell residential property at a price and at a velocity.

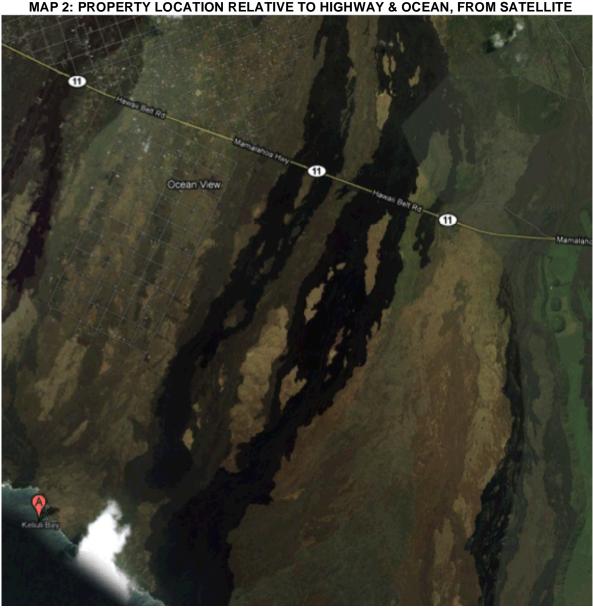
This study analyzes the future market for real property within a new master planned community on the Big Island, known as Kakuku Village. In particular, it will project product pricing and absorption for the various product types. The study entailed collecting, comparing and analyzing information that has a bearing on the numerous aspects of market demand for the proposed project, including but not limited to publicly available real property, economic and commercial data.

The author makes every effort to verify that all of the information in the database on real estate transactions is accurate, but is aware that 100% accuracy is unlikely. Finally, the analysis and statements herein are based on independent research by the author.

II. Project Description & Development Plan

Project

The Project is in Kahuku, Ka'u, on the southwest corner of the Big Island, in the state of Hawaii. It is situated to the south of the west side of the island's major urban center, Kailua- Kona. From that area's southern most resort (Keauhou), it is, approximately a 45-minute drive from. It sits on 16,457 acres on the southwestern side of the largest volcano on the island, Mauna Loa.



The property is bounded, in the picture above by the Hawaiian Ocean View Ranchos subdivision to

the northwest, and then by a large parcel owned by Kamehameha Schools to the southeast. It runs from the ocean to the highway (Mamalahoa Highway/Hawaii Belt Road). It will be comprised of three general areas:

- 1. Hawaiian Heritage Center
- 2. Makai Village
- 3. Community Facilities Reserve

The Community Facilities Reserve component of the master plan is as follows:

TABLE 1: PROPOSED PROGRAM, IN CIVIC USE LANDS BY PROPERTY TYPE

Civic Use Lands	Acres	Units
District Park	37	na
Elementary School	12	na
Police / Fire / Civic	7	na
Emergency Medical Facility	4	na
Farmer's Market / Other Uses	3	na
Rodeo Ground	25	na
Steep Slopes / Open Space	37	na
Subtotal	125	

The Makai Village and Hawaiian Heritage Center components of the master plan on or near the water are illustrated in the map below:

LEGEND

R Partil Residential Les.

ME Man Family

H Hotel / Eco Lodge

Washer Administration Facility

Civilic Civil Pelosal

Cost / Moderal

Heastern Heitings Village

Control Control Cubriouse

Cost Control Control Cubriouse

Cost Control Control Cubriouse

Cost Control Control Cubriouse

Cost Control Control Cubriouse

Cost Control Control Cubriouse

Cost Control Control Cubriouse

Cost Control Control Cubriouse

Cost Control Control Cubriouse

Cost Control Control Cubriouse

Cost Control Cubriouse

Cost Control Cubriouse

Cost Control Cubriouse

Cost Control Cubriouse

Cost Control Cubriouse

Cost Control Cubriouse

Cost Control Cubriouse

Cost Control Cubriouse

Cost Control Cubriouse

Cost Control Cubriouse

Cost Control Cubriouse

Cost Control Cubriouse

Cost Control Cubriouse

Cost Control Cubriouse

Cost Control Cubriouse

Cost Control Cubriouse

Cost Control Cubriouse

Cost Control Cubriouse

Cost Control Cubriouse

Cost Control Cubriouse

Cost Control Cubriouse

Cost Control Cubriouse

Cost Control Cubriouse

Cost Control Cubriouse

Cost Control Cubriouse

Cost Control Cubriouse

Cost Control Cubriouse

Cost Control Cubriouse

Cost Control Cubriouse

Cost Control Cubriouse

Cost Control Cubriouse

Cost Control Cubriouse

Cost Control Cubriouse

Cost Control Cubriouse

Cost Control Cubriouse

Cost Control Cubriouse

Cost Control Cubriouse

Cost Control Cubriouse

Cost Control Cubriouse

Cost Control Cubriouse

Cost Control Cubriouse

Cost Control Cubriouse

Cost Control Cubriouse

Cost Control Cubriouse

Cost Control Cubriouse

Cost Control Cubriouse

Cost Control Cubriouse

Cost Control Cubriouse

Cost Control Cubriouse

Cost Control Cubriouse

Cost Control Cubriouse

Cost Control Cubriouse

Cost Control Cubriouse

Cost Control Cubriouse

Cost Control Cubriouse

Cost Control Cubriouse

Cost Control Cubriouse

Cost Control Cubriouse

Cost Control Cubriouse

Cost Control Cubriouse

Cost Control Cubriouse

Cost Control Cubriouse

Cost Control Cubriouse

Cost Control Cubriouse

Cost Control Cubriouse

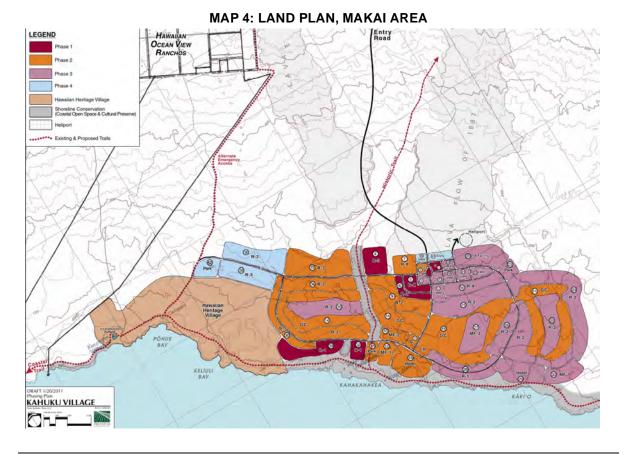
Co

As seen, the Hawaiian Heritage Center is to the left, in brown. The support area is in the purple, near and around the dark red quadrant. The resort and resort residential is the light yellow and tan around the green of the golf course, as well as the two pink areas, which are the hotel sites. The overall property mix is described in the table below:

TABLE 2: PROPOSED PROGRAM, IN MIXED USE VILLAGE BY PROPERTY TYPE

Mixed Use Village	Acres	Units
Hawaiian Heritage Center (with Eco-Lodge)	500	100
R-X: Single Family (15,000 sf)	55	135
R-1: Oceanfront / Preserve Lots (1+ acres)	84	60
R-2: Golf Estates (1.5 - 2 acres)	483	291
R-3: Estates (2+ acres)	180	75
MF-1: Oceanfront Condo / Fractional	40	140
MF-2: Golf Villas (4-5 du/acre)	50	180
VMX: Village Mixed-use	38	169
Visitor Accommodation Units	75	500
Village Green	2	na
Commercial	24	na
Civic Areas	9	na
VA Facility	45	na
Community Parks	22	na
18-hole Golf Course and Clubhouse	330	na
Subtotal	1,937	1,650

This program will be built out in four phases of three years each, starting in 2016.



By Ricky Cassiday rcassiday@me.com May, 2011

The following tables correspond to the phasing seen above.

TABLE 3: PROPOSED PROGRAM, BY ACRES

Туре	Pre-2016	2016-18	2019-21	2022-24	2025-27	Total
HH Center	482					482
Commercial		1	3	7	9	20
Civic			9	56	9	74
Hospitality			367	38		405
Residential		89	268	480	97	934
Total	482	90	647	581	115	1,915

The following table breaks this down further:

TABLE 4: PROPOSED PROGRAM, BY ACRES

Туре	Product	Pre-2016	2016-18	2019-21	2022-24	2025-27	Total
HH Center	HHC	482					500
Commercial	Comm.		1	3	7	9	24
Civic	Civic					9	9
	Park			9	11		22
	VA Facility				<i>4</i> 5		45
Hospitality	Hotel			37	38		75
	Golf Course			330			330
Residential	MF			30	95	5	130
	SF		89	238	385	92	804

Finally, in terms of residential units, the following tables describe that product and the timing.

TABLE 5: PROPOSED PROGRAM, BY RESIDENTIAL UNITS

Туре	Pre-2016	2016-18	2019-21	2022-24	2025-27	Total
HH Center	40	60				100
Hospitality	60	40	250	250		500
Residential		76	281	635	58	1,050
Total	100	176	531	885	58	1,650

The following table breaks this down further:

TABLE 6: DETAILED PROPOSED PROGRAM, BY RESIDENTIAL UNITS

Туре	Product	Pre-2016	2016-18	2019-21	2022-24	2025-27	Total
HHC	Tentalows	40	60				100
Hospitality	Hotel			250	250		500
Residential	MF			105	364	20	489
	SF		76	176	271	38	561

Development Plan

ECONOMIC CONTEXT: The following puts into context the proposed project with the economy of the Big Island.

Historically, economic development on the Big Island since statehood has rested largely on the production of commodities at a low cost and the provision of a 'quality of life' experience.

The first involves 'manufacturing' in terms of making flowers, coffee, cattle, etc., while the second involves 'services' in terms of providing an experience, such as rest and recreation, education, entertainment.

Since statehood, the manufacturing component of the Big Island economy has shrunk significantly, primarily due to the high cost of labor and high cost of logistics (Big Island manufacturers are a very long way away from their input and output markets). This was seen in the demise of the sugar industry, and also in the lack of replacement industry(s). At the same time, the service component the Big Island's economy has expanded, lead most significantly by the visitor industry, starting with low-level tourism in and around Kona in the 1950s.

The strong success of this has rested upon the quality of life 'experiences' that both residents and visitors alike enjoy.

Economically, it is important to appreciate the uniqueness of this quality of life, inasmuch as it grew the visitor industry from nothing to the size it is today. But it is also encompasses growing a primary housing market, a second home market, the B&B market, the timeshare market, the wellness market, and so on. All of these markets rest upon the experiences people have when located on the Big Island. And all of these markets support a myriad of other commercial activities in support of this.

To date, this quality of experience has placed the Big Island at a comparative advantage, relative to the rest of the world. And until it is replicated or surpassed by another set of experiences in another part of the world, the Big Island will continue to be able to depend on it having good economic activity, as well as having the potential to grow it's economy. The manifestation of this is the tremendous investment that has been placed in these resources by offshore capital sources (as seen in the many world-class resorts, golf courses, residential and second home communities, visitor attractions, world-class sports events, etc.).

It is mindful of this economic reality, to say nothing of the cultural history of South Kona, that the Kahuku Village development plan was created. In the first place, it is direct result of the long and successful history of the county economy in attracting those living elsewhere to enjoy either a visit or extended stay (residence). It also does justice to the social and cultural history of the area, by being respectful of the area's history, conservative of the area's beauty and historical artifacts and encouraging of Hawaiian cultural practices (notwithstanding contemporary science, in the sense of being good stewards of the land and resources).

It is, in one sense, one more example of upgrading the area by investing in a number of improvements to the area's infrastructure and housing stock, thus allowing a wider enjoyment by a wider population of a unique place. It is very reminiscent of Mauna Kea's inception, with the closest airport being up in Waimea, and no shoreline road to travel between there and Kona.

Also, it is in the modern context, by its emphasis on the basics: remote location, unspoiled nature, simple accommodations, and a window into an ancient time and traditional culture. This is in direct contrast with development norms and attitudes apparent in this last real estate boom, where luxury was emphasized, where larger was better than smaller and where simpler gave way to sophisticated.

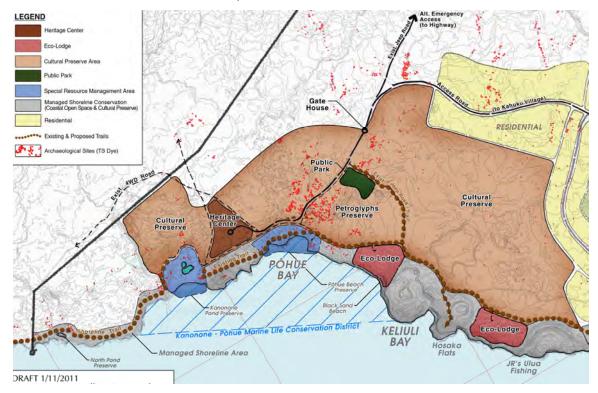
Development Overview:

Historically, resort and resort residential development and Hawaiian cultural practices have been somewhat at odds: the resort came first, i.e., the creation of facilities for recreational activities, be they for short term visitor or longer-term second home ownership, have always been foremost in terms of development. Thereafter, in second place or worse, were the attention paid to the host culture's practices and activities. Indeed, this made sense, from a return on investment: put in your money, get as much of it out as fast as possible.

Kahuku Village turns this norm on its head, investing first into making cultural practices possible, through the creation of a Hawaiian Heritage Center (HHC, a nonprofit organization) that will provide the place and resources to nurture the natural and cultural attributes of the area. In this, the HHC will locate itself on 500 acres near the coast, as well as become the active steward of the property. Of particular stewardship will be one of the largest petroglyph fields (approximately 200 acres) in Hawaii, one of the most productive active nesting grounds for the hawksbill turtle and a system of anchialine ponds on the coastline.

In this, the HHC shall partner with entities that share similar missions in land management, stewardship of marine, wildlife and cultural resources and education, i.e.: UH Hilo, Hawaii Institute of Marine Biology (UH), U.S. Fish and Wild Life (USFWL), National Oceanic & Atmospheric Administration, Office of Hawaiian Affairs, Hawaii Department of Education, Na Lei Na'auao Association of Charter Schools, National Science Foundation, the Native Hawaiian Educational Council, the Environmental Protection Agency, Association of Hawaiian Civic Clubs, Pacific American Foundation, I'miloa and the Veterans Administration.

The layout for this is illustrated below:



MAP 5: LAND PLAN, HAWAIIAN HERITAGE CENTER LAYOUT

Phasing of the Community.

Pre-2016: the HHC launches itself as a self-sustaining community and society rooted in Hawaiian values and cultural practices. One way to envision the totality of it would be to appreciate what has been achieved by the Polynesian Cultural Center, but this would be a different model: instead of largely commercial entertainment in front of a large audience nightly, this would be a set of daily activities in pursuit of cultural practice, education and/or research by the HHC community (with the invitation of the larger community, including visitors and residents, to participate). Another way of envisioning this would be the 1950's hukilau, held in Laie, which was something of the Polynesian Cultural Center precursor, where the community came together with the visitor community to fish, cook and serve food and entertain/recreate.

What would be involved here is a set of activities that support both a traditional livelihood and a contemporary lifestyle - fishing/farming/gathering food (traditional) (and hiking, exploring, diving, sailing, canoeing, surfing, paddle boarding (non-traditional). It would include nighttime activities, including story telling, hula dancing, singing/chanting, etc., and special weekly or monthly events (canoe racing, halau competitions, campfires, etc.).

Besides engaging in cultural practices, there would be a parallel development of the scientific activities on site, starting with caring for the turtle and broader aquatic environment and ecology, but extending outward to include the low and the highland environment and overall volcano ecology.

With the activity programming up and running, the HHC would provide on-site accommodations for daily, weekly or monthly visitations. Accommodations would be fairly basic, including tents and dorms. A central community area would be there for eating and gathering. The target market, actually the 'audience,' would be students, both on and off island, across all grades – kindergarten to post-graduate, but with an emphasis on visiting college students from out of state or out of country, as this constituency would most appreciate the unique features of the site, as well as enjoy the rustic nature of their experiences.

By 2015, this aspect of the HHC is up and running, albeit on a low level basis. This includes a core community of 35-50 staff or volunteer people on-site on a daily basis, of which 12-18 actually live on-site or nearby. There is a daily visitor base of 80-100 people weekday, and 125-150 weekend. There are another 40-50 students on-site on a daily basis, with 15-20 of them on a weekly basis, living on-property.

At this milestone of proven activity programming and critical mass visitor interest, the HHC initiates the first of their Eco-Lodge accommodations, on the model of Molokai Ranch beachside tentalows, on the order of 50 units. There would be basic services provided, including communal meals and room maintenance on a daily basis. The attraction of the outdoor experience in an unspoiled area in a non-intrusive way would grow the awareness of the area, and provide potential community members, aka homebuyers, with the kind of experiences that motivate them to set down roots.

The operator would be knowledgeable about running a sustainable community and providing his guests with unique and memorable experiences. The operator would also be given the responsibility to cultivate a loyal following, and seed the idea of ultimately joining the community as a homeowner. If he is able to identify and steer the tastemakers and leaders within this constituency, the operator will be rewarded both on a commission basis, as well as being allowed the inside track to invest in and/or operate one of the two hotels, when they come available.

By 2016, in terms of infrastructure, there is the major arterial road down to the village center, with a road to the HHC, the ocean, and the first hotel site. Ideally, there would be a very low level of commercial activity on one of the retail sites in the village center. The initial retail opportunities include hiking, camping, aquatic goods and services, plus the provision of simple staples, including lunch wagon type food (Kahuku Shrimp, a la Oahu north shore). Finally, there would be an extensive network of trails leading linking the HHC, the park and hotel site and the village center up mauka.

Phase One, 2016-2018:

With these core activities in place, marketing for home ownership can commence on three levels: off-water small lot 15,000 sf home sites (R-X), off-water 2-3 acre estate home sites (R-2, R-3) and on-water one-acre parcels (R-1). This is described below:

Ave. Final Ave. Price Point Price Point Offshore Product Count Sales p.a. Buyer % (Lot only) (Unit & Lot) R-1 28 9.3 \$850,000 \$2,550,000 78% R-2 7 2.3 \$125,000 \$375,000 71% R-3 3.7 73% 11 \$150,000 \$450,000 R-X 43% 30 10.0 \$65,000 \$195,000 25.3 76 \$408,000 \$1,224,000 68%

TABLE 7: PROPOSED PROGRAM, 2016-2018, BY RESIDENTIAL UNITS

For the R-X, demand would come from offshore and local households in search of a special and natural place. They also would see the potential in the area for attracting more and more buyers, and expect some price appreciation to occur overtime. These prices are for just the home site: the final price point is what the lot would bring with a house on it.

For the R-2, R-3 lots, these would be the up-hill two-acre estate parcels overlooking the HHC and the water at the 200 feet level, and within walking distance to ocean. Here, the buyer profile shifts to the offshore demand.

The R-1 would be one-acre water front lots (setback is 500-1,000 feet) at \$850,000, again with most of the buyers coming from the mainland. Besides the buyers believing in the unique lifestyle and community, they could easily think they are getting an extraordinary value (inasmuch as waterfront homes in the resorts above Kona are getting three and four times that in 2010).

By the end of this period, the commercial activity at the village center will be basic, with only one acre or less being utilized. Additionally, the second eco-lodge will be up and running. Thus, the ground will have been prepared for a hotel investor / operator to take down one of the two hotel sites.

Phase Two, 2019-2021:

For the first 3 years of marketing the community, we expect a low level of activity, as well as the first buyers needing low prices to motivate them. However, the next three years, 2019-2021, this activity will increase more than three fold, and prices will more than double.

The rationale behind the rise in activity is that this coincides with the spreading realization that the area has attributes that provide compelling experiences, and is nearly impossible to replicate. At this point in time, buyers will think of themselves as pioneers, but there will be a lot more of them. By this period, there will be good word of mouth from prior visitors (having had ample proof that this is a viable community with unusual features and enduring experiences). This then can be translated from a tentalow accommodation to one of a larger accommodation facility.

Besides, the expectation that the resort component is in place, the rational behind the price rise is the expected up swing in the real estate cycle, and the accumulated effect of rising inflation. On top of that, it will coincide with heightened economic activity across the globe, thus driving greater and greater numbers of offshore buyers to this market.

Sales Ave. Ave. Final Offshore Product Count p.a. Price Point Price Point Buyer % MF MF-1 55 18 \$900,000 \$900,000 82% MF-2 50 17 \$550,000 \$550,000 84% Total, MF 105 35 \$725,000 \$725,000 83% SF R-2 37 110 \$341,667 \$1,025,000 70% R-3 26 9 \$300,000 \$900,000 69% R-X 40 \$110,000 \$330,000 50% 13 Total, SF 176 59 \$287,000 \$861,000 66% **Grand Total** 281 94 \$412,143 \$822,143 71%

TABLE 8: PROPOSED PROGRAM, 2019-2021, BY RESIDENTIAL UNITS

Over a third of the units are a new product type, the resort condominium unit. Half of those are surrounded by a golf course, and the other half are waterfront, located next to the hotel and park. The price point on these is at a discount of approximately 50% to 60%, relative to similar units up the coast at established resorts. Thus, they are well priced.

The R-2 product is also well located, arguably the best parcel other than the three waterfront parcels, as it fronts the HHC on one side and the golf course on the other.

The total annual absorption is 94 units a year, half of which is priced under \$350,000. Further, almost three quarters of the buyers would come from off-island, or about 70 households.

Another 2-3 acres of commercial property will be sold and developed during this phase. A hardware, nursery and grocery store will be initiated, to begin to serve the new community. There will also be a number of businesses that deepen or broaden the wilderness activities — explorer tours, self-realization camps, self-esteem visits, etc. Then, a number of national companies who are committed to sustainability or an active lifestyle will consider having a presence there, similar to the North Shore of Oahu having the large group of companies active in surfing there (Patagonia, Quicksilver, Volcom). Finally, the hotel will be inaugurated, and the golf course construction commenced.

Phase Three, 2022-2024:

The penultimate three years will see heightened activity and good price appreciation. The increase in activity will be a function of the establishment of the hotels, as well as the continuation of the development of the HHC, the broadening exposure and awareness of the project in the media, and the acceptance (on the level of a herd mentality) in embracing this new type of resort.

As for the rising values, this will be the logical result of years of inflation, of real estate cycle pushing prices higher, of the development progressing to a higher order of product, of the lack of competing supply of resorts and residential property over the rest of the West Coast of the Big Island at these price points. On this later point, our best estimate of the differential in price between the units at Kahuku Village versus comparable projects (around, say, Mauna Lani or Waikoloa) would be to discount the Kahuku Village units by 35%-40%. This is based on conversations with local real estate appraisers, developers and other professionals, as well as an examination of the difference in average prices between North Kohala resorts and Kahuku Village. The table below describes this for years that are arguably at the top and the bottom of the markets.

TABLE 9: AVERAGE PRICES, RESORT CONDOMINIUM UNITS

	Mauna Lani	Waikoloa	Kahuku	Differential
2006	\$1,057,213	\$1,039,971	\$659,917	63%
2010	\$677,465	\$539,879	\$344,882	64%

It is notable that since 1980, the average for price appreciation for new resort residential property over a complete real estate cycle on the Big Island is 187%, and the counterpart depreciation rate over that cycle is 25%. Thus, the net appreciation over a cycle thus is over 160%, quite a large number. While this is no guarantee that the next cycle will experience a similar appreciation, it does support the conclusion that the prices posited below are conservative.

TABLE 10: PROPOSED PROGRAM, 2022-2024, BY RESIDENTIAL UNITS

			Sales	Ave.	Ave. Final	Offshore
	Product	Count	p.a.	Price Point	Price Point	Buyer %
MF	MF-1	85	28	\$1,200,000	\$1,200,000	81%
	MF-2	130	43	\$675,000	\$675,000	73%
	VMX	149	50	\$192,000	\$192,000	24%
MF Total		364	121	\$405,000	\$405,000	39%
SF	R-1	32	11	\$1,500,000	\$4,500,000	94%
	R-2	174	58	\$510,000	\$1,530,000	82%
	R-X	65	22	\$225,000	\$675,000	77%
SF Total		271	90	\$610,714	\$1,832,143	83%
Grand Total		635	212	\$507,857	\$1,118,571	61%

Another new product type will be introduced this period in order to cover demand from the workforce. These will be apartments in and around the village center, designed to meet the needs of employees and small businesses employers, as well as people who value living in an unspoiled area. These could be 4- to 6- plex buildings with one and two bedroom units above living area slash/ commercial space underneath, with outdoor parking. They are very reasonably priced, resulting a high absorption rate (which constitutes a quarter of all units sold p.a.).

There will also be marketed the last two waterfront parcels, one a condo parcel next to the last hotel site in the master plan, the other a R-1 parcel on the other side of that hotel site. They will enjoy widespread attention, as there will be very few developable parcels on the water in West Hawaii.

Helping to augment the demand for the VMX and the R-X units is the initiation of the Veteran's Administration facility in the village center. This will also help demand for the commercial acreage.

The absorption for this period will be very high, but several factors allow for it.

The primary reason for such strong absorption would be the coming dearth of developable waterfront or resort property on the Big Island. As seen of late, a number of proposed residential and resort projects have been denied or terminated by the LUC or the county (or substantially scaled down). Examples that come to mind include Aina Lea and Ooma.

The second factor would be the broadening and deepening of the hardware and software of the resort and village (better infrastructure, more extensive activities), which both reaffirms and upgrades the concept. Similar to this is the maturation in the lifecycle of a pioneer community, a lifecycle wherein the area starts out empty, and attracts pioneers to fill in. They bond and then set up events and community activities that are special to area: iron man competition, mountain biking downhill over the lava, Puu scaling or rappelling (South Point). They also join in to form community organizations and establish community facilities, all of which (software and hardware) attracts likeminded residents.

Phase Four, 2025-2027:

The last phase will see lowered activity but continued price appreciation. The increase in activity will be again due to very good values offered, as well as the continuation of the development of the area and the HHC. At this point in the lifecycle of a wilderness resort, most of the activity will focus on the refinement of the facilities, a broadening of the activities and accommodating the popularity that

years of exposure brings (the basic herd mentality embracing this resort).

TABLE 11: PROPOSED PROGRAM, 2025-2027, BY RESIDENTIAL UNITS

			Sales	Ave.	Ave. Final	Offshore
	Product	Count	p.a.	Price Point	Price Point	Buyer %
MF	VMX	20	7	\$290,000	\$290,000	25%
MF Total		20	7	\$290,000	\$290,000	25%
SF	R-3	38	13	\$700,000	\$2,100,000	87%
SF Total		38	13	\$700,000	\$2,100,000	87%
Grand Total		58	19	\$563,333	\$1,496,667	66%

In sum, the key to this program will be the establishment of the HHC, providing the opportunity for the housing program to be successful. And this is followed by the depth of demand for waterfront Hawaiian resort property – which allowed 2 of the last 3 resorts initiated on the Big Island to be successful (Hualalai and Kukio – Hokulia did not focus on waterfront, but rather on the golf course).

Additional to that, there will be a number of home-based businesses that grow up in the area. The most predominant will be professionals and executives that can work anywhere there is Internet access, whose choices can be made in favor of living a wilderness lifestyle. Another home based business type will be those able to monetize their location by catering to visitors, such as running explorer tours, self-esteem camps, or have visitor units (bed and breakfasts, or VRBO). This also includes businesses that perform the obvious basic services (landscaping, contracting, accounting, cooking, schooling, etc.).

In light of this, we now look carefully at the resort market, the target market and the competitive market area. After that, we will look at current conditions in the market.

III. Target Market, Competitive Area and Community

Target Market

With multiple product types in the master plan, there will be multiple target markets for Kahuku Village. The preponderance of housing contemplated here would be appropriate for high net worth individuals: shoreline home sites, large home sites, and shoreline condominium owners. These product types generally have been attractive to second homebuyers residing in North America or around the Pacific Basin, local homebuyers on the Big Island or around the state who are looking for a good investment and local residents of other islands who like to 'get away for the weekend'.

Then there are other two housing types that are more appropriate to local residents in the low and middle-income groups. One is the attached multifamily VMX product, that would appeal to work force families, and would be priced affordably (including unit in and around the 80%-100% of AMI target market). The other would be the smaller lot, 15,000 sf home site units, targeted on middle income and small business owner households. Both products would be attractive to the blue and white-collar demographics, such as those families working within the resort as well as on nearby properties. Due to the fact there is very light population in the immediate area, most homebuyers will be in migrating from other areas of the island and nation. There will definitely be some retirees, and veterans, but also starter families.

In terms of the secondary homebuyer, they will be a mix of local residents who find the investment attractive on a cash flow and future price appreciation basis; long-time visitors who find the area and the investment potential attractive; and new visitors who find the area attractive, the concept congruent with their world outlook and the opportunities unique and challenging. Of the three groups,

the last one is the most important, as they will be the foundation on which others that follow will build on. This last group will be proven by their usage of the tentalows and the time they spend on site.

Competitive Market Area

The competitive market area for the second home owners will come from the island, the state and the Pacific Rim area, and will be those who appreciate a unique and authentic Hawaiian setting, an intimate relationship with nature, in a sustainable and ecologically responsible community. Some of these things have been already established in other resorts, Hualalai comes to mind, but there is nothing quite like this.

The competitive market area for the support housing (mainly primary) consists of homeowners from the Big Island, as well as households from outside the island and the state, who see the potential and enjoy the challenge.

Subject Property's Community

The largest of the major Hawaiian Islands, the Big Island, is 90 miles long by 80 miles wide at its furthest points. Larger than the State of Connecticut, it contains roughly 4,000 square miles (2.5 million acres), which compares to Oahu with 600 and Maui with 1,200 square miles. It is the youngest island in the chain (being 35 million years old) and the southernmost point of the United States. Five volcanoes formed the Big Island, including the world's most active and safest volcano, Kilauea, which has become one of the state's most popular visitor attractions. Its major landmark, Mauna Kea, is the tallest mountain at 13,736 feet in the Pacific Basin and provides astronomers with the best stargazing on the Planet.

Only 2% of the land area on the Big Island has been developed for commercial and residential use leaving the remaining 98% divided between agriculture and conservation, with the mountainous core of the island taking up much of this area. This compares to the statewide average of 4% zoned for urban usage.

The majority of the island's roughly 164,000 residents lives and works in the coastal areas leaving the interior of the island spectacularly beautiful and pristine. The weather is near perfect year round with daytime temperatures down at sea level ranging from the mid 70's to the mid 80's, slightly warmer in the summer. The northeast trade winds average about 15 mph for most of the year, and provide refreshing breezes. Rain showers usually fall in the evening and early morning hours, predominantly over the mountain ranges. The temperature of the ocean ranges from 68 to 80 degrees Fahrenheit. Almost all of the major flagged hotels have a presence on the island including Starwood, Sheraton, Four Seasons, Marriot, Hilton and Hyatt. The Big Island has one of the highest levels of room rates and occupancy in the state.

In fact, DBEDT, the state's economic research organization, has projected that (given current visitor trends) Hawaii will 'run out of hotel rooms,' or hit 100% occupancy in 2009-2014, a point at which the rational for developing additional hotel room capacity becomes compelling. Indeed, much of the second home demand on the island comes from short-term visitors wanting either a longer-term housing alternative or an investment vehicle that allows for frequent visitation opportunities.

West Hawaii has more than 6,000 hotel, resort and condominium rooms and is host to more than a million visitors annually. This stock of hotel units is vitally important to the second home market, inasmuch as it provides a stream of qualified and motivated visitors to model homes and/or resale open homes. The Big Island of Hawaii has three major resort areas:

- North Kohala, a 40-minute drive from the airport, it has the oldest resort master planned resort in the island, Rockefeller's Mauna Kea. There are also two other major resorts, Mauna Lani and Waikoloa, both developed in the late 1980's. It is very close to the upcountry communities of Kamuela and Kohala, both of which have rainforests and temperate climates.
- **North Kona** a 15 minute drive from the airport, it hosts the newest resort master planned communities, also the most exclusive and most expensive: Hualalai and Kukio. They have excellent golfing, limited beaches and are located atop a recent lava flow.
- **South Kona**, a 20-minute drive south, it is on the warmer side of the coast. It boasts better weather, in the sense of being less windy. It has some of the most spectacular golfing, with no disturbing trade winds. It includes the resort areas of Keauhou and Hokulia, plus the village center of Kona.

There is no other resort development to the south of Hokulia, save for where the proposed master planned community will be. As such, the Kahuku Village master planned diversifies the overall resort market in the county and provides the visitor community with a bigger and better reason for circumventing the island on the south side. This in turn will stimulate greater spending and more opportunities for businesses and entrepreneurs on and off the island.

IV. County Economic Context and Real Estate Market

Background

Big Island is the southernmost landmass in the United States, and with an area of approximately 4,020 square miles, comprises nearly two thirds of the total land area in the State. The mountains of Mauna Kea and Mauna Loa each rise over 13,000 feet above sea level and extend about 19,000 feet below the surface, making these the highest mountains in the world when measured from base to summit. The Kilauea volcano on the southern flank of Mauna Loa has been erupting continuously since 1983 and has the distinction of being the world's most active volcano. Geothermal energy from the volcano has been a reliable source of electricity production, and watching lava flow into the ocean is a top visitor attraction. The Big Island is the only area in the country that is expanding its size as the lava forms new land at the shore.

The city of Hilo, on the east side of the island, is the county seat and the transportation and financial center of the Big Island. It is also home to the only four-year university in the State outside of the Island of Oahu. Kailua-Kona, on the west side of the island, offers many natural attractions such as sport fishing, scuba diving and other water sports. The South Kohala coast, just north of Kailua-Kona, is a major tourist destination with a number of luxury resort developments, many with manicured golf courses surrounded by high-end vacation homes.

The Big Island is served by two deep-water ports (one in the east at Hilo and the other at Kawaihae on the northwest comer of the island) and two international airports, also east and west. The Hilo and Kona International Airports each have 10,000-foot runways to accommodate transcontinental jets. The highway system allows travelers to access the island's east and west population centers from three directions.

Over the past several decades, the Big Island has transitioned from an agricultural-based economy to a more diversified economy by capitalizing on its many unique features. For example, the elevation and isolation of the Big Island's mountains have helped to make Mauna Kea and Mauna Loa the world's premier locations for astronomical observatories and atmospheric research. In addition, deep ocean waters off the island's coast provide prime research, aquaculture, and water bottling conditions.

The Big Island economy peaked in 2006 and is now experiencing the effects of the national and international economic downturn. The impact on tourism and construction has been most noticeable. The bankruptcies of Aloha Airlines and ATA Airlines and the reduction of service to the island by Norwegian Cruise Lines have had a significant effect on tourism-visitor counts, hotel occupancy, and retail sales. Construction activity, which had begun to decline in 2007, followed with more this year as a result of uncertainty in the financial markets. Many residential and commercial development projects have been postponed or cancelled.

The Big Island has experienced stagnant growth and difficult economic times in the past. When the sugar plantations closed in the latter part of the last century, the emerging tourist industry and a more diversified agricultural industry absorbed a large number of the unemployed.

Thanks to the success of the visitor industry and the affiliated growth of the second home community, the economy is positioned to overcome adversity. This is because the economy's comparative advantage – the high quality of life - is unique and enduring. Thanks to this, the county's real estate base has grown substantially over the 'past decade and provides a strong foundation for continued local governmental spending that enhances this comparative advantage.

That is not to say that there are not threats to this comparative advantage or challenges to future economic growth.

The natural conditions underwriting the island's high quality of life can cut the other way: natural disasters, such as tsunamis, earth quakes, volcanic activity, flooding, and droughts have hampered the economic development on this island. For example, volcanic activity - lava and volcanic fog - has destroyed homes and damaged crops (at the same time, it is also the County's largest single tourist attraction).

It is not blessed with a number of factors that support and sustain large economies and high growth rates, i.e., a large population, cheap energy, an advantageous location (at a crossroads), a multitude of educational institutions and research organizations, large-scale political, legal, scientific and cultural activity.

Further, a number of problems have limited the growth of the island. Most imported and exported goods must be transshipped through Honolulu. The long distances from the Big Island's major markets, and the attendant transportation costs, have increased the cost of living and of doing business.

As such, the island's successful exports are usually unique (deep sea water) and/or have high value (such as macadamia nuts, flowers and nursery products, coffee, and papaya). Furthermore, thanks to the quality brand name and strong brand loyalty, many of these products enjoy a demand perhaps wider than otherwise, thanks to the 'cache' of being from the 'Big Island.'

Indeed, agriculture currently constitutes the other major economic sector of the island of Hawaii. Including processing, the agricultural industry accounts for about 9.5 per cent of the island's employment. Local agricultural pursuits include the raising of cattle and other livestock, the growing of coffee, macadamia nuts, papaya, flowers and nursery products, vegetables, aquaculture, forestry and aquaculture. In addition, there are a variety of processing plants that can employ a large number of workers.

The most pressing problems faced by today's agricultural industries is their ability to attract labor. It faces increasing competition for labor from other sectors of the economy, such as the visitor, retail and construction industries. There is also a demand for a greater number of personnel with technical and professional agricultural training. A related problem is the chronic housing shortage for both minimum wage and seasonal labor.

Finally, as the centers of employment are located at a distance from the centers of population, it

would be beneficial to the labor force if the transportation infrastructure on the island was made more extensive and efficient. Similarly, it would also be beneficial if future master planned communities allowed for workforce housing next to the resort and other employment opportunities.

Given that this study focuses on the current and future market for the proposed development at Kahuku Village, we now take a look at current economic trends that have an impact on the market for real estate.

Current Economic Conditions

Currently, county is slowly emerging from the most significant economic slowdown in the last 20 years. As a result, the general measures of public wellbeing are suffering: employment and spending are down: crime, bankruptcies and foreclosures are up.

For the last few years, the county's major economic drivers - tourism, construction, and real estate – have been all struggling to emerge from this down turn. And it has not been helpful that all sectors have been struggling simultaneously.

As a result (as seen below), the number of jobs in the county (job counts) has fallen significantly, and the unemployment percentage on the island is up even more significantly. To be sure, the job market over the last two years appears to have stabilized at these levels, but until economic activity spreads significantly, there will continue to a lot of underused capacity in the labor market (which is another way of saying that there is widespread economic hardship amongst both labor and management).

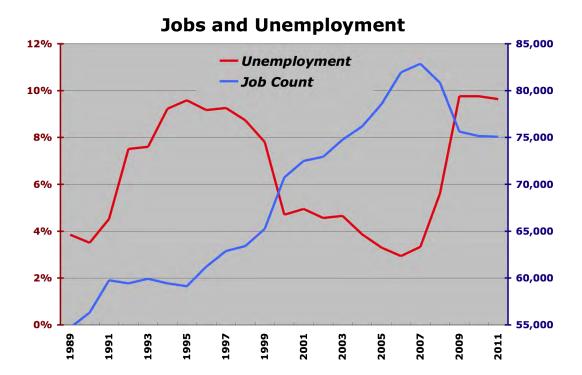


CHART 1: JOBS AND UNEMPLOYMENT

The state of business and consumer finances is indicated by the trend in the Personal Income Tax and the General Excise Tax revenues. As seen below, it appears that though 2011 that Big Island businesses are rebounding slightly. On the other hand, consumers, whose spending constitutes the largest component in economic activity, are still struggling.

By Ricky Cassiday rcassiday@me.com May, 2011

\$12,000 \$10,000 \$6,000 \$4,000 \$2,000 \$0

CHART 2: ECONOMIC ACTIVITY: CONSUMER & BUSINESS

Within the Big Island, there are big differences economically between East and West. The West Hawaii economy is highly concentrated on tourism, and has been down of late volatile, while East Hawaii is the political and social center of the island (with a large university and research facility) and acts as an economic stabilizer, thanks to government spending. Indeed, without stimulus from the private sector, many in the community are looking toward public spending on infrastructure and other projects for help in providing some stimulus to the economy.

2000



CHART 3: BIG ISLAND VISITOR INDUSTRY TRENDS

Currently, there are signs that visitor spending at the high end of the market is making a comeback. This is reflected in the strong upswing in the trend line for Room Rates and Occupancy for 2011. This is having an effect on the number of job counts in certain jobs sectors (Hotels, Trade), as seen below.

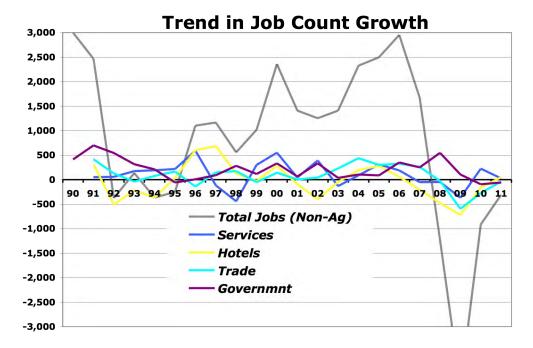


CHART 4: TREND IN JOB COUNT GROWTH

Overall, labor conditions in the county are improving. That trend is rebalancing the ratio between jobs and population. Although still negative, as seen in the chart below, the trend of this ratio is going in the right direction: it is about halfway through the up-cycle.

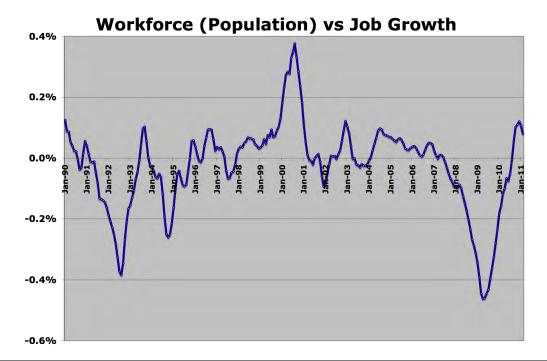


CHART 5: WORKFORCE (POPULATION) VS. JOB GROWTH

By Ricky Cassiday rcassiday@me.com May, 2011

The other cyclical driver of the county's economy, construction, peaked in mid-2006, about a year before the rest of the state. Industry sources expected see a recovery in and about mid-2010, as seen, but this was followed by a fall-off again YTD in 2011. This mirrors the double dip in the real estate market nationally. The construction industry is a very large employer in West Hawaii, the downturn in building has hurt the larger economy, as well as the local real estate market.

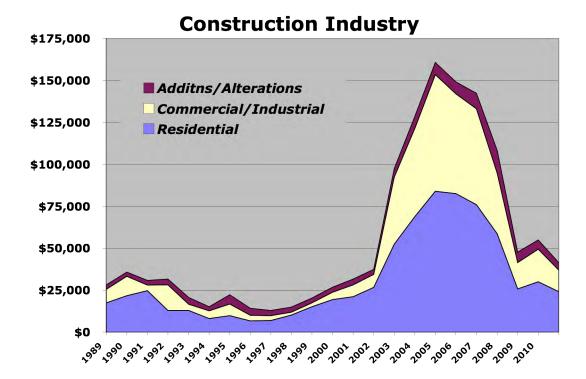


CHART 6: CONSTRUCTION INDUSTRY

There is only one housing project underway on the Big Island now, an affordable project in Kona. Observers foresee the resort condo market to be the last to show a recovery. Some such developments on the Kohala Coast are clearly overbuilt now, particularly commercial development.

Clearly, the real estate market is a large part of the economy, particularly the west side. And clearly, it is experiencing soft demand, with an ample supply of listings putting pressure on prices. And this is the source of much of the hardship being experienced by construction workers and professionals.

But in the long term, there will be a return to high levels of commercial activity on the Big Island, once the global economic recovery takes hold. When this happens, there will be another long-term upswing in real estate activity and property values, similar to earlier real estate cycles (this will be especially so, if there is no new supply of entitled land made available for development).

Current Real Estate Market Conditions

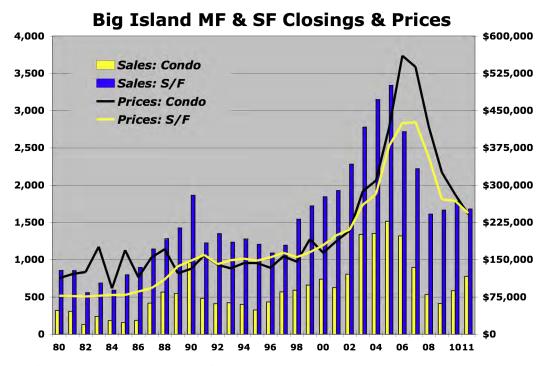
Now, we will briefly describe the overall market, as a prelude to putting the Kahuku Village development into the real estate market context. The chart on the next page looks at the relationship between the number of sales and the cost of financing a home purchase. As seen, the fall in the interest rates from their last high in 1995 begat ever growing sales activity. This culminated in a market top in 2005, wherein rising prices undermined the salubrious effects of lower and lowr interest rates.

CHART 7: CLOSINGS VS. MORTGAGE RATES



In concert with national markets, the residential market enjoyed an upswing in the market cycle 1995-2005, with the cyclical peak occurring in 2005. Last year, 2010, was the bottom of the market in terms of closings. It remains to be seen if there will be a double dip in activity, a la the mainland.

CHART 8: BIG ISLAND FM & SF CLOSINGS & PRICES



The trend for the other major indicator of the market, average prices, lagged closings by one and two years: prices for single family homes turned down in 2006, with condos following in 2007.

Developer Share of Total Market 4,000 56% Resales 3,500 49% New % New Share 3,000 42% 2,500 35% 2,000 28% 1,500 21% 1,000 14% **500** 00 96 98

CHART 9: DEVELOPER SHARE OF TOTAL MARKET

This strength and the longevity of the recent real estate cycle encouraged a lot of developer activity, right up until 2006. Looking ahead, we expect the developer market to remain at a very low level of activity in the short term. It will try to concentrate mainly on the higher end and offshore homebuyer demand, as opposed to local demand. As such, we expect single family units produced over condos.

The Bigh Island single family trend in prices peaked in 2006-2007, with the highest resale prices for single-family homes ion the island being in Kona.

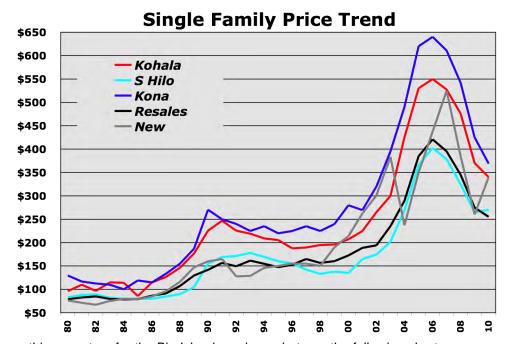


CHART 10: SINGLE FAMILY PRICE TREND

The same thing was true for the Big Island condo market, per the following chart.

\$150,000

\$100,000

\$50,000

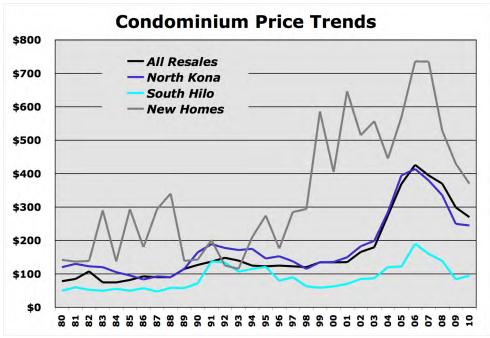


CHART 11: CONDOMINIUM PRICE TREND

As seen, the fall in prices has been dramatic. Much in the last 12-18 months has been driven by foreclosures, and is expected to run another 12-18 months, but on a declining bias. Thereafter, most feel that the market will recover, but at a reduced level of sales, relative to the 2000-2010 decade.

Housing Permits

1,500

1,000

500

Big Island permitting activity has fallen off the cliff, dropping every year since 2004. That said, in 2010 it rebounded, up 60%. That was thanks to developers targeting the lower income segments of the population. As seen, the price per permitted unit has fallen for 5 years, the last one by 13%.



CHART 12: ALL PERMITS, M/F & S/F



85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 00 01 02 03 04 05 06 07 08 09 10 11

The good news here is that that developers are building homes for local families, mainly – as opposed to building second homes for offshore buyers, which was a good part of developer activity in the last real estate cycle. The bad news is there is absolutely no work to be had in building.

YTD 2011, we see that there has been a fall off in permits being pulled. This is because developers have pulled back their activity in terms of supplying condominiums to the market. Single family permit activity is roughly the same as last year, and the value per single family permit is slightly lower, befitting these economically constrained conditions.

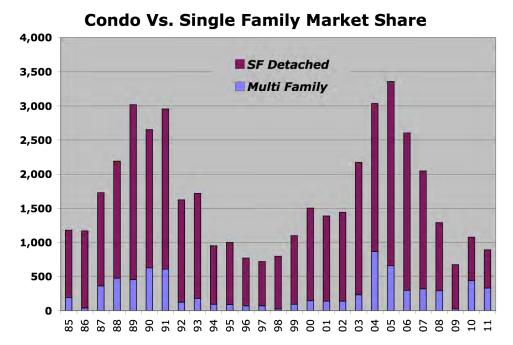


CHART 13: CONDO VS. SINGLE FAMILY MARKET SHARE

That said, there was a lot more activity on the multifamily side of the market in 2010 than 2009 and 2011, thanks to the affordable housing projects that have been given the green light.

Going forward, we believe that there is ample demand for affordable housing and that development will respond to that. However, there is a question as to whether there will be adequate financing in place for this development to occur.

Developer Production

A review of developer product coming to market since 1980 was made and it was ascertained that the average annual production over the last real estate cycle (1997-2010) was a little more than 600 residence a year. And the average for the cycle before that (1986-1996) was 566 units a year.

As seen at the beginning of this section, the Kahuku Village subject property is proposing to close, at most, 2022-2024, 71 developer units a year (22 of which are home sites, which do not immediately become residential units – given the lag time for building a home). As such, this level of housing production is very low, relative to the average annual demand: an annual market share of 12%, assuming the home sites become dwellings that year, or 8%, assuming that it will take 1-2 years to transition into a built home.

V. County Resort Industry and Resort Residential Market

Subject Property's Community

The largest of the major Hawaiian Islands, the Big Island is 90 miles long by 80 miles wide at its furthest points. Larger than the State of Connecticut, it contains roughly 4,000 square miles (2.5 million acres), which compares to Oahu with 600 and Maui with 1,200 square miles. It is the youngest island in the chain (being 35 million years old) and the southernmost point of the United States. Five volcanoes formed the Big Island, the world's most active and safest volcano, Kilauea, which has become one of the islands most popular visitor attractions. It's major landmark, Mauna Kea, is the tallest mountain at 13,736 feet in the Pacific Basin and provides astronomers with the best stargazing on the planet earth.

Only 2% of the land area has been developed for commercial and residential use leaving the remaining 98% divided between agriculture and conservation, with the mountainous core of the island taking up much of this area. This compares to the statewide average of 4% zoned for urban usage. Of all the islands, this one is the most rural.

The majority of the island's roughly 164,000 residents lives and works in the coastal areas leaving the interior of the island pristine and beautiful. The weather is temperate year round with daytime temperatures down at sea level ranging from the mid 70's to the mid 80's, slightly warmer in the summer and slightly colder in the winter. The northeast trade winds average about 15 mph for most of the year, and provide refreshing breezes. Rain showers usually fall in the evening and early morning hours, predominantly over the mountain ranges. The temperature of the ocean ranges from 68 to 80 degrees Fahrenheit. The combination of predominately blue skies, gentle winds, moderate temperature, warm ocean and light rain in the evening support the sense of residents and visitors that the climate is near perfect. Which itself supports a strong visitor industry, as well as a second home and retirement community.

Almost all of the major flagged hotels have a presence on the island including Starwood, Sheraton, Four Seasons, Marriot and Hyatt. The Big Island has one of the highest levels of room rates and occupancy in the state. In fact, DBEDT, the state's economic research organization, has projected that (given current visitor trends) Hawaii will 'run out of hotel rooms,' or hit 100% occupancy in 2009-2014, a point at which the rational for developing additional hotel room capacity becomes compelling. Interestingly, much of the second home demand on the island comes from short-term visitors wanting either a longer-term housing alternative or an investment vehicle that allows for frequent visitation opportunities.

The Big Island of Hawaii has three major resort areas:

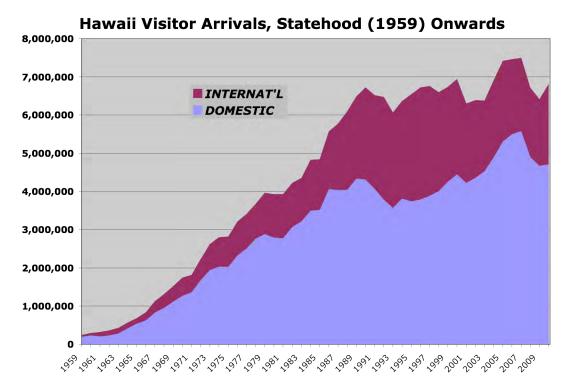
- North Kohala, a 40-minute drive from the airport, it has the oldest resort master planned resort in the island, Rockefeller's Mauna Kea. There are also two other major resort, Mauna Lani and Waikoloa, both developed in the late 1980's. It is very close to the upcountry communities of Kamuela and Kohala, both of which have rainforests and temperate climates.
- **North Kona** a 15 minute drive from the airport, it hosts the newest resort master planned communities, also the most exclusive and most expensive: Hualalai and Kukio. They have excellent golfing, limited beaches and are located atop a recent lava flow.
- South Kona, a 20-minute drive south, it is on the warmer side of the coast. It boasts better
 weather, in the sense of being less windy. It has some of the most spectacular golfing, with no
 disturbing trade winds. It includes the resort areas of Keauhou and Hokulia, plus the village center
 of Kona.

Resort (Visitor) Market Overview

West Hawaii has more than 6,000 hotel, resort and condominium rooms and is host to more than a million visitors annually. This stock of hotel units is vitally important to the second home market, inasmuch as it provides a stream of qualified and motivated visitors to model homes and/or resale open homes.

As seen in the long-term chart below, the industry statewide grew rapidly from Statehood until 1989, after which it balanced out.

CHART 14: HAWAII VISITOR ARRIVALS, STATEHOOD ONWARDS



Over the decade, the visitor industry statewide experienced very steady growth in room rates and occupancy. Then, in 2005, occupancy rates started falling off, probably due to room rates reaching a point that was too 'high' for the market then to bear.

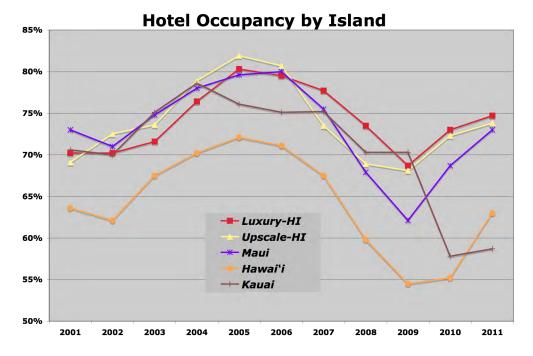


CHART 15: HOTEL OCCUPANCY BY ISLAND

Indeed, looking at the chart below, we see the room rates did climb steadily in the aftermath of the 9/11 sneak attack in 2001. As noted, this was what put a ceiling on room occupancies. Then, with the financial meltdown 2007-2008, the downturn in occupancies was mirrored in rates.

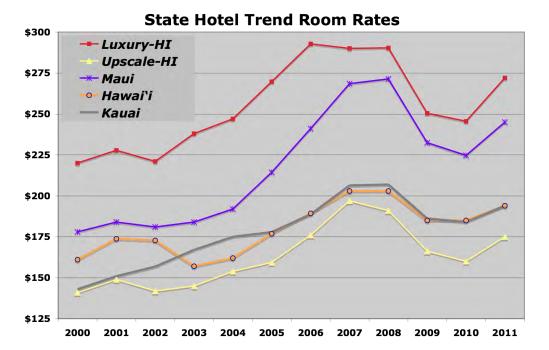


CHART 16: STATE HOTEL TREND ROOM RATES

Historically, the high-end luxury market has done the best, having the state's highest average daily rate. Looking ahead, the Big Island visitor industry growth has been negative for going on three years and, as such, has rebounded back to positive growth, with the Budget and Luxury segments looking the strongest.

To be sure, the continuation of the current positive trend is contingent upon the shape and pace of the recovery of the national and global economy, which can be characterized as "Cloudy with a chance of rain."

Clearly, the global economy is still adjusting to slower growth. According to the IMF, after suffering a 3.2% drop in 2009, the Advanced Economies group will grow at 2.3% and 2.4% in 2010 and 2011 (slower than the US, with 3.1% and 2.6% forecast – to say nothing of the global economy as a whole: 4.2% and 4.3% respectively). Looking ahead, we assume a steady rate of real economic growth over the life of this project, per the long-term economic projections by the OECD below:

	2011	2011-15	2016-20	2021-25
US	3.2%	2.7%	2.5%	2.3%
China	9.7%	9.5%	8.0%	6.4%
Japan	2.0%	1.5%	1.0%	0.9%
Asia	7.6%	6.7%	5.9%	5.4%

TABLE 12: REAL GNP GROWTH RATE PROJECTIONS 2011-2025 BY OECD

Resort Residential Market Overview

The second home market nationally has been very healthy over the last few decades (albeit not the last 3-4 years), thanks to three major trends: a growing diversity of ownership models, benign interest rates and, most importantly, demographics. US Baby boomers - those born between 1946 and 1964 (ages 43-59 years old) and numbering about 79 million or 29% of the total population – are the most likely source of offshore demand driving the purchase of Hawaiian resort primary residential homes, second homes and retirement homes.

The Federal Reserve Bank reports that the baby-boom generation has the largest household net worth of all U.S. age groups. Boston College's Social Welfare Institute says there is a great deal of wealth ready to be handed down from one generation to the next. Although Boston College's range of estimates varies wildly - suggesting the wealth transfer will be between \$41 trillion to \$136 trillion in the next 50 years - it clearly shows that vast sums of assets are about to be changing hands. which could result in a wider dispersion of wealth and a broadening demand for primary and secondary and resort homes. (Note: this trend is not just limited to the US - Canada, in particular, is the second largest source internationally of housing in Hawaii, both primary and resort.)

This demand is particularly appropriate for Hawaii and the Big Island, based on its unique advantages relative to other locales: it's in America, it's socially safe, politically stable, and under American jurisprudence. Additionally, it is naturally beautiful, with a benign environment and climate. Indeed, the proof of its attractiveness can be found in the quality of those who have bought in Hawaii, starting with Lawrence Rockefeller in 1960 (Paul Allen, Charles Schwab, Michael Dell, etc.)

Several years ago, a major national real estate investor, IHP, funded a project in Hawaii based on their projections that high-end California second home and retirement demand for residences priced at \$1 million plus was about 18,500 total units annually. These numbers will be growing over the coming decade because the bulk of the baby boomers are now reaching their prime second-home buying age, while its "leading edge" will be ready to retire soon.

In this regard, the proposed project of Kahuku Village will be receive more than ample attention for it's 1,650 residential units, as they come to market over the planned marketing period of 2016-2027, eleven years.

Next, we turn to look at the resort market statewide, and then just for the Big Island.

Resort Market, Statewide

OVERVIEW: The slowdown starting in 2006 appears to have bottomed out, at least with the data up to 2nd Q 2010.

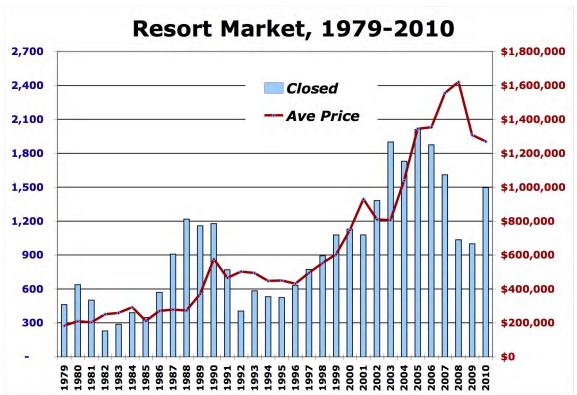


CHART 17: RESORT MARKET, 1979-2010, STATE

As seen, there is a strong rebound in activity, coming after two years of falling prices. The magnitude of the price decline over these last two years -24% - is greater in size than any correction since 1977, when overall average prices dropped by 27%. In contrast, the falloff in prices in the market due to the surprise attack on 9/11 was only 14%. Obviously, falling prices helps to stoke demand.

The table below describes the data behind the trend chart above.

	2007	2008	2009	2010
Closed	1,713	1,089	1,046	1,612
Ave Price	\$1,513,230	\$1,577,303	\$1,277,463	\$1,211,774
Top Price	\$29,000,000	\$20,000,000	\$26,250,000	\$17,500,000
Gross Revs	\$2,592,162,137	\$1,717,682,588	\$1,336,226,584	\$3,901,911,889
% Change	2007	2008	2009	2010
Closed	-15.3%	-36.4%	-3.9%	54.1%
Ave Price	15.0%	4.2%	-19.0%	-5.1%
Gross Revs	-2.6%	-33.7%	-22.2%	192.0%

TABLE 13: OVERALL RESORT MARKET TRENDS STATEWIDE

This strong YTD sales growth also can be seen in the following table, which isolates and shows just the first two quarters over the last few years. As seen, 2010 YTD is the strongest start of any years since 2007, when the economy began tipping downward:

2007 2008 2009 2010 Closed 998 725 488 806 Ave Price \$1,509,418 \$1,654,237 \$1,352,998 \$1,211,774 Top Price \$17,500,000 \$20,000,000 \$20,000,000 \$14,700,000 \$1,506,399,530 \$1,199,321,990 \$660,263,078 \$975,477,972 **Gross Revs** % Change 2007 2008 2009 2010 Closed -4.3% -27.4% -32.7% 65.2% Ave Price 15.0% 9.6% -18.2% -10.4% 10.0% -44.9% 47.7% **Gross Revs** -20.4%

TABLE 14: OVERALL RESORT MARKET TRENDS, 2010 1Q & 2Q ONLY

Given this, exactly when did sales demand begin to return? Per the following chart, which shows the quarterly activity since 1987, demand hit a high 3Q 2005, followed by a low in 2008 4Q. Since then, with prices still falling hard, demand has ticked up for 5 of the ensuing 6 quarters.

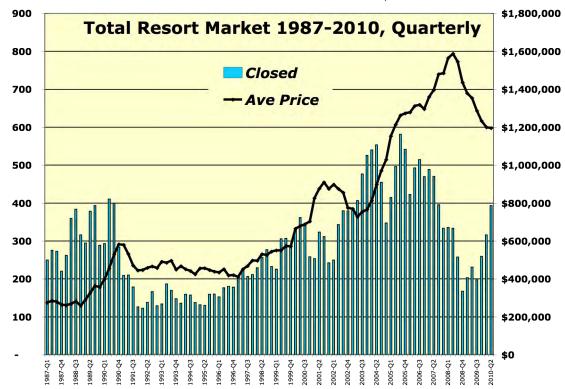


CHART 18: TOTAL RESORT MARKET 1987-2010, QUARTERLY

Another way to track market sentiment is to focus just on resales, since developer closings make the trend look erratic (i.e., large number of closings occurring all of a sudden, making the data look lumpy). And since resales don't have the long lag between reserving and closing (18 to 24 months) the resale trend best reflects what today's buyers are thinking currently.

As seen, this market segment has had four quarters of rising activity. In addition, average prices appear to have stabilized, around and around the \$1 million mark, after falling by a quarter since their peak in 3Q 2007.

By Ricky Cassiday rcassiday @me.com May, 2011

PRICE SEGMENTS: The following section breaks the overall market into its respective price segments, regardless of product types, in order to get a sense of where on the spectrum from expensive to inexpensive there are buyers.

The table below tabulates the number of closings into the different price segments.

As seen, there was a large decline in activity overall the mid and upper middle priced segments 2008-2009, but that the low and the high end price segments held up, in comparison. YTD 2010 the same pattern holds, except that the growth is evident across the board.

This general pattern is a reversal of the market, if one goes back 6 years or more. Back in 2002-2004, the market grew most in the mid and upper mid ranges.

TABLE 15: STATE OVERALL MARKET, CLOSINGS BY PRICE RANGE

(\$000s)	2006	2007	2008	2009	2010
\$250-\$499	171	143	106	211	366
\$500-\$749	630	441	194	245	362
\$750-\$999	413	305	175	167	258
\$1000-\$1249	170	168	99	68	88
\$1250-\$1499	125	132	93	66	72
\$1500-\$1749	111	113	83	47	54
\$1750-\$1999	68	71	56	34	44
\$2-\$3M+	214	167	150	75	86
\$3M+	139	161	116	88	148

Better than looking at the numbers is seeing the percentage change in sales over a span of time.

TABLE 16: STATE OVERALL MARKET, PERCENTAGE CHANGE OF CLOSINGS

(\$000s)	2006	2007	2008	2009	2010
\$250-\$499	-47%	-14%	-26%	99%	73%
\$500-\$749	-7%	-28%	-56%	26%	48%
\$750-\$999	5%	-26%	-43%	-5%	54%
\$1000-\$1249	14%	0%	-41%	-31%	29%
\$1250-\$1499	-28%	6%	-30%	-29%	9%
\$1500-\$1749	21%	2%	-27%	-43%	15%
\$1750-\$1999	-12%	8%	-21%	-39%	29%
\$2-\$3M+	18%	-21%	-10%	-50%	15%
\$3M+	-21%	16%	-28%	-24%	68%

With that in hand, we were able to create the following two charts, each showing the information, but in two different time frames.

The first chart shows years 1, 2 and 5, and the second shows years 3, 6, and 9.

CHART 19: SALES GROWTH TRENDS, 1, 2 & 5 YEARS

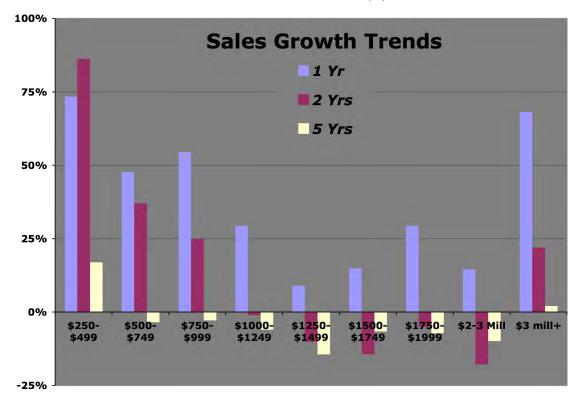
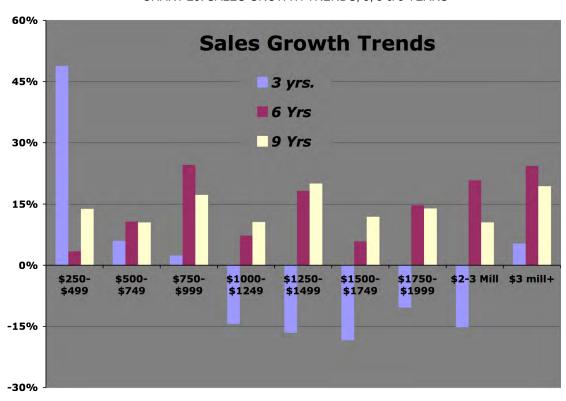


CHART 20: SALES GROWTH TRENDS, 3, 5 & 9 YEARS



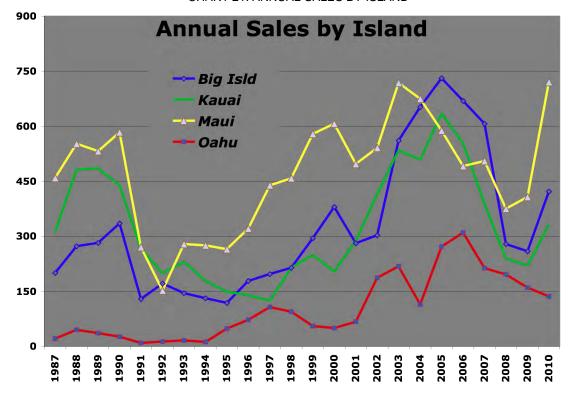
ISLAND SEGMENTS: The following looks at the market by island, in terms of sales activity. , As seen, the island of Maui has rebounded nicely this year, as has the Big Island and Kauai.

TABLE 17: CLOSING COUNTS BY ISLAND

	Big Isld	Kauai	Maui	Oahu
2005	731	635	588	272
2006	669	553	491	310
2007	607	388	505	213
2008	279	239	375	196
2009	259	220	407	160
2010	422	332	720	136
	Big Isld	Kauai	Maui	Oahu
1 Yr.	62.9%	50.9%	76.9%	-15.0%
2 Yrs.	27.9%	21.5%	42.7%	-16.7%
5 Yrs.	-3.2%	-7.6%	9.2%	-11.7%
1Q ONLY	Big Isld	Kauai	Maui	Oahu
2008 1&2Q	198	145	249	133
2009 1&2Q	114	72	254	48
2010 1&2Q	422	332	720	136

Sales activity on Oahu does not look as strong at the other island, but it bears mentioning that this is because we do not Waikiki in the data (inasmuch as Waikiki has mixed usages and non-resort zoning areas). But if we were to do so, then there would be another 100 closings in the data this year, thanks to the Trump Tower and Allure condo project completions.

CHART 21: ANNUAL SALES BY ISLAND



Resort Market, Big Island

OVERVIEW: Like the rest of the state, the Big Island market is seeing good activity YTD 2010.

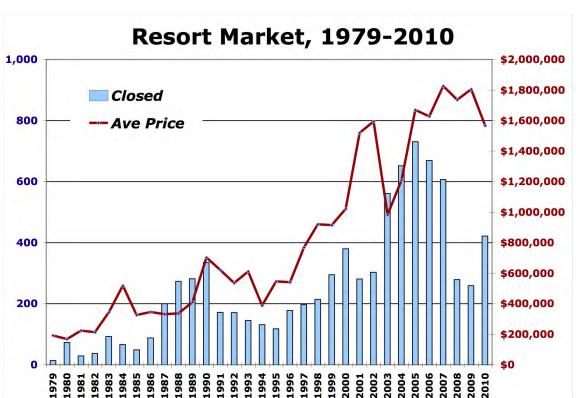


CHART 22: RESORT MARKET 1979-2010

The difference is that the average prices in this sub-market have remained pretty high, and the sales activity fell off pretty far, starting in 2008. While falling prices helps to stoke demand, in this case it appears that demand has shown up in spite of the fact prices are not coming down drastically.

The table below describes the data behind the trend chart above.

	2007	2008	2009	2010
Closed	607	279	259	422
Ave Price	\$1,825,747	\$1,736,588	\$1,805,428	\$1,567,935
Top Price	\$29,000,000	\$20,000,000	\$26,250,000	\$14,500,000
Gross Revs	\$1,108,228,206	\$484,507,960	\$467,605,858	\$1,323,337,464
% Change	2007	2008	2009	2010
Closed	-9.3%	-54.0%	-7.2%	62.9%
Ave Price	12.2%	-4.9%	4.0%	-13.2%
Gross Revs	1.8%	-56.3%	-3.5%	183.0%

TABLE 18: OVERALL BIG ISLAND RESORT MARKET TRENDS

This strong YTD sales growth also can be seen in the following table, which isolates just the first two quarters. As seen, 2010 YTD is the strongest start of any years since 2007, when the economy began tipping downward:

2007 2008 2009 2010 Closed 346 198 114 211 Ave Price \$1,889,981 \$1,795,460 \$1,514,745 \$1,567,935 Top Price \$20,000,000 \$20,000,000 \$14,700,000 \$14,500,000 \$653,933<u>,464</u> \$355,500,995 \$172,680,939 \$330,834,366 **Gross Revs** % Change 2007 2008 2009 2010 Closed 0.0% -42.8% -42.4% 270.2% Ave Price 23.7% -5.0% -15.6% 3.5% **Gross Revs** 23.7% -45.6% -51.4% 91.6%

TABLE 19: OVERALL RESORT MARKET TRENDS, 2010 1Q & 2Q ONLY

When did sales demand return? Per the following chart, which shows the quarterly activity since 1987, demand hit a high 4Q 20053, followed by a low in 4Q 2008. Since then, demand has risen steadily.

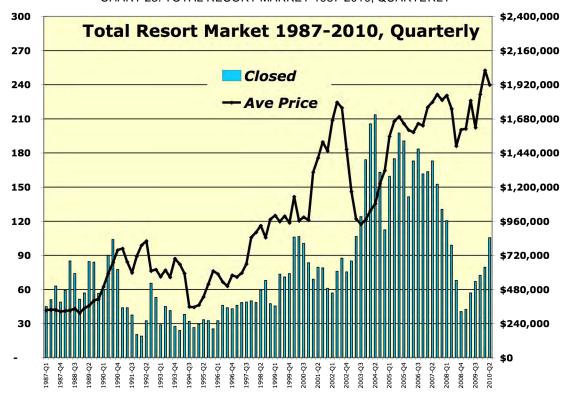


CHART 23: TOTAL RESORT MARKET 1987-2010, QUARTERLY

Another way to observe sentiment is isolate resales, since developer closings make the trend look erratic (i.e., large number of closings occurring all of a sudden, making the data look lumpy). And as resale don't have a long lag between reserving and closing (18 to 24 months) the resale trend best reflects what today's buyers are thinking currently.

The resale segment has had four quarters of rising activity, especially this last one. In addition, average prices were rising, hitting up to around the \$2 million mark, and then falling back by about 12%. Nonetheless, they are at very high levels.

The resale segment has had four quarters of rising activity, especially this last one. In addition, average prices were rising, hitting up to the \$2 million mark, and then falling back by 12%. Nonetheless, they are at very high levels.

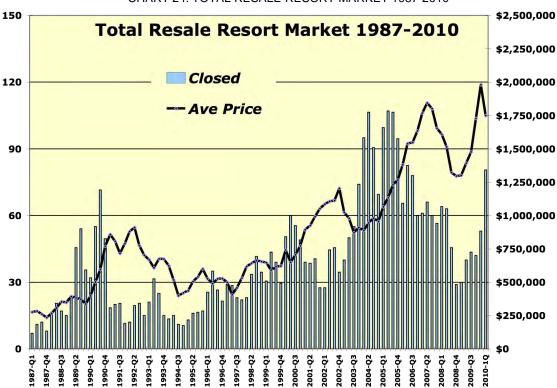


CHART 24: TOTAL RESALE RESORT MARKET 1987-2010

Finally more way to look at this market is to isolate just the resale condominiums, as they are, numerically speaking, the mainstay of the market.

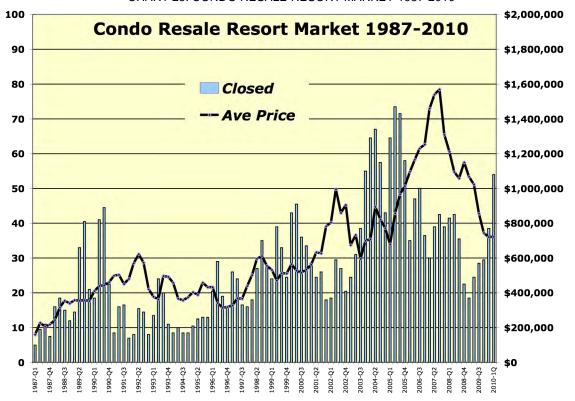


CHART 25: CONDO RESALE RESORT MARKET 1987-2010

The resale condo market shows that there has been a significant price correction since mid-2007. At that time, sales activity had fallen off by about a third from the peak level in 2005. Now, with prices at 2004 levels, we are seeing good activity. This pattern is similar to ones that presage a market bottom.

PRODUCT SEGMENTS: Next, we describe the recent trend, 2009-2010, comparing the performances of the different market segments in terms of product type and price range.

We begin with the entire market (note: 2010 is YTD data extrapolated for the full year). The table shows that All Sales of All Types were up 63% this year, while prices were down 13%.

Thereafter, the table looks just at sales in the higher price segments (and does this for both Resale and New Developer closings).

Closed Ave Price All Types % ▲ Closed % ▲ Prices All Sales 422 \$1,567,935 63% -13% Over \$1.0 million 138 \$3,810,934 23% 10% Over \$2.0 million 100 \$4,743,403 45% 0% RESALE Closed Ave Price % ▲ Closed % ▲ Prices All Sales 322 \$1,374,402 96% -17% 100 \$3,425,417 75% -9% Over \$1.0 million Over \$2.0 million 66 \$4,474,683 83% -13% NEW Closed Ave Price % ▲ Closed % ▲ Prices All Sales 100 \$2,191,112 5% 6% Over \$1.0 million 38 \$4,825,453 -31% 53% Over \$2.0 million 34 \$5,265,035 3% 23%

TABLE 20: ALL RESORT SALES AND PRICE COMPARISONS, 2009 vs. 2010

As seen, the bulk of activity is under \$1 million, and that prices are still falling. But, for units priced over \$1 million, this market segment is enjoying positive sentiment, with increasing sales and prices, year over year.

Next, we look at the different market components, starting with condos:

Condos Closed Ave Price % ▲ Closed % ▲ Prices All Sales 272 \$684,273 61% -22% Over \$1.0 million 34 \$2,357,201 -21% 23% Over \$2.0 million 16 \$3,458,125 100% 13% Condos, RESALE Closed Ave Price % ▲ Closed % ▲ Prices All Sales 216 \$715,317 100% -8% Over \$1.0 million 32 \$2,435,776 78% 14% Over \$2.0 million 16 \$3,458,125 100% 13% Condos, NEW Closed Ave Price % ▲ Closed % ▲ Prices All Sales 56 \$564,536 -8% -46% Over \$1.0 million 2 \$1,100,000 -92% -37% 0 Over \$2.0 million \$0 -100% -100%

TABLE 21: CONDO RESORT MARKET TRENDS 2010 vs. 2009

Again, the meat of the market is under \$1 million, but that above that threshold price, sales activity and price trends are positive. They also drop dramatically in absolute numbers, with very little developer activity.

With having taken a look at this short-term trend, for comparison purposes, we show the long-term trend in pricing and activity over the last 20+ years, starting with condos. As seen, there have been four market cycle peaks and four bottoms, if this year turns out to be positive.

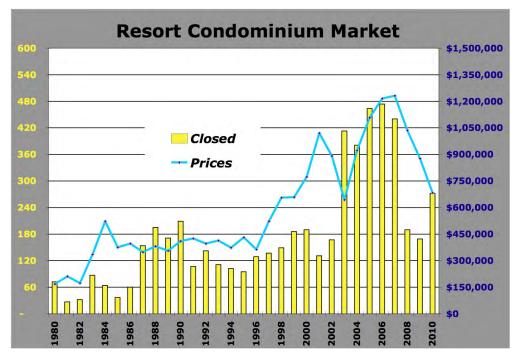


CHART 26: RESORT CONDOMINIUM MARKET

The resale component of the condo market is a good indicator of market sentiment, with steady inclines and drop-offs.



CHART 27: RESORT RESALE CONDOMINIUM MARKET

Turning now to the single-family segment:

TABLE 22: RESORT SINGLE FAMILY MARKET TREND 2010 vs. 2009

	Closed	Ave Price	% ▲ Closed	% ▲ Prices
All Sales	76	\$3,870,803	40.7%	-3.6%
Over \$1.0 million	50	\$5,555,934	28.2%	4.2%
Over \$2.0 million	38	\$6,866,919	26.7%	5.8%
Home Site, RESALE	Closed	Ave Price	% ▲ Closed	% ▲ Prices
All Sales	54	\$3,079,700	107.7%	-20.4%
Over \$1.0 million	30	\$5,038,317	100.0%	-19.9%
Over \$2.0 million	20	\$6,822,586	122.2%	-28.1%
Home Site, NEW	Closed	Ave Price	% ▲ Closed	% ▲ Prices
All Sales	22	\$5,812,600	-21.4%	40.1%
Over \$1.0 million	20	\$6,332,360	-16.7%	33.8%
Over \$2.0 million	18	\$6,916,178	-14.3%	32.8%

As seen, the bulk of the market sits well above \$1 million.

Interestingly, the resale market is down at all price levels, but shows very good activity relative to last year. On the other hand, the developer market shows lower sales but higher prices.

This could be due to developers cutting prices in order to make sales (in which case, they would be getting a slightly lower absolute price but a much lower price per square foot).

TABLE 23: SINGLE FAMILY MARKET TRENDS, ALL SALES

	2007	2008	2009	2010
Closed	73	38	52	76
Ave Price	\$4,342,407	\$4,451,835	\$4,154,100	\$3,870,803
Ave Size	3,544	3,555	3,726	3,647
\$/sf	\$1,225	\$1,252	\$1,115	\$1,061
% Change	2007	2008	2009	2010
Closed	15.9%	-47.9%	36.8%	46.2%
Ave Price	42.4%	2.5%	-6.7%	-6.8%
\$/sf	25.4%	2.2%	-11.0%	-4.8%

Indeed, on the basis of value, the price per square foot has been going south slightly more than the absolute price point.

TABLE 24: SINGLE FAMILY MARKET TRENDS, RESALES

	2007	2008	2009	2010
Closed	42	19	25	54
Ave Price	\$2,190,158	\$2,338,531	\$4,012,272	\$3,079,700
Ave Size	2,928	3,249	3,296	3,400
\$/sf	\$748	\$720	\$1,217	\$906
% Change	2007	2008	2009	2010
Closed	-4.5%	-54.8%	31.6%	116.0%
Ave Price	-7.6%	6.8%	71.6%	-23.2%
\$/sf	-9.5%	-3.8%	69.1%	-25.6%

Turning to the developer segment trend:

TABLE 25: SINGLE FAMILY MARKET TRENDS, NEW SALES

	2007	2008	2009	2010
Closed	31	19	27	22
Ave Price	\$7,258,357	58,357 \$6,565,138 \$4,285,423		\$5,812,600
Ave Size	4,502	4,502 3,917 4,174		4,386
\$/sf	\$1,612	\$1,676	\$1,027	\$1,325
% Change	2007	2008	2009	2010
Closed	63.2%	-38.7%	42.1%	-18.5%
Ave Price	57.0%	-9.6%	-34.7%	35.6%
\$/sf	30.3%	3.9%	-38.7%	29.1%

Here, this trend appears much more volatile than the resale market's trend – but it does follow relatively closely with the price point trend.

Vis-à-vis the long-term trend, what sticks out is the strength of activity 2010 YTD.

CHART 29 HOME SITE RESORT MARKET

Inasmuch as it isn't coming from the developer market, it appears the strength in activity might be foreclosure activity in the resale segment.

Finally, we look at the home site segment tables.

TABLE 26: RESORT HOME SITE MARKET TREND 2010 vs. 2009

Home Sites	Closed	Ave Price	% ▲ Closed	% ▲ Prices	
All Sales	70	\$2,570,748	94%	-10%	
Over \$1.0 million	54	\$3,110,506	80%	-6%	
Over \$2.0 million	46	\$3,436,247	109%	-14%	
Home Site, RESALE	Closed	Ave Price	% ▲ Closed	% ▲ Prices	
All Sales	48	\$2,506,924	60%	-13%	
Over \$1.0 million	38	\$2,985,456	58%	-13%	
Over \$2.0 million	30	\$3,451,578	58%	-13%	
Home Site, NEW	Closed	Ave Price	% ▲ Closed	% ▲ Prices	
All Sales	22	\$2,710,000	267%	0%	
Over \$1.0 million	16	\$3,407,500	167%	26%	
Over \$2.0 million	16	\$3,407,500	100%	-37%	

This market appears to be rebounding somewhat in terms of activity this year. And prices are sticky to the downward, a bit similar to the single-family market. As a good part of the activity is coming from developer sales, it looks like they are being proactive in terms of making sales.

Home Site Resort Market

\$3,000,000

\$2,700,000

- Prices

\$1,800,000

\$1,800,000

\$1,200,000

\$1,200,000

\$1,200,000

\$1,200,000

\$1,200,000

\$1,200,000

\$1,200,000

\$1,200,000

\$1,200,000

\$1,200,000

\$1,200,000

\$1,200,000

\$1,200,000

\$1,200,000

\$1,200,000

\$1,200,000

\$1,200,000

\$1,200,000

\$1,200,000

\$1,200,000

\$1,200,000

\$1,200,000

\$1,200,000

\$1,200,000

CHART 29 HOME SITE RESORT MARKET

In the long-term, this market looks like it is trying to regain a good level of activity. However, it does not look like it has come down very much in terms of pricing.

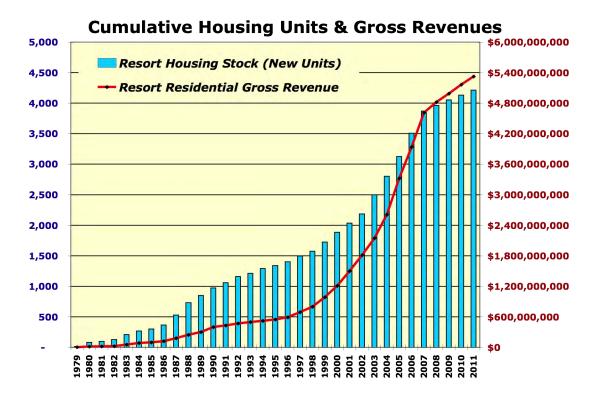
Next, we look at the market purely in terms of price segments. This allows us to take note of the purchasing power of the market by expenditure.

VI. Resort Residential Market Forecast

Given the potential to achieve residential sales on the subject property, we here look specifically at the residential market in terms of demand and supply, and do so over the long-run (as this master plan community, like most developments, are active over a 15-20 year span of time), and do so first for the resort residential market demand and second for the primary housing demand.

In order to get a perspective on the size of the resort residential market and the contribution that it has made to the real estate market on the Big Island, the following chart describes the growth of housing stock and the total gross sales revenues that has been generated by the development of second homes on resort master plans in the county.





At the risk of repeating the old cliché that the past is prologue, it is important to appreciate the size and scale of the county's resort residential market, and understand that this provides a very substantial base from which substantial future demand will be generated.

DEMAND: On the demand side of the market, future demand for the resort property portion of Kahuku Village will be tied to economic and population growth in the home nations where the second home buyers reside in – basically the US (mainly California, Washington, Colorado, and Nevada), Canada, Japan and East Asia (Korea, Hong Kong). Clearly, their home prosperity is what drives Big Isle resort sales activity and property prices.

In the short run, economic growth in these markets will be below the historical averages, particularly in the advanced economies of the world, as they work themselves through the recovery. As forecasted by the IMF and Goldman Sachs in their latest review of the global economy, it will take a few years for these economies, including the US, to improve the functioning of the financial system, rebalance pubic and private spending and pay down the national debt and balance of payments.

Fortunately, the developing world does not have similar restraints and should grow at above average rates. The net will be 4.6% real growth globally by 2015 (compared with 2.4% growth for the US).

Thereafter, with these repairs and rebalancings largely accomplished, higher rates of growth should be re-established, reflective of the longer-term trend. Part and parcel to exiting of the slow-recovery stage will be, hand-in-hand with faster economic growth, rising nominal and real interest rates. Indeed, the IMF forecast for real interest rates posits that this will happen after another 4-6 years.

The import of this is that the global economic trend will feed into the local Big Island real estate cycle. Per usual, the real estate cycle upswing starts upwards when fed by low interest rates and low prices. Given these forecasts prove out, and then around 2015-2017 the Big Island resort market should enjoy noticeably higher sales activity. This then will be followed in a couple years by noticeably higher prices, starting in 2018-2021.

What this then means for the marketability of this project is that it will be reasonably well timed:

- In the first place, the initiation of higher demand (2015-2017) at the onset of the sales and marketing phase (2016) means that sales will be easier to achieve more buyers means there will be more interest in the area and, then as higher sales take units off the market, there will be less and less inventory to satisfy the higher levels of interest.
- In the second place, and feeding off of the diminution of supply, the project will be positively affected by rising prices. This will help to maintain sales momentum over the life of the project. Given the pricing differentiation between this project and similar, established communities to the north, initial sales will go to those seeking either an authentic lifestyle or good values (or both). Subsequent sales will be supported by prices raising, inasmuch as higher prices indicate the development to be inherently valuable

The following table identifies the average sale prices for condos, homes and home sites within a resort zoned master planned community over the last 14 years (since 1996, which is when the market bottomed out in the last real estate cycle). As this average is derived from all the sales made in that market cycle, it is not immediately current. However, it is accurate over the long-term market cycle, which then gives us a sense of a conservative price that the subject property can be tied to over a 5-10 year development cycle.

Resort	Condo	Home	Land
Hualalai	\$2,498,523	\$6,414,970	\$2,534,100
Kukio	\$4,014,067	\$7,381,096	\$3,644,830
Mauna Kea	\$1,549,100	\$2,497,381	\$2,093,530
Mauna Lani	\$1,011,040	\$3,991,391	\$2,091,423
Hokulia		\$6,750,000	\$1,039,944
Keauhou	\$430,134	\$1,069,043	\$430,134
Waikoloa	\$671,520	\$7,777,000	\$3,106,629
Average	\$1,128,950	\$4,678,667	\$2,805,059

TABLE 27: AVERAGE PRICES FOR THE BIG ISLAND RESORT MARKET. 1996-2010

As importantly, these averages are derived from a total of almost 6,000 closings, or about 400 sales a year. This is an average number for resort sales over the whole real estate cycle, so it includes the top and bottom of the cycle. Interestingly, the previous cycle, 1985-1995, had only an average of 220 resort residential sales a year.

Thus, the coming next cycle should be expanded in terms of average annual closings, inasmuch as there is a greater stock of high-end residential units than there were at the beginning of this last cycle, 1996. It is not inconceivable that over the span of the coming cycle, 2012-2022+ that the annual count of sales on resort master planned communities could very easily make 550 sales a year, particularly as the projects already with zoning get built out.

NOTE: this does NOT include non-resort high-end sales. If the data set included sales from Puako, Kona/Captain Cooke waterfront, Kohala waterfront and uplands, Waikii, Waimea, etc., the number of high-end sales would have been closer to 600 sales a year for this cycle (and add at least another 300 sales a year for the coming 2012-2022 cycle).

SUPPLY: On the other side of the market, the potential supply of resort residential units in the future is pretty much set in the short run, as the entitlement process is lengthy and costly. In the long run, supply can be expanded, if the political and economic climate combine in such a way that t it is conducive in terms of investing in the future. However, given that most if not all of the best locations for resort housing (as well as primary housing) have already been developed, the future projects will either be of a lower quality (inferior site) or be more expensive (superior site, but not as accessible).

Turning first to the short run, the potential supply of resort residential units can be quantified by summarizing the number of entitled units there are located within the current resort master planned communities on the Big Island. This is done by looking at the entitled parcels, identifying the property type (condominiums, home sites, etc.), estimating the number of units the parcel can produce and price points of these future units might command.

Given total supply, annual demand is then set against that inventory of entitled units. When done over a number of years, one can see how supply will interact with demand and then get an idea just how long before supply begins to run short. To make this simple, we have aggregated these potential sales into 3-year time spans, corresponding the time frame for this project.

(Note: these units can be defined as in partially or fully zoned - given that the time frame being contemplated here stretches out fifteen years plus, we are assuming that the partially zoned units will become fully entitled).

The table below describes our projection of how the stock of entitled units will complete their sales. As seen, the number of resort units sold will increase significantly after 2012.

For example, Oahu will deliver more units than any other island in the next time period, 2013-2025. This is thanks to stronger demand for Oahu properties, plus the fact that Ko Olina has a number of parcels readied for development (as does Turtle Bay, once through the EIS process). On the other hand, Maui does not have either the demand of the entitlements to increase it's sales until 2016, when Makena and Wailea 670 will be in full swing production.

	2010-2012	2013-2015	2016-2018	2019-2021	2022-2024	2025-2027
Big Island	108	904	1,611	1,061	1,112	373
Kauai	129	966	1,447	1,071	555	584
Maui	475	536	1,142	1,694	1,306	875
Oahu	10	1,365	1,936	1,130	0	0
Kahuku			46	241	421	38

6,136

4,956

2.973

1,832

3,771

722

TABLE 28: FORECASTED RESORT RESIDENTIAL CLOSINGS STATEWIDE, 2010-2027

For comparison's sake, we included the delivery schedule of Kahuku Village as a separate line item. This allows for the calculation of Kahuku Village's share of market. As seen, this share would be 5% or under of the total market, save for the 2022-2024 time frame, when it should rise to command a 14% market share. This rise in market share in that period is a function of the other resorts statewide beginning to run out of their current inventory of entitled land.

To be sure, this and other conditions could change, including a falloff of demand and/or an increase in supply (i.e., there could be more resort communities zoned and units entitled). However, current political conditions across the state and within the county have resulted in some current projects

losing their entitlements, either incrementally or completely – Turtle Bay exemplifies the former and Ooma, and Aina Lea the latter.

Looking at just the Big Island forecast, the table below describes the resort future sales:

TABLE 29: FORECASTED RESORT RESIDENTIAL CLOSINGS HAWAII ISLAND, 2013-2027

	2013-2015	2016-2018	2019-2021	2022-2024	2025-2027	2028-2030
Hokulia	140	120	79	100	90	40
Hualalai	123	104	60	23	0	0
Keauhou	80	171	108	80	20	0
Kohanaiki	93	96	53	36	0	0
Kukio	60	92	93	80	75	25
M Kea	20	170	75	20	0	0
M Lani	198	352	10	10	0	0
Waikoloa	190	460	342	277	150	0
Kahuku		46	241	421	38	0
Total	904	1,611	1,061	1,047	373	65

As seen, sales will expand dramatically as the economy recovers (or after a lag period of 2-4 years). This forecast, again, assumes there are no new resort areas entitled. And it does not count a few areas that have zoning in place, but have not been active over the last 10 years (e.g., Sea Mountain), because the recent Supreme Court decision on Turtle Bay makes those entitlements questionable.

Also, as seen, the overall resort sales on the Big Island will significantly contract after 2024, simply due to low supply of entitled land. The Kahuku Village project would have added significantly to this supply, from 2019 onwards, constituting upwards of a third of the sales in the 2022-2024 period.

We note that the projected sales rate above, if looked at in 9-year summaries (which approximates a real estate cycle), averages slightly higher than the sales rate that was achieved during this last real estate cycle, 1996-2010. To wit, the sales rate for 2016-2024 is an average of 438 units per year, whereas the last real estate cycle was 400 units a year. We believe demand for resort residential units should come in at a higher level during the next cycle relative to the last one, a reasonable assumption given that the market expanded significantly from one cycle to the next (from 220 to 400 unit annual sales, 1985-1995 vs. 1996-2010).

Finally, we note that the average prices for the resort housing in Kahuku Village are below all of the other resorts. This discount should mean that the subject property here could actually enjoy more demand than what is estimated above. If so, then Kahuku Village could enjoy either higher sales rates, or higher prices.

Next, we look at the primary housing market of the Big Island in the context of the Kahuku Village contemplated supply.

VII. Primary Housing Market Forecast

The other source of demand for the housing of this project comes from households looking for primary housing, or permanent resident housing. This includes those who are currently living on the Big Island and those looking to relocate there. The level of demand is contingent on the traditional factors of job and population growth, as well as that of personal assets (mainly the home equity of these households).

First, however, we want to review the scope of primary housing being contemplated by this project. As seen, the bulk of these closings will occur in 2022 and after. Furthermore, over 80% of those units, the 149 VMX condo units, are priced to be affordable, per county standards (note: they are already at a 30% discount to the 2010 median price for condominiums, or \$270,000).

		2016-18	2019-21	2022-24	2025-27	Total
MF	Closings			149	20	169
	Ave Price			\$192,000	\$290,000	\$208,333
SF	Closings	30	40	65		135
	Ave Price	\$65,000	\$110,000	\$225,000		\$133,333
Total (Closings	30	40	214	20	304

TABLE 30: PROJECTED RESIDENTIAL CLOSINGS, 2016-2027

In order to derive the level of future demand for housing on the Big Island, we took the projections of population growth for these years from DBEDT, the State of Hawaii's economic forecasting arm. It was updated in June, 2009, and is detailed below (from the 2035 Series):

	2007	2015	2020	2025	2030	2035	Totals
Resident population	172,547	199,488	221,862	242,643	261,758	279,706	
Pop Growth		26,941	22,374	20,781	19,115	17,949	107,159
Housing Demand		9,290	7,715	7,166	6,591	6,189	35,720
Annual Housing Demand		1,161	1,543	1,433	1,318	1,238	12,317

TABLE 31: FORECASTED RESIDENT POPULATION, 2007-2035

As seen, the total resident population of the Big Island County is measured from 2007 outwards to 2035.

After 2007, the table shows the growth of the population over 5 year time periods. Using these numbers, we can project the level of future housing demand that will be generated by that population growth. In doing so, we use an industry standard factor of an average of 2.9 people per household to divide into that population growth. This number for housing demand in that 5 year period is then converted to an annual demand for new housing, i.e., the 'new' homes demand for the 'new' population needs to be housed.

As seen, the average annual demand for new housing, 2007-2035, is 1,339 dwelling units. This is more than double the amount of what has been the average annual production of new homes by developers on the Big Island, seen in the section on developer production of new housing. Indeed, this is a large disparity between what is supplied and what is demanded (potentially), and serves to indicate that the local residents of the Big Island suffer from housing scarcity.

Other evidence of housing scarcity can be seen by comparing this potential demand to the table describing planned developments in the prior section.

Again, using the DBEDT projects, we forecast a total demand for housing for the entire island from 2007 to 2035 of 35,720 dwellings. We note that this is more than double than the 15,360 dwellings in

the 8 major master planned developments or housing projects for the west side of the Big Island that are listed below. In other words, a housing shortage is indicated by comparing population growth forecasts to the number of dwelling units that are entitled in the developments on the west side of the Big Island that are described below:

TABLE 32: FORECASTED RESIDENT POPULATION, 2007-2035

	Projected	Domestic	Proposed
Development	Start Date	Units	Hotel Rooms
Kaloko Heights	2013?	710	
Kaloko Makai	2013?	5,000	
Kamakana Villages/HHFDC	2012?	2,330	
Palamanui	2012?	1,016	120
QLT Keahoulu	2012?	6,000	
Kahuku - Ka'u	2016	304	500
		15,360	720

Also relevant to the Kahuku Village primary housing demand is how their schedule for delivering primary residences compares with this DBEDT forecast of housing. Here, we take a look at dwelling unit deliveries for the period when Kahuku Village would be producing homes.

From 2010 to 2025, a total of 20,689 dwelling units will be needed to house the expected growth in the population, according to the DBEDT forecast above. Over that time period, Kahuku Village's total production of 304 dwellings suitable as primary housing represents some 0.0147% of the total forecasted demand. In sum, these homes will not contribute much to relieving the chronic housing shortage that this and the other counties in the state suffer from.

VIII. Commercial Property Demand Projection

The calculation of demand for commercial property being supplied by Kahuku Village is relatively straight forward, thanks to its isolation. Because the village is located at the end of a 15 minute drive (downhill) – and because the point where that road accesses the highway is about 15 miles away from the nearest town – and because that town has a population of 964, in 2010 – it is safe to say there is no direct competition from any current or ongoing enterprises with the commercial component of Kahuku Village. In other words, any and all demand for commercial property in the village will be to be generated from within the Kahuku Village master planned community (and not from outside, particularly at the start of development).

To that end, a daily visitor and residential population count was developed, the composition and sum of which was then the basis for deriving the market demand for commercial property. In terms of the daily resident and visitor population counts, the volume of this was averaged for each of the three year time periods that served for the housing model, with the period years being the same ones: 2016-18, 2019-21, 2022-24 and 2025-27.

Overall, the visitor counts for those periods looked like this:

TABLE 33: FORECASTED DAILY RESIDENTIAL AND VISITOR POPULATION, 2016-2027

	2016-18	2019-21	2022-24	2025-27
People/Day	760	2,967	7,144	9,080
People/Year	277,517	1,115,958	2,607,458	3,314,112

The visitor component is the largest, particularly at the start. We benchmarked this volume for the HHC to a comparable visitor attraction. For the first time period, the start-up one, the comparable attraction for the HHC was the Hawaii Tropical Botanical Garden, at roughly 76,000 people a year, or 100 groups daily. The comparable attraction for the next time period, 2019-2021, was the Pu'ukohola Heiau National Historic Site, or City of Refuge, at 295,000 annual visitors or 300 groups a day. The penultimate period was comparable to the Polynesian Cultural Center with 600,000 visitors or 500 groups. Finally, the last period would match up with Diamond Head State Park, at 722,000 visitors or 600 groups a day.

Note that the attendance numbers for these comparable tourist attractions were counts that were achieved in 2008-9, which was a period in which there were not a lot of visitors on island AND the visitors on island were not spending very freely (given that this was during the height of the economic and financial market distress). We think that, with the passage of time to the next decade, it is very likely that in 2016 there will be a much better economy. Thus, it is likely that the HHC visitor numbers will be much higher then, 2016+, than these comparable attendance numbers, are now.

The breakdown of the projected daily area population count (including local residents), in percentage terms, is as follows:

TABLE 49: FORECASTED COMPOSITION OF DAILY POPULATION. 2016-2027

	2016-18	2019-21	2022-24	2025-27
Locals from Outside Village (visiting beach etc.)	13%	12%	13%	17%
Workers, Contractors, HHC staff	7%	11%	7%	7%
Hotel Guests	20%	12%	12%	12%
Kahuku Village Residents	18%	24%	31%	26%
HHC Attendees Only	28%	26%	23%	22%
Others (Golfers, VRBO guests)	14%	14%	14%	17%

As seen, the HHC attendee/sightseer percentage component is very high at the inception of the community, and then declines as the other sources for the daily population count grow and fill in. We note that the most significant component of this ultimately becomes the residential component.

In the next two tables, we characterize Kahuku Village's residents, noting whether they are offshore buyers, as well as the average price of their homes and their income ranges. For the resort-housing component, the owners look like this:

TABLE 50: FORECASTED RESORT RESIDENTIAL DEMOGRAPHICS, 2016-2027

	2016-18	2019-21	2022-24	2025-27	Total
Households (Closings)	46	241	421	38	746
Offshore Buyer Percentages	70%	76%	85%	87%	80%
Est. Home Value (Sales Prices)	\$1,481,250	\$904,167	\$1,753,125	\$2,100,000	\$1,478,750
Ave. Annual Income, Minimum	\$168,750	\$125,000	\$206,250	\$237,500	\$177,500
Ave. Annual Income, Maximum	\$215,000	\$158,333	\$278,125	\$287,500	\$230,500

For the primary housing component, the buyer profile would look like this:

TABLE 51: FORECASTED PRIMARY RESIDENTIAL DEMOGRAPHICS, 2016-2027

	2016-18	2019-21	2022-24	2025-27	Total
Households (Closings)	30	40	214	20	304
Offshore Buyer Percentages	17%	50%	33%	25%	32%
Est. Home Value (Sales Prices)	\$195,000	\$330,000	\$272,500	\$290,000	\$272,222
Ave. Annual Income, Minimum	\$40,000	\$60,000	\$48,333	\$50,000	\$48,889
Ave. Annual Income, Maximum	\$44,999	\$74,999	\$56,666	\$59,999	\$57,777

Given the sources and composition of the daily visitor count, the following demand projection was derived by a Colliers Monroe, Friedlander, an outstanding commercial property market research firm, for Kahuku Village. Their detailed analysis is found in the appendix.

TABLE 52: FORECASTED RETAIL DEMAND ANALYSIS, 2016-2027

	2016-18	2019-21	2022-24	2025-27
Consumer Expenditure Model (Moderate)	9,987	28,281	71,294	87,252
Population Demand Model	4,930	19,993	57,547	64,000
Commercial Acreage Allotted	1/2 to 1 acre	2 to 3 acres	6 to 7 acres	7 to 9 acres

IX. Hotel Property Demand Projection

At present, the hospitality industry is at a low ebb. More than at any other time in recent history, a large number of hotel properties are being marketed formally or informally across the state. On the Big Island, these properties include the Fairmont, the Orchid, the Sheraton Keauhou, and the Prince at Hapuna, as well as the real estate component of a number of properties. This can be seen in the latest DBEDT report on hotel inventory on the Big Island, comparing 2009 to 2010.

TABLE 53: HOTEL UNIT INVENTORY

	2010	2009	Change
Apartment/Hotel	0	5	-5
B&B	362	382	-20
Condo-Hotel	872	968	-96
Hostel	6	11	-5
Hotel	6,958	6,846	112
Individual Units	1,675	1,540	135
Timeshare	1,609	1,669	-60
Other	113	120	-7
Total	11,595	11,541	54

That noted, current conditions will respond overtime to the coming global economic rebound. Over the next 3 to 5 years, the demand for visitor accommodations will rebound once again. That said, it is unlikely that there will be much upkeep of the current properties, nor will there be much in the way of upgrades. And finally, with no new resort master plans coming forward, other than Kahuku Village it is unlikely there will be any new hotels being built.

As such, it is reasonable to expect there will be no competitive interference from the hotel stock in place when Kahuku Village goes to market the two hotel sites in the master plan. We think it likely that they will be sold in sequence, as described in the table below:

TABLE 54: HOTEL UNIT DELIVERY SCHEDULE

	2016-18	2019-21	2022-24	2025-27	Total
Hotel		37	38		75

The advantage to marketing these sites would be primarily the uniqueness of the location and community, as well as its originality. It should have a strong attraction for a youthful demographic that is energetic and conscious. As noted earlier, the operator of the eco-lodge would have a hand in creating these conditions, as well as an opportunity to invest in the fixed construction property.

X. Concluding Remarks

In light of the contemporary buyer trends and economic realities at play now and going forward, this project will be (and must be) more unusual and unique than was Mauna Kea in Its time. Instead of playing to Rockefeller's model of catering to the high-end market's interests - a world-class hotel on a protected beach - this project sticks with the basics: remote location, raw nature, simple accommodations, and a window into an ancient time and traditional culture. This is in direct contrast with attitudes of this last real estate boom, where larger, more complex and more luxurious was emphasized.

As such, we see this community doing well by validating current desire to be a part of unspoiled nature and have a direct experience with an authentic culture and real community.

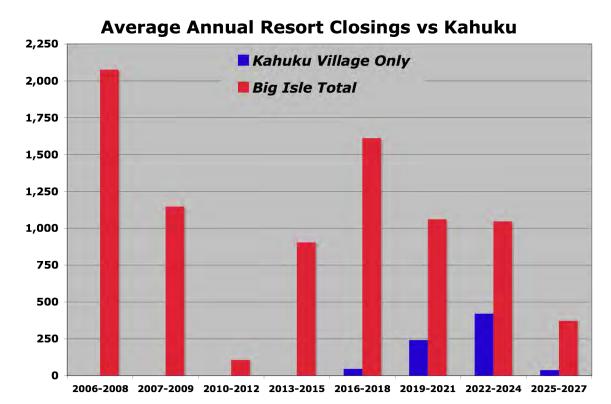


CHART 30: AVERAGE ANNUAL RESORT CLOSINGS VS KAHUKU

APPENDIX: ISSUES AND CONCERNS

ACCESSING THE VOG AND LAVA HAZARD AFFECTS MARKETABILITY:

While there is ample evidence of the detrimental affects of VOG on the respiratory health of residents of Kona and Kau, there is little or no discernable linkage to what this study concerns itself with – sales activity and values. To be sure, this is not to say there is none, but there is no evidence of it in the market data.

We start by looking into the time frame when the presence, thus the effect, of VOG increased dramatically, 2008, and then looked at the trends going on in the market before 2008 and after.

By way of background, the market was in the downswing portion of the real estate cycle – this downswing started in 2006 for activity and in 2007 for values. Thus over the period when VOG increased - 2008, 2009 and 2010 - the real estate market continued to contract for the reasons elaborated earlier: the financial market's meltdown, the significant drop off of economic activity globally, the shrinkage of Hawaii's visitor market, and the subsequent effects on Big Island job counts and income levels. To our mind, these economic events were much more significant, and are evidenced across property markets worldwide, than VOG was in negatively affecting the residential markets of West and South Hawaii.

To prove this, we made comparisons between the sales and values in the South and West Hawaii market where VOG is with areas where VOG is not. We looked for a South and West Hawaii market decline at the same time that a similar market did not (which would show that the market was uniquely affected). However, after looking at the data, we found no such trend.

We looked at the different areas on the Big Island, and found that they all declined, regardless of the different experiences with VOG that were had. We also looked at the level of activity for all resort residential sales in West Hawaii against the same markets but on Maui and Kauai. Here, we isolated for just the resale activity, as new home sales are not as indicative of the trend (as the new sales are usually contracted 18-24 months before they close, thus the buyer's sentiments are 18-24 months 'old').

As seen, the Big Island declined slightly less than Maui, 2008-2009, -36% to -42%. This says that, all things being equal, the VOG issue did not result a lower level of activity. In addition, in 2010, the Big Island enjoyed an increase in sales activity at almost the same level as Maui, 96% to 102%, again indicating that there isn't any significant negative impact on sales due to VOG.

TABLE 55: RESORT RESIDENTIAL RESALE ACTIVITY

	Big Isle	Kauai	Maui	Oahu
	Dig iolo	rtadai	ividai	Ouna
2007	245	257	321	76
2008	184	177	210	67
2009	164	174	196	90
2010	322	302	396	86
	Big Isle	Kauai	Maui	Oahu
2008	-25%	-31%	-35%	-12%
2009	-11%	-2%	-7%	34%
2010	96%	74%	102%	-4%

The other indicator of a VOG impact on the market would be through prices. Here, we look at the sales price data for resale condos, again because resales are a better indication of the trend. Also, we isolate for condos, since they are concentrated in the VOG areas of the Big Island.

Oahu Maui Kauai Big Isle 07 325,000 \$550,000 \$565,000 \$394,900 80 325,000 \$549,500 \$545,000 \$370,000 09 302,000 \$450,000 \$390,000 \$278,100 10* 305,000 \$377,500 \$344,500 \$265,000 Oahu Maui Kauai Big Isle 2008 0% 0% -4% -6% 2009 -7% -18% -28% -25% 2010 1% -16% -12% -5% 2009-10 -6% -34% -40% -30% -34% -44% 2008-10 -6% -36%

TABLE 56: RESALE CONDOMINIUM VALUES

As seen, the trend for condo resale prices on the Big Island is very similar to that of Maui, and both of them are more stable than Kauai. This indicates that the effect of VOG is not the primary determinate of prices, otherwise the Big Island condo resale values would be a lot lower than both Maui and Kauai.

Finally, the VOG should be much more an issue for local buyers and particularly local buyers with young children than it would be for offshore buyers (especially offshore buyers attracted to extreme nature, which is characteristic of the site). The project, however, is not putting a great deal of emphasis on this buyer demographic. The current supply schedule for Kahuku Village posits about 20 sales a year to local buyers of primary housing, or about 3% of the annual sales level of condos, 2001-2010. It projects another 15 sales per annum to local buyers for the less affordably priced single family homes, or about 0.07% of annual sales, 2001-2010. In other words, the amount of housing supply targeted on local buyers is insignificant.

In an informal poll of local realtors on this issue, they noted that while VOG is mentioned by potential buyers visiting open houses in the area as a major consideration whether to purchase a house or not, it is just one of several other important ones mentioned, including affordable pricing, potential for appreciation, livability, convenience.

Similar to VOG, the question was raised whether or not there is or will be an impact on the market for these homes stemming from area's lava hazard. Unlike the VOG issue, there is very little objective data to go by, inasmuch as the last major eruption on this side of the Big Island occurred over 100 years ago. With no data on home sales that can be compared with today's data, or extrapolated into the future, there is little objective that can be said.

However, an informal poll was taken on this issue amongst the local real estate community on the west side of the Big Island. In general, most real estate practitioners understood the potential for damage from volcanic lava in abstract terms. However, few respondents were able to articulate a concrete feeling of threat or hazard, and fewer yet identified the impact of this feeling, save for one who stated their personal property was located where lava was unlikely to trespass. It seems that only after an actual experience of lava damage would there be an impact on the market. This is to say that if there was an eruption on the west side of the island such that lava traveled westward, then this event could and should trigger a market effect, specifically the diminution of values and the exodus of residents.

AFFORDABLE HOUSING REQUIRMENT:

If the requirements concerning the affordable housing requirement of developers that are currently on the books hold true for when Kahuku Village receives it's approvals, that requirement will be based on a 20% factor applied against the total number of dwelling units (or 210 units) produced. Additionally, there is another requirement generated if the number of jobs generated by hotel or resort uses exceeds 100 jobs (which it will), with the developer required to produce one affordable dwelling per four jobs created (or 0.25 homes per job).

In terms of meeting the 20% requirement, the following table describes the generation of the affordable housing requirement, and the one thereafter, it's satisfaction.

TABLE 57: HOUSING TYPE, UNIT DELIVERIES AND AVERAGE PRICES, PER SCHEDULE

Primary	Data	2016-18	2019-21	2022-24	2025-27
MF/VMX	Units			149	20
	Ave. Price			\$192,000	\$290,000
SF/15,000 sf	Units	30	40	65	
	Ave. Price	\$195,000	\$330,000	\$675,000	
Totals, Primary		30	40	214	20
MF, Resort	Units		105	215	
	Ave. Price		\$725,000	\$937,500	
SF, Resort	Units	46	136	206	38
	Ave. Price	\$1,481,250	\$993,750	\$2,025,000	\$2,100,000
Totals, Resort		46	241	421	38
Grand Total	_	76	281	635	58

The table above shows the unit counts and the average prices for both primary housing units and resort residential units, both of which total 1,050 units. The table below uses the delivery schedule for all units to derive the affordable housing requirement.

TABLE 58: UNIT DELIVERIES AND AFFORDABLE REQUIREMENTS

	2016-18	2019-21	2022-24	2025-27	Total Units
Total Units	76	281	635	58	1,050
Affordable Units Due @ 20%	15	56	127	12	210
Cumulative Units Due	15	71	198	0	
Affordable Units Delivered	0	0	298	20	318
Balance	-15	-71	100	108	108

Please note that this second table takes the total units delivered for each period, identifies that 20% of them are required to be affordable, and then accumulates them overtime until they are satisfied by the delivery of affordable units. This is shown in the Balance Row.

As seen, there will be 298 affordable units delivered in 2022-2024, the first such affordable unit deliveries chronologically. These 298 affordable units are the 149 MF/VMX units called out in the top table. Note that they have been doubled under the affordable regulations that allow a developer to receive two affordable unit credits for each affordable unit built. This is because the VMX units delivered are priced at a level that targets buyers making no more than 80% of Area Median Income (AMI), or \$192,000.

This affordable credits to affordable housing units relationship is described in the following table, drawn from the affordable housing guidelines for the county, 2010.

TABLE 59: TOP PRICES ALLOWABLE PER AMI TARGET INCOME

Top Price	Top AMI %	Credits/Unit
\$228,000	80%	2.0 credits/unit
\$275,000	100%	1.5 credits/unit
\$330,000	120%	1.0 credits/unit
\$384,000	140%	0.5 credits/unit

The table shows the top (highest) dwelling unit price allowable for the average household size (three members, the norm for a two bedroom unit) related to the top (highest) percent allowable within the targeted AMI. The 149 units are priced at \$192,000, a price which is well under the \$228,000 targeted top price (and thus qualifies for 2 credits per unit, as shown).

With the two credits per units, the development is more than able to satisfy the 20% requirement governing the total unit production (as shown in positive numbers shown in the Balance row of the UNIT DELIVERIES AND AFFORDABLE REQUIRMENTS table).

Note also that this program also has to satisfy the affordable housing requirement generated by having a number of jobs generated by a resort activity.

Per the development plan, there will be two hotels of 250 rooms each, one built in the 2019-2021 period and one build 2022-2024. With there being a positive balance of 100 affordable credits in 2022-2024, this then should be sufficient to cover some hotel 400 jobs (one affordable dwelling per four jobs created - or 0.25 homes per job). The next period shows a delivery of another 58 units, with an obligation of 12 units, being met by the delivery of the 20 VMX units. These units are priced above the \$275,000 threshold, and thus are accorded only one credit per dwelling. This works out to an additional 8 units, which gets translated into positive credits for another 32 jobs.

Note that we are using the 2010 guidelines to translate prices for units sold in 12+ years in the future. It is most likely that the guidelines in existence in 2022 will show prices far in excess of these prices. This makes it much more likely that the developer can either receive more credits per dwelling unit (by keeping these prices low) or sell the units for higher prices.

IMPACT OF KAHUKU VILLAGE ON THE SURROUNDING COMMUNITIES AND REAL ESTATE MARKETS

The question was posed: what will be the potential impact of the Kahuku Village development on the sales activity and housing values of the surrounding communities in Kau.

Per general economics, when there is more of something (housing) for sale on the market, this increase in supply acts to move values lower by satisfying more and more demand (and as demand gets satisfied overtime, subsequent sellers feel they must lower their prices so as to encourage subsequent buyers).

In this case, however, the commodity in question (housing, in this case) is not very similar to what is pre-existing in the market, and therefore will not affect the same buyers that the current sellers are attracting. Thus, the relationship described above will not exist or be relevant.

To start with, the communities in the immediate neighborhoods surrounding Kahuku Village contain rural housing, basic homes on large lots in very large subdivisions (Hawaiian Ocean View Estates) that are priced reasonably relative to the rest of the county. The proposed project also will provide rural homes on large lots but with the major difference that it will not be located in an undifferentiated and homogenous subdivision. It will be in a large master planned community, one that contains a lot of different elements (the cultural preserve, the beach parks, the ocean trails, the village center and the resort, etc).

Given these desirable features and amenities, the master planned units will be more valuable. Thus, the essential differentiation between the mauka and makai homes will be price: the units in the beachside master planned community will be priced at a multiple to those units further up the mountain.

As the Kahuku Village community gets underway, it could well improve the market for the mauka homes in the surrounding community. For one, Kahuku Village will bring new and higher levels of activity to the area. This makes it easier for potential buyers to familiarize themselves with the area, a prerequisite to purchasing a home. Then, the higher activity makes it easier for those households active or vested in the growth of the Kahuku Village area to relocate there in order to work. Last, as the unit sales in the Kahuku Village master plan establish higher values in the community, this will, overtime, affect the values in the homes in the surrounding area positively.

Overall, housing values and activity rise when there is investment in the surrounding area, especially ones that bring job activity and raise the level of incomes.

Kahuku Village Commercial Market Assessment Retail Demand Analysis

February 3, 2011



Study Conducted by Colliers Monroe Friedlander Consulting for Data@Work



LIMITING CONDITIONS

The research undertaken in our report and which underpins the estimates of future performance of the project are prepared in accordance with industry practice. Colliers Monroe Friedlander Consulting ("CMFC") undertakes steps to determine whether the Client's assumptions underlying the estimates included in our report are fair and reasonable in the light of information provided and available. In our experience, these assumptions will have to be reviewed and revised by the Client periodically to reflect changes in the underlying market trends, trading patterns and the competitive environment.

Accordingly, we can offer no guarantees or warranties (expressed or implied) that the assumptions and resulting estimates set out in our report will be achieved. Our report identifies these hypothetical events or assumptions and any limitations to the usefulness of the presentation. Even if the hypothetical assumptions were to occur, there will usually be differences between the projected and actual results because events and circumstances frequently do not occur as expected, and the differences may by material.

The Client is responsible for representations about its plans, expectations, final assumptions to be used in the model and for disclosure of significant information that might affect the ultimate realization of the projected results. Our findings constitute only one of several factors for the Client to consider in its decision making process. The ultimate decision to move forward with the project rests with the project's management team.

TABLE OF CONTENTS

PROJECT OBJECTIVE4
DEMOGRAPHIC ANALYSIS5
RETAIL DEMAND ANALYSIS
Consumer Expenditure Demand Model
Population Based Demand Model
RECOMMENDATIONS10
APPENDIX11
Demographic Report

PROJECT OBJECTIVE

Colliers Monroe Friedlander Consulting ("CMFC") was engaged by Data@ Work to conduct a retail demand analysis for the proposed Kahuku Village mixed use project Environment Impact Statement ("EIS").

The objective of this market study is to identify the potential retail demand for the project site over the planned 2016 to 2025 development timeline. Additionally, CMFC is to provide an estimate of the commercial acreage likely to be required to satisfy the consumer demand for retail goods and services over the 10 year project plan.

Demographic Analysis

<u>Isolated Undeveloped Sparsely Populated</u> Region

Based on the demographic reports generated from 2000 Census data with estimates created for 2010, this information verified the isolated nature of the project site. Within a one mile radius of Kahakahakea Beach, there were only an estimated 16 people that reside in this area. Within a five mile radius, 361 people live for a population density of 4.6 people per square mile. A ten mile radius from the development site indicates more than 1,700 residents principally located mauka of the Mamalahoa Highway.



Below Average Household and Per Capita Income

The estimated 2010 household income for residents within a 10 mile radius is \$58,226. Per capita income is \$23,796. Roughly 75% of this population generate less than \$75,000 per year in household income. This area is below the statewide average for household income of \$86,489 and per capita income of \$30,782.

Relative Small Households

There are an estimated 718 households that reside within a 10 mile radius of the site. This figure declines to 158 within a five mile radius. The average household size is 3.18. Generally, 25% to 28% of these households have children.

Of the 1,002 housing units in the 10 mile area, 72% are occupied and 22% vacant. Of those units that are occupied, 74% are owner occupants.

Few Businesses

The census estimates that there are 17 businesses within the 10 mile radius of the project site. These businesses employ 98 people.

Of the working age population (16+ years old) 51% are employed in blue collar positions with 16% in construction, 9% in transport and 7% in fishing and farming.

Retail Demand Analysis

Market Segmentation

Based on the analysis conducted by Data @Work, there were three primary markets identified as the potential retail demand base for the project site, the transient, resident and hotel components.

The average daily population census is what is used to project retail demand. Table 1.0 indicates that during the 2016 to 2018 timeframe, there will be roughly 760 people visiting the site per day.

Table 1.0

	2016-18	2019-21	2022-24	2025-27
HHV Siteseers	210	810	1,650	1,980
HHV Researcher/Overnighters	80	160	270	310
Recreational Day Trippers	100	375	900	1,500
Construction Workforce	50	350	500	600
Transient Hotel/Tentalows	154	364	888	1,122
Hotel Visitors - non overnight	20	120	240	360
Golfers			270	360
Residential Households	138	728	2,240	2,378
Visitors to Residents	8	60	186	470
People/Day	760	2,967	7,144	9,080
Transient Market	468	1,875	3,746	5,220
Households Established	49	260	800	849
Hotel Visitors	154	364	888	1,122

Consumer Expenditure Demand Model

Utilizing the population estimates for the transient, resident and hotel visitor segments, CMFC is able to extrapolate projected retail sales for each market (see Table 2.0). Based on total combined retail sales, standard ratios for retail sales per square foot are used to estimate the retail demand for square footage.

The **Transient Market** is comprised of those consumers that spend less than 24 hours at the project site. These individuals may be contract workers, recreational activities participants or researchers. Typically these individuals would spend the fewest amount of dollars for retail goods and services, as many are residents and have the broadest array of competitive retail outlets to purchase goods and services in the area resulting in a low market penetration rate.

The **Resident Household Market is** identified as recent purchasers of lots and home sites with the intent on residing in the area. This target segment would spend on the broadest array of goods and services of the three consumer markets. The average monthly household retail expenditures for families within a 10 mile radius of the target site is \$1,700. The 45% market penetration rate is supported by limited retail competition in the area.

The **Hotel Visitor Segment** is comprised initially of those tourists that are renting the tentalow accomodations during 2016-2018 timeframe. This segment is typically very adverse to traveling far distances in an unfamiliar location for goods and services. As a result, they have a stronger tendency to purchase goods from concessions and retailers in close proximity to their living quarters. It can be expected that the majority of food, recreation and entertainment purchases will be on-site. CMFC estimates an 85% market penetration for this market sector.

Table 2.0

	2016-18	2019-21	2022-24	2025-27
Transient Market	468	1,875	3,746	5,220
Daily Expenditure \$8/day	\$3,744	\$15,000	\$29,968	\$41,760
Market penetration rate 25%	\$936	\$3,750	\$7,492	\$10,440
Annual retail sales (360 days)	\$336,960	\$1,350,000	\$2,697,120	\$3,758,400
Resident Household Market	49	260	800	849
Household Monthly Expenditure (\$1700) ¹	\$83,980	\$442,255	\$1,359,830	\$1,443,640
Household Daily Expenditure (30 days)	\$2,799	\$14,742	\$45,328	\$48,121
Market penetration rate 45%	\$1,260	\$6,634	\$20,397	\$21,655
Annual retail sales (360 days)	\$453,492	\$2,388,177	\$7,343,082	\$7,795,656
Hotel Visitors	154	364	888	1122
				1-,,
Daily Visitor Retail Expenditures (\$68 Big Island) ₂	\$10,472	\$24,752	\$60,384	\$76,296
Market Penetration Rate 85%	\$8,901	\$21,039	\$51,326	\$64,852
Annual retail sales (360 days)	\$3,204,432	\$7,574,112	\$18,477,504	\$23,346,576
Total Retail Sales	\$3,994,884	\$11,312,289	\$28,517,706	\$34,900,632
Retail Square Footage Demand Estimates				
\$350/sf - Aggressive	11,414	32,321	81,479	99,716
\$400/sf - Moderate	9,987	28,281	71,294	87,252
\$450/sf - Conservative	8,878	25,138	63,373	77,557

^{1 –} U.S. Census, Sites USA demographics

For successful in-line retail spaces, typical retail sales per square foot ratios exceed \$400. For purposes of this study, we projected a range from \$350 to \$450 per square foot for retailers to achieve for this project site.

For the first two years, it is estimated that under the moderate scenario, the site could support up to 10,000 square feet of retail/commercial space. For a retail development, a rule of thumb is to a lot a parking lot, three times the size of the building improvements. By 2018, this site could support up to one acre of commercial development.

For years 2019 to 2021, our consumer expenditure model provides support for roughly 30,000 square feet of commercial retail space. This translates into a commercial development site of roughly 3 acres. Similarly, for years 2022-2024, this site could support up to 7 acres of commercial land and by 2027 a 9 acre site could be supported by the projected consumer demand.

^{2 – 2009} Annual Visitor Tourism Report, Hawaii Tourism Authority

Population Based Demand Model

As a way to corroborating the consumer expenditure retail demand model, CMFC also calculates retail demand based on population counts and corresponding it to an appropriate retail sales per person ratios. We have segmented the consumer demand into three similar markets of Transient, Resident and Hotel Visitor. (see Table 3.0).

Table 3.0

	2016-18	2019-21	2022-24	2025-27
Transient Market	468	1,875	3,746	5,220
Retail Sales \$2 PSF	936	3,750	7,492	10,440
Penetration Rate 25%	234	938	1,873	2,610
Resident Market	138	728	2,240	2,378
Retail Sales \$44 PSF	6,072	32,032	98,560	104,632
Penetration Rate 45%	2,732	14,414	44,352	47,084
Visitor Market	154	364	888	1,122
Retail Sales \$15 PSF	2,310	5,460	13,320	16,830
Penetration Rate 85%	1,964	4,641	11,322	14,306
Retail Demand				
Estimate	4,930	19,993	57,547	64,000

The population demand model estimates that in the first two years, retail demand would support a commercial development of up to 5,000 square feet. This is followed by subsequent demand projected for years, 2019-2021, 2022-2024 and 2025-2027 of 20,000 square feet, 60,000 square feet and 64,000 square feet, respectively.

These square footage estimates correspond to demand for ½ acre of commercial land in the first two years, 2 acres of retail demand for years 2019 to 2021, five acres total demand by 2022 to 2024, and 6 acres of demand by years 2025 to 2027.

Recommendations

Based on our two demand models, we estimate the level of commercial retail demand for the site to be as noted on Table 4.0:

Table 4.0

Square Footage Demand Estimates	2016-18	2019-21	2022-24	2025-27
Consumer Expenditure Model (Moderate)	9,987	28,281	71,294	87,252
Population Demand Model	4,930	19,993	57,547	64,000
Commercial Acreage Alotment	1/2 acre to 1 acre	2 acres to 3 acres	6 acres to 7 acres	7 acres to 9 acres

1990 - 2000 Census, 2010 Estimates with 2015 Projections *Calculated using Proportional Block Groups*



Kahakahakea Demographics	1 Mile		5 Miles	;	10 Miles	
Population						
Estimated Population (2010) Census Population (1990) Census Population (2000) Projected Population (2015) Forecasted Population (2020)	16 5 12 17 20		361 122 269 394 464		1,756 954 1,366 1,891 2,181	:
Historical Annual Change (1990-2000) Historical Annual Change (2000-2010) Projected Annual Change (2010-2015)	4	2.0% 3.4% 1.8%	147 92 33	12.0% 3.4% 1.8%	412 390 134	4.3% 2.9% 1.5%
Est. Population Density (2010) Trade Area Size	5.08 <i>psm</i> 3.14 <i>sq m</i>		4.60 p 78.49 s		5.59 <i>ps</i> 314.02 <i>sq</i>	
Households Estimated Households (2010) Census Households (1990) Census Households (2000) Projected Households (2015) Forecasted Households (2020)	7 2 5 8 9		158 50 113 177 213		718 336 531 797 945	:
Historical Annual Change (1990-2000) Projected Annual Change (2000-2015)		2.6% 3.8%	63 65	12.6% 3.8%	195 267	5.8% 3.4%
Average Household Income Est. Average Household Income (2010) Census Average Hhld Income (1990) Census Average Hhld Income (2000) Proj. Average Household Income (2015) Historical Annual Change (1990-2000)		\$ \$ \$ 3.8%	58,898 28,931 39,956 65,803	3.8%	\$58,226 \$28,356 \$39,671 \$64,846 \$11,315	4.0%
Projected Annual Change (2000-2015) Median Household Income Est. Median Household Income (2010) Census Median Hhld Income (1990)	\$25,847 \$41,834 \$22,155	\$	25,847 41,834 22,155	4.3%	\$25,175 \$41,846 \$22,308	4.2%
Census Median Hhld Income (2000) Proj. Median Household Income (2015)	\$28,936 \$48,370	\$ \$	28,936 48,370	2.40/	\$29,914 \$47,804	
Historical Annual Change (1990-2000) Projected Annual Change (2000-2015)			\$6,781 19,434	3.1% 4.5%	\$7,605 \$17,890	3.4% 4.0%
Per Capita Income Est. Per Capita Income (2010) Census Per Capita Income (1990) Census Per Capita Income (2000) Proj. Per Capita Income (2015)	\$25,709 \$11,745 \$16,515 \$29,580	\$	25,709 11,745 16,515 29,580		\$23,796 \$9,980 \$15,249 \$27,354	Ī
Historical Annual Change (1990-2000) Projected Annual Change (2000-2015)			\$4,770 13,065	4.1% 5.3%	\$5,269 \$12,105	5.3% 5.3%
Other Income Est. Median Disposable Income (2010) Proj. Median Disposable Income (2015)	\$36,526 \$41,319	\$	36,526 41,319		\$36,474 \$40,836	
Est. Average Household Net Worth (2010)	\$225,103	\$2	25,103		\$221,650	

1990 - 2000 Census, 2010 Estimates with 2015 Projections *Calculated using Proportional Block Groups*



Laureon: 19.00304/-135.7676						
Kahakahakea Demographics	1 Mile		5 Miles		10 Mile	S
Household Income Distribution (2010)						
HH Income \$200,000 or More	_	1.1%	2	1.1%	9	1.2%
HH Income \$150,000 to 199,999	_	6.3%	10	6.3%	42	5.8%
HH Income \$125,000 to 149,999	_	4.2%	7	4.2%	29	4.1%
HH Income \$100,000 to 124,999	_	6.9%	11	6.9%	40	5.5%
HH Income \$75,000 to 99,999	_	7.1%	11	7.1%	61	8.5%
HH Income \$50,000 to 74,999	1	17.8%	28	17.8%	122	17.0%
HH Income \$35,000 to 49,999	1	12.7%	20	12.7%	101	14.1%
HH Income \$25,000 to 34,999	1	8.6%	14	8.6%	65	9.1%
HH Income \$15,000 to 24,999	1	8.7%	14	8.7%	68	9.5%
HH Income \$10,000 to 14,999	1	11.9%	19	11.9%	81	11.3%
HH Income \$0 to 9,999	1	14.7%	23	14.7%	99	13.8%
HH Income \$35,000+	4	56.1%	89	56.1%	404	56.3%
HH Income \$50,000+	3	43.4%	69	43.4%	303	42.2%
HH Income \$75,000+	2	25.6%	40	25.6%	181	25.2%
Race & Ethnicity (2010)						
Total Population	16		361		1,756	
White	9	56.5%	204	56.5%	793	45.1%
Black or African American	-	2.6%	9	2.6%	36	2.1%
American Indian & Alaska Native	_	1.6%	6	1.6%	21	1.2%
Asian	1	5.1%	18	5.1%	221	12.6%
Hawaiian & Pacific Islander	1	9.1%	33	9.1%	195	11.1%
Other Race	-	1.9%	7	1.9%	26	1.5%
Two or More Races	4	23.1%	83	23.1%	464	26.4%
Not Hispanic or Latino Population	14	89.9%	325	89.9%	1,594	90.8%
Non Hispanic: White	9	60.7%	197	60.7%	764	47.9%
Non Hispanic: White Non Hispanic: Black or African American	-	2.0%	7	2.0%	26	1.6%
Non Hispanic: Amer Indian & AK Native	_	1.6%	5	1.6%	19	1.2%
Non Hispanic: Asian	1	5.4%	17	5.4%	216	13.5%
Non Hispanic: Hawaiian & Pacific Islander	1	9.6%	31	9.6%	186	11.6%
Non Hispanic: Other Race	-	0.2%	1	0.2%	4	0.3%
Non Hispanic: Two or More Races	3	20.5%	67	20.5%	380	23.8%
Hispanic or Latino Population	2	10.1%	37	10.1%	162	9.2%
Hispanic: White	-	19.4%	7	19.4%	29	17.6%
Hispanic: Black or African American	_	8.1%	3	8.1%	10	6.4%
Hispanic: American Indian & Alaska Native	-	1.9%	1	1.9%	2	1.5%
Hispanic: Asian	-	2.8%	1	2.8%	5	3.2%
Hispanic: Hawaiian & Pacific Islander	-	5.3%	2	5.3%	9	5.7%
Hispanic: Other Race	-	16.7%	6	16.7%	22	13.7%
Hispanic: Two or More Races	1	45.8%	17	45.8%	84	51.8%
Not of Hispanic Origin Population (1990)	5	92.3%	113	92.3%	891	93.4%
Hispanic Origin Population (1990)	-	7.7%	9	7.7%	63	6.6%
Not Hispanic or Latino Population (2000)	11	92.1%	248	92.1%	1,270	92.9%
Hispanic or Latino Population (2000)	1	7.9%	21	7.9%	97	7.1%
Not Hispanic or Latino Population 5yr (2015)	15	89.0%	351	89.0%	1,701	90.0%
Hispanic or Latino Population 5yr (2015)	2	11.0%	43	11.0%	190	10.0%
Historical Annual Change (1990-2000)	1	12.3%	12	12.3%	34	5.4%
Projected Annual Change (2000-2015)	1	6.9%	22	6.9%	93	6.4%

1990 - 2000 Census, 2010 Estimates with 2015 Projections *Calculated using Proportional Block Groups*



Kahakahakea Demographics	1 Mile		5 Miles		10 Miles	6
Age Distribution (2010)						
Total Population	16		361		1,756	
Age 0 to 4 yrs	1	5.9%	21	5.9%	106	6.0%
Age 5 to 9 yrs	1	6.2%	23	6.2%	113	6.4%
Age 10 to 14 yrs	1	5.5%	20	5.5%	104	5.9%
Age 15 to 19 yrs	1	5.8%	21	5.8%	113	6.4%
Age 20 to 24 yrs	1	3.3%	12	3.3%	71	4.0%
Age 25 to 29 yrs	1	4.6%	17	4.6%	82	4.7%
Age 30 to 34 yrs	1	5.2%	19	5.2%	100	5.7%
Age 35 to 39 yrs	1	5.9%	21	5.9%	102	5.8%
Age 40 to 44 yrs	1	6.1%	22	6.1%	97	5.5%
Age 45 to 49 yrs	1	7.4%	27	7.4%	116	6.6%
Age 50 to 54 yrs	2	9.6%	35	9.6%	147	8.4%
Age 55 to 59 yrs	2	10.7%	39	10.7%	178	10.2%
Age 60 to 64 yrs	1	9.0%	32	9.0%	156	8.9%
Age 65 to 69 yrs	1	6.6%	24	6.6%	111	6.3%
Age 70 to 74 yrs	1	3.8%	14	3.8%	69	3.9%
Age 75 to 79 yrs	-	2.3%	8	2.3%	47	2.7%
Age 80 to 84 yrs	-	1.1%	4	1.1%	21	1.2%
Age 85 yrs plus	-	1.0%	4	1.0%	23	1.3%
Median Age	ر 45.0	ırç	45 O v	45.0 <i>yrs</i>		ırs
Age 19 yrs or less	4	23.4%	85	23.4%	42.8 <i>y</i> 435	24.8%
Age 20 to 64 years	10	61.7%	223	61.7%	1,050	59.8%
Age 65 years Plus	2	14.9%	54	14.9%	271	15.4%
Female Age Distribution (2010)						
Female Population	7	46.6%	169	46.6%	837	47.7%
Age 0 to 4 yrs	, -	6.5%	11	6.5%	55	6.5%
Age 5 to 9 yrs	_	5.8%	10	5.8%	53	6.3%
Age 10 to 14 yrs	_	6.1%	10	6.1%	52	6.2%
Age 15 to 19 yrs	_	5.9%	10	5.9%	51	6.1%
Age 20 to 24 yrs	_	3.2%	5	3.2%	30	3.5%
Age 25 to 29 yrs	_	5.2%	9	5.2%	42	5.0%
Age 30 to 34 yrs	_	5.3%	9	5.3%	47	5.6%
Age 35 to 39 yrs	_	6.5%	11	6.5%	52	6.2%
Age 40 to 44 yrs	_	5.4%	9	5.4%	43	5.2%
Age 45 to 49 yrs	1	7.4%	13	7.4%	56	6.6%
Age 50 to 54 yrs	1	9.7%	16	9.7%	72	8.6%
Age 55 to 59 yrs	1	11.2%	19	11.2%	94	11.2%
Age 60 to 64 yrs	1	8.0%	13	8.0%	69	8.2%
Age 65 to 69 yrs	-	5.2%	9	5.2%	44	5.3%
Age 70 to 74 yrs	-	3.7%	6	3.7%	34	4.0%
Age 75 to 79 yrs	-	2.6%	4	2.6%	23	2.7%
Age 80 to 84 yrs	-	1.4%	2	1.4%	11	1.3%
Age 85 yrs plus	-	1.0%	2	1.0%	11	1.3%
Female Median Age	44.1)		44.1 <i>y</i>		43.2 <i>y</i>	
Age 19 yrs or less	2	24.2%	41	24.2%	211	25.2%
Age 20 to 64 years	5	61.9%	104	61.9%	504	60.2%
Age 65 years Plus	1	13.9%	23	13.9%	123	14.7%

1990 - 2000 Census, 2010 Estimates with 2015 Projections *Calculated using Proportional Block Groups*



Kahakahakea Demographics	4 881-			C Miles		•
	1 Mile		5 Miles		10 Mile	5
M A B: 4 4 (0040)						
Male Age Distribution (2010)	0	F2 40/	400	F2 40/	040	F2 20/
Male Population	9	53.4%	193	53.4%	919	52.3%
Age 0 to 4 yrs	-	5.4%	11	5.4%	51	5.6%
Age 5 to 9 yrs	1	6.6%	13	6.6%	60	6.5%
Age 10 to 14 yrs	-	5.0%	10	5.0%	52	5.6%
Age 15 to 19 yrs	-	5.7%	11	5.7%	62	6.7%
Age 20 to 24 yrs	-	3.4%	7	3.4%	41	4.5%
Age 25 to 29 yrs	-	4.0%	8	4.0%	41	4.4%
Age 30 to 34 yrs	-	5.1%	10	5.1%	53	5.8%
Age 35 to 39 yrs	-	5.4%	11	5.4%	50	5.4%
Age 40 to 44 yrs	1	6.8%	13	6.8%	54	5.9%
Age 45 to 49 yrs	1	7.3%	14	7.3%	61	6.6%
Age 50 to 54 yrs	1	9.6%	18	9.6%	75	8.1%
Age 55 to 59 yrs	1	10.2%	20	10.2%	84	9.2%
Age 60 to 64 yrs	1	9.8%	19	9.8%	88	9.5%
Age 65 to 69 yrs	1	7.8%	15	7.8%	67	7.2%
Age 70 to 74 yrs	-	4.0%	8	4.0%	35	3.8%
Age 75 to 79 yrs	-	2.0%	4	2.0%	24	2.7%
Age 80 to 84 yrs	-	0.9%	2	0.9%	10	1.1%
Age 85 yrs plus	-	1.1%	2	1.1%	12	1.3%
Male Median Age	45.8 y	rs	45.8	ITS .	42.7	rs .
Age 19 yrs or less	2	22.7%	44	22.7%	225	24.4%
Age 20 to 64 years	5	61.6%	119	61.6%	546	59.5%
Age 65 years Plus	1	15.7%	30	15.7%	148	16.1%
Males per 100 Females (2010)						
Overall Comparison	114		114		110	
Age 0 to 4 yrs	96	49.0%	96	49.0%	94	48.3%
Age 5 to 9 yrs	131	56.8%	131	56.8%	114	53.2%
Age 10 to 14 yrs	93	48.3%	93	48.3%	99	49.7%
Age 15 to 19 yrs	110	52.4%	110	52.4%	121	54.7%
Age 20 to 24 yrs	124	55.3%	124	55.3%	139	58.2%
Age 25 to 29 yrs	87	46.7%	87	46.7%	98	49.4%
Age 30 to 34 yrs	111	52.7%	111	52.7%	114	53.2%
Age 35 to 39 yrs	96	49.0%	96	49.0%	96	49.1%
Age 40 to 44 yrs	143	58.8%	143	58.8%	124	55.4%
Age 45 to 49 yrs	112	52.9%	112	52.9%	109	52.1%
Age 50 to 54 yrs	113	53.0%	113	53.0%	103	50.8%
Age 55 to 59 yrs	104	51.0%	104	51.0%	90	47.3%
Age 60 to 64 yrs	140	58.4%	140	58.4%	128	56.1%
Age 65 to 69 yrs	170	63.0%	170	63.0%	151	60.2%
Age 70 to 74 yrs	122	54.9%	122	54.9%	104	51.1%
Age 75 to 79 yrs	88	46.9%	88	46.9%	106	51.6%
Age 80 to 84 yrs	78	43.7%	78	43.8%	90	47.3%
Age 85 yrs plus	126	55.8%	126	55.8%	105	51.2%
Age 19 yrs or less	107	51.8%	107	51.8%	107	51.6%
Age 20 to 39 yrs	102	50.6%	102	50.6%	109	52.2%
Age 40 to 64 yrs	119	54.4%	119	54.4%	108	52.0%
Age 65 years Plus	130	56.5%	130	56.5%	120	54.6%

1990 - 2000 Census, 2010 Estimates with 2015 Projections *Calculated using Proportional Block Groups*



	1 Mile		5 Miles		10 Miles	
Household Type (2010)						
Total Households	7		158		718	
Households with Children	2	25.7%	41	25.7%	200	27.9%
Average Household Size	2.29		2.29		2.45	
Est. Household Density	2.22 p	osm	2.01 μ	osm	2.29 p	osm
Population Family	12	77.3%	279	77.3%	1,403	79.9%
Population Non-Family	4	22.7%	82	22.7%	353	20.19
Population Group Qtrs	-	-	-	-	-	
Family Households	4	59.0%	93	59.0%	441	61.59
Married Couple Hhlds	3	72.2%	67	72.2%	317	71.79
Other Family Hhlds	1	27.8%	26	27.8%	125	28.39
Family Households With Children	2	40.9%	38	40.9%	188	42.69
Married Couple With Children	1	57.9%	22	57.9%	112	59.79
Other Family Hhlds With Children	1	42.1%	16	42.1%	76	40.39
Family Households No Children	2	59.1%	55	59.1%	253	57.49
Married Couple No Children	2	82.0%	45	82.0%	204	80.79
Other Family Households No Children	-	18.0%	10	18.0%	49	19.39
Average Family Household Size Average Family Income	3.00		3.00		3.18	
Median Family Income	\$74,658 \$61,351		\$74,658 \$61,351		\$70,764 \$57,988	
-						
Non-Family Households	3	41.0%	65	41.0%	276	38.59
Non-Family Hhlds With Children	-	3.9%	3	3.9%	12	4.39
Non-Family Hhld No Children	3	96.1%	62	96.1%	264	95.79
N-F Hhld Lone Person No Children Lone Male Householder	2	75.5% 62.7%	49 31	75.5% 62.7%	214 126	77.59 58.79
Lone Female Householder	1	37.3%	18	37.3%	89	41.39
N-F Hhld 2+ Persons No Children	1	20.5%	13	20.5%	50	18.19
Average Non-Family Hhld Size	1.27	20.070	1.27	20.070	1.28	10.17
,						
Marital Status (2010)	40		000		4 400	
15 Years or Older)	13	2/1 10/	298	24 10/	1,433	JE J0
Never Married Now Married	3 6	24.1% 49.3%	72 147	24.1% 49.3%	362 718	25.29 50.19
Previously Married	3	26.7%	79	26.7%	354	24.79
Separated	1	20.7%	16	20.7%	74	21.09
Widowed	1	15.3%	12	15.3%	76	21.59
Divorced	2	64.0%	51	64.0%	203	57.49
Educational Attainment (2010)						
Adult Population (25 Years or Older)	12		265		1,250	
Elementary (0 to 8)	-	0.7%	2	0.7%	38	3.09
Some High School (9 to 11)	1	5.8%	15	5.8%	80	6.49
High School Graduate (12)	4	33.7%	89	33.7%	450	36.09
como (collogo (12 to 16)	3 1	28.3%	75 22	28.3%	320	25.69
Some College (13 to 16)	1	8.2%	22	8.2%	103	8.29
Associate Degree Only			11	16 00/	107	15.00
Associate Degree Only Bachelor Degree Only	2	16.8%	44 17	16.8%	187 74	15.09 5.09
Associate Degree Only			44 17 159	16.8% 6.6% 59.8%	187 74 683	15.09 5.99 54.69

1990 - 2000 Census, 2010 Estimates with 2015 Projections *Calculated using Proportional Block Groups*



Kahakahakea Demographics	1 Mile	5 Miles	10 Miles			
Housing (2010) Total Housing Units Housing Units, Occupied Housing Units, Owner-Occupied Housing Units, Renter-Occupied Housing Units, Vacant Total Housing Units (2000) Historical Annual Change (2000-2010)	10 7 68.7% 5 75.3% 2 24.7% 3 23.8% 7 3 4.6%	230 158 68.7% 119 75.3% 39 24.7% 72 23.8% 158 72 4.6%	1,002 718 71.6% 532 74.2% 185 25.8% 285 22.1% 710 293 4.1%			
Household Size (2010) Total Households 1 Person Household 2 Person Households 3 Person Households 4 Person Households 5 Person Households 6 Person Households 7+ Person Households	7 2 31.0% 3 40.7% 1 11.9% 1 8.0% - 4.8% - 1.5% - 2.1%	158 49 31.0% 64 40.7% 19 11.9% 13 8.0% 8 4.8% 2 1.5% 3 2.1%	718 214 29.8% 275 38.3% 88 12.2% 62 8.6% 40 5.6% 18 2.5% 21 2.9%			
Household Stability (2010) Total Households In current residence < 1 year In current residence 1-2 years In current residence 3-5 years In current residence 6-10 years In current residence > 10 years Turnover (% Annual Residential Turnover) Stability (% In Current Residence 5+ Years) Median Years in Residence	7 1 13.0% 3 45.4% 1 19.3% 1 10.8% 1 11.4% 13.0% 22.3% 2.6 yrs	158 20 13.0% 72 45.4% 30 19.3% 17 10.8% 18 11.4% 13.0% 22.3% 2.6 yrs	718 98 13.7% 313 43.6% 135 18.8% 79 11.1% 92 12.8% 13.7% 23.9% 2.7 yrs			
Household Vehicles (2010) Total Vehicles Available Household: 0 Vehicles Available Household: 1 Vehicles Available Household: 2 Vehicles Available Household: 3+ Vehicles Available Average Per Household Owner Occupied Hhlds Vehicles Average Per Owner Household Renter Occupied Hhlds Vehicles Average Per Renter Household	13 - 4.0% 2 32.9% 3 43.3% 1 19.8% 1.9 Vehicles 10 79.0% 2.0 Vehicles 3 21.0% 1.6 Vehicles	295 6 4.0% 52 32.9% 68 43.3% 31 19.8% 1.9 Vehicles 233 79.0% 2.0 Vehicles 62 21.0% 1.6 Vehicles	1,367 34 4.7% 234 32.6% 289 40.3% 160 22.3% 1.9 Vehicles 1,076 78.8% 2.0 Vehicles 290 21.2% 1.6 Vehicles			
Travel Time (2000) Worker Base (16 Years or Older) Travel to Work in 14 Minutes or Less Travel to Work in 15 to 29 Minutes Travel to Work in 30 to 59 Minutes Travel to Work in 60 Minutes or More Work at Home Average Travel Time to Work	4 1 20.8% - 10.8% 1 15.0% 2 43.1% - 10.3% 43.9 mins	96 20 20.8% 10 10.8% 14 15.0% 41 43.1% 10 10.3% 43.9 mins	469 118 25.3% 65 13.8% 66 14.0% 180 38.4% 40 8.5% 41.0 mins			

1990 - 2000 Census, 2010 Estimates with 2015 Projections *Calculated using Proportional Block Groups*



Kahakahakea Demographics								
	1 Mile	1 Mile		5 Miles		10 Miles		
Transportation To Work (2000)								
Work Base	4		96		469			
Drive to Work Alone	2	52.9%	51	52.9%	266	56.8%		
Drive to Work in Carpool	1	28.6%	28	28.6%	124	26.6%		
Travel to Work - Public Transportation	-	0.1%	-	0.1%	1	0.3%		
Drive to Work on Motorcycle	-	1.5%	1	1.5%	5	1.1%		
Bicycle to Work Walk to Work	-	3.8%	-	3.8%	-	4 4 0 /		
	-		4		22	4.6%		
Other Means Work at Home	-	2.8% 10.3%	3 10	2.8% 10.3%	10 40	2.1% 8.5%		
Daytime Demos (2010)								
Total Number of Businesses	-		2		17			
Total Number of Employees	-		6		98			
Company Headqtrs: Businesses	-	-	-	-	-	-		
Company Headqtrs: Employees	-	-	-	-	-	-		
Employee Population per Business	3.1 to	o 1	3.1 t	3.1 to 1		5.8 to 1		
Residential Population per Business	194.0 to	o 1	194.0 t	o 1	103.1 t	o 1		
Est. Adj. Daytime Demographics (Age16+)	7		147		796			
Labor Force (2010)								
Labor: Population Age 16+	13	=	294	=	1,412	= 40/		
Unemployment Rate	-	5.6%	450	5.6%	7.10	7.1%		
Labor Force Total: Males	7	53.9%	158	53.9%	746	52.8%		
Male civilian employed	4	52.6%	83	52.6%	388	52.0%		
Male civilian unemployed Males in Armed Forces	-	7.0%	11	7.0%	56 1	7.5% 0.2%		
Males not in labor force	3	40.4%	- 64	40.4%	300	40.2%		
Labor Force Total: Females	6	46.1%	135	46.1%	666	47.2%		
Female civilian employed	3	50.8%	69	50.8%	325	48.8%		
Female civilian unemployed	-	3.9%	5	3.9%	44	6.6%		
Females in Armed Forces	-	-	-	-	-	-		
Females not in labor force	3	45.2%	61	45.2%	297	44.6%		
Employment Force Change (2000-2010)	2	57.7%	56	57.7%	246	52.6%		
Male Change (2000-2010)	1	64.7%	33	64.7%	145	59.5%		
Female Change (2000-2010)	1	50.1%	23	50.1%	101	45.1%		
Occupation (2000)			00		407			
Occupation: Population Age 16+	4	E0 E0/	96 51	E2 E0/	467	EO 10/		
Occupation Total: Males Occupation Total: Females	2 2	52.5% 47.5%	51 46	52.5% 47.5%	243 224	52.1% 47.9%		
Mgmt, Business, & Financial Operations	1	11.9%	11	11.9%	49	10.4%		
Professional and Related	1	16.9%	16	16.9%	81	17.4%		
Service	1	19.9%	19	19.9%	88	18.9%		
Sales and Office	1	21.2%	20	21.2%	99	21.3%		
Farming, Fishing, & Forestry	-	3.8%	4	3.8%	31	6.7%		
Construction, Extraction, & Maintenance	1	18.0%	17	18.0%	76	16.2%		
Production, Transport, & Material Moving	-	8.3%	8	8.3%	43	9.1%		
White Collar		49.9%		49.9%		49.0%		
Blue Collar		50.1%		50.1%		51.0%		

1990 - 2000 Census, 2010 Estimates with 2015 Projections *Calculated using Proportional Block Groups*

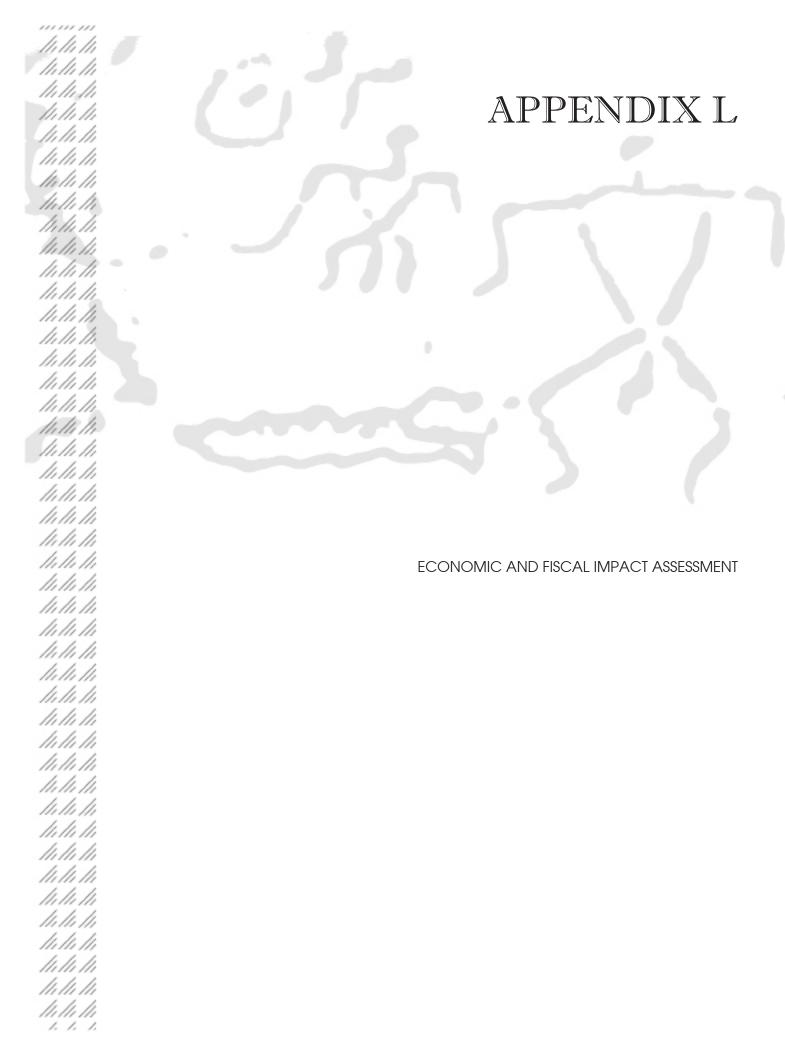


hakahakea Demographics 1 Mile			5 Miles		10 Miles		
Units In Structure (2000)							
Total Units	7		158		710		
1 Detached Unit	6	92.2%	145	92.2%	641	90.3%	
1 Attached Unit	-	3.8%	6	3.8%	30	4.2%	
2 Units	-	0.2%	_	0.2%	13	1.8%	
3 to 4 Units	-	-	-	-	2	0.2%	
5 to 9 Units	-	-	-	-	3	0.4%	
10 to 19 Units	-	-	-	-	-	-	
20 to 49 Units	-	-	-	-	-	-	
50 or more Units	-	0.5%	1	0.5%	3	0.4%	
Mobile Home or Trailer	-	0.8%	1	0.8%	5	0.7%	
Other Structure	-	2.6%	4	2.6%	14	2.0%	
Homes Built By Year (2000)							
Homes Built 1999 to 2000	-	4.2%	7	4.2%	25	3.5%	
Homes Built 1995 to 1998	1	18.3%	29	18.3%	109	15.4%	
Homes Built 1990 to 1994	2	26.9%	42	26.9%	157	22.1%	
Homes Built 1980 to 1989	2	33.4%	53	33.4%	194	27.3%	
Homes Built 1970 to 1979	1	11.0%	17	11.0%	80	11.2%	
Homes Built 1960 to 1969	-	4.2%	7	4.2%	42	5.9%	
Homes Built 1950 to 1959	-	-	-	-	24	3.4%	
Homes Built 1940 to 1949	-	0.6%	1	0.6%	32	4.4%	
Homes Built Before 1939	-	1.2%	2	1.2%	48	6.7%	
Median Age of Homes	ر 10.0	//S	ر 10.0	ITS	ر 17.7	rs	
Home Values (2000)							
Owner Specified Housing Units	3		75		352		
Home Values \$1,000,000 or More	-	0.9%	1	0.9%	3	0.7%	
Home Values \$750,000 to \$999,999	-	-	-	-	-	-	
Home Values \$500,000 to \$749,999	-	-	-	-	-	0.1%	
Home Values \$400,000 to \$499,999	-	-	-	-	-	0.1%	
Home Values \$300,000 to \$399,999	-	2.9%	2	2.9%	9	2.5%	
Home Values \$250,000 to \$299,999	-	0.4%	-	0.4%	2	0.7%	
Home Values \$200,000 to \$249,999	-	1.9%	1	1.9%	6	1.6%	
Home Values \$175,000 to \$199,999	-	5.1%	4	5.1%	16	4.5%	
Home Values \$150,000 to \$174,999	-	8.3%	6	8.3%	27	7.6%	
Home Values \$125,000 to \$149,999	-	11.4%	9	11.4%	36	10.2%	
Home Values \$100,000 to \$124,999	1	15.8%	12	15.8%	50	14.3%	
Home Values \$90,000 to \$99,999	-	7.2%	5	7.2%	24	6.7%	
Home Values \$80,000 to \$89,999	-	9.2%	7	9.2%	44	12.4%	
Home Values \$70,000 to \$79,999	-	5.2%	4	5.2%	27	7.7%	
Home Values \$60,000 to \$69,999	-	4.2%	3	4.2%	21	5.9%	
Home Values \$50,000 to \$59,999	-	6.4%	5	6.4%	23	6.6%	
Home Values \$35,000 to \$49,999	-	4.6%	3	4.6%	19	5.5%	
Home Values \$25,000 to \$34,999	-	4.0%	3	4.0%	12	3.5%	
Home Values \$10,000 to \$24,999	-	7.9%	6	7.9%	21	5.9%	
Home Values \$0 to \$9,999	-	4.6%	3	4.6%	12	3.5%	
Owner Occupied Median Home Value	\$95,546		\$95,546		\$94,360		
Renter Occupied Median Rent	\$357		\$357		\$322		

1990 - 2000 Census, 2010 Estimates with 2015 Projections *Calculated using Proportional Block Groups*



Kahakahakea Demographics	1 Mile		5 Miles		10 Mile	s
Consumer Expenditure (Annual Total) Total Household Expenditure (2010) Total Non-Retail Expenditures (2010) Total Retail Expenditures (2010)	\$340 K \$195 K \$145 K		\$7.71 M \$4.42 M \$3.29 M		\$34.8 M \$19.9 M \$14.8 M	
Apparel (2010) Contributions (2010) Education (2010) Entertainment (2010) Food And Beverages (2010) Furnishings And Equipment (2010) Gifts (2010) Health Care (2010) Household Operations (2010) Miscellaneous Expenses (2010) Personal Care (2010) Personal Insurance (2010) Reading (2010) Shelter (2010) Tobacco (2010) Transportation (2010) Utilities (2010)	\$16.3 K \$12.7 K \$8.25 K \$18.8 K \$52.5 K \$14.7 K \$9.05 K \$21.3 K \$12.0 K \$5.69 K \$4.94 K \$3.43 K \$1.12 K \$65.8 K \$2.29 K \$67.1 K \$24.0 K		\$369 K \$288 K \$187 K \$427 K \$1.19 M \$334 K \$205 K \$483 K \$273 K \$129 K \$112 K \$77.9 K \$25.4 K \$1.49 M \$51.9 K \$1.52 M \$545 K		\$1.66 M \$1.29 M \$833 K \$1.92 M \$5.38 M \$1.50 M \$916 K \$2.18 M \$1.23 M \$582 K \$506 K \$350 K \$114 K \$6.73 M \$237 K \$6.88 M \$2.47 M	
Consumer Expenditure (per Household per Month) Total Household Expenditure (2010) Total Non-Retail Expenditures (2010) Total Retail Expenditures (2010)	\$4,074 \$2,335 \$1,739	57.3% 42.7%	\$4,074 \$2,335 \$1,739	57.3% 42.7%	\$4,039 \$2,315 \$1,724	57.3% 42.7%
Apparel (2010) Contributions (2010) Education (2010) Entertainment (2010) Food And Beverages (2010) Furnishings And Equipment (2010) Gifts (2010) Health Care (2010) Household Operations (2010) Miscellaneous Expenses (2010) Personal Care (2010) Personal Insurance (2010) Reading (2010) Shelter (2010) Tobacco (2010) Transportation (2010)	\$195 \$152 \$99 \$226 \$629 \$176 \$108 \$255 \$144 \$68 \$59 \$41 \$13 \$789 \$27 \$804	4.8% 3.7% 2.4% 5.5% 15.4% 4.3% 2.7% 6.3% 3.5% 1.7% 1.5% 1.0% 0.3% 19.4% 0.7% 19.7%	\$195 \$152 \$99 \$226 \$629 \$176 \$108 \$255 \$144 \$68 \$59 \$41 \$13 \$789 \$27 \$804	4.8% 3.7% 2.4% 5.5% 15.4% 4.3% 2.7% 6.3% 3.5% 1.7% 1.5% 1.0% 0.3% 19.4% 0.7% 19.7%	\$193 \$150 \$97 \$223 \$625 \$174 \$106 \$253 \$142 \$68 \$59 \$41 \$13 \$781 \$28 \$798	4.8% 3.7% 2.4% 5.5% 15.5% 4.3% 2.6% 6.3% 3.5% 1.7% 1.5% 0.3% 19.3% 0.7% 19.8%



Economic Impact Analysis and Public Costs/Benefits Assessment of the

PROPOSED KAHUKU VILLAGE COMMUNITY

Kahuku, Kau, Hawaii



July 6, 2011

Mr. Aaron Eberhardt Nani Kahuku Aina, LLC c/o PBR Hawaii & Associates Inc. 1001 Bishop Street ASB Tower, Suite 650 Honolulu, Hawaii 96813

Sent via email: aeberhardt@hawaiiwdg.com

Economic Impact Analysis and Public Costs/Benefits Assessment of the Proposed Kahuku Village Community Kahuku, Kau, Hawaii

Dear Mr. Eberhardt:

At your request, we have completed a series of econometric analyses associated with Kahuku Village, a proposed master-planned community to be located on 2,100 acres in the Kau District of the Hawaii County, Hawaii. The mixed-use resort, residential and commercial project is to extend along approximately four miles of ocean frontage between Pohue Bay and Kakio, some seven miles makai of the Hawaii Belt Road, near the Ocean View community, ten miles north of Kalaeloa.

The development analyzed is envisioned as including 561 single family homes/lots, 489 multifamily units, 500 hotel rooms, up to 24 acres of commercial properties, an 18-hole golf course, VA hospital facility, and 50 acres of civic and park lands, situated adjacent to a 482 acre Hawaiian Heritage Village.

Based on market study, cost and planning input provided us, our study is comprised of two elements:

1. **Economic Impact Analysis**. To estimate the general and specific effects on the local economy which will result from the development of Kahuku Village, including: construction and long-term employment, wages and income; on-going business operations profits; end-user expenditures; and other regional monetary and employment effects. And, to quantify the de facto population of the project, and estimate household incomes and discretionary expenditures on and off-site.

ARBITRATION VALUATION AND MARKET STUDIES

SUITE 1350 1003 BISHOP STREET HONOLULU HAWAII 96813-6442

(808) 526-0444 FAX (808) 533-0347 email@hallstromgroup.com www.hallstromgroup.com Mr. Aaron Eberhardt July 6, 2011 Page 2

2. **Public Cost/Benefit Assessment**. To quantify the fiscal impact on the public purse arising from the subject project in regards to tax/fee revenues which will be received by the State of Hawaii and Hawaii County due to the project's actualization, versus the implied costs of providing needed governmental services to the population of the development on a per capita basis.

The pertinent results of our analysis are presented in the following summary report, which contains a series of tables and models with narrative describing our modeling perspective, methodology, identification of model variables and assumptions, and resulting conclusions.

As part of our investigation program, we have viewed the subject property, researched the economics and employment levels for West Hawaii construction and on-going operations for the resort, residential and commercial market sectors, interviewed knowledgeable developers and other parties active in the regional economy, reviewed government statistics, policies and publications, accessed on-line data bases, and compiled materials from published and private sources.

All conclusions presented herein are subject to the identified limiting conditions, assumptions and certifications of The Hallstrom Group, Inc., in addition to any others specifically set forth in the text. All work has been completed in conformance with the Code of Professional Ethics and Standards of Professional Appraisal Practice of the Appraisal Institute, and the Uniform Standards of Professional Appraisal Practice (USPAP).

We appreciate the opportunity to prepare these Economic Impact and Public Cost/Benefit Assessment analyses. Please contact us if further discussion or detail is required.

Respectfully submitted,

Som w. Helliday

THE HALLSTROM GROUP, INC.

Tom W. Holliday Senior Analyst

/as



Economic Impact Analysis, and Public Costs/Benefits Assessment of the

PROPOSED KAHUKU VILLAGE MASTER-PLANNED COMMUNITY

Located at Kahuku, Kau, Hawaii

Prepared for Nani Kahuku Aina, LLC

ARBITRATION VALUATION AND MARKET STUDIES

SUITE 1350 1003 BISHOP STREET HONOLULU HAWAII 96813-6442

(808) 526-0444 FAX (808) 533-0347 email@hallstromgroup.com www.hallstromgroup.com July 2011



ASSIGNMENT AND SUMMARY OF CONCLUSIONS

Assignment

The Hallstrom Appraisal Group, Inc. was retained to identify and quantify probable economic impacts associated with the proposed Kahuku Village community master plan in light of demand, pricing and absorption projections prepared by other trends. We address two basic study questions:

- 1. What will be the general/specific and direct/indirect economic impacts on the Big Island resulting from the undertaking of the subject development via employment, wages, business operations, population, and other economic activity related to the real property asset?
- 2. What will be the effect on the state and county "public purse" from the project in regards to costs of services required to service the Kahuku Village population versus increased primary tax/fee receipts?

These issues were quantified through a comprehensive research and inquiry process utilizing data from the market investigations, cost and employment experiences of recent major neighbor island developments, review of comparable hotel and commercial operating ledgers, materials from state and county governmental agencies, various Hawaii-based media sources, discussions with industry spokespersons, online databases, and published public and private documents.

These indicators were combined with our analysis of construction and operations of the various components of the proposed Kahuku Village master plan to generate a series of models depicting the decade-plus "lifespan" of the subject project from ground-breaking through build-out and the community reaching long-term stabilization.



Using the absorption/use and pricing/income estimated prepared by Colliers and Cassiday, the models forecast the major economic and demographic impacts resulting from the development, and the public costs/benefits associated with its services.

The cumulative projected economic and public fiscal impacts associated with the subject development during the anticipated 12-year build-out period and on an annual "stabilized" basis after construction is complete are summarized on Table 1.

All estimated dollar figures throughout our study are in constant 2011 dollars, with no appreciation, inflation or discounting.

The primary findings from our economic and public fiscal impact models are summarized later in this introductory section.

The body of the report is comprised of three chapters providing greater detail regarding our modeling process and outcome:

- 1. The Proposed Kahuku Village Community
- 2. Economic Impacts Analysis
- 3. Public Fiscal Impact (Costs/Benefits) Assessment

The presentation is focused around nine tables, the majority of which are annualized models depicting the construction, absorption and "stabilization" of the Kahuku Village Community from commencement of development activity "pre-2016" to final build-out in 2027.

It is noted study details beyond those presented in the narrative are contained in the footnotes for each table.

Our models are built upon planning and market studies completed by others, including;

SUMMARY COMPARISON OF MAJOR ECONOMIC IMPACTS AND PUBLIC FISCAL COSTS/BENEFITS Economic Impact Analysis of the Proposed Kahuku Village Master Plan <u>Kahuku, Kau, Hawaii</u> All Amounts Expressed in Constant, Uninflated 2011 Dollars

Analysis Item	Cumulative During 13-Year Build-Out/Absorption Period	Stabilized Annually Thereafter
Direct Capital Investment	\$1,107,002,769	
Local Contractor's Profits	\$110,700,277	
Local Supplier's Profits	\$44,280,111	
Worker Years of Jobs	19,356	1,937
Employee Wages	\$736,503,772	\$59,253,205
De Facto Resident/Guest Population		2,685
Full-Time Resident Household Income	\$230,643,330	\$40,285,697
Owners/Guest Expenditures (On & Off Site)	\$1,277,462,490	\$181,776,610
Total Operating Gross Receipts	\$1,867,512,970	\$292,660,940
Outside Patronage Expenditures	\$296,702,850	\$46,478,790
Total Big Island "Base" Economic Impact	\$2,798,168,109	\$275,462,200
County of Hawaii Gross Tax Receipts	\$118,295,355	\$16,681,755
State of Hawaii Gross Tax Receipts	\$223,077,103	\$22,733,314
County of Hawaii Costs of Services (per capita basis)	\$45,123,206	\$6,833,179
State Costs of Services (per capita basis)	\$148,478,001	\$22,484,591
County of Hawaii Net Benefits or (Loss)	\$73,172,149	\$9,848,576
State Net Benefits or (Loss)	\$74,599,103	\$248,724

Source: The Hallstrom Group, Inc.



- "Conceptual Master Plan, Kahuku Village", PBR Hawaii, Inc., January 20, 2011, and associated Land Use Summary, Phasing and other materials.
- "Kahuku Village Commercial Market Assessment Retail Demand Analysis", Colliers Monroe Friedlander Consulting, February 7, 2011.
- "Kahuku Village Market Study", Ricky Cassiday, 2010.

Additional inputs were also provided by other development team members, consultants retained for preparation of the Environmental Assessments/Impact Statement, and from Nani Kahuku Aina, LLC principals.

These studies and inputs provided the estimates for demand/absorption of the various components, their pricing parameters, commercial space patronage and sales, infrastructure costs, and numerous other model variables.

Data points were also taken from public agency materials and websites such as:

- The US 2010 Census.
- The State of Hawaii Departments of Labor & Industrial Relations; Business, Economic Development & Tourism; and Budget & Finance.
- The County of Hawaii Departments of Real Property Tax Assessment, Finance, and Housing.

Our experience with major projects in Hawaii, interviews with developers/builders and business persons, accumulated market-based data, and case studies, provided insight into employee requirements for the constituent use types, profit margins, and operating levels.



We have not completed any market studies for the proposed subject. For those uses which were not covered by studies prepared by others (as cited foregoing), such as the envisioned Hawaiian Heritage Village, VA Medical facility and the two hotels, we have made moderate allowances based on the best available data, which was then reviewed and "approved" for use by the client and development team.

Economic Impacts from Development

Kahuku Village will generate more than \$1.107 billion in capital investment into the Big Island economy during the projected 12-year build-out period, including \$151.2 million in project infrastructure, \$659.8 million in residential construction, and \$295.9 million in hotel, commercial and other facilities.

Annual development expenditures range from \$8.2 million to a peak of \$156.4 million, averaging \$85.1 million per year.

Profits to local contractors are projected at \$111 million and \$44 million to local suppliers.

On-site construction employment will total 5,104 "worker years" during build-out, averaging 393 full-time-equivalent (FTE) positions annually.

From the commencement of operations of the Hawaiian Heritage Village in 2016 through completion of the project in 2027, there will be 10,380 years of FTE employment created by the village, hotels, golf course, commercial businesses, residential units and central facilities.

After completion, the community will support some 1,509 FTE employment positions on-site on a stabilized basis.

Off-site/secondary employment will total 3,871 years of FTE positions during build-out and 387 on-going in support of the subject community.



A total of \$295.3 million in wages is projected to be paid to construction (and associated) workers from start of development "pre-2016" through 2027.

On-going business employee wages are forecast to total \$305.3 million during the build-out period and \$45.6 million annually thereafter.

Off-site employee wages are estimated at \$135.9 million 2016-2027, and at \$13.6 million per year once stabilization is reached.

The total resident population of Kahuku Village upon build-out is projected to be 1,075 persons. Non-residents, including hotel/Heritage Village/TVR guests and vacation/second-home owners, are estimated to total 1,610 persons, resulting in a total de facto population for the project of 2,685 persons.

Resident household income upon completion of the subject is projected at \$40.3 million, and the total amount of "Discretionary Expenditures" by all members of the community's population is forecast to total \$125.4 million per year in 2027 and beyond.

Operating economic activity, the cumulative gross revenues flowing to Kahuku Village's on-going businesses, is projected to total \$1.285 billion during the build-out period and stabilize at \$208.2 million annually. Primary components include:

- Hawaiian Heritage Village -- \$8.7 million in gross revenues per year.
- **Hotels** -- \$105.1 million.
- **Commercial Businesses** -- \$99.0 million.
- Transient Vacation Rentals (TVRs) -- \$34.3 million.
- VA Facility -- \$39.0 million.



An estimated 84 percent of the economic activity will be via spending by residents and guests of the subject community (the "de facto population"), or \$246.2 million per year on a stabilized basis, with the other 16 percent, \$46.5 million annually going-forward after build-out, spent by others from off-site coming into the village.

The cumulative economic impact associated with the 13-year construction period ("pre-2016" through 2027) of Kahuku Village is estimated to total \$1.87 billion, and at \$292.7 million per year after build-out and stabilization of the community.

Primary Public Fiscal Impacts

At build-out the value of the privately-owned real estate of Kahuku Village for Real Property Tax Assessment purposes is projected to be \$1.855 billion (excluding the non-profit heritage village and VA Medical facility components), divided as follows:

- Hotel, Commercial and Golf Course Properties -- \$361 million.
- Single Family Residential Homes -- \$1.20 billion.
- Multifamily Residential Units -- \$293 million.

Utilizing current tax rates (including allowances for homeowner rates), the County of Hawaii will receive some \$112.6 million in real property tax receipts during the 2016-2027 construction period of the project, and annual collections of \$15.9 million on a stabilized basis thereafter.

The county will also receive 8.33 percent of the Transient Accommodation Tax collected on the 500 hotel rooms, 157 TVRs, and 100 heritage village "tentalows". These taxes, divided between the state and counties, will total \$68.5 million during the 13 years of build-out, and \$9.3 million per year on a stabilized basis.



Total primary county tax receipts will cumulatively add to \$118.3 million while the Village is being constructed and total some \$16.7 million per year in 2027 and beyond.

The county will additionally receive fees and levies associated with entitlement conditions, permitting, inspections and other secondary/minor items.

The State of Hawaii will receive primary taxes from several sources, including:

- 1. **Income Taxes** from employee wages, resident household incomes, and business/corporate profits, projected to total \$58.2 million during build-out and stabilize at \$6.4 million annually thereafter.
- 2. **Gross Excise Tax** on all construction costs, on-going business activity within the Village, resort rentals, and off-site discretionary expenditures by the community's population, estimated at \$127.1 million from pre-2016 through 2027 and circa \$10.8 million per year upon stabilization.
- 3. 55.20 percent of the **Transient Accommodation Tax**, quantified foregoing.

Total primary state tax receipts will cumulatively add to \$223.01 million while the Village is being constructed and total more than \$22.5 million per year in 2027 and beyond.

In estimating the costs of providing county and state services to the population of Kahuku Village, we have adopted an equitable "per capita contribution" perspective, wherein it is assumed the cost to the county and state to provide services to the subject de facto population will be the same as the current average cost for providing services to all the existing population on a per person basis.



This is a conservative method, as the "actual" costs of additional services required as a result of the development will likely be well less than "per capita contribution" estimates, given the development will be new, modern, with private security, private infrastructure systems, parks and civic facilities, access to proximate emergency health care services, and other centralized community services.

The County of Hawaii will expend approximately \$2,545 per person of de facto population on the island in 2011-12, including operating and capital costs. The state will spend some \$8,373 per de facto person in Hawaii (residents and visitors).

During the 12-year construction and absorption period, the county will spend about \$45.1 million on services to the subject project on a per capita allowance basis; the state, an estimated \$148.5 million. Once the community is built-out and fully populated, the county will spend \$6.8 million per year and the state \$22.5 million annually.

The county will generate a net fiscal "profit" (tax receipts exceeding per capita expenditures) of \$73.2 million during the construction period, and \$9.8 million per year in 2027 and beyond.

The state will show a net profit from Kahuku Village of \$74.6 million from pre-2016 through 2027, stabilizing around \$250,000 annually thereafter.

THE PROPOSED PROJECT

Our economic impact analysis and public fiscal assessment modeling of the proposed Kahuku Village development, from ground-breaking through build-out, is based on the following Land Use Summary.



KAHUKU VILLAGE CONCEPTUAL PLAN LAND USE SUMMARY

MIXED-USE VILLAGE	Concept Plan						
MIXED-USE VILLAGE	Аррі	. Acres	Appr. Units				
R-X: Single Family (15,000 sf)	±	55	135				
R-1: Oceanfront / Preserve Lots (1+ acres)	<u>+</u>	84	60				
R-2: Golf Estates (1.5 - 2 acres)	<u>+</u>	483	291				
R-3: Estates (2+ acres)	<u>+</u>	180	75				
MF-1: Oceanfront Condo / Fractional	±	40	140				
MF-2: Golf Villas (4-5 du/acre)	±	50	180				
VMX: Village Mixed-use	±	38	169				
Visitor Accomodation Units	±	75	500				
Village Green	±	2	-				
Commercial	±	24	=1				
Civic	±	9	-				
VA Facility	<u>+</u>	45	-				
Community Parks	±	40	=				
18-hole Golf Course and Clubhouse	<u>+</u>	330	121				
Hawaiian Heritage Village (with Eco-Lodge)	<u>±</u>	482	100				
Subtotal	±	1,937	1,650				
CIVIC USE LANDS							
District Park	±	37	-				
- Community Center / Multi-use Facility			-				
- Active Play Fields			-				
- Picnic Areas			-				
Elementary School	<u>±</u>	12	-				
Police / Fire / Civic	±	7	=				
Emergency Medical Facility	<u>±</u>	4	-				
Farmer's Market / Other Uses	±	3	-				
Rodeo Ground	±	25	-				
Steep Slopes / Open Space	±	37	-				
Subtotal	±	125	(-				
SAY	2,10	00 ac.	1,650 units				

It is assumed the construction will be undertaken in four consecutive three-year "phases", with the incremental infrastructure providing inventory as market absorption progresses over time.

Overall densities will be low; the majority of residential and resort product upscale; commercial activities will be oriented towards Kahuku Village residents and guests, nearby local residents, and other tourists visiting the community. The



Hawaiian Heritage Village and VA Medical center will provide unique facilities which will also add substantially to the economic impact of the subject project and its standing in the region.

The Cassiday market study concluded that approximately onethird of the residential units, including the approximately 300 units meeting affordable-pricing guidelines, will be purchased by resident households. The remaining two-thirds of the inventory were projected as being oriented towards off-shore buyers at upper-end prices comparable to those found in other West Hawaii vacation communities.

Colliers Monroe Friedlander Consulting (CMFC) opined the Hawaiian Heritage Village would attract some 1,980 visitors daily upon stabilization, in addition to researchers and those staying overnight at the facility; the hotels would host 360 non-overnight dinners and shoppers each day; and, the golf course 360 players and visitors. And, another 1,500 would enter Kahuku Village for beach and park access and other recreational opportunities.

They also projected commercial sales in the community at ranging up to \$450 per square foot of leasable area, with patronage comprised of nearly 7,200 persons daily; a mix of residents, guests, nearby households and "transients". We note the master plan includes more commercial space than covered by the CMFC study, and we spread their sales estimates over the additional space.

The developer envisions hotels of four-plus to five stars in quality, generating commensurate Average Daily Rates and overall revenues. The golf course will be a "private daily fee" complex having an expansive 18-hole championship resort layout with pro shop and club house.

Upon completion and stabilization, Kahuku Village will be an "intermediate-size" resort/residential community, representing the largest ever focused capital investment, employment-generator and urban enclave in Kau. It will provide a broad-spectrum of product, use and business types (and associated



economic opportunities) to a presently under-serviced region of the island.

Cassiday and developer estimates are that the entire project will require approximately twelve years to be fully absorbed by the market, with some initial work commencing "pre-2016", and primary construction and sales running from 2016 through 2027. At build-out, the population (resident, guest and transient visitors) and operations (all components) will be going-forward at stabilized levels.

Our economic impact and public fiscal costs/benefits models were developed based upon the identified master plan, the market studies completed by others (including their absorption, pricing and operational estimates), and representations made by the developer and PBR Hawaii; and depict the Kahuku Village community from ground-breaking to build-out and stabilization.

The subsequent chapters of the report summarize the variables/inputs forming the models (and where applicable their source), brief discussion on pertinent issues, and the conclusions resulting from their application.

All values are expressed in constant 2011 dollars, with no appreciation, escalations, inflation or discounting used. We note, even were the absorption time-frame to extend longer than 12 years (2016-2027), the stabilized population, operational and fiscal indicators would remain the same as concluded herein.

ECONOMIC IMPACTS OF THE PROPOSED DEVELOPMENT

The development of Kahuku Village will create significant expenditures that will favorably impact the Big Island economy on both a direct and indirect basis, increasing the level of <u>capital investment</u> and <u>capital flow</u> in the region, which will in turn create employment and widen the tax base.



From a direct perspective, the proposed 560 single-family homes, 489 multi-family units, two hotels (500 total rooms), golf course facility, 220,000 square foot of commercial space, VA Medical Facility and Hawaiian Heritage Village, will create numerous construction, equipment operator and specialty trade jobs on- and off-site, directly and indirectly, during the planning and emplacement of the infrastructure, and building of the improvements.

After completion of the common systems, vertical construction, support facilities and amenities over a multi-phase, 12-year development period, there will be permanent employment positions created by the hotels, hospital, heritage center, golf course/clubhouse, and commercial operations and the buildings themselves (landscape, service, maintenance, and renovation needs in the course of their use).

Numerous local businesses will see significant profit opportunities arising for contracting companies constructing the improvements, and for local businesses which would supply a substantial portion of the materials needed in the building efforts.

The island's economy also will benefit from the subject development, as its residents, guests, employees, businesses, non-resident owners/users, transient day visitors, and nearby households spend large amounts of discretionary income in on and off-site shops, restaurants, and service establishments throughout Hawaii County, and in purchasing goods and services. Non-residents owners, users and hotel guests will be generally upper-income and have daily expenditures comparable with those found at Hawaii's more upscale vacation communities.

Indirectly, as these wages, profits, and expenditures move through the regional economy, they will have a ripple, or "multiplier," effect--increasing the amount of capital flowing to the entire community resulting from the development of the subject.



Construction, operational and other workers earning wages via Kahuku Village development and associated off-site/supporting efforts will spend the majority of their income on living and entertainment expenses while supporting and patronizing other island businesses. Much of this spending would be re-directed by these businesses to other island industries, and significant portions of these secondary profits would in turn be put back through the region's economic and tax structure.

Substantial <u>direct</u> and <u>indirect</u> economic impacts associated with the proposed subject project, as quantified in the following sections, are all the result of the capital investment and entrepreneurship necessary to convert undeveloped, mostly poor quality (lave strewn) lands into a low intensity diverse resort-residential community. The Big Island economy will be meaningfully stimulated by the capital investments, population/user spending and business operations of the development.

As previously noted, our economic modeling is based on a 12-year build-out and absorption period as projected by Cassiday and the developer. The vertical home construction may take longer if large numbers of house lots are sold instead of finished homes. However, whether full development takes 12 or 25 years, the stabilized "operation" of the community and its de facto population will be the same following completion. As constant, uninflated 2011 dollars are used throughout the model, time is not a significant variable in the analysis.

It is anticipated that final approvals, surveys, planning and engineering will require approximately four years (into 2015), with some basic site work, infrastructure and the initial Hawaiian Heritage Village complex beginning towards the end of this period.

The first major phase of infrastructure completion, vertical construction, and product sales would commence in 2016, and last approximately three years. Three subsequent three-year phases (2018-21, 2022-24, and 2025-27) would follow in an unbroken cycle providing infrastructure-serviced development



pods for additional residential, commercial and other product as the demand arose.

The first "closings" of residential units would occur in 2016, the first commercial spaces would be finished in 2017, and the initial hotel and golf course in 2018. With the exception of the final 58 residential units, all of the other elements of the community are projected to be built-out by the end of the third phase (2024).

Capital Investment and Construction Costs

The subject will bring an estimated \$1.107 billion in direct development capital into the Big Island over the build-out period for the project, as summarized on Table 2 previously presented.

<u>Infrastructure</u> cost estimates prepared for Nani Kahuku Aina LLC are forecast at \$151.21 million.

The <u>Hawaiian Heritage Village</u> was projected to have direct costs to build of \$11.0 million, comprised of 10,000 square feet of total floor space (visitor center, research, gift shop and support areas) at \$250 per square foot; 100 "tentalows" transient units at \$75,000 each; and, \$1 million for other site improvements.

The <u>golf course and clubhouse</u> facilities were estimated at \$21.0 million based on the actual expenses to build Hawaii courses in recent years.

<u>Hotel</u> construction was estimated to total \$158 million, assuming two 250 room hotels; one of four-plus stars quality with a total floor area of 187,500 square feet and all-in construction costs of \$375 per square foot; and, a five-star facility, with a total floor area of 206,250 square feet and all-in costs of \$425 per square foot.

<u>Commercial</u> construction is estimated to cost \$78 million total, all-in including any tenant allowances, which is based on a figure of \$325 per square foot overall for the 220,000 square feet of space proposed for the 24 acres of sites in the Village center.

PROPOSED PHASED DEVELOPMENT SCHEDULE AND ESTIMATED CONSTRUCTION COSTS Economic Impact Analysis of the Proposed Kahuku Village Master Plan

Kahuku, Kau, Hawai

_												Totals .		
		Phase				Phase II			Phase III			Phase IV		Totals
=	Pre-2016	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	
Infrastructure Emplacement (1)	\$64,323,472	\$32,161,543		\$16,819,754	\$8,408,616		\$14,550,888	\$7,274,352		\$3,836,498	\$3,836,498			\$151,211,621
Hawaiian Heritage Village (2)	\$11,000,000													\$11,000,000
Golf Course (3)			\$14,000,070	\$6,999,930										\$21,000,000
Hotel Construction (4)			\$43,828,125	\$43,828,125		\$35,156,250	\$35,156,250							\$157,968,750
Commercial Construction (5)		\$6,500,000	\$6,500,000		\$16,250,000	\$16,250,000		\$16,250,000	\$16,250,000					\$78,000,000
VA Facility (6)								\$9,333,332	\$9,333,332	\$9,333,332				\$27,999,997
Residential Product														
R-X														
Number of Homes Sold		10	10	10	13	13	13	21	22	22				134
Cumulative Construction Cost		\$2,499,000	\$2,499,000	\$2,499,000	\$3,248,700	\$3,248,700	\$3,248,700	\$5,247,900	\$5,497,800	\$5,497,800				\$33,486,600
R-1														
Number of Homes Sold		8	10	10				10	11	11				60
Cumulative Construction Cost		\$11,022,000	\$13,777,500	\$13,777,500				\$13,777,500	\$15,155,250	\$15,155,250				\$82,665,000
R-2														
Number of Homes Sold		2	2	3	36	37	37	58	58	58				291
Cumulative Construction Cost		\$2,371,200	\$2,371,200	\$3,556,800	\$42,681,600	\$43,867,200	\$43,867,200	\$68,764,800	\$68,764,800	\$68,764,800				\$345,009,600
R-3														
Number of Homes Sold		3	4	4	8	9	9				12	13	13	75
Cumulative Construction Cost		\$1,663,200	\$2,217,600	\$2,217,600	\$4,435,200	\$4,989,600	\$4,989,600				\$6,652,800	\$7,207,200	\$7,207,200	\$41,580,000
MF-1														
Number of Units Sold					18	18	19	28	28	29				140
Cumulative Construction Cost					\$9,817,200	\$9,817,200	\$10,362,600	\$15,271,200	\$15,271,200	\$15,816,600				\$76,356,000
MF-2														
Number of Units Sold					16	17	17	43	43	44				180
Cumulative Construction Cost					\$5,030,400	\$5,344,800	\$5,344,800	\$13,519,200	\$13,519,200	\$13,833,600				\$56,592,000
VMX														
Number of Units Sold								49	50	50	6	7	7	169
Cumulative Construction Cost								\$6,997,200	\$7,140,000	\$7,140,000	\$856,800	\$999,600	\$999,600	\$24,133,200
TOTAL HOMES/UNITS SOLD		23	26	27	91	94	95	209	212	214	18	20	20	1,049
Cumulative Residential Constructio	n Costs	\$17,555,400	\$20,865,300	\$22,050,900	\$65,213,100	\$67,267,500	\$67,812,900	\$123,577,800	\$125,348,250	\$126,208,050	\$7,509,600	\$8,206,800	\$8,206,800	\$659,822,400
TOTAL ANNUAL CONSTRUCTION CO:	\$75,323,472	\$56,216,943	\$85,193,495	\$89,698,709	\$89,871,716	\$118,673,750	\$117,520,038	\$156,435,485	\$150,931,582	\$139,377,880	\$11,346,098	\$8,206,800	\$8,206,800	\$1,107,002,769
	A7 500 04-	AT (04 (0)	40.540.055	*0.040.07	40.007.477	444.07.0	444 7F0 0F :	045 / 40 5/5	A45 000 455	A40.007.70-	44.404.44-	4000 405	4000 /	4440 700
Contractor Profits	\$7,532,347	\$5,621,694	\$8,519,350	\$8,969,871	\$8,987,172	\$11,867,375	\$11,752,004	\$15,643,548	\$15,093,158	\$13,937,788	\$1,134,610	\$820,680	\$820,680	\$110,700,277
Supplier Profits	\$3,012,939	\$2,248,678	\$3,407,740	\$3,587,948	\$3,594,869	\$4,746,950	\$4,700,802	\$6,257,419	\$6,037,263	\$5,575,115	\$453,844	\$328,272	\$328,272	\$44,280,111

⁽¹⁾ Assumes three-years for Phase I, 18 months for Phases II & III, and one-year for Phase IV. The timing of each phase of construction will allow the phase to be completed in first year of each phase period.

Source: PBR Hawaii, Colliers Monroe Friedlander, Rick Cassiday, and The Hallstrom Group, Inc.

⁽²⁾ Assumes 10,000 square feet of floor space (visitors center, gift shop, support areas) at \$250 per square foot, plus 100 "tentalows" at \$75,000 each, plus \$1 million allowance for other site improvements.

⁽³⁾ Estimated construction cost of \$18 million for course and \$3 million for clubhouse. 18 month total construction period.

⁽⁴⁾ Assumes one four-plus and one five-star, full-service facilities with 250 guest rooms each, and total floor space of 750/825 square feet per room, at cost of \$375/\$425 per square foot "all-in", including F,F&E.

Or, \$70.3 million for the four-star hotel and \$87.7 million for the five-star hotel. Construction to require two years and timed for hotel to be completed in initial year of its development phase.

⁽⁵⁾ Assumes Floor Area Ratio of .23, or 10,000 square feet of finished space per site acre. "All-in" development cost of \$325 per square foot, or \$3,250,000 per acre. One-year construction period per project.

⁽⁶⁾ Assumes 130-bed facility with floor area of 45,000 square feet and "all-in" development cost of \$400 per square foot, including general F,F&E but not specialized equipment.



The VA Medical complex is assumed to be a moderate-sized facility, with 130 beds and a total floor area of 45,000 square feet. Construction costs are allocated at \$400 per square foot all-in, including general furnishings, fixtures and equipment, but excluding specialized medical equipment.

<u>Unit/Home construction costs</u> would total \$659.8 million during modeling period. This is based on average total (direct and indirect) vertical construction costs per unit of, by product-type:

- R-X -- \$249,000 per unit, with an average unit size of 1,190 square feet and total costs of \$210 per square foot.
- R-1 -- \$1,377,750 per unit, with an average unit size of 4,175 square feet and total costs of \$330 per square foot.
- R-2 -- \$1,185,600 per unit, with an average unit size of 3,800 square feet and total costs of \$312 per square foot.
- R-3 -- \$554,400 per unit, with an average unit size of 2,200 square feet and total costs of \$252 per square foot.
- MF-1 -- \$545,400 per unit, with an average unit size of 2,020 square feet and total costs of \$270 per square foot.
- MF-2 -- \$314,400 per unit, with an average unit size of 1,310 square feet and total costs of \$240 per square foot.
- VMX -- \$142,800 per unit, with an average unit size of 680 square feet and total costs of \$210 per square foot.

The estimates include basic site work and landscaping, but exclude allowances for the underlying land costs and common element emplacement expenses (where applicable).

Kahuku Village development will infuse on average an anticipated \$85.2 million annually into the Big Island building industry on average over the build-out period; with a peak of \$156.4 million in development year 8 (2022). This will provide a significant near to mid-term boost for the construction trades,



which have been hit particularly hard during the current recession.

Direct Business Profits from Construction

While a significant percentage of the materials needed to build the subject infrastructure and the resort, residential and commercial structures must be imported to Hawaii, a portion of the construction costs spent in the development will directly flow to local businesses in the form of contractor profits and supplier profits.

Typically, within the industry net contractor profit margins are expected to be at 8 to 20 percent of total construction costs. We have used a conservative ten percent figure. Supplier profits were extrapolated at four percent of total costs. The estimates were shown along the bottom of Table 2.

The total <u>Contractor's Profit</u> generated by Kahuku Village for local building companies ranges from \$820,000 to \$15.6 million per year, with a cumulative profit of \$110.7 million during the pre-2016 through 2027 construction period. The total annual <u>Supplier's Profit</u> ranges from a low of \$329,000 to a high of \$6.3 million, and equates to \$44.3 million in aggregate.

Employment Opportunities Created

Based on indicators provided by the construction of comparable sized projects and Hawaii industry averages, we have estimated the demand for on- and off-site, direct and indirect, full-time equivalent employment positions associated with laying of initial infrastructure systems, construction of the resort, residential, commercial and other spaces, the on-going businesses in the project, and in providing continuing services to the occupied buildings.

The construction, maintenance and indirect/off-site employment opportunities created by the subject development will not be "new" jobs requiring new Big Island residents but will be vitally needed new opportunities for in-place resident construction trade workers and existing local businesses.



The jobs associated with the Hawaiian Heritage Village, hotels, golf, commercial, VA Medical center, and owners association operations will represent an expansion of the employment pool; although, a few tenants in the commercial centers may be relocating from elsewhere and not generate "new" positions.

It is assumed the off-site/indirect work created will be steered towards existing Big Island supply, equipment providers, and other service companies, which are experiencing a "lean" period following the large scale development activity which peaked in 2007 and has been subsequently slow.

In this regard, the combination of employment types generated by the subject development with some going to support existing businesses and a substantial number of new employment opportunities, is strongly needed in Kau, one of the most "jobpoor" districts in the Hawaiian Islands which was hit hard by the 2008-09 and is experiencing marginal recovery since..

Overall, unemployment on the island was at 9.2 percent in May 2011, down one-half point from the 9.7 percent of the year prior (which was among the highest levels in this generation). The rate is the highest among the major islands apart from Molokai, and its one-half point more than the national average of 8.7 percent.

Although there are insufficient data for completing detailed regional rates, it is estimated the unemployment rate in Kau is as much as twice the island-wide average.

The gains from a year ago indicate some job growth is occurring, but many employers are reluctant to add payroll until there are more definite signs of recovery in the local economy, and are continuing to staff at reduced levels.

There is a need to both bolster existing companies so they can recover "lost" jobs and to provide new employment for the overall health and natural growth of the community. Each year on the Big Island some 1,700 youths turn 18 and become potential entrants into the workforce, with most requiring either a job opportunity or facing out-migration.



Our employment estimates on are based on full-time "worker-years," although one worker-year (or circa 2,080 working hours) may be comprised of many employees involved in specialized construction tasks of a much shorter duration.

Our projections are founded on examples provided by various resort/residential developments undertaken on the neighbor islands over the past decade, and via formulae expressing relationships between total worker wages/benefits and construction task costs.

<u>Infrastructure</u> and <u>golf course</u> construction employment forecasts are taken from discussions with developers, review of project records and ratios of direct costs to job creation, which currently project one worker-year for every \$400,000 in development costs expended for a project of this quality, type and complexity. The ratio of job creation to costs is relatively low for these components due to the high equipment, materials and systems expenses associated with major site work.

Resort, residential, commercial and other vertical constructions, which are more labor intensive in regards to overall costs, are anticipated to require one worker-year per \$200,000 in construction expenses.

The <u>Hawaiian Heritage Village</u> is estimated to have one employment position for every 400 square feet of gross floor area (including researchers) and one worker for every five tenatlows. This is a general allocation as the extent of the center and its demand for workers is not yet finalized.

Golf operations are estimated at 40 full-time equivalent positions encompassing the pro shop, bar & grill employees, starter/range personnel, course and equipment maintenance, and management, based on the experience of similar quality neighbor island facilities.

The five-star <u>hotel</u> is estimated to require .9 full-time equivalent position for every guest room, and the four-plus star facility .7 workers per room.



<u>Commercial operations</u> in the various centers are forecast to generate one FTE for every 400 square feet of gross floor area.

The <u>VA Medical</u> complex assumes 2.2 FTE per bed; a modest allowance based upon the experience of similar-sized suburban and rural hospitals. Should the center provide specialty services, research facilities or be a training hospital, employment counts could double (or more).

The finished homes, condominium units and community assets will require <u>maintenance</u>, landscaping, service, and renovation and repair workers, rental agents and cleaning personnel for <u>transient units</u> and <u>common element staff</u>. We project centralized community management and upkeep personnel of seven workers, with maintenance and common element staff at the equivalent of two FTE workers for every 15 completed residential units.

<u>Off-site employees</u> were estimated at 25 percent of on-site workers, and are comprised of three groups:

- Off-site building/trade industry positions will be enhanced by the subject development, including such jobs as administration, office help, material providers, equipment maintenance and specialty tasks.
- Off-site support businesses, including contractor/retail/counter sales, fuel providers, shipping, storage and professional services will also benefit.
- Each on-site worker creates demand for services (and related employment) during and directly attributable to the work day. These positions include food businesses, providers of tools and trade goods, payroll/financial and insurance businesses, medical requirements and other secondary indirect/off-site employment.

Application of these ratios to the proposed Kahuku Village master plan is shown on Table 3.

ESTIMATED YEARLY FULL-TIME EQUIVALENT EMPLOYMENT POSITIONS CREATED BY DEVELOPMENT Economic Impact Analysis of the Proposed Kahuku Village Master Plan

Kahuku, Kau, Hawaii

		Phas	el			Phase II			Phase III			Phase IV		
Construction Employment (1)	Pre-2016	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	Totals
Infrastructure Emplacement	161	80		42	21		36	18		10	10			378
Hawaiian Heritage Village	55													55
Golf Course			35	17										53
Hotel Construction			219	219		176	176							790
Commercial Construction		33	33		81	81		81	81					390
VA Facility								47	47	47				140
Residential Construction														
R-X		12	12	12	16	16	16	26	27	27				167
R-1		55	69	69				69	76	76				413
R-2		12	12	18	213	219	219	344	344	344				1,725
R-3		8	11	11	22	25	25				33	36	36	208
MF-1					49	49	52	76	76	79				382
MF-2					25	27	27	68	68	69				283
VMX								35	36	36	4	5	5	121
Total Annual Construction Jobs	216	201	391	389	428	593	551	764	755	687	47	41	41	5,104
On-Going Business Employment														
Hawaiian Heritage Village (2)	40	40	40	40	40	40	40	40	40	40	40	40	40	520
Golf Course (3)				36	36	36	36	36	36	36	36	36	36	360
Hotel (4)					225	225	225	400	400	400	400	400	400	3,075
Commercial (2)			100	100	100	350	350	350	600	600	600	600	600	4,350
VA Facility (5)										286	286	286	286	1,144
Maintenance & Common Element (6))	10	14	17	29	42	54	82	111	139	142	144	147	931
Total Annual Business Jobs	40	50	154	193	430	693	705	908	1,187	1,501	1,504	1,506	1,509	10,380
Off-Site Employment (7)	64	63	136	146	215	322	314	418	485	547	388	387	387	3,871
TOTAL ANNUAL JOBCOUNT	320	313	681	728	1,073	1,608	1,571	2,090	2,427	2,736	1,938	1,934	1,937	19,356

⁽¹⁾ Infrastructure and Golf Course construction employment estimated at 1 worker-year for every \$400,000 in costs. Vertical construction (all types) employment estimated at 1 worker-year for every \$200,000 in costs.

Source: Hallstrom Group, Inc.

⁽²⁾ Employment estimated at 1 full-time-equivalent worker for every 400 square feet of gross floor area, and one worker for every five tentalows.

⁽³⁾ Estimate based on surveyed actual employment at neighbor island resort golf course facilities. Includes Pro Shop and small Bar & Grill.

⁽⁴⁾ Full-service hotel with average employment of .9 workers per guest room in five-star hotel and .7 workers per room in thr four-star hotel.

⁽⁵⁾ Allowance assuming 2.2 FTE workers for every bed.

⁽⁶⁾ Includes common element administration and maintenance staff of 7 jobs, and ratio of two full-time-equivalent landscaping/maintenenance/repair worker for every 15 units.

⁽⁷⁾ Estimated at one cumulative off-site employment position for every four on site positions.



During the 13-year modeling period (pre-2016 through build-out in 2027) the number of worker-years created on- and off-site, directly and indirectly, by the development varies from 320 to 2,736 positions annually, totaling 19,356 worker-years over the entire timeframe. Of this total, 5,104 worker-years (an annual average of 393 positions) are construction-oriented, 10,380 (or 798 per year) are on-going, on-site business operating and maintenance positions; and 3,871 are off-site/indirect worker-year requirements.

On a stabilized basis, after the completion of construction (2027 and beyond), the project will generate some 1,896 permanent full-time equivalent employment opportunities—1,509 directly related to on-site activities, and 387 indirect positions throughout the island.

Wage Income Generated

In accordance with data compiled by the state Department of Labor and Industry Relations, as tempered through our analysis, we have estimated the personal income (in the form of wages) which will flow to Big Island workers as a result of Kahuku Village construction and use. The results are presented on Table 4 in correspondence to the previously-described estimated worker requirements.

The gross full-time equivalent wage estimates for a worker-year according to the identified employment categories for 2011 are as follows:

- Construction workers (covering all trades), \$57,846 per year.
- Hawaiian Heritage Village retail workers \$27,464 and lodging (tentalow) workers \$28,002 per year.
- Golf course employees, \$27,464 annually.
- Hotel workers, \$28,002 per year.
- Commercial businesses workers, \$27,464.

ESTIMATED YEARLY EMPLOYEE WAGES CREATED BY DEVELOPMENT Economic Impact Analysis of the Proposed Kahuku Village Master Plan

		Pha	ise I			Phase II			Phase III			Phase IV		Totals
Construction Wages (1)	Pre-2016	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	10(0)3
Infrastructure Emplacement	\$9,302,190	\$4,651,067		\$2,432,402	\$1,216,019		\$2,104,288	\$1,051,986		\$554,818	\$554,818			\$21,867,590
Hawaiian Heritage Village	\$3,181,548													\$3,181,548
Golf Course			\$2,024,631	\$1,012,300										\$3,036,932
Hotel Construction			\$12,676,479	\$12,676,479		\$10,168,298	\$10,168,298							\$45,689,554
Commercial Construction		\$1,880,005	\$1,880,005		\$4,700,014	\$4,700,014		\$4,700,014	\$4,700,014					\$22,560,065
VA Facility								\$2,699,495	\$2,699,495	\$2,699,495				\$8,098,484
Residential Construction														
R-X		\$722,790	\$722,790	\$722,790	\$939,627	\$939,627	\$939,627	\$1,517,859	\$1,590,137	\$1,590,137				\$9,685,383
R-1		\$3,187,911	\$3,984,888	\$3,984,888				\$3,984,888	\$4,383,377	\$4,383,377				\$23,909,330
R-2		\$685,826	\$685,826	\$1,028,739	\$12,344,867	\$12,687,780	\$12,687,780	\$19,888,953	\$19,888,953	\$19,888,953				\$99,787,679
R-3		\$481,050	\$641,400	\$641,400	\$1,282,800	\$1,443,150	\$1,443,150				\$1,924,200	\$2,084,550	\$2,084,550	\$12,026,250
MF-1					\$2,839,444	\$2,839,444	\$2,997,191	\$4,416,914	\$4,416,914	\$4,574,661				\$22,084,568
MF-2					\$1,454,951	\$1,545,885	\$1,545,885	\$3,910,180	\$3,910,180	\$4,001,114				\$16,368,195
VMX								\$2,023,811	\$2,065,114	\$2,065,114	\$247,814	\$289,116	\$289,116	\$6,980,084
Total Annual Construction Wages	\$12,483,738	\$11,608,649	\$22,616,020	\$22,498,999	\$24,777,721	\$34,324,199	\$31,886,220	\$44,194,099	\$43,654,183	\$39,757,669	\$2,726,832	\$2,373,666	\$2,373,666	\$295,275,661
On-Going Business Wages														
Hawaiian Heritage Village (2, 3)	\$1,106,619	\$1,106,619	\$1,106,619	\$1,106,619	\$1,106,619	\$1,106,619	\$1,106,619	\$1,106,619	\$1,106,619	\$1,106,619	\$1,106,619	\$1,106,619	\$1,106,619	\$14,281,041
Golf Course (2)				\$988,687	\$988,687	\$988,687	\$988,687	\$988,687	\$988,687	\$988,687	\$988,687	\$988,687	\$988,687	\$9,886,874
Hotel (3)					\$6,300,455	\$6,300,455	\$6,300,455	\$11,200,808	\$11,200,808	\$11,200,808	\$11,200,808	\$11,200,808	\$11,200,808	\$86,106,212
Commercial (2)			\$2,746,354	\$2,746,354	\$2,746,354	\$9,612,239	\$9,612,239	\$9,612,239	\$16,478,124	\$16,478,124	\$16,478,124	\$16,478,124	\$16,478,124	\$119,466,399
VA Facility (4)										\$10,715,190	\$10,715,190	\$10,715,190	\$10,715,190	\$42,860,761
Maintenance & Common Element ((5)	\$353,498	\$475,232	\$601,649	\$1,027,719	\$1,467,835	\$1,912,634	\$2,891,191	\$3,883,794	\$4,885,762	\$4,970,039	\$5,063,681	\$5,157,323	\$32,690,357
Total Annual Business Wages	\$1,106,619	\$1,460,117	\$4,328,205	\$5,443,309	\$12,169,834	\$19,475,835	\$19,920,634	\$25,799,544	\$33,658,032	\$45,375,190	\$45,459,468	\$45,553,109	\$45,646,751	\$305,291,644
Off-Site Employment Wages (5)	\$2,245,724	\$2,201,292	\$4,780,127	\$5,110,013	\$7,537,613	\$11,291,173	\$11,032,378	\$14,681,206	\$17,042,148	\$19,212,065	\$13,613,231	\$13,583,044	\$13,606,454	\$135,936,468
TOTAL ANNUAL WAGES	\$15,836,081	\$15,270,058	\$31,724,352	\$33,052,321	\$44,485,168	\$65,091,206	\$62,839,232	\$84,674,850	\$94,354,363	\$104,344,924	\$61,799,530	\$61,509,819	\$61,626,871	\$736,503,772

⁽¹⁾ Average annual wage for full-time-equivalent vertical construction worker (all trades) at \$57,846 on Big Island.

Source: Hallstrom Group, Inc.

⁽²⁾ Average annual wage for full-time-equivalent retail trade worker at \$27,464 on Big Island.

⁽³⁾ Average annual wage for full-time-equivalent hotel worker at \$28,002 on Big Island.

⁽⁴⁾ Average annual wage for full-time-equivalent health care worker at \$37,466 on Big Island.

⁽⁵⁾ Average annual wage for full-time-equivalent general worker at \$35,116 on Big Island.



- VA Medical complex employees, \$37,466 annually.
- Maintenance/common element and off-site and indirect employment, \$35,166.

Overall average wages paid Big Island employees via the subject development are equal to \$38,050 per worker-year created during the 13-year modeling time-frame.

In the first year of development, the "Total Annual Wages Generated" by the subject development effort would be \$104.3 million, increasing to as high as \$38.6 million in 2024. After completion of all construction, the stabilized on-going resort, VA center, commercial operations, maintenance/common element, off-site indirect and employment would result in total annual wages of \$59.3 million thereafter in uninflated 2011 dollars. This is equates to an average wage of \$31,252 per worker-year.

During the development period, on- and off-site, direct and indirect worker wages would total \$736.5 million.

Population, Income and Expenditures

The homes and units of Kahuku Village will be a collection of primary and second home residences, with some of the latter being used as Transient Vacation Rentals (TVRs). In conjunction with the hotel and tentalow guests, these resident households, non-resident owners and guests, and TVR users will constitute the de facto population of the community, whose income and discretionary expenditures will create major positive impacts on the Big Island economy.

We have quantified these focal statistics within the modeling process. The results are shown on Table 5.

The top portion of the table depicts the construction/absorption and use of the 100 tentalows, 500 hotel rooms, and 1,050 residential units with their expected division between resident and non-resident ownership (including TVR use).

ESTIMATED DE FACTO POPULATION, RESIDENT HOUSEHOLD INCOME AND DISCRETIONARY EXPENDITURES Economic Impact Analysis of the Proposed Kahuku Village Master Plan

Kahuku, Kau, Hawaii

EXCLUDES PATIENTS AT VA HOSPITAL FACILITY

	Pre-2016	Phase I 2016	2017	2018	2019	Phase II 2020	2021	2022	Phase III 2023	2024	2025	Phase IV 2026	2027
Hawaiian Heritage Village Guests (1)		108	126	144	153	153	153	153	153	153	153	153	153
Hotel Guests (2)					308	359	410	718	769	820	820	820	820
Residential Product (3, 4 & 5)													
R-X													
Number of Sales Yearly		10	10	10	13	13	13	21	22	22			
Cumulative Sales		10	20	30	43	56	69	90	112	134	134	134	134
Resident Units		6	12	18	26	34	42	55	69	82	82	82	82
Non-Resident Units		4	8	12	17	22 90	27	35	43	52	52	52	52
Resident Population Non-Resident Population		16 3	32 6	48 8	69 12	90 16	111 20	145 25	180 32	215 38	215 38	215 38	215 38
R-1		•	ŭ	•			25	25	52	55	50	50	55
Number of Sales Yearly		8	10	10				10	11	11			
Cumulative Sales		8	18	28	28	28	28	38	49	60	60	60	60
Resident Units		1	2	4	4	4	4	5	7	8	8	8	8
Non-Resident Units		7	16	24	24	24	24	33	42	52	52	52	52
Resident Population		3	6	10	10	10	10	13	17	21	21	21	21
Non-Resident Population (6)		7	16	25	25	25	25	34	43	53	53	53	53
R-2													
Number of Sales Yearly		2 2	2	3 7	36	37	37	58	58	58 291	204	204	204
Cumulative Sales Resident Units		0	1	,	43 10	80 18	117 27	175 40	233 53	291	291 66	291 66	291 66
Non-Resident Units		2	3	5	33	62	90	135	180	225	225	225	225
Resident Population		1	2	4	26	48	70	104	139	174	174	174	174
Non-Resident Population (6)		2	3	6	34	63	92	138	184	230	230	230	230
R-3													
Number of Sales Yearly		3	4	4	8	9	9				12	13	13
Cumulative Sales		3	7	11	19	28	37	37	37	37	49	62	75
Resident Units Non-Resident Units		1 2	1	2	4 15	6 22	8 29	8 29	8 29	8 29	10 39	13 49	16 59
Resident Population		2	6	6	11	16	29	29	29	29	27	35	42
Non-Resident Population (6)		2	6	9	15	23	30	30	30	30	39	50	60
MF-1													
Number of Sales Yearly					18	18	19	28	28	29			
Cumulative Sales					18	36	55	83	111	140	140	140	140
Resident Units					3	7	10	15	21	26	26	26	26
Non-Resident Units Resident Population					15 9	29 18	45 27	68 40	90 54	114 68	114 68	114 68	114 68
Non-Resident Population (6)					15	30	46	69	92	116	116	116	116
MF-2													
Number of Sales Yearly					16	17	17	43	43	44			
Cumulative Sales					16	33	50	93	136	180	180	180	180
Resident Units					4	8	12	22	33	43	43	43	43
Non-Resident Units					12	25	38	71	103	137	137	137	137
Resident Population					10	21	31	58	85	113	113	113	113
Non-Resident Population (6)					12	26	39	72	106	140	140	140	140
VMX Number of Sales Yearly								49	50	50	6	7	7
Cumulative Sales								49	99	149	155	162	169
Resident Units								49	99	149	155	162	169
Non-Resident Units								0	0	0	0	0	0
Resident Population								128	259	390	406	424	442
Non-Resident Population								0	0	0	0	0	0
Total Resident Population		22	45	68	134	201	269	510	755	1,002	1,024	1,050	1,075
Total Non-Resident Population		122	156	192	574	694	814	1,239	1,408	1,580	1,589	1,600	1,610
TOTAL DE FACTO POPULATION		144	201	260	708	895	1,083	1,749	2,164	2,581	2,613	2,649	2,685
RESIDENT HOUSEHOLD INCOME (7)		\$815,405	\$1,678,099	\$2,563,148	\$5,022,080	\$7,547,714	\$10,091,595	\$19,109,985	\$28,299,873	\$37,531,481	\$38,370,270	\$39,327,983	\$40,285,697
TOTAL DISCRETIONARY EXPENDITURES (8)		\$12,643,134	\$16,534,438	\$20,516,113	\$60,131,929	\$73,394,590	\$86,749,868	\$133,894,977	\$155,521,925	\$177,331,250	\$178,719,567	\$180,248,089	\$181,776,610

⁽¹⁾ Assumes 100 tentalows with average party size of 1.8 persons and stabilized occupancy of 85%, reached in 2019.

Source: Rick Cassiday, and The Hallstrom Group, Inc.

⁽²⁾ Assumed average hotel guest party size of 2.05 persons and stabilized occupancy of 80 percent, reached three years after hotel opening(s).

⁽³⁾ Mix of resident and non-resident units based on average percentages for product type estimated in Cassiday market study.

⁽⁴⁾ Resident households estimated to have average size of 2.67 persons (based on 2010 Hawaii County census), with average occupancy of 98%.

⁽⁵⁾ Non- resident parties estimated to have average size of 2.94 persons (resident size plus 10%), with average occupancy of 25%.

⁽⁶⁾ Includes Transient Vacation Rental units, estimated at circa 21 percent of total inventory of this type, with average party size of 3.5 persons and average occupancy of 60%.

⁽⁷⁾ Estimated at circa \$100,050 annually per household based on unit mix and pricing guidelines, or about 150% of the 2010 household average for Hawaii County.

⁽⁸⁾ Based on average daily expenditures of \$275 per day for non-resident population members and 50% of resident household income.



The Cassiday study projected that some 356 of the subject units/homes, including the large majority of multifamily units will be purchased by full-time residents, with the remaining 694 units, including the majority of single family product, will be bought by non-residents.

Of the latter, the developer estimates that 157 units will be used as TVRs, either privately managed (via an outside agent) or operated within on-site rental pools.

Our de facto population projections are based on the following occupancy and household/party size assumptions:

- 1. <u>Hotels</u>. Average party size of 2.05 persons and a stabilized occupancy of 80 percent achieved three-years after opening.
- 2. <u>Tentalows</u>. Average party size of 1.8 persons and a stabilized occupancy of 85 percent reached in Year Three of the projection model (2019).
- 3. <u>Resident Households</u>. Average family size of 2.67 persons (based on 2010 Census of Hawaii County) with average occupancy of 98 percent.
- 4. <u>Non-Resident Households</u> (excluding TVRs). Average party size of 2.94 persons (ten percent above resident household average) and average occupancy of 25 percent.
- 5. <u>Transient Vacation Rentals</u> (21 percent of non-resident purchased units). Average party size of 3.5 persons with average occupancy of 60 percent.

The total de facto population at build-out is forecast to be 2,685 persons, comprised of 1,075 full-time residents and 1,610 non-resident users and lodging/transient guests. Occupancy is projected to start during the first development year (2016).



The population estimates do not include overnight patients at the VA Medical complex, which could add upwards of 100 persons to the total.

Based on affordable-pricing guidelines coupled with the level of income necessary to support the purchase of the market-priced inventory, we estimate the average annual income for resident households at Kahuku Village will be circa \$100,500 in 2011 dollars. This is the equivalent of 150 percent of the Big Island average. During the 2016-2027 build-out period, the total resident household income will be \$230.6 million, and at \$40.3 million annually thereafter.

The de facto population of the project will place significant discretionary expenditure dollars into the Hawaii County economy. This will be comprised of the spending by lodging/transient rental guests (typically upper-income); the daily purchases made by full-time resident households; and, the expenditures made by non-resident owners during use of their units.

In light of the expected high average daily rates for the hotel rooms and TVR units, and the relatively high cost of the marketpriced finished homes and units, the non-resident subject population segments will be in the upper-income brackets with substantial amounts available for spending in Kahuku Village and elsewhere during their Big Island visit.

We estimate that full-time resident households will spend about 50 percent of their total income on discretionary items; the remainder going towards mortgage debt service (or rent), insurance and other fixed expenses.

The combined daily per capita spending by lodging/TVR guests and non-resident owner parties into the Hawaii County economy is estimated will be on average \$275; or about 60 percent above what the typical Big Island visitor spends daily. This pays for all room/unit rental fees, dining/food, entertainment, recreation, souvenirs, and non-resident household goods, locally purchased fixtures and furnishings,



clothing and other items associated with owning a vacation home.

The above-average expenditure estimates are moderate in consideration of the anticipated average daily room rates for the four-plus (\$350 nightly) and five-star hotels (\$500), the average cost of a TVR in the project (\$1,000 nightly), and the income levels of the non-resident purchasers in the community.

By build-out, the total discretionary expenditures made by the de facto population members in the local market will be at \$181.8 million annually on a stabilized basis, in 2011 dollars. During the 13-year development and stabilization model period, the total sum of these expenditures will be \$1.28 billion.

While meaningful portions of this discretionary income will be spent in the various Kahuku Village operations, facilities and businesses, significant amounts will also flow into other West Hawaii and island-wide companies.

Operating Economic Activity

The estimated level of total gross on-site economic activity within the proposed subject community, from all major sources, during the modeling period and on a stabilized basis is summarized on Table 6. The contributing activity includes:

- Hawaiian Heritage Village assumes the average visitor spends \$12 on admissions, in the gift shop and/or food & beverage items. Village attendance projections were taken from the CMFC study. It is projected 15 percent of the total sales will come from Kahuku Village guests, residents and other owners; the other 85 percent will be from transient (non-Village) daily visitors. At stabilization, revenues will reach an estimated \$8.7 million annually.
- Golf Course income is based on the experience of other neighbor island resort daily fee facilities, and assumes 35,000 total rounds played each year upon stabilization, with average green fees of \$90 per round and additional

PROJECTED ON-SITE OPERATING ECONOMIC ACTIVITY Economic Impact Analysis of the Proposed Kahuku Village Master Plan Kahuku, Kau, Hawaii

					Phase II			Phase III			Phase IV		Totals During
	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	Build-Out
Hawaiian Heritage Village (1)	\$919,800	\$919,800	\$919,800	\$3,547,800	\$3,547,800	\$3,547,800	\$7,227,000	\$7,227,000	\$7,227,000	\$8,672,400	\$8,672,400	\$8,672,400	\$61,101,000
In-Project Patronage %	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%
Outisde Project Patronage Expenditures	\$781,830	\$781,830	\$781,830	\$3,015,630	\$3,015,630	\$3,015,630	\$6,142,950	\$6,142,950	\$6,142,950	\$7,371,540	\$7,371,540	\$7,371,540	\$51,935,850
Golf Course (2)				\$2,362,500	\$2,756,250	\$3,150,000	\$3,543,750	\$3,937,500	\$3,937,500	\$3,937,500	\$3,937,500	\$3,937,500	\$31,500,000
In-Project Patronage %				70%	70%	70%	70%	70%	70%	70%	70%	70%	70%
Outisde Project Patronage Expenditures				\$708,750	\$826,875	\$945,000	\$1,063,125	\$1,181,250	\$1,181,250	\$1,181,250	\$1,181,250	\$1,181,250	\$9,450,000
Hotels & Tentalows (3)	\$4,380,000	\$5,110,000	\$49,640,000	\$56,940,000	\$56,940,000	\$56,940,000	\$94,900,000	\$100,010,000	\$105,120,000	\$105,120,000	\$105,120,000	\$105,120,000	\$845,340,000
In-Project Patronage %	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%
Outisde Project Patronage Expenditures	\$219,000	\$255,500	\$2,482,000	\$2,847,000	\$2,847,000	\$2,847,000	\$4,745,000	\$5,000,500	\$5,256,000	\$5,256,000	\$5,256,000	\$5,256,000	\$42,267,000
Commercial Businesses (4)			\$9,000,000	\$9,000,000	\$9,000,000	\$54,000,000	\$54,000,000	\$54,000,000	\$99,000,000	\$99,000,000	\$99,000,000	\$99,000,000	\$585,000,000
In-Project Patronage %			67%	67%	67%	67%	67%	67%	67%	67%	67%	67%	67%
Outisde Project Patronage Expenditures			\$2,970,000	\$2,970,000	\$2,970,000	\$17,820,000	\$17,820,000	\$17,820,000	\$32,670,000	\$32,670,000	\$32,670,000	\$32,670,000	\$193,050,000
<u>Transient Vacation Rentals (5)</u>	\$597,870	\$1,333,710	\$2,115,540	\$5,702,760	\$9,427,950	\$13,199,130	\$19,591,740	\$26,030,340	\$32,560,920	\$33,112,800	\$33,710,670	\$34,308,540	\$211,691,970
In-Project Patronage %	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Outisde Project Patronage Expenditures	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
VA Facility (6)										\$39,000,000	\$39,000,000	\$39,000,000	\$117,000,000
In-Project Patronage %										100%	100%	100%	100%
Outisde Project Patronage Expenditures										\$0	\$0	\$0	\$0
Maintenance/Renovations (7)	\$57,500	\$122,500	\$190,000	\$417,500	\$652,500	\$890,000	\$1,412,500	\$1,942,500	\$2,477,500	\$2,522,500	\$2,572,500	\$2,622,500	\$15,880,000
In-Project Patronage %	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Outisde Project Patronage Expenditures	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Iotal Economic Activity													
In-Project Patronage Spending	\$4,954,340	\$6,448,680	\$55,631,510	\$68,429,180	\$72,664,995	\$107,099,300	\$150,903,915	\$163,002,640	\$205,072,720	\$244,886,410	\$245,534,280	\$246,182,150	\$1,570,810,120
% of Total Activity	83.2%	86.1%	89.9%	87.8%	88.3%	81.3%	83.5%	84.4%	81.9%	84.0%	84.1%	84.1%	84.1%
Outside Project Patronage Spending	\$1,000,830	\$1,037,330	\$6,233,830	\$9,541,380	\$9,659,505	\$24,627,630	\$29,771,075	\$30,144,700	\$45,250,200	\$46,478,790	\$46,478,790	\$46,478,790	\$296,702,850
% of Total Activity	16.8%	13.9%	10.1%	12.2%	11.7%	18.7%	16.5%	15.6%	18.1%	16.0%	15.9%	15.9%	15.9%
TOTAL PROJECT GROSS REVENUES	\$5,955,170	\$7,486,010	\$61,865,340	\$77,970,560	\$82,324,500	\$131,726,930	\$180,674,990	\$193,147,340	\$250,322,920	\$291,365,200	\$292,013,070	\$292,660,940	\$1,867,512,970

Source: Hallstrom Group, Inc.

⁽¹⁾ Assuming \$5 per person entry fee plus \$7 per person retail/F&B expenditures. Patronage based on Colliers estimates.

⁽²⁾ Assuming 35,000 rounds per year at stabilization with average green fee of \$90 plus ancillary revenue at 25% of green fee income.

⁽³⁾ Assuming Average Daily Rate of \$500 for 5-star and \$350 for 4-plus star hotel rooms and \$125 for tentalows, with ancillary department revenues at 60% of Rooms Department income, reaching stabilized occupancy of 80% by third year after opening.

⁽⁴⁾ Estimated based on average annual sales of \$450 per square foot; based on projections by Colliers.

⁽⁵⁾ Assuming average daily unit rental rate of \$1,000 per home/unit with 60 percent occupancy.

⁽⁶⁾ Estimated based on average annual revenues of \$300,000 per bed.

⁽⁷⁾ Estimated at \$2,500 per unit/home per year.



clubhouse, pro shop and bar & grill revenues at 25 percent of green fees. Seventy percent of the golf revenues are projected to be generated from the Kahuku Village de facto population. At stabilization, revenues will reach an estimated \$3.9 million annually.

- The <u>lodging</u> operating revenues include the four-plus star hotel at \$350 average daily rate (ADR), similar to rates at the Mauna Lani Bay and Mauna Kea Beach hotels, 80 percent occupancy, and an additional 60 percent in non-rooms sales. The five-star hotel was ascribed an ADR of \$500 (20 percent less than the Four Season Hualalai), an estimated 80 percent occupancy and 60 percent in non-rooms sales. And, the tenatlows were projected to have an ADR of \$125, an average of 85 percent occupancy and 60 percent in non-rooms revenues. For this component of the master plan, revenues will reach an estimated \$105.1 million annually upon stabilizing. Ninety percent of these revenues will be from subject lodging guests.
- Commercial Operations in the 220,000 square feet of total gross leasable area in the various general, neighborhood and resort-oriented centers are projected to have average sales volumes of \$450 per square foot annually, of which an estimated 67 percent will be from the on-site population and 33 percent will be from outside project patronage. At stabilization, revenues at the commercial space businesses will reach an estimated \$99.0 million annually.

It is noted, not all of these commercial sales represent "new" revenues for the Big Island. Of the one-third of sales flowing from outside project patronage a portion (perhaps 25 to 40 percent or more) will be expenditures by area residents which are being re-directed towards subject businesses from other existing operations in the county.

• <u>Transient Vacation Rentals</u> in the subject development will produce significant taxable revenues, much of



which, however, may rapidly flow out of Kahuku Village (and in many cases off-island or out-of-state) to non-resident owners. The ADR is estimated at \$1,000 or comparable to slightly below the average nightly rental fees for TVRs at Hualalai, Mauna Lani and Mauna Kea beach resorts. Revenues are anticipated to stabilize at \$34.3 million per year, with 100 percent being spent by in-project users.

- Revenues for the proposed <u>VA Medical complex</u> were projected based on "per bed" incomes achieved at non-specialized ("general") hospitals of similar-size and extent in suburban and rural locations, at \$300,000 per bed annually. At stabilization, this equates to yearly gross revenues of \$39.0 million. One hundred percent of this income will come from the on-site population.
- <u>Maintenance/Landscaping/Renovations</u> will be required by the residential components of the development. We have estimated these costs will average \$2,500 per home/unit per year. At build-out this equates to \$2.6 million annually on a stabilized basis, and 100 percent of these revenues will be generated by on-site demand.

Overall, Kahuku Village will create taxable gross operating revenues of \$292.7 million per year following stabilization, of which about \$46.5 million (or nearly 16 percent) will be from outside project patronage and \$246.2 million will be spent by the on-site population. During the development period (2016-2027), this model projects total on-site sales of \$1.87 billion.

Summary of Direct, Local Economic Impacts

As correlated on Table 7, annual Total Base Economic Impact from the subject increases from \$145.2 in Year 1 of the development effort (projected to be 2016) to a peak of \$362.0 million by Year 9 (2024), in 2011 dollars, before stabilizing after build-out at in 2027 at \$267.2 million per year. During the development period, the aggregate total is \$2.8 billion.

SUMMARY OF ECONOMIC IMPACTS ASSOCIATED WITH DEVELIOPMENT Economic Impact Analysis of the Proposed Kahuku Village Master Plan

Kahuku, Kau, Hawai

					Phase II			Phase III			Phase IV		Totals During
	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	Build-Out
Construction Activity Construction Wages	\$24,092,387	\$22,616,020	\$22,498,999	\$24,777,721	\$34,324,199	\$31,886,220	\$44,194,099	\$43,654,183	\$39,757,669	\$2,726,832	\$2,373,666	\$2,373,666	\$295,275,661
Construction wages	\$24,092,367	\$22,616,020	\$22,498,999	\$24,777,721	\$34,324,199	\$31,860,220	\$44,194,099	\$43,034,163	\$39,757,009	\$2,720,832	\$2,373,000	\$2,373,000	\$293,273,001
Contractor Profits	\$13,154,042	\$14,141,044	\$17,489,220	\$17,957,043	\$20,854,547	\$23,619,379	\$27,395,552	\$30,736,707	\$29,030,946	\$15,072,398	\$1,955,290	\$1,641,360	\$111,520,957
Supplier Profits	\$5,261,617	\$5,656,418	\$6,995,688	\$7,182,817	\$8,341,819	\$9,447,752	\$10,958,221	\$12,294,683	\$11,612,379	\$6,028,959	\$782,116	\$656,544	\$44,608,383
Other Construction Costs	\$89,032,370	\$42,780,014	\$42,714,802	\$39,954,135	\$55,153,186	\$52,566,687	\$73,887,612	\$64,246,010	\$58,976,886	-\$12,482,091	\$3,095,728	\$3,535,230	\$655,597,768
Other Construction Costs	\$89,032,370	\$42,780,014	\$42,714,602	\$39,954,135	\$33,133,166	\$52,500,087	\$73,867,012	\$04,240,010	\$38,970,886	-\$12,482,091	\$3,095,728	\$3,535,230	\$055,597,768
Total Construction Impact	\$131,540,415	\$85,193,495	\$89,698,709	\$89,871,716	\$118,673,750	\$117,520,038	\$156,435,485	\$150,931,582	\$139,377,880	\$11,346,098	\$8,206,800	\$8,206,800	\$1,107,002,769
Project De Facto Population Spending On-Site Spending	\$4,954,340	\$6,448,680	\$55,631,510	\$68,429,180	\$72,664,995	\$107,099,300	\$150,903,915	\$163,002,640	\$205,072,720	\$154,886,410	\$155,534,280	\$156,182,150	\$1,300,810,120
On-site spending	\$4,954,540	\$0,448,060	\$55,631,510	\$66,429,160	\$72,004,995	\$107,099,300	\$150,903,915	\$103,002,040	\$205,072,720	\$154,860,410	\$155,534,280	\$150,182,150	\$1,300,810,120
Off-Site Spending	\$7,688,794	\$10,085,758	-\$35,115,397	-\$8,297,251	\$729,595	-\$20,349,432	-\$17,008,938	-\$7,480,715	-\$27,741,470	\$23,833,157	\$24,713,809	\$25,594,460	-\$23,347,630
Total Project Population Impact	\$12,643,134	\$16,534,438	\$20,516,113	\$60,131,929	\$73,394,590	\$86,749,868	\$133,894,977	\$155,521,925	\$177,331,250	\$178,719,567	\$180,248,089	\$181,776,610	\$1,277,462,490
Outside Patronage Spending	\$1,000,830	\$1,037,330	\$6,233,830	\$9,541,380	\$9,659,505	\$24,627,630	\$29,771,075	\$30,144,700	\$45,250,200	\$46,478,790	\$46,478,790	\$46,478,790	\$296,702,850
	* 1,,	**,,	**,=**,***	**,-**,	**,,	4-1,1,		***************************************	**-,,	****	****	4.2,2,2	+=,,
VA Facility										\$39,000,000	\$39,000,000	\$39,000,000	\$117,000,000
TOTAL BASE ECONOMIC IMPACT	\$145,184,380	\$102,765,263	\$116,448,652	\$159,545,025	\$201,727,845	\$228,897,535	\$320,101,537	\$336,598,207	\$361,959,331	\$275,544,455	\$273,933,679	\$275,462,200	\$2,798,168,109
1													

Source: Hallstrom Group, Inc.



PUBLIC COSTS/BENEFITS FROM THE PROPOSED DEVELOPMENT

The purpose of this assessment is to delineate how the development and long-term operation of Kahuku Village will potentially impact the public "purse" during its construction and its stabilized use going-forward.

Specifically, the goal is to quantify and compare the costs of providing expanded county and state services to the project and its population versus the economic benefits that accrue to governmental coffers via an increase in primary local and state tax payments arising from the new economic activity associated with the development.

Among the major direct potential <u>costs</u> to governmental services and programs are:

- -- Police Protection
- -- Fire Protection
- Public Oversight Agencies
- -- Infrastructure Systems
- -- Recreational Demands
- -- Educational Needs
- -- County and State Oversight and Administration
- -- Public Capital Improvements
- -- Various Other Services and Financial Commitments

Primary direct tax <u>benefits</u> to the state and county funds will primarily flow from the project and its operation over time from four major sources:

- -- Real Property Taxes (to the County)
- -- Gross Excise Tax Receipts (to the State)
- -- State Income Taxes (State)
- -- Transient Accommodation Taxes (divided between State and Counties)

Some cost/benefit issues are considered as off-setting, or "a wash," as the cost of the services to the government is theoretically directly reimbursed in the form of user fees.



Building permits and utility hook-up fees are two prime examples. Other such items include workers compensation premiums and benefits, utility operations and associated use billing rates, and business oversight/registration verses licensing fees. These items are excluded from this study.

We also have not included assessment and fees associated with the proposed subject development that have yet to be quantified and/or negotiated and could add substantially to the revenues received by the state and county. These would include contributions to the Department of Education, for state and county parks, pro-rata emergency services enhancements, regional infrastructure funds, etc.

However, as part of the master plan, the developers are including significant amenities, facilities and land donations for beach and interior parks, public recreational opportunities, school site(s), and civic and emergency uses.

As a privately built project using private capital for its major infrastructure components, some of identified public costs will not be directly increased on state or county levels as a result of the proposed subject project. Further, the relatively low occupancy of the non-resident owned (non-TVR) homes and units means about 548 units of the residential inventory, or 52 percent, would not need daily services a majority of the time.

Further, the project will have a private security force and an incommunity medical complex, limiting the need for enlarging public emergency services in the region (and perhaps mitigating the existing stress for some services). There will be similar cost-savings benefits to the government from a variety of primary and secondary project aspects.

Therefore, the <u>actual costs</u> to the state and county arising from the Kahuku Village development will be limited to figures wellbelow typical for a project of this magnitude and/or population.

However, the diversity of units types and businesses within the Village will result in a development which is highly reflective of the larger West Hawaii community in regards to population



demographics, general uses, household sizes and make-up, and other factors, and as such it would be expected to carry its fair share of public costs burdens on a per capita basis.

This perspective, where each person of the island-wide de facto population is responsible for a comparable cost of public services, either directly or indirectly as part of the commonweal, is very appropriate for a development as the subject which will have some members in need of above-average amounts of services and others with below-average demands.

Government services are holistic in nature, providing a foundation throughout a community, regardless of any actual or specific impact on any given land holding. Parks and schools are essential to the full-time resident households, visitors, nonresident owners, and other patrons of the Village, whether or not they specifically use them, as these facilities create the climate in which local businesses, the real estate market, the tourist industry, and the general economy operates. Similarly, government administration, public education, capital projects and public welfare items may have no direct relation to a particular development, but provide the economic underpinnings that enhances overall regional sustainability.

We have therefore looked at the public costs issue only from an altruistic <u>per capita allocation</u> basis, and have not considered the estimating of <u>actual costs</u> as being an appropriate method for use in this specific analysis.

Public Costs

Per Capita Costs

The selected method for determining public costs was through assessment of per capita expenditures incurred by the State of Hawaii and Hawaii County relative to the de facto population area of the jurisdiction.

As noted foregoing, this approach is founded on the principal that each individual on the island equitably benefits from all governmental costs, regardless of type or focus, with each new member of the community (whether resident or non-resident)



creating a proportionate new cost burden on public services in their daily life.

Although a de facto population member may create revenues and expenses across an entire region or island, the typical application is to associate most governmental costs as accruing to the residential aspects of a persons' lifestyle and land use; where they "live" (or on the case of a tourist, where they stay).

We consider the per capita method based on location of "residency" as the best means of demonstrating the maximum overall public fiscal impact potential of the proposed subject project. We judge this method as setting the absolute upper limit on all public costs (actual, indirect and inferred).

According to their Financial Services/Budgeting database, the state expects to spend a total of \$11.36 billion on services, salaries, infrastructure, capital costs and financing in the coming 2011-12 fiscal year. The total <u>de facto</u> population in the state on an average daily basis at present is about 1,558,301 persons, including residents, tourists, and military personnel.

The per capita expenditure by the state will thus be about \$8,373 for this year.

The average de facto population (residents, non-residents and their guests) at Kahuku Village at build-out will be 2,685 persons, a figure projected to be reached in year 2027. The annual total "costs" to the State of Hawaii public purse from the subject at stabilization using the per capita allowance method would be \$22.5 million in constant year 2011 dollars (2,685 population x \$8,373).

Analyzed on a similar basis, the County of Hawaii's budget for the island government in year 2011-12 is at \$366.1 million. The current de facto population in Hawaii County is some 213,479 persons. The resulting de facto per capita county expenditure for this year is therefore anticipated to be \$2,545.

Application of this per person figure to the total on-site de facto population at subject build out would be \$6.8 million annually



in costs to the county government on a stabilized basis (2,685 population x \$2,545).

<u>Total Public Costs</u> -- On a <u>per capita</u> allowance basis, at buildout the total governmental costs to the state and county would be \$29.3 million annually.

Public Fiscal Benefits

<u>Real Property Taxes</u> -- Property taxes which will be paid by Kahuku Village landowners to the County of Hawaii were calculated using the 2011 tax rates for both land and buildings, improved and unimproved, and accounting for home-owner rates for qualified housing units.

The projected real property assessment and resulting taxes for the subject development over time are shown on Table 8.

The bases for the assessments were generally presented earlier. The market value for each property type was taken either from projections made in the Cassiday market study or via a "built-up" calculation consisting of:

- Estimated market value of the building site and/or allocation of actual costs.
- Vertical construction costs, as calculated in the previous chapter.
- Common element costs, as applicable.
- Allowance for costs of sale and developer's profit.

The total assessments and resulting taxes for the finished units, resort facilities, commercial, medical and golf course components are added to the tax rolls as they are completed and absorbed. Conversely, the assessed value and taxes attributable to the underlying land diminishes as it is built-out and sold.

The total forecast real property taxes to be paid to Hawaii County in 2011 dollars ranges from \$808,698 in Year 1 of development model ("pre-2016), to a stabilized level of \$15.9 million at build-out in Year 13 (2027) and beyond. The

ESTIMATED REAL PROPERTY TAXES GENERATED BY THE SUBJECT COMMUNITY Economic Impact Analysis of the Proposed Kahuku Village Master Plan

Kahuku, Kau, Hawaii

All Assessments and Taxes Expressed in Constant 2011 Dollars

Assessment Values Include Allocated Finished Lot Value, and Cost of All Construction, Fees and Profit Allowance Assumes Hawaiian Heritage Village and VA Medical Facility are Tax-Exempt

	Tax rate	Phase I				Phase II			Phase III			Phase IV			Totals
	Per \$1,000	Pre-2016	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	
1. Commercial Properties															
Golf Course Assessment					\$29,900,000	\$29,900,000	\$29,900,000	\$29,900,000	\$29,900,000	\$29,900,000	\$29,900,000	\$29,900,000	\$29,900,000	\$29,900,000	
Real Property Tax	\$9.85				\$294,515	\$294,515	\$294,515	\$294,515	\$294,515	\$294,515	\$294,515	\$294,515	\$294,515	\$294,515	\$2,945,150
Hotel Assessment Real Property Tax	\$9.85				\$126,531,250 \$1,246,333	\$126,531,250 \$1,246,333	\$126,531,250 \$1,246,333	\$253,062,500 \$2,492,666	\$253,062,500 \$2,492,666	\$253,062,500 \$2,492,666	\$253,062,500 \$2,492,666	\$253,062,500 \$2,492,666	\$253,062,500 \$2,492,666	\$253,062,500 \$2,492,666	\$21,187,658
	7.122														
Commercial Assessment Real Property Tax	\$9.10		\$6,500,000 \$59,150	\$13,000,000 \$118,300	\$13,000,000 \$118,300	\$29,250,000 \$266,175	\$45,500,000 \$414,050	\$45,500,000 \$414,050	\$61,750,000 \$561,925	\$78,000,000 \$709,800	\$78,000,000 \$709,800	\$78,000,000 \$709,800	\$78,000,000 \$709,800	\$78,000,000 \$709,800	\$5,500,950
Total Commercial Real Property	Тах		\$59,150	\$118,300	\$1,659,148	\$1,807,023	\$1,954,898	\$3,201,231	\$3,349,106	\$3,496,981	\$3,496,981	\$3,496,981	\$3,496,981	\$3,496,981	\$29,633,758
. ,			•	•											
2. Single Family Homes															
R-X Number of Homes Sold	\$9.10 \$5.55		10	10	10	13	13	13	21	22	22				
Cumulative Assessment	φυ.υυ		\$4,847,902	\$9,695,803	\$14,543,705	\$20,845,977	\$27,148,249	\$33,450,522	\$43,631,115	\$54,296,499	\$64,961,882	\$64,961,882	\$64,961,882	\$64,961,882	
R-1	\$9.10														
Number of Homes Sold Cumulative Assessment	\$5.55		8 \$26,339,830	10 \$59,264,618	10 \$92,189,405	\$92,189,405	\$92,189,405	\$92,189,405	10 \$125,114,193	11 \$161,331,459	11 \$197,548,725	\$197,548,725	\$197,548,725	\$197,548,725	
			\$20,337,030	\$37,204,010	\$72,107,403	\$72,107,403	\$72,107,403	\$72,107,403	\$123,114,173	\$101,331,437	\$177,546,725	\$177,546,725	\$177,546,725	\$177,546,725	
R-2 Number of Homes Sold	\$9.10 \$5.55		2	2	3	36	37	37	58	58	58				
Cumulative Assessment			\$5,860,000	\$11,720,000	\$20,510,000	\$125,990,000	\$234,400,000	\$342,810,000	\$512,750,000	\$682,690,000	\$852,630,000	\$852,630,000	\$852,630,000	\$852,630,000	
R-3	\$9.10														
Number of Homes Sold Cumulative Assessment	\$5.55		3 \$3,450,000	4 \$8,050,000	4 \$12,650,000	8 \$21,850,000	9 \$32,200,000	9 \$42,550,000	\$42,550,000	\$42,550,000	\$42,550,000	12 \$56,350,000	13 \$71,300,000	13 \$86,250,000	
Total Single Family Real Property	Tax		\$338,010	\$742,389	\$1,171,061	\$2,165,924	\$3,194,676	\$4,223,427	\$5,986,641	\$7,781,597	\$9,576,552	\$9,691,702	\$9,816,448	\$9,941,194	\$64,629,620
,			,	\$1.1 <u>2</u> ,221	***************************************	*=,,.=	***************************************	¥ 1,222,121	\$1,125,2 to	**/***	**, =**5,===	**/*/	**/***	*********	V-1/1/
3. Multifamily Units															
MF-1 Number of Units Sold	\$9.85 \$5.55					18	18	19	28	28	29				
Cumulative Assessment	\$0.00					\$18,338,958	\$36,677,916	\$56,035,705	\$84,562,973	\$113,090,241	\$142,636,340	\$142,636,340	\$142,636,340	\$142,636,340	
MF-2	\$9.85														
Number of Units Sold Cumulative Assessment	\$5.55					16 \$9,450,056	17 \$19,490,741	17 \$29,531,425	43 \$54,928,451	43 \$80,325,476	44 \$106,313,130	\$106,313,130	\$106,313,130	\$106,313,130	
						\$7,430,030	\$17,470,741	\$27,551,425	434,720,431	\$00,323,470	\$100,313,130	\$100,313,130	\$100,313,130	\$100,313,130	
VMX Number of Units Sold	\$5.55								49	50	50	6	7	7	
Cumulative Assessment									\$12,768,910	\$25,798,410	\$38,827,910	\$40,391,450	\$42,215,580	\$44,039,710	
Total Multifamily Real Property Tax						\$249,318	\$503,846	\$767,595	\$1,320,644	\$1,875,139	\$2,444,064	\$2,452,742	\$2,462,866	\$2,472,990	\$14,549,204
Total Annual Product Assessed Va	lue		\$46,997,732	\$101,730,421	\$309,324,360	\$474,345,646	\$644,037,561	\$925,029,557	\$1,221,018,141	\$1,521,044,584	\$1,806,430,487	\$1,821,794,027	\$1,838,568,157	\$1,855,342,287	
		404.050.00													
Underlying Site Assessed Value Annual Taxes	\$8.35	\$96,850,000 \$808,698	\$87,165,000 \$727,828	\$77,480,000 \$646,958	\$48,425,000 \$404,349	\$38,740,000 \$323,479	\$29,055,000 \$242,609	\$24,212,500 \$202,174	\$19,370,000 \$161,740	\$14,527,500 \$121,305	\$9,685,000 \$80,870	\$4,842,500 \$40,435	\$2,421,250 \$20,217	\$0 \$0	\$3,780,661
TOTAL ANNUAL REAL PROPERTY TA:	XES	\$808,698	\$1,124,987	\$1,507,647	\$3,234,557	\$4,545,745	\$5,896,029	\$8,394,426	\$10,818,130	\$13,275,021	\$15,598,467	\$15,681,860	\$15,796,512	\$15,911,165	\$112,593,243
Source: PBR Hawaii, Rick Cassida	v and The Hell-t	rom Group, Inc.													
runce. For nawall, RICK Cassida	y, and me nalist	rom Group, Inc.													



aggregate taxes paid over the development modeling time-frame will be \$112.6 million.

<u>State Income Tax</u> -- The state will receive income taxes from three sources, which were quantified in the Economic Impact Analysis portion of our study:

- The wages of the workers associated with the construction, maintenance, and operation of the Kahuku Village components.
- The corporate profits from contractors and suppliers serving the construction and maintenance phases of the development, and as generated by the on-going hotel, TVR, commercial, maintenance and golf operations. It is assumed both the Hawaiian Heritage Village and VA Medical center will be non-profit organizations.
- The household income of full-time residents of the development.

According to DBEDT data, individual State of Hawaii income tax liability as a ratio to gross income has averaged ranged from about 5.0 to just over 5.80 percent during the past two decades, with the more current figures tending toward the mid to lowerend of the range. We have employed an effective tax rate of 5.10 percent of gross <u>personal income</u> for individual workers and full-time resident households.

The effective tax rate for the <u>corporate income</u> is estimated at 4.40 percent of gross operating profits, based on available DBEDT statistics. Operating profits are assumed to equal ten percent of forecast gross revenues.

The total income tax revenues to be received by the state are projected at \$1.7 million in the first year of construction ("pre-2016") increasing to a peak level at model Year 10 (2024) of \$8.4 million. On a stabilized basis, after build-out, the permanent worker incomes, building maintenance and off-site workers, and operating businesses, would pay an annual state income tax of about \$6.4 million.



Over the 13-year projection period, the cumulative income taxes paid are estimated at \$58.2 million.

We have not included any corporate income or other taxes which will be paid by the developing venture as a result of its profits from undertaking the subject development, or from the secondary jobs created by the discretionary spending of owners, workers and businesses. Such items have the potential to be substantial contributions to the state coffers.

<u>State Gross Excise Tax</u> -- This 4.166 percent of expenditures tax was applied against:

- The total estimated construction contract costs.
- Discretionary spending of wage income by workers associated with the project's construction and operation.
- Spending by transient lodging guests of the community staying at the hotels, in TVRs, or the tenatlows of the Hawaiian Heritage Village.
- Discretionary spending of full-time resident Kahuku Village households.
- Expenditures of non-resident subject unit owners and their guests on and off-site while staying at their vacation home.
- Expenditures in the subject community businesses made by transient day visitors and nearby residents.

The anticipated state excise tax receipts arising from the subject development range from an estimated \$4.9 million in the second operating year of the project (2017) to a peak of \$17.3 million in 2024. Over the 13-year study period, the receipts total \$127.1 million and stabilize at circa \$10.8 million per year.

We have not included any excise tax revenues associated with the direct, local "multiplier effect" expenditures on Maui, or



those created in the secondary market by the suppliers to the operating businesses or secondary worker expenditures.

<u>Transient Accommodations Tax</u> -- The state levies the TAT on all transient rentals equal to 9.25 percent of the Average Daily Rate for the unit; payable each day it is occupied.

The Kahuku Village resort units, including the 500 hotel rooms, 100 tentalows and 157 TVRs, will be subject to the TAT, the proceeds of which are divided between the state and the individual counties according to formula. The state general fund receives 55.2 percent of the tax receipts and the County of Hawaii 8.33 percent.

Based on the ADR and occupancy calculation made previously, we estimate the TAT in the first operating year (2016) will total \$308,522 and increase to a stabilized level of \$9.3 million annually upon build-out in 2027 and thereafter. Over the 13 year construction and absorption period, the total TAT generated is estimated at \$68.5 million.

Our public fiscal (costs/benefits) assessment model for Kahuku Village is compiled on Table 9, with the correlation of per capita public service "costs" and the anticipated tax revenue "benefits" shown on the bottom line.

As construction activity (which generates tax revenues) is completed and the full de facto population is established (which results in increasing public costs), the net returns to the State of Hawaii decreases, while the payments to the County of Hawaii reach their stabilized peak.

The indicators from the model are summarized as follows:

• The net benefit (tax receipts less per capita costs) to Hawaii County from the development of the subject increases from a low \$1.0 million in Year 2 of the project (2017) to a peak of \$9.8 million per year at build-out in 2027 and beyond. The county is forecast to experience an aggregate benefit of \$73.2 million during the 13-year projection period.

Correlation

PUBLIC FISCAL COSTS/BENEFITS SUMMARY TABLE Economic Impact Analysis of the Proposed Kahuku Village Master Plan Kahuku, Kau, Hawaii

All Amounts Expressed in Constant 2011 Dollars

				All	Amounts Expresse	a in Constant 2011	Dollars						
	Pre-2016 and												Totals Years
Development Year	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	Totals
PUBLIC BENEFITS (Revenues)													
REAL PROPERTY TAXES	\$1,933,685	\$1,507,647	\$3,234,557	\$4,545,745	\$5,896,029	\$8,394,426	\$10,818,130	\$13,275,021	\$15,598,467	\$15,681,860	\$15,796,512	\$15,911,165	\$112,593,243
	,*,***	**,==*,=**	72,221,221	* 1,2 12,1 12	**********	**/** */ ***	****	***,=***,***	***********	****	*,,	412,111,122	***=,=**=,=**
2. STATE INCOME TAXES													
Taxable Personal Income	\$31,921,544	\$33,402,451	\$35,615,469	\$49,507,248	\$72,638,920	\$72,930,827	\$103,784,835	\$122,654,236	\$141,876,405	\$100,169,800	\$100,837,802	\$101,912,568	\$967,252,105
Taxable Corporate Profits	\$2,437,083	\$1,941,310	\$7,442,316	\$9,055,260	\$9,893,883	\$14,817,974	\$20,257,596	\$21,427,776	\$26,983,582	\$29,295,365	\$29,316,202	\$29,380,989	\$202,249,336
Personal Taxes Paid	\$1,627,999	\$1,703,525	\$1,816,389	\$2,524,870	\$3,704,585	\$3,719,472	\$5,293,027	\$6,255,366	\$7,235,697	\$5,108,660	\$5,142,728	\$5,197,541	\$49,329,857
Corporate Taxes Paid	\$107,232	\$85,418	\$327,462	\$398,431	\$435,331	\$651,991	\$891,334	\$942,822	\$1,187,278	\$1,288,996	\$1,289,913	\$1,292,764	\$8,898,971
TOTAL STATE INCOME TAXES	\$1,735,230	\$1,788,943	\$2,143,851	\$2,923,301	\$4,139,916	\$4,371,463	\$6,184,361	\$7,198,188	\$8,422,974	\$6,397,656	\$6,432,641	\$6,490,304	\$58,228,828
3. STATE GROSS EXCISE TAX													
Taxable Transactions													
Construction Contracts	\$131,540,415	\$85,193,495	\$89,698,709	\$89,871,716	\$118,673,750	\$117,520,038	\$156,435,485	\$150,931,582	\$139,377,880	\$11,346,098	\$8,206,800	\$8,206,800	\$1,107,002,769
Worker Disposable Income Purchases	\$15,553,069	\$15,862,176	\$16,526,160	\$22,242,584	\$32,545,603	\$31,419,616	\$42,337,425	\$47,177,182	\$52,172,462	\$30,899,765	\$30,754,909	\$30,813,436	\$368,304,388
Unit Owner/Guest Expenditures (on/off site)	\$12,643,134	\$16,534,438	\$20,516,113	\$60,131,929	\$73,394,590	\$86,749,868	\$133,894,977	\$155,521,925	\$177,331,250	\$178,719,567	\$180,248,089	\$181,776,610	\$1,277,462,490
Non-Resident Patronage Expenditures	\$1,000,830	\$1,037,330	\$6,233,830	\$9,541,380	\$9,659,505	\$24,627,630	\$29,771,075	\$30,144,700	\$45,250,200	\$46,478,790	\$46,478,790	\$46,478,790	\$296,702,850
Total Taxable Transactions	\$160,737,449	\$118,627,439	\$132,974,813	\$181,787,609	\$234,273,448	\$260,317,151	\$362,438,961	\$383,775,389	\$414,131,793	\$267,444,220	\$265,688,588	\$267,275,636	\$3,049,472,497
TOTAL STATE EXCISE TAX	\$6,697,447	\$4,942,849	\$5,540,662	\$7,574,544	\$9,761,472	\$10,846,635	\$15,101,744	\$15,990,769	\$17,255,629	\$11,143,598	\$11,070,446	\$11,136,574	\$127,062,371
4. TRANSIENT ACCOMMODATIONS TAX													
Taxable Lodging Revenues	\$3,335,370	\$4,527,460	\$33,140,540	\$41,290,260	\$45,015,450	\$48,786,630	\$78,904,240	\$88,536,590	\$98,260,920	\$98,812,800	\$99,410,670	\$100,008,540	\$740,029,470
TOTAL TRANSIENT ACCOMMODATIONS TAX	\$308,522	\$418,790	\$3,065,500	\$3,819,349	\$4,163,929	\$4,512,763	\$7,298,642	\$8,189,635	\$9,089,135	\$9,140,184	\$9,195,487	\$9,250,790	\$68,452,726
TOTAL GROSS PUBLIC REVENUES													
To County of Hawaii (Item #1 & 8.33% of #4)	\$1,959,385	\$1,542,533	\$3,489,913	\$4,863,896	\$6,242,884	\$8,770,339	\$11,426,107	\$13,957,218	\$16,355,592	\$16,443,237	\$16,562,496	\$16,681,755	\$118,295,355
To State (Items #2, #3 & 55.20% of #4)	\$8,602,982	\$6,962,964	\$9,376,668	\$12,606,126	\$16,199,876	\$17,709,143	\$25,314,956	\$27,709,636	\$30,695,806	\$22,586,636	\$22,578,996	\$22,733,314	\$223,077,103
AGGREGATE TAX REVENUES	\$10,562,366	\$8,505,497	\$12,866,582	\$17,470,022	\$22,442,761	\$26,479,482	\$36,741,062	\$41,666,853	\$47,051,398	\$39,029,873	\$39,141,492	\$39,415,070	\$341,372,459
PUBLIC COSTS (Expenses)													
By County of Hawaii	\$365,548	\$511,842	\$661,663	\$1,801,760	\$2,277,471	\$2,756,538	\$4,449,793	\$5,505,617	\$6,568,369	\$6,649,891	\$6,741,535	\$6,833,179	\$45,123,206
By State of Hawaii	\$1,202,836	\$1,684,219	\$2,177,203	\$5,928,696	\$7,494,024	\$9,070,393	\$14,642,053	\$18,116,244	\$21,613,230	\$21,881,478	\$22,183,034	\$22,484,591	\$148,478,001
TOTAL PUBLIC COSTS	\$1,568,384	\$2,196,061	\$2,838,866	\$7,730,457	\$9,771,495	\$11,826,931	\$19,091,846	\$23,621,861	\$28,181,599	\$28,531,369	\$28,924,569	\$29,317,770	\$193,601,207
TOTAL NET PUBLIC BENEFITS													
To County of Hawaii	\$1,593,837	\$1,030,690	\$2,828,250	\$3,062,136	\$3,965,413	\$6,013,802	\$6,976,314	\$8,451,600	\$9,787,223	\$9,793,347	\$9,820,961	\$9,848,576	\$73,172,149
To State of Hawaii	\$7,400,146	\$5,278,746	\$7,199,466	\$6,677,430	\$8,705,853	\$8,638,750	\$10,672,903	\$9,593,392	\$9,082,576	\$705,158	\$395,962	\$248,724	\$74,599,103
AGGREGATE NET BENEFITS	\$8,993,983	\$6,309,436	\$10,027,716	\$9,739,565	\$12,671,266	\$14,652,552	\$17,649,216	\$18,044,992	\$18,869,799	\$10,498,504	\$10,216,923	\$10,097,300	\$147,771,252

Note: 36.47 percent of the Transient Accommodations Tax goes to the counties of Maui, Kauai, and Honolulu.

Source: The Hallstrom Group, Inc.



- The net benefit to the State of Hawaii reaches a maximum net gain of \$18.8 million in the tenth year of development as construction activity peaks. As the project moves to build-out and the de facto population increases, the forecast state "profits" decrease to a total of \$248,724 in 2027 and on a stabilizes basis thereafter. An aggregate gain of \$74.6 million is accrued over the course of the modeling period.
- The overall combined yearly net benefit to state and county coffers local government agencies (state and county) varies from \$6.3 million to a peak of \$18.9 million, with a stabilized yearly "profit" of circa \$10.0 million per year following build-out, and a cumulative benefit figure of \$147.7 million during construction.

Limiting Conditions and Assumptions

The research, analysis, and conclusions for valuation or market studies, performed by The Hallstrom Group, Inc., are subject to and influenced by the following:

- The report expresses the opinion of the signers as of the date stated in the letter of transmittal, and in no way has been contingent upon the reporting of specified values or findings. It is based upon the then present condition of the national and local economy and the then purchasing power of the dollar.
- Legal descriptions used within the report are taken from
 official documents recorded with the State of Hawaii,
 Bureau of Conveyances, or have been furnished by the
 client, and are assumed to be correct. No survey is made
 for purposes of the report.
- Any sketches, maps, plot plans, and photographs included in the report are intended only to show spatial relationships and/or assist the reader in visualizing the property. They are not measured surveys or maps and we are not responsible for their accuracy or interpretive quality.



- It is assumed that the subject property is free and clear of any and all encumbrances other than those referred to herein, and no responsibility is assumed for matters of a legal nature. The report is not to be construed as rendering any opinion of title, which is assumed to be good and marketable. No title information or data regarding easements which might adversely affect the use, access, or development of the property, other than that referenced in the report, was found or provided. The property is analyzed as though under responsible ownership and competent management.
- Any architectural plans and/or specifications examined assume completion of the improvements in general conformance with those documents in a timely and workmanlike manner.
- Preparation for, attendance, or testimony at any court or administrative hearing in connection with this report shall not be required unless prior arrangements have been made therefor.
- If the report contains an allocation of value between land and improvements, such allocation applies only under the existing program of utilization. The separate valuations for land and building must not be used in conjunction with any other purpose and are invalid if so used.
- If the report contains a valuation relating to a geographical portion or tract of real estate, the value reported for such geographical portion relates to such portion only and should not be construed as applying with equal validity to other portions of the larger parcel or tract; and the value reported for such geographical portion plus the value of all other geographical portions may or may not equal the value of the entire parcel or tract considered as an entity.
- If the report contains a valuation relating to an estate in land that is less than the whole fee simple estate, the



value reported for such estate relates to a fractional interest only in the real estate involved, and the value of this fractional interest plus the value of all other fractional interest may or may not equal to the value of the entire fee simple estate considered as a whole.

- It is assumed that there are no hidden or inapparent conditions of the property, subsoil, or structures which would render it more or less valuable; we assume no responsibility for such conditions or for engineering which might be required to discover such factors.
- Nothing in the report should be deemed a certification or guaranty as to the structural and/or mechanical (electrical, heating, air-conditioning, and plumbing) soundness of the building(s) and associated mechanical systems, unless otherwise noted.
- Information, estimates, and opinions provided by third parties and contained in this report were obtained from sources considered reliable and believed to be true and correct. However, no responsibility is assumed for possible misinformation.
- Possession of the report, or a copy thereof, does not carry with it the right of publication, and the report may not be used by any person or organization except the client without the previous written consent of the appraiser, and then only in its entirety. If the client releases or disseminates the reports to others without the consent of the appraiser, the client hereby agrees to hold the appraiser harmless, and to indemnify the analysts from any liability, damages, or losses which the analysts might suffer, for any reason whatsoever, by reason of dissemination of the report by the client. Further, if legal action is brought against the analyst by a party other than the client concerning the report or the opinions stated therein, the client agrees, in addition to indemnifying the analysts for any damages or losses, to defend said analysts in said action at client's expense. However, nothing herein shall prohibit the client or analysts from



- disclosing said report or opinions contained therein as may be required by applicable law.
- Disclosure of the contents of this report is governed by the By-Laws and Regulations of the Appraisal Institute. Neither all nor any part of the contents of this report (especially any conclusions as to value, the identity of the appraisers or the firm which they are connected, or any reference to the Appraisal Institute or to the MAI designation) shall be disseminated to the public through advertising media, public relations media, news media, sales media, or any public means of communication without the prior consent and approval of the appraisers.
- Unless otherwise stated in this report, the existence of hazardous material, which may or may not be present on the property, was not observed by the appraiser. The appraiser has no knowledge of the existence of such materials on or in the property. The appraiser, however, is not qualified to detect such substances. The presence of substances such as asbestos, urea-formaldehyde foam insulation, or other potentially hazardous materials may affect the value of the property. The value estimate is predicated on the assumption that there is no such material on or in the property that would cause a loss in No responsibility is assumed for any such value. or for any expertise or engineering conditions, knowledge required to discover them. The client is urged to retain an expert in this field, if desired.
- The Americans with Disabilities Act (ADA) became effective January 26, 1992. We have not made a specific compliance survey and analysis of this property to determine whether or not it is in conformity with the various detailed requirements of the ADA. It is possible that a compliance survey together with a detailed analysis of the requirements of the ADA could reveal that the property is not in compliance with one or more of the requirements of the act. If so, this fact could have a negative effect upon the value of the property. We did not consider possible noncompliance with the



requirements of ADA in estimating the value of the property.

- The function of this report is for the sole purpose(s) stated herein. It may not be used in connection with any proposed or future construction for a real estate syndicate(s), real estate investment trust(s) or limited partnership to solicit investors or limited partners, and may not be relied upon for such purposes.
- The appraiser's conclusion of value is based upon the assumption that there are no hidden or unapparent conditions of the property that might prevent buildability. The appraiser recommends that due diligence be conducted through the local building department or the municipality to investigate buildability and whether the property is suitable for its intended use. The appraiser makes no such representations, guarantees or warranties.

Tom W. Holliday Senior Analyst

Som w. Holliday

/as

5040_R01



PROFESSIONAL BACKGROUND AND SERVICES

The Hallstrom Group, Inc. is a Honolulu based independent professional organization that provides a wide scope of real estate consulting services throughout the State of Hawaii with particular emphasis on valuation studies. The purpose of the firm is to assist clients in formulating realistic real estate decisions. It provides solutions to complex issues by delivering thoroughly researched, objective analyses in a timely manner. Focusing on specific client problems and needs, and employing a broad range of tools including after-tax cash flow simulations and feasibility analyses, the firm minimizes the financial risks inherent in the real estate decision making process.

The principals and associates of the firm have been professionally trained, are experienced in Hawaiian real estate, and are actively associated with the Appraisal Institute and the Counselors of Real Estate, nationally recognized real estate appraisal and counseling organizations.

The real estate appraisals prepared by The Hallstrom Group accomplish a variety of needs and function to provide professional value opinions for such purposes as mortgage loans, investment decisions, lease negotiations and arbitrations, condemnations, assessment appeals, and the formation of policy decisions. Valuation assignments cover a spectrum of property types including existing and proposed resort and residential developments, industrial properties, high-rise office buildings and condominiums, shopping centers, subdivisions, apartments, residential leased fee conversions, special purpose properties, and vacant acreage, as well as property assemblages and portfolio reviews.

Market studies are research-intensive, analytical tools oriented to provide insight into investment opportunities and development challenges, and range in focus from highest and best use determinations for a specific site or improved property, to an evaluation of multiple (present and future) demand and supply characteristics for long-term, mixed-use projects. Market studies are commissioned for a variety of purposes where timely market information, insightful trends analyses, and perceptive conceptual conclusions or recommendations are critical. Uses include the formation of development strategies, bases for capital commitment decisions, evidence of appropriateness for state and county land use classification petitions, fiscal and social impact evaluations, and the identification of alternative economic use/conversion opportunities.

ARBITRATION VALUATION AND MARKET STUDIES

PAUAHI TOWER SUITE 1350 1003 BISHOP STREET HONOLULU HAWAII 96813-6442

(808) 526-0444 FAX (808) 533-0347 email@hallstromgroup.com www.hallstromgroup.com

PROFESSIONAL QUALIFICATIONS OF THOMAS W. HOLLIDAY

Business Affiliation

Supervisor/Senior The Hallstrom Group, Inc.

Analyst Honolulu, Hawaii

Since 1980

Former Staff Appraiser Davis-Baker Appraisal Co.

Avalon, Santa Catalina Island, California

Education

- B.A. (Communications/Journalism) 1978 California State, University at Fullerton
- SREA Course 201- Principles of Income Property Appraising
- Expert witness testimony before State of Hawaii Land Use Commission and various state and county boards and agencies since 1983.
- Numerous professional seminars and clinics
- Contributing author to <u>Hawaii Real Estate Investor</u>, Honolulu Star Bulletin

On January 1, 1991, the American Institute of Real Estate Appraisers (AIREA) and the Society of Real Estate Appraisers (SREA) consolidated, forming the Appraisal Institute (AI).

Recent Neighbor Island Assignments

 Market Study, Economic Impact Analyses and Public Costs/ Benefits (Fiscal Impact) Assessments

Big Island

- -- Kamakana Villages (Mixed-Use Residential Development)
- -- W.H. Shipman Ltd, Master Plan (Various Urban Uses)
- -- Nani Kahuku Aina (Mixed-Use Resort Community
- -- Kona Kai Ola (Mixed-Use Resort Community)
- -- Waikoloa Highlands (Residential)
- -- Waikoloa Heights (Mixed-Use Residential Development)

Kauai

- Village at Poipu (Resort/Residential)
- -- Ocean Bay Plantation (Resort/Residential)
- -- Waipono/Puhi (Mixed-Use Planned Development)
- -- Eleele Commercial Expansion (Commercial)

Maui

- -- Upcountry Town Center (Mixed-Use Project)
- -- Maui Lani (Mixed-Use Community)
- -- Honuaula (Mixed-Use Community)
- -- Maui Business Park, Phase II (Industrial/Commercial)
- -- Kapalua Mauka (Master Planned Community)
- -- Hailimaile (Mixed-Use Master Planned Community)
- -- Pulelehua (Master Planned Community)
- Westin Kaanapali Ocean Villas Expansion (Resort/ Timeshare)