

Wetlands Habitat Restoration Plan for Honu‘apo Estuary

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Acronyms and Abbreviations

AIS	Archeological Inventory Survey	MPA	Marine Protected Area
BLNR	Board of Land and Natural Resources	MSL	Mean Sea Level
BMP	Best Management Practice	NEPA	National Environmental Policy Act
CDUP	Conservation District Use Permit	NFWF	National Fish and Wildlife Foundation
CWA	Clean Water Act	NHPA	National Historic Preservation Act
CWB	Clean Water Branch	NMFS	National Marine Fisheries Service
CZM	Coastal Zone Management	NOAA	National Oceanic and Atmospheric Administration
DAR	Division of Aquatic Resources	NPDES	National Pollutant Discharge Elimination System
dBA	Decibels	NRCS	Natural Resources Conservation Service
DBEDT	Department of Business, Economic Development, and Tourism	NWHI	Northwestern Hawaiian Islands
DLNR	Department of Land and Natural Resources	OCCL	Office of Conservation and Coastal Lands
DO	Dissolved Oxygen	ORMP	Ocean Resources Management Plan
DOCARE	Division of Conservation and Resources Enforcement	PCJV	Pacific Coast Joint Venture
DOFAW	Division of Forestry and Wildlife	PDO	Pacific Decadal Oscillation
DOH	Department of Health	PSA	Pacific Subtropical Anticyclone
DPR	Department of Parks and Recreation (County of Hawai'i)	PSE	Plans, Specifications and Estimates
EA	Environmental Assessment	SHPD	State Historic Preservation Division
EFH	Essential Fish Habitat	SMA	Special Management Area
EIS	Environmental Impact Statement	SRGII	Sustainable Resources Group Intn'l, Inc.
ENSO	El Niño-Southern Oscillation	TWI	Trade Wind Inversion
ESA	Endangered Species Act	USACE	U.S. Army Corps of Engineers
ET	Evapotranspiration	USDA	U.S. Department of Agriculture
HRS	Hawai'i Revised Statutes	USEPA	U.S. Environmental Protection Agency
HWJV	Hawai'i Wetland Joint Venture	USFWS	U.S. Fish and Wildlife Service
IUCN	International Union for Conservation of Nature	WHRP	Wetlands Habitat Restoration Plan for Honu'apo Estuary
Ka 'Ohana	Ka 'Ohana O Honu'apo		
MACZAC	Marine and Coastal Zone Advocacy Council		
MBTA	Migratory Bird Treaty Act		
MHI	Main Hawaiian Islands		
MHW	Mean High Water		
MHHW	Mean Highest High Water		
MLW	Mean Low Water		
MLLW	Mean Lowest Low Water		

1.0 INTRODUCTION

Through the efforts of Ka 'Ohana O Honu'apo (Ka 'Ohana), with assistance and funding from the National Oceanic and Atmospheric Administration (NOAA), State of Hawai'i Legacy Land Program, County of Hawai'i, and members of the community, the Honu'apo Estuary and surrounding lands are permanently protected from development. Honu'apo Estuary, located in the Ka'ū District, on the Island of Hawai'i, contains approximately eight acres of estuary and marsh. Although the estuary wetland system supports a diversity of endemic species and microhabitats, decades of neglect and misuse have resulted in altered hydrology, sedimentation, and invasion by non-native plants and animals. This contributes to impairment of wetland functions and habitat for native resident and migratory birds and other native fauna. For example, springs along the inland margin of the estuary are encroached on by invasive California grass (*Urochloa mutica*) and *kiawe* (*Prosopis pallida*), resulting in decreased habitat and adverse impacts to the system's hydrology. *Kiawe* is a nitrogen fixer and a phreatophyte, plants that are efficient at mining groundwater, and may be decreasing freshwater inputs into the estuary and elevating nitrogen levels. Previous studies of the estuary and surrounding area indicate that native species, including birds listed as endangered or species of conservation concern, are present in the area. Although the system shows signs of degradation, a variety of management actions can be employed to help enhance habitat for native flora and fauna and to restore sections that have been filled or irreversibly altered. Enhancement and restoration actions are expected to increase habitat and improve wetland function.

This *Wetlands Habitat Restoration Plan for Honu'apo Estuary* (WHRP) provides guidance for a wetland restoration project that will restore the aquatic functions of the estuary through removal of invasive non-native plants; excavation of fill and contouring the topography to enhance physical habitat; planting native and endemic plants; and controlling predation on avian species. These actions are expected to improve habitat for native waterbirds, fish, and turtles and enhance other wetland functions. The WHRP is part of a Resource Management Plan that has been developed/adopted for Honu'apo Park that provides land use guidance to help protect and restore the important natural and cultural resources of the property while providing integrated and respectful recreational and educational opportunities for the Ka'ū community (Townscape 2010).

Ka 'Ohana's mission is to restore, care for, and protect the cultural and natural resources within the Honu'apo area. Ka 'Ohana secured funding from the State of Hawai'i Coastal Zone Management (CZM) Program (through County of Hawai'i Department of Planning), the U.S. Fish and Wildlife Service (USFWS), the Pacific Coast Joint Venture (PCJV) (whose Hawaiian arm is the Hawai'i Wetland Joint Venture (HWJV)), and private sources to develop this WHRP. The WHRP provides the basis of design and technical information needed to acquire additional funding to implement the wetland restoration and enhancement activities.

1.1 Background of Wetland Restoration Planning Process

The area containing Honu'apo Park has played an integral role in Ka'ū's community life for many generations. Historically the area was a fishing village called Honu'apo Village. The large estuary at Honu'apo was used as a fishpond. Freshwater springs discharging into the estuary provided water for the residents of the village. Part of this place was also said to have had a well-known *pu'uhonua*, a place of refuge.

In 1868 a massive earthquake and resulting tsunami destroyed the village and the surrounding area. Honu‘apo remained a well-used fishing and shoreline access point until Honu‘apo Bay was dredged and a wharf was constructed in 1883 to serve the needs of the Hutchinson Sugar Company. A sugar mill, large warehouses, a small railroad, and many residences and other company buildings were erected in the area. Use of the port declined in the late 1930s, and in 1946 another tsunami destroyed most of wharf and some of the remaining industrial buildings. After this, much of the area *mauka* (inland) of Honu‘apo Bay, including the estuary, was utilized for grazing cattle, although the sugar industry maintained a presence until the 1990’s. The sugar company dumped industry effluent into the ocean from the adjacent Mill Ditch Road (just northeast of and next to Honu‘apo Bay) during a portion of its operation. Due to operational issues with the ditch, the effluent was later discharge on land *mauka* of the shoreline just north of the estuary. A third tsunami and earthquake in 1975 further destroyed the shoreline, leaving only a few remnants of concrete foundations of the sugar cane and port facilities. This earthquake was responsible for a major subsidence of the coastal area along the shoreline in the Ka‘ū District.

Decades of using the area for sugar operations and cattle grazing caused the wetland complex and surrounding area to become impacted and overgrown with invasive species including seashore paspallum (*Paspallum viginatum*), California grass (*Urochloa mutica*), and guinea grass (*Panicum maximum*). Cattle have trampled within the wetland and a portion of the estuary was altered through landscaping and planting to create a Japanese garden, complete with walking bridge. The estuary and surrounding area also became a dumping ground for old car parts and trash.

In the early 2000’s, the community learned that the owner/developer of the 225 acres surrounding the estuary had submitted plans to the county to build 18 luxury estates. Local residents became concerned that the subdivision would threaten remaining habitat, lead to even more development, and limit shoreline access for local fishermen and families. This prompted a group of dedicated local volunteers to organize and create a nonprofit, Ka ‘Ohana O Honu‘apo, to oversee restoration efforts and park expansion at Honu‘apo.

In 2003–2004 volunteers spent thousands of hours cleaning up the degraded wetlands and bay, including the removal of encroaching vegetation, which made the estuary wetland complex visible and was a driving force behind this WHRP. In 2005, with assistance from the Trust for Public Land, and working together with hundreds of residents and individuals across the state, Ka ‘Ohana raised \$1.5 million from NOAA, \$1 million from the State, \$0.5 million from the County, and hundreds of thousands of dollars from generous donors, to buy the 225 acres. The State purchased the land and by executive order gave control of the land to the County of Hawai‘i.¹ On August 14, 2008, Ka ‘Ohana signed a Memorandum of Understanding with the County to assist in the planning, restoration, and management of the environmental, cultural, and recreational resources of Honu‘apo Park, now managed by the County’s Department of Parks and Recreation (DPR). In 2010 Townscape, Inc. completed a Resources Management Plan for Honu‘apo Park (Townscape 2010). This WHRP complements that effort.

1.2 Plan Purpose and Scope

The purpose of this WHRP is to provide Ka ‘Ohana, its partners, interested parties and stakeholders, and regulatory agencies with reliable technical information and analysis regarding restoration and

¹ Executive Order 4164 relating to the set-aside of lands at Honu‘apo for estuarine land conservation and public recreational purposes, dated June 2, 2006.

enhancement of the coastal wetland habitats in the project area.² The plan describes the ecohydrology of the wetlands, identifies stressors to the system, and presents designs to enhance and restore the wetlands for native flora and fauna. The plan provides a framework and sufficient detail for the County, Ka 'Ohana, and partners in a restoration process that also protects cultural and archeological resources and allows for appropriate passive recreational and educational uses.³ The WHRP outlines actions necessary to achieve the project goals, identifies necessary permits, and generates order of magnitude cost estimates. A restoration plan is needed to support planning and fundraising efforts for the estuary restoration as well as to provide guidance for on-going management.

The primary objective of the restoration and enhancement is to restore and enhance habitat form and function for the benefit of native flora and fauna, with an emphasis on resident and migratory avian species. The restoration plan for Honu'apo Estuary identifies the stressors to the avian habitat, the prescriptions necessary to alleviate the stressors, actions to restore and enhance habitat, and maintenance to sustain those actions. Secondary objectives include enhancing habitat for native fish and turtles; accommodating estimated sea level rise; improving aesthetics of the site; allowing for passive recreational and educational uses; and preserving cultural and historical values. Although the plan does not address restoration of cultural uses of the estuary (i.e. fishpond / aquaculture), the actions to restore biological functions are aligned with Hawaiian cultural values, as the two elements are intertwined.

2.0 HONU'APO ESTUARY – SITE DESCRIPTION

2.1 Location and Description

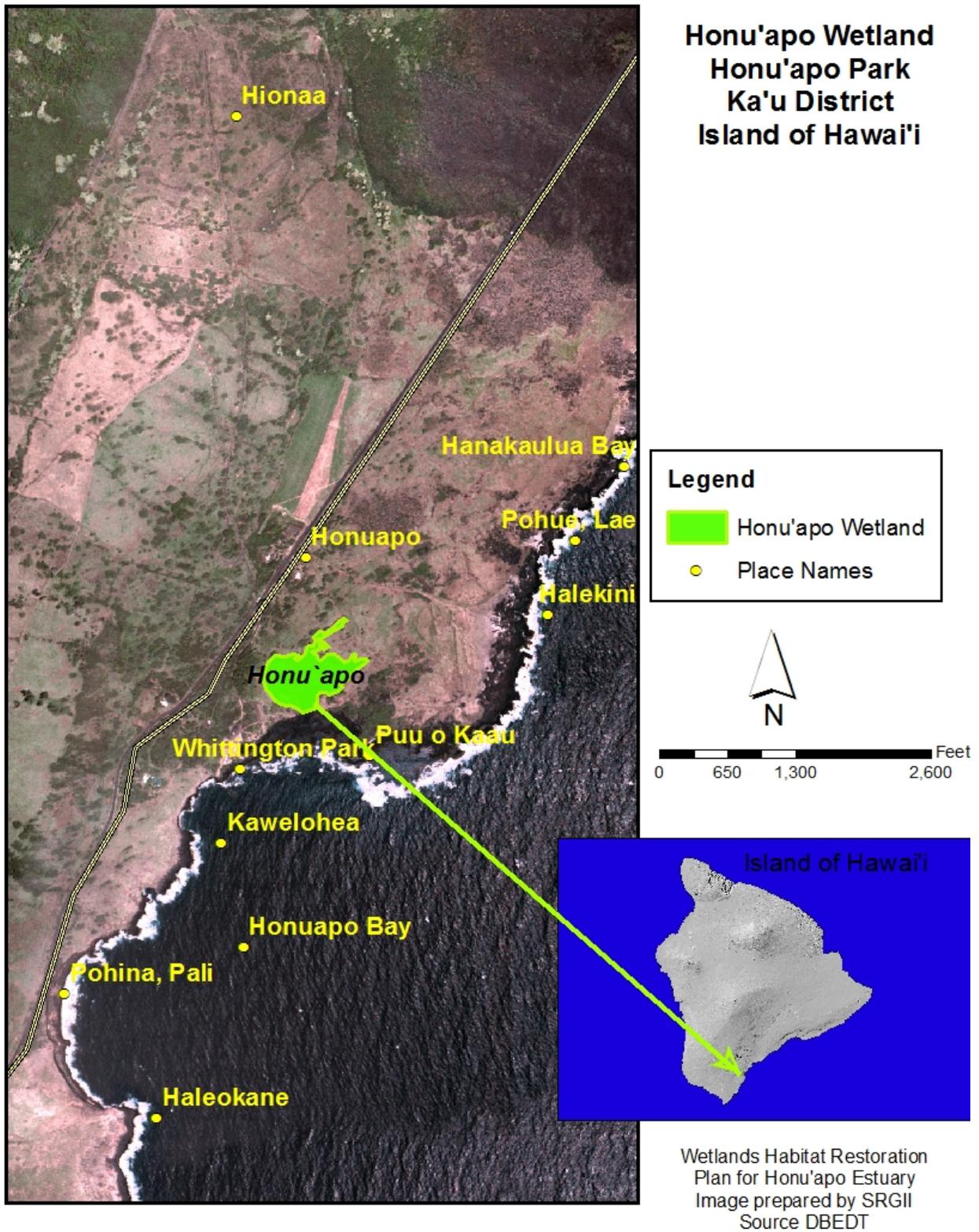
Honu'apo Estuary is located along the coast in rural Ka'ū District of Hawai'i Island (19° 05'N, 155° 33'W). It is within the 225-acre Honu'apo Park, which includes the County's Whittington Beach Park (Figure 2-1). The estuary is part of a wetland complex that encompasses approximately 8 acres comprised of three distinct wetland types (Appendix C, Sheet G-4). The estuary proper is a subtidal water body covering approximately 2.1 acres. Water levels and the wetted surface of the estuary vary with tides, due to the direct ocean connection. Four and half acres of the wetland are classified as intertidal, inundated by tides on a periodic basis. One and a third acres of the complex are classified as a palustrine wetland, located above the intertidal zone, and not submerged except during wave run-up and following heavy rain events.

There are no natural freshwater streams or channels that flow into the estuary. Freshwater from springs and seeps has been observed discharging into the wetland along its margins and in the estuary, creating small pockets of freshwater that transition quickly to brackish water in the main body of the estuary and to sea water near its mouth. It is possible, although not verified, that in the past a manmade channel carried effluent water from the sugar cane mill into the estuary at its northeast arm.

² *Restoration* is a term used to describe activities that seek to return wetlands to a previously existing natural condition from a disturbed or totally altered state. *Enhancement* is the improvement, maintenance, and management of existing wetlands and/or associated uplands for a particular function or value.

³ *Passive recreation* may be defined as a non-motorized activity that: offers constructive, restorative, and pleasurable human benefits and fosters appreciation and understanding of open space and its purpose; is compatible with other passive recreation uses; does not significantly impact natural, cultural, or scientific values; and requires only minimal visitor facilities and services directly related to safety and minimizes passive recreation impacts.

Figure 2-1. Location Map



Vegetation changes in a short distance from wetland to upland species, creating a distinct boundary. The adjacent coastline represents one of the longest undeveloped coastlines in the State of Hawai'i. The shoreline in the Ka'ū District is rugged *pali* (cliff) and inaccessible by land along large stretches. The strong ocean currents and the rough conditions make diving and boating in the area challenging, which limits extraction of ocean resources to the shoreline and near-shore waters.

There is no definitive explanation as to how the geomorphology of the estuary was created, resulting in a low point on the landscape and a perennial water body. A logical geologic explanation is that subsidence due to seismic activity occurred sometime following cessation of lava flows and prior to habitation by Polynesians, since archeological evidence indicates the estuary was used by humans as a fishpond. The estuary was most likely created by natural processes, though moderately altered by humans, and is a unique feature along the Ka'ū shoreline.

The wetland complex is part of a unique coastal ecosystem of semi-sheltered near-shore pools, brackish ponds, and open ocean environs. Estuarine wetlands are relatively rare on Hawai'i Island and the location of this system makes it of high value to native and migratory bird species utilizing the southern portion of the island. Historically, the area was used by *ka po'e kahiko* (ancient Hawaiians) as a fishpond to cultivate '*ama'ama* (striped mullet, *Mugil cephalus*) and other valuable species. The estuary outlet channel to the sea was fitted with a *mākāhā* (gate) that was used to control water flow into and out of the estuary making its use as a fishpond possible.

2.2 Prior Studies and Reports

The Honu'apo Estuary has been studied by researchers from several government, non-profit, and research institutions. An annotated bibliography of reference documents and data sets used to prepare this report is presented in Appendix A. Species lists are included in Appendix B. Informal interviews with individuals knowledgeable about Honu'apo have been conducted to assist in preparation of the WHRP.

Biological inventories of flora and fauna have been conducted as part of various research efforts and plans, though most are relatively recent. Historic data and information on species presence/absence or populations estimates are limited or do not exist. Avian surveys are conducted biannually by the State Department of Land and Natural Resources (DLNR) Division of Forestry and Wildlife (DOFAW) and observations of birds using the estuary and Whittington Beach Park are made by bird watchers and other visitors to the area. Anecdotal information finds that both native resident and migratory birds use the estuary, and their presence, albeit infrequent, indicates the estuary is along flight paths and utilized in its degraded condition. A general consensus of resource managers and persons familiar with Honu'apo Estuary is that predators are the primary reason bird use at the site is limited. Evidence includes the extensive mongoose trails in the vegetation surrounding the wetland and a large cat colony at the beach park.

Biological inventories by U.S. Department of Agriculture (USDA) researcher Dr. Richard MacKenzie show that fish found in the estuary include both native and non-native species (R. MacKenzie, pers. comm.). Non-native fish such as guppies and mosquito fish are known to eat native crustaceans and harass native fish. Predatory fish such as barracuda that enter the estuary via the open channel place a control on the non-native fish, and is one reason why the open channel connecting the estuary to the ocean is a vital feature of the system. Based on observations and anecdotal information, the estuary is also utilized by green sea turtles (*Chelonia mydas agassizii*) as resting habitat.

There are alien and native plant species in both the upland area adjacent to the wetland and in the wetland. The upland zone inland of the wetland is dominated by alien species whereas areas seaward of the wetland contain several species of native plants along the coastal strand zone. The wetland vegetative community has been altered by human activities, however several native plant species that native resident birds use for foraging and nesting materials are found, though their distribution and density are limited.

Since there was limited data pertaining to the volume and quality of fresh groundwater flows into the wetland complex, hydrologic data was collected as part of this planning process (Section 2.3). Hydrodynamic analysis of the estuary was conducted to estimate the salinity gradient within the water body and hydraulic variables of depth and velocity under daily tidal fluxes (Section 2.4.3). This information was used to develop enhancement and restoration designs.

2.3 Field Surveys

2.3.1 Site Investigations

Sustainable Resources Group Intn'l, Inc. (SRGII) personnel conducted four site investigations over a total of six days between February 2010 and January 2011. The investigations were multi-purpose: to become familiar with the physiographic variables of the project area; collect biological and hydrologic data and information; meet and interview persons familiar with the site and management of the park; and conduct a topographic survey of the estuary wetland complex.

Summaries of key site investigations include:

1. February 1, 2010; SRGII personnel: Andy Hood

Held meeting with Lehua Lopez-Mau, Ka 'Ohana Director, to discuss project goals, objectives, and scope of work needed to prepare wetland restoration plan. Conducted reconnaissance survey by walking perimeter of estuary wetland and making observations.

2. March 26, 2010; SRGII personnel: Andy Hood and Kristin Duin

Held meetings with Lehua Lopez-Mau and Wendy Scott (Ka 'Ohana) and Dennis Riordan (County DPR). Conducted reconnaissance survey by walking perimeter of estuary wetland and making observations. Discussed County maintenance of Honu'apo Park, including actions conducted inside estuary complex, with Mr. Riordan.

3. November 3–5, 2010; SRGII personnel: Andy Hood and Jennifer Garrison

Held meetings with Ka 'Ohana's Board of Directors, Megan Lamson, John Replogle, and Dennis Riordan. Reviewed project scope. Delineated boundaries of area to be surveyed November 3–9, 2010 by Island Survey, a licensed survey firm. Collected biological and hydrologic data and vegetation, soil, and water samples for identification and analysis. Deployed three remotely operated pressure transducers and one multi-probe water quality sensor to collect 15 minute interval data on water levels and quality at two locations.

4. January 27, 2011; SRGII personnel: Andy Hood

Collected biological data and information including: inventory and identification of vegetation in and immediately adjacent to the wetland; survey of birds via point count method at three different times and

locations as well as continuously during field operations; and assessment of habitat structure, conditions, and quantity.

Collected hydrologic/soil data and information including: collection and in-situ analysis using a multi-probe YSI water quality sensor to measure water quality parameters (Dissolved oxygen, pH, temperature, salinity, chlorophyll, depth and turbidity) at numerous locations; collection and field analysis of soil cores extracted from 0 to 12 inch depths at numerous locations; and inventory and delineation of seeps and springs along the entire estuary shoreline and within the estuary, and measurements of discharge rates where possible.

2.3.2 Topographic Survey

A licensed land surveyor conducted a ground-based topographic survey of Honu'apo Estuary from November 3–9, 2010. Survey points were measured with a total digital station using a datum of mean sea level equal to 0.00 feet for all vertical controls. Vertical controls are located in the vicinity and can be used for subsequent surveys during restoration activities. The topography was surveyed from the upper banks of the estuary down to its shoreline. Topography of the submerged sections of the estuary was not surveyed by the surveyor. Topography of the estuary bottom was generated by SRGII using measured water depths at equally spaced intervals at locations visible on a high resolution air image of the site. Three dimensional coordinates were derived for each estuary topography sample location and combined with the topography coordinate file created by the land surveyor. The topography data is used to compute water volume and surface area under varying tides, to compute cut and fill volumes, and to quantify habitat areas for restoration designs. The topography map is depicted in Appendix C, Sheet G-3.

2.4 Physical Features

2.4.1 Physiography

Geological Setting

Honu'apo, including the coastal zones to its north and south, is located on geologically young lava flows discharged from the vents of the Mauna Loa volcano. Both *a'ā* and *pāhoehoe* lavas form the relatively flat narrow coastal plain of the area, with *pāhoehoe* being the dominant lava. Lavas in and around Honu'apo are estimated to be five thousand years old. Seismic activity concurrent with and subsequent to volcanic eruptions has altered the topography of the ground surface, and numerous locations along the Ka'ū coast have been subjected to uplift and subsidence. The Honu'apo Estuary is likely a depression feature due to subsidence induced by seismic activity. To the north of the wetland complex near the shoreline there are numerous small *pukas* (holes) that were probably formed from seismic activity, collapse of lava tubes in the underlying *pāhoehoe* flows, or where lavas did not infill during flow advancement.

The geologic substrate extending from the crest of the Mauna Loa volcano to the offshore zones contains lava tubes, fractures, and contact zones between various lava flows, creating preferential flow paths for groundwater. The upland areas that receive moderate to high rainfall levels recharge ground water, which is conveyed via these flows paths to coastal areas, where they discharge either off-shore as submarine groundwater or to the atmosphere as springs and seeps.

Topography

The topography of the Honu'apo area is best described as a rocky coastal plain. The longest axis of the coastal plain is aligned in a northeast to southwest direction with the wetland complex located between the base of the slopes formed from lava flows, approximately 600 to 1,000 feet from the ocean shoreline. Immediately southwest of the adjacent Whittington Beach Park sea cliffs cutoff the coastal plain, while to the northeast the plain extends for several miles and increases in width.

Slopes across the Honu'apo coastal area are flat to less than 0.5%, resulting in a fairly uniform terrain. The estuary is the lowest elevation feature within the terrestrial environment. *Mauka* of the shoreline, at varying distances, the surface slopes increase rapidly, a result of lava flows discharged by vents of Mauna Loa. There are no perennial stream channels in the immediate area of the Honu'apo watershed and it does not have well developed natural drainage network. Surface water channels draining the flanks of the volcano are not well formed. Gullies dissect the watershed, though most only carry water in response to high intensity rainfall events.

Soils

The area in and around Honu'apo is depicted on soil maps as rocky broken land (Sato et al. 1973). Soil layers on top of the 'a'ā and *pāhoehoe* lavas is intermittent across the landscape where its development is favorable. Due in part to the young age of the lava deposits and the arid conditions of the Ka'ū District that tempers biogeochemical weathering, many of the lava flows are only moderately weathered and covered with a thin soil layer and in some areas volcanic ash. Depths of soil in the larger project area range from a few inches thick near the coast to several feet within a few isolated locations in the wetland complex. In other areas lavas are covered with a veneer of volcanic ash derived from eruptions during the Pāhala volcanic series. In pockets along the shoreline, and in cracks across the coastal plain, organic and inorganic material deposited by wind and by vegetation locally fills in the depressions and acts as grow media for plants in the otherwise windswept, dry, and harsh coastal environment.

Soils in the wetland complex appear to be developed under hydric conditions and are classified as organic due to the abundance of organic material. A 1.4 acre portion of this organic soil extends from the *mauka* side of the complex into the estuary proper, forming a delta-like feature. Approximately half of this zone is slightly submerged and/or saturated during high tides. Vegetation on the *makai* (toward the sea) half is covered with a monotypic stand of Salt grass (*Distichlis spicata*), and the *mauka* half is covered with Seashore paspalum (*Paspalum vaginatum*). Along the upper margins of the wetland there is evidence of fill in the form of gravel and larger rock materials that appear to have been pushed, possibly during sugar cane activities. These fill areas are likely remnants of historic land use on the parcel, and may have buried wetland soils or filled in open water pockets. The upland zone immediately surrounding the wetland is moderately sloped to near flat with numerous rocks protruding above the soil layer.

Wetlands

This plan refers to the estuary and associated wetlands as an 'estuary wetland complex'. The complex contains three wetland types: subtidal estuary, intertidal and palustrine. The subtidal estuary submerges approximately four acres. Its surface area varies with the tides, as it is directly connected to the ocean via a natural channel cut into the lava. Depths in the estuary are a function of tides, with an approximate maximum at high tide of five feet near the center. Using the 1979 wetland classification developed for the USFWS, the estuary classification is: Estuarine, Subtidal, Unconsolidated bottom, Rubble (E1UB2) (Cowardin et al. 1979). The estuary is brackish to saline, with the salinity concentration being a function

of tide levels, rainfall inputs, and proximity to springs and seeps. Historically the surface area of the estuary was larger, as determined by comparing historic and recent oblique and air photographs of the site. Reduction of its surface area is most likely due to vegetation encroachment, possible filling during sugar cane operations, and settling of organic debris from dead vegetation. It is not possible to definitively quantify the amount of open water decrease between historic and present; an estimate is two acres.

The intertidal wetland encompasses the zone around the estuary that is submerged on a nearly daily basis from normal high tides. This wetland type covers approximately three acres and contains small stretches of exposed mudflats, a deltaic feature with dense low growing emergent grasses, and backwater areas with dense vegetative cover. Sections of this wetland have soil and water chemistry ranging from nearly salt free to saline. Vegetation growing on and along this wetland type is a function of the soil type and its soil water salinity concentrations. Under the USFWS classification this wetland is: Estuarine, Intertidal, Emergent, Persistent (EIEM1). Intertidal wetlands are frequently used by wading waterbirds (such as stilts) that forage on crustaceans, fish, and insects. The density and high stature vegetation present in most of this wetland type at Honu'apo reduces its use by wading birds, since they are not able to walk over the vegetation or access the ground surface to reach food sources.

The palustrine wetland is classified as Palustrine, Emergent, Persistent (PEM1). It covers approximately one and a third acres and is located in areas slightly to moderately elevated above the high tide water surface elevation. Most of this wetland type is covered with dense high growing non-native plants. The soils in this wetland support facultative and obligate wetland plants due to the proximity of the phreatic surface (groundwater level) to the ground surface. Pockets of this wetland are dominated by California grass, a species with low salinity tolerance.

The estuary provides habitat for numerous aquatic species (Section 2.5). Along its *makai* sections the shoreline was manipulated by humans to decrease the area of contact between the estuary and the ocean and create a narrow channel between the water bodies. This narrowing facilitated the placement of a gate across the outlet that was used to regulate water levels and aquatic organism passage into and out of the estuary, creating a fishpond. Archeological evidence suggests the estuary was used as fishpond possibly 500 years ago. Concrete weirs on both sides of the outlet suggest that plantation personnel manipulated flows and water levels more recently.

2.4.2 Hydrology

Climate Overview

The ancient Hawaiians distinguished the annual precipitation cycle into two six-month seasons: *kau* (May to October) and *ho'oīlo* (November to April) (Lau and Mink 2006). Modern analysis now divides the annual cycle in the Hawaiian Islands into a summer season of five months (May to September) and a winter season of seven months (October to April) (Blumenstock and Price 1967). During the summer season, when the northeast trade winds prevail 80-95% of the time, areas of maximum rainfall are generally located on windward slopes where orographic effects are most pronounced (Chu and Chen 2005). During the winter season, the trade winds prevail 50-80% of the time and are often interrupted by mid-latitude frontal systems, upper-level troughs, and cutoff lows in the upper-level subtropical westerlies, locally known as *Kona* storms. These three mechanisms can generate widespread rainfall and comprise the major producers of winter season rainfall.

The island of Hawai'i is subject to a complicated but distinct diurnal trade wind regime that influences rainfall spatial and temporal patterns across the island (Chen and Nash 1994). The mean annual rainfall isohyetal⁴ map for the island of Hawai'i indicates that maximum rainfall occurs at elevations ranging from 2,000–4,000 ft along the windward slopes of Mauna Kea and Mauna Loa (Giambelluca, Nullet et al. 1986). High rainfall in these windward regions is caused by thermally forced diurnal circulations, including land–sea breezes and mountain–valley winds, that enhance orographic uplifting of the trade winds and induce low-level convergence (Chen and Nash 1994). A trade wind inversion, occurring around 6,500 ft (Cao, Giambelluca et al. 2007), acts as a lid to vertical motion and convection, and a much drier climate prevails at higher elevations. The southeastern flank of Mauna Loa above Honu'apo is characterized by a secondary rainfall maximum. During the winter season, southeasterly winds associated with synoptic systems can bring heavy rainfall to this region *mauka* of Honu'apo (Kodama and Barnes 1997).

Average annual rainfall at Honu'apo is 47 inches, but increases dramatically to the northwest where the secondary maximum produces more than 120 inches at an elevation of 2,500–3,500 ft (Giambelluca, Nullet et al. 1986). The change in mean annual rainfall from Honu'apo to the secondary maximum occurs over a distance of just under five miles, which results in a rainfall gradient of 15 in/mile. The daily rainfall temporal pattern around Honu'apo is generally characterized by an afternoon rainfall maximum, particularly during the summer season, which is consistent with the diurnal wind pattern (Roy and Balling Jr. 2004).

Recent studies show that rainfall has declined state-wide with observable negative effects on freshwater availability on four of the main Hawaiian Islands including Kaua'i, O'ahu, Moloka'i, and Maui. Using a regional rainfall index compiled from 27 rain gage stations on three of the main Hawaiian Islands including the island of Hawai'i, Chu and Chen (2005) showed that state-wide wet season rainfall (November–March) has declined from 1905 to 2002. Similarly, Oki (2004) reported significant decline in annual rainfall at 17 locations state-wide from 1913 to 2001, including three gages located in the Kona and Hilo areas. However, the rain gage at Nā'ālehu (gage 14) near Honu'apo showed no significant upward or downward trend in annual rainfall over different time periods ranging from 1913–2001 to 1973–2001. As an apparent response to rainfall decline, annual mean total base flow also declined significantly in seven streams from 1913 to 2002 on the islands of Kaua'i, O'ahu, Moloka'i, and Maui (Oki 2004). A similar analysis of streamflow data from the island of Hawai'i could not be conducted for the same time period due to insufficient data. Thus, it is not clear whether perennial streams on the island of Hawai'i are experiencing similar declines in total base flow.

Significant downward trends in rainfall in Hawai'i since the 1970s, particularly at higher elevations, may be related to the increased persistence of the trade wind inversion (TWI) and upward trends in temperature at high elevations (Cao, Giambelluca et al. 2007; Giambelluca, Diaz et al. 2008; Mair and Fares 2010). Cao et al. (2007) noted that the TWI occurrence frequency at opposite ends of the main Hawaiian Islands (Hilo, Hawai'i; Lihue, Kaua'i) has increased since 1979. The TWI influences spatial patterns of cloudiness, rainfall, solar radiation and humidity by strongly inhibiting vertical atmospheric circulation and is a dominant control on local weather and strongly influences orographic rainfall on Hawaiian mountain slopes (Giambelluca and Nullet 1991; Schroeder 1993; Tran 1995). Giambelluca et

⁴ Isohyetal maps are comprised of lines aligned perpendicular to the slope of the landscape where each line represents average annual rainfall.

al. (2008) reported significant warming in mean temperature at four high elevation stations (>2600 ft) in the main Hawaiian Islands from 1975 to 2006, including two stations on the island of Hawai'i. Their results indicate that higher elevations in Hawai'i are warming more rapidly than lower elevations (<2600 ft), especially with respect to nighttime temperature. More rapid warming at high elevations results in a reduced temperature lapse rate, and implies a more stable atmosphere and drier climate (Giambelluca and Luke 2007). Mair and Fares (2010) reported significant rainfall decline since 1979 atop Mt. Ka'ala (elev. 4,000 ft) on the island of O'ahu, which is consistent with the trends for increased TWI persistence and more rapid warming at higher elevations. These studies suggest that warming at higher elevation combined with the TWI persistence may be a cause for downward rainfall trends at higher elevations over the past 30 years. The lack of long-term rainfall data from the high rainfall area northwest of Honu'apo prohibits an analysis of long-term trends at high elevations. Thus, although the gage at Nā'ālehu (gage 14) showed no significant trend in rainfall, it is possible that rainfall may have significantly declined in the high rainfall area from 2,500-3,500 ft northwest of Honu'apo over the past 30 years.

In regions where a downward trend in total rainfall has been observed, such as Hawai'i, significant decline in extreme precipitation events have also been observed (Chu, Chen et al. 2010). Analysis of climate change indices for extreme rainfall show that moderate and heavy rainfall intensity, frequency, and magnitude have decreased at Nā'ālehu (gage 14) while the length of dry periods has increased from the 1950s to 2007 (Chu, Chen et al. 2010). The downward trends at Nā'ālehu contrast with other parts of the island of Hawai'i where upward trends in extreme rainfall have been observed, but are consistent with observations on the islands of Kaua'i and O'ahu where rainfall intensity, frequency, and magnitude have declined over the same period. Given no apparent trend in annual rainfall, the extreme rainfall trends at Nā'ālehu imply that the rainfall regime in the Honu'apo area from the 1950s to 2007 has become less intense with less frequent extreme rainfall events accompanied by a lengthening of the annual maximum number of consecutive dry days. These changes in extreme rainfall are negatively impacting surface runoff generation, however, further analysis is needed to determine if these changes in rainfall are also negatively impacting groundwater recharge upslope of Honu'apo and groundwater discharge occurring in and around Honu'apo. The rainfall regime and its associated shifts due to climate forcing did not dictate the designs presented in this report to enhance and restore wetlands functions.

Analysis of extreme rainfall event frequency on the island of Hawai'i indicates a high frequency of extreme events along the eastern slopes of Mauna Kea and a low frequency of events along the western portion of the island (Chu, Zhao et al. 2009). The frequency of extreme events in the Honu'apo area lies between that observed in the eastern and western portions of the island. For example, the mean annual number of days with 24-hour rainfall accumulations above 2 inches ranges from 0 to 5 days in the Kona area to 20 to 25 days in the Hilo area, while the Honu'apo area experiences a range of only 5 to 10 days. The 1-year recurrence interval of annual maximum daily rainfall ranges from 2 to 4 inches on the Kona coast to 8 to 10 inches in the Hilo area, while Honu'apo experiences a range of only 4 to 6 inches.⁵ Similar to other areas on the island of Hawai'i, the Ka'ū District has been subjected to persistent drought conditions beginning in 2008 and extending to present.

⁵ A recurrence interval is defined as the inverse of the probability that the event will be exceeded in any one year. A 1-year recurrence interval implies that an event of equal or greater magnitude is *expected* to occur each year. It is a statistic typically based on observations collected over a long period.

Rainfall in Hawai'i is influenced by ocean-atmosphere system fluctuations including the El Niño-Southern Oscillation (ENSO) and the Pacific Decadal Oscillation (PDO) (Chu and Chen 2005). On an inter-annual time scale, the Hawaiian Islands tend to be dry during most of the warm ENSO (El Niño) events and wet during most of the cold ENSO (La Niña) events. The effects of ENSO and PDO on Hawaiian rainfall are enhanced during years when the two system fluctuations are constructively matched (i.e. La Niña/-PDO and El Niño/+PDO). The enhanced synergistic effects of ENSO and PDO on rainfall measured at Nā'ālehu (gage 14) are highly evident (Chu, Chen et al. 2010). These results imply that the Honu'apo area tends to experience above average rainfall and more extreme rainfall events in La Niña/-PDO years, and below average rainfall and fewer extreme events with longer dry periods in El Niño/+PDO years. The PDO was in a negative phase from the 1950s to 1976, a positive phase from 1977 to 1999, and has been in a negative phase since 2000.

Global warming is likely to impact the Hawaiian trade wind regime and may have negative impacts on Hawaiian rainfall. A decrease in atmospheric circulation in the tropical Pacific Ocean has already been observed and attributed to global warming (Vecchi, Soden et al. 2006). Timm and Diaz (2009) noted that significant changes in the wind fields around Hawai'i are forecast to occur by the late twenty-first century under one of several climate change scenarios described by the Intergovernmental Panel on Climate Change (IPCC 2007). However, the predicted impact on rainfall is not clear and Timm and Diaz (2009) concluded that the most likely scenario for Hawai'i is a 5 to 10% reduction of wet-season rainfall and a 5% increase of dry-season rainfall as a result of changes in the wind field.

Tidal Data

NOAA maintains a network of tide monitoring stations and tide predictions across the Hawaiian Islands including at Honu'apo. For each 24 hour period there are four tide levels at six hour intervals: mean low water (MLW), mean lowest low water (MLLW), mean high water (MHW), and mean highest high water (MHHW). As the names indicate, the lowest and highest water levels occur at MLLW and MHHW on a 24-hour cycle. Tide levels reported by NOAA use MLLW equal to 0.00 ft as the '0' vertical datum for all tidal benchmarks.⁶ The Honu'apo NOAA tide station number is 1618578 and has a period of record of 19 years. Mean range between MLLW and MHHW is 1.7 ft, and the mean tide level is recorded as 1.1 ft. The Honu'apo wetland complex is affected daily by tide fluxes that raise and lower its water surface to elevations consistent with the tide's minimum and maximum. A topographic survey and map prepared as part of this project was used to quantify difference of the wetted area, volume of water and wetted perimeter of the estuary between high and low tides. This analysis was used to develop restoration designs.

The flow of water between the ocean and the estuary is constricted between the two abutments of a concrete weir at the estuary outlet. Flow into and out of the estuary at its outlet was observed during four tide fluxes. The cross sectional area at the outlet does not restrict or adversely alter the flow conveyance (timing or magnitude) and does not impact water depths or area of inundation in the estuary. The two remnant manmade rock and mortar concrete walls that were constructed to enclose the estuary and create a fishpond do decrease the free water contact area between the estuary and mouth of the Honu'apo Bay. This in turn restricts fish, turtles, and other swimming animals entering and exiting the estuary to the channel defined by the remnant fishpond structures. At tide levels less than or equal to 0.00 ft MLLW the

⁶ This tidal datum is different than the '0' vertical datum used for topographic surveys, which is set to mean sea level. At Honu'apo the absolute difference between the two datums is 0.84 ft, with the tidal datum the lower of the two.

depth of water in the outlet channel is about 1.0 ft, which would likely restrict large turtles from passing through. The walls may dissipate large wave run up energy, which is most likely dampening turbulent mixing in the estuary.

Surface Water

Honu'apo Estuary is located in a watershed that covers approximately 18,000 acres, extending from an upper elevation of 10,400 ft down to the watershed outlet at the estuary. U.S. Geological Survey 7.5 minute series topographic maps and air photos were reviewed, and on-the-ground inspections of the watershed were conducted to locate gulches or gullies that extend from the upland zones of the watershed and terminate at the estuary. There does not appear to be a drainage channel that conveys runoff from the uplands to the estuary directly. However high magnitude rainfall events have generated sheet flow runoff from the upper slopes of the watershed and flooded the former sugar mill and town site as well as the estuary. Two ditches aligned perpendicular to the slopes above the mill site were constructed after such a flood event to intercept overland flow and prevent flooding of the sugar mill property. The condition of the two ditches, which function to cutoff overland flow and carry it to the north, is unknown. The ditches have likely not been maintained since cessation of sugar cane operations, resulting in degraded capture and conveyance efficiency, and with time will not function as designed.

A historical air image from the 1950's of the Honu'apo area near the sugar cane mill, shows what appears to be a ditch running between the mill and the northeast arm of the estuary. This ditch may have transported bagasse (fibrous residue from sugar cane) and other mill byproducts, which may help explain how the deltaic feature in the center of the estuary formed. During the plantation era a second ditch, commonly known as the mill ditch, was excavated from the mill directly to the shoreline to carry bagasse and effluent to the ocean. This ditch would periodically get clogged by debris and spill out the mill effluent, which would run overland to the estuary. These events likely caused some filling of the estuary. As result of the overflows mill operators installed a pipeline and pump to transport and discharge the effluent over the coastal plain rather than into the ocean.

One source of surface water input to the estuary is rainfall, which, depending on the amount, can alter the water quality (e.g. reduce salinity concentrations). The free exchange of surface water between the ocean and the estuary helps to regulate the water quality via the flushing of the estuary into the ocean and the input of high quality ocean water into estuary.

Groundwater

Groundwater flows into the wetland complex at numerous locations under moderate artesian conditions. Observations during field investigations recorded eleven seeps and springs along the edge of the estuary and another three discharging from the bed of the estuary. At several of these springs water salinity was measured and found to be fresh. An estimate of the fresh water influx into the estuary was completed as part of the hydrology investigation of the wetland complex (Section 2.4.3).

2.4.3 Water Budget

The water budget of the estuary complex is the balance between the inputs and outputs of water. Inputs include sea water during all tide levels, and fresh water from rainfall, and groundwater inflows from seeps and springs. Outputs or water losses are from outflows via the estuary outlet and evapotranspiration. See Section 2.4.2 for a discussion of the tide and rainfall inputs.

Inputs

Seeps and Springs

There is ongoing dilution of salinity concentrations at discrete locations from fresh water inflows out of seeps and springs along the shoreline and bed of the estuary. Seeps and springs flowing into the estuary were located by walking the shoreline of the estuary during low tide and wading across the estuary at various locations. A total of eleven springs and seeps were observed and their positions mapped (Figure 2-2). The figure also shows the approximate boundary of the wetland zone, which was drawn in for display purposes. Locations of springs and seeps were recorded using a Garmin Global Positioning System receiver and by marking the locations on laminated air photographs of the project area. An oblique photograph of each feature was also collected. Salinity concentration and flow measured at six of the springs indicated fresh water. The other five seeps had diffuse discharge, creating boggy areas and making collection of water for sampling and measuring flow rates difficult.

Four of the measured springs discharge over a twenty foot stretch along the north bank of the estuary. The water discharged from these four springs combines into a small channel and flows into the estuary in one location. The two other measured springs discharge out of the bottom of the estuary into the water column. Table 2-1 summarizes the measured volume and salinity concentrations at the four shoreline springs and the two water column springs.

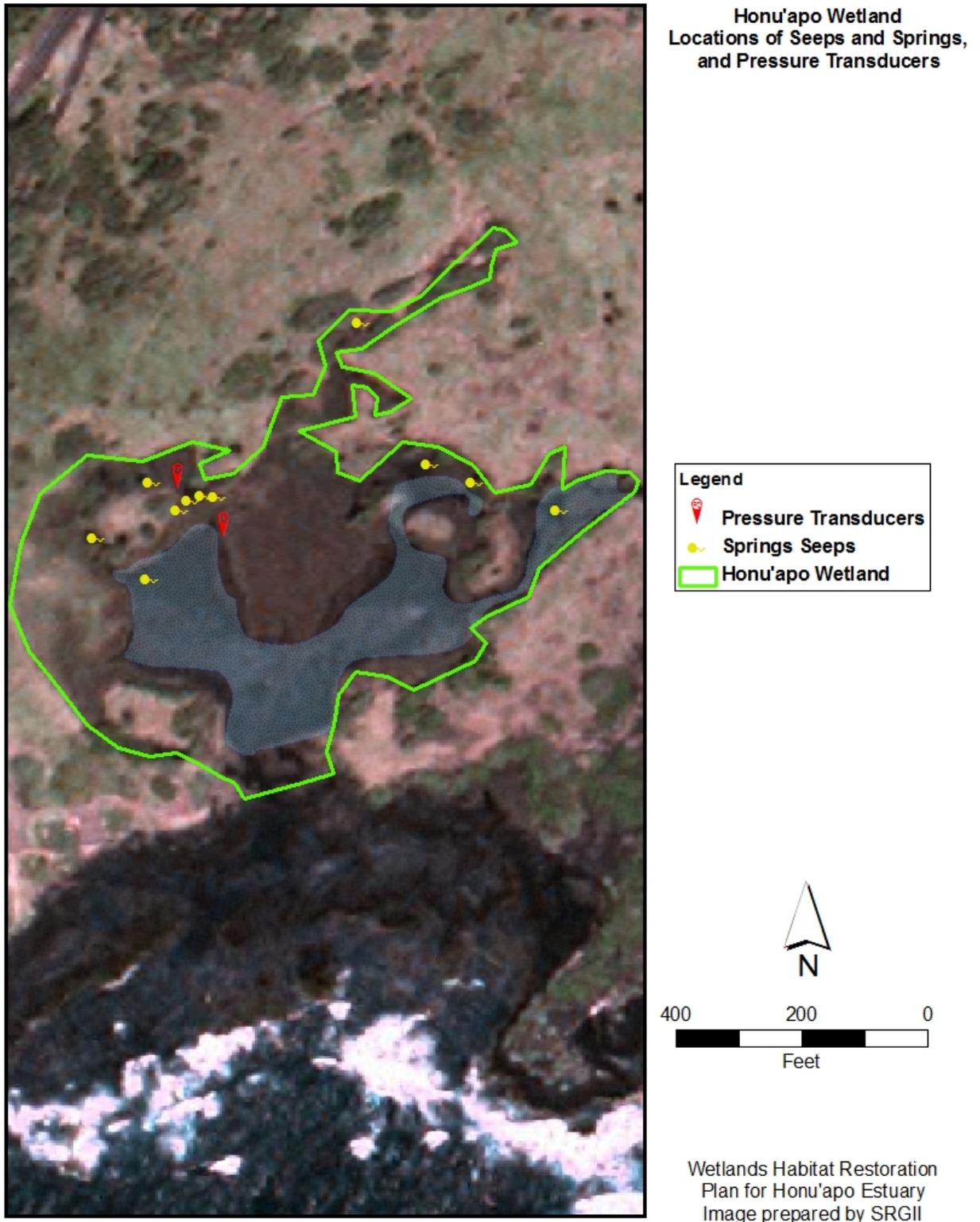
Table 2-1. Inflow Rates and Salinity Concentrations of Springs

Location	Inflow Rate		Salinity Concentration at Inflow (ppt)	Salinity Concentration Adjacent to Inflow (ppt)
	Gallons per minute (gpm)	Gallons per day (gpd)		
Shoreline Spring 1	0.75	1080	0.8	3
Shoreline Spring 2	0.65	936	0	4.7
Shoreline Spring 3	0.55	792	0	13
Shoreline Spring 4	0.5	720	0	14
Bottom Spring 5	0.4	576	4	17
Bottom Spring 6	0.1	144	3	17
Total		4248		

Measurements of flows at the four springs along the shoreline were made using a collection method during low tide when the inflows discharged above the estuary water surface. Flows should be considered estimates. At two locations the discharge was diffuse and spread over an area greater than the bucket opening, making capture of the entire flow difficult. Volume was measured using a bucket and stopwatch. After filling the bucket for two minutes the water level was measured and the gallons computed and recorded in gallons per minute. Salinity was measured using a YSI 6600 multi probe water quality sonde fitted with a salinity probe accurate to 0.05 parts per thousand (ppt) salts.

Flows from springs discharging from the bottom of the estuary were estimated using a Sontek Acoustic Doppler Velocimeter to measure the velocity, in feet per second, of the water discharging from the spring and multiplying it by the area of the spring opening. Salinity measurements of these springs were made using the YSI sonde, however it was difficult to collect measurements that were not affected by the water column above the spring due to the rapid mixing between the estuary water and the spring water.

Figure 2-2. Locations of Springs and Seeps, and Pressure Transducers



The fresh water springs dilute the salinity of the estuary at the inflow locations. As a result, vegetation growing around two of the seeps is dominated by species such as California grass (*Bracharia mutica*), which prefers fresh to slightly brackish water (<7 ppt). Based on the presence of vegetation that requires consistent fresh water around the margin of the estuary, it is likely that there are additional fresh water seeps and springs discharging in the intertidal zones. Vegetation growing in and around each spring was documented. Polygons depicting the vegetation community were drawn on the laminated air photograph and later transposed onto Geographic Information System maps. This investigation was conducted to determine if the spring water was diluting the salinity concentration of the estuary and whether localized dilution controlled plant species distribution near the spring. The findings will be used to guide habitat enhancement and estuary restoration designs.

Outputs

Tidal Outflows

Surface water outflow occurs when the tide is falling and never completely drains the estuary. During falling tides, the salinity concentration at and around the springs is likely at its lowest due to the falling water level and the constant inflow of fresh water.

Evapotranspiration

Evapotranspiration (ET) describes the sum of evaporation and plant transpiration from the earth's land surface to the atmosphere. Evaporation accounts for the movement of water vapor to the air from sources such as the soil, plant interception, and waterbodies. Transpiration accounts for the movement of water within a plant and the subsequent loss of water as vapor through stomata in its leaves. In vegetated landscapes, transpiration makes up the bulk of ET. Evaporation in Hawai'i is affected by the three primary controls that govern rainfall: the position of the major Hawaiian islands, the Pacific Subtropical Anticyclone (PSA), and the high mountains (Lau and Mink 2006). Trade winds and temperature inversion are two principal features of the PSA and their interaction with the high mountains accounts for the spatial variation of the evaporation climate. Evaporation generally decreases with elevation to a minimum at about 4,000 ft mean sea level (MSL); however, evaporation begins to increase with elevation above about 6,500 ft MSL. As trade winds move onshore in windward areas, the orographic cloud cover reduces radiation and evaporation beneath the cloud becomes nearly constant throughout the year. Transpiration is affected by plant stomatal regulation, structural and physiological adaptations, rooting characteristics, and water availability.

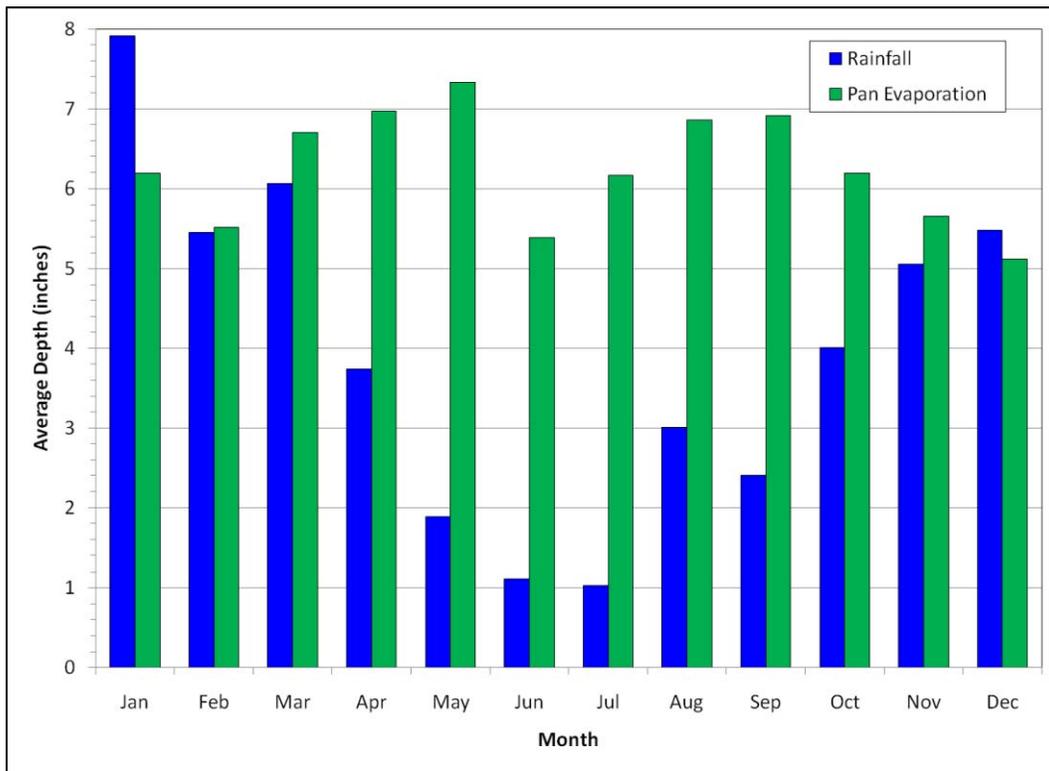
Evaporation losses at Honu'apo are greatest during the summer months of May-September. Salinity concentration in the estuary likely does not exceed that of sea water (35 ppt) due to the tide fluxes and mixing effect they have on the estuary's main water body. In the palustrine wetland areas that are flooded and submerged during high tides, where there are no fresh water springs, and that are left isolated during low tides, salinity concentrations may exceed 35 ppt during the summer months when evapotranspiration rates are highest.

Pan Evaporation

Pan evaporation is the amount of water that evaporates from the open water contained in a pan of standardized dimensions. During the plantation era, evaporation pans were established at numerous locations across Hawai'i to monitor evaporation rates, including near Honu'apo. Ekern and Chang (1985) standardized these data to prepare maps of adjusted annual pan evaporation for four of the major

Hawaiian Islands, including the island of Hawai'i. Adjusted mean annual pan evaporation at Honu'apo is roughly 75 inches, and decreases to less than 50 inches northwest of Honu'apo over a distance of roughly five miles. Evaporation pan 11.00 (Makino, Ka'ū Sugar) was installed west of Honu'apo in 1962 and recorded an annual average of 52.2 inches from 1962 to 1972 (Ekern and Chang 1985). Evaporation at this location fluctuates during the year from a low of 3.6 inches in December to a high of 5.1 inches in May. The seasonal evaporation pattern at Honu'apo was estimated using the seasonal pattern at evaporation pan 11.00 and an estimated mean annual pan evaporation of 75 inches (Figure 2-3). A comparison of the seasonal rainfall and pan evaporation patterns suggests that, on average, the Honu'apo area experiences rainfall in excess of evaporative demand only during the wet months of December and January. Monthly average pan evaporation greatly exceeds average rainfall throughout most of the year with substantial deficits occurring from April to October. While evaporation pan measurements can be used to estimate evaporation from open water bodies such as lakes and reservoirs, they should be used with caution when estimating plant transpiration. The impacts of global warming and trade wind inversion persistence on potential evapotranspiration rates in Hawai'i have not yet been quantified.

Figure 2-3. Seasonal Rainfall and Pan Evaporation at Honu'apo



Effects of Non-native Vegetation on Evaporation and Transpiration

The type, density, and cover of plants in a watershed influence evaporation (i.e., canopy interception) and transpiration losses over time. ET is a dynamic process and the proliferation of non-native tree species can increase or decrease ET losses. Tropical island ecosystems are especially vulnerable to non-native species invasions because of high net resource availability and the poor ability of native species to preempt those resources (Denslow 2003). In arid and semi-arid regions of the world such as the southwestern U.S. and South Africa, non-native trees and shrubs have created macro-scale water scarcity problems

such as streamflow decline (Zavaleta 2000; Le Maitre et al. 2002). Non-native tree species have many ecological impacts to Hawaiian ecosystems (Vitousek et al. 1987) but the hydrological effects of replacing native tree species with non-native trees in Hawai'i remains largely unquantified. Recent studies conducted on the island of Hawai'i have shown that selected non-native tree species including Strawberry guava (*Psidium cattleianum*), eucalyptus (*Eucalyptus saligna*), and Tropical ash (*Fraxinus uhdei*) are capable of transpiring much more than native 'ōhi'a (*Metrosideros polymorpha*) (Giambelluca et al. 2007; Kagawa et al. 2009). Kagawa et al. (2009) reported whole plant water use of around 8 kg or 146 gallons H₂O/day in native 'ōhi'a, and higher water use of around 32 kg or 585 gallons H₂O/day in non-native eucalyptus and Tropical ash.

Phreatophyte plants utilize long roots to tap into ground water or other permanent sources of water. The growth of phreatophyte plants is much less dependent upon surface water supplies than shallow-rooted plants that extract water from the unsaturated zone. They are often characterized as “water spenders” because they transpire large quantities of water per unit mass of dry matter produced (Jarrell and Virginia 1990).

The tap roots from *kiawe* (*Prosopis pallida*), a non-native phreatophyte tree found throughout the Hawaiian Islands including Honu'apo, have been known to reach water tables 65 to 80 feet deep (Pasicznik et al. 2001). In Hawai'i, *kiawe* is most common in leeward coastal areas of the larger islands where mean annual rainfall ranges from 10 to 30 in and temperature ranges from range 55° to 95° F. On the islands of Lāna'i, Kaho'olawe, and Ni'ihau, which are in the lee of larger islands, *kiawe* occupies both windward and leeward coastal areas. In Hawai'i and in other locales, *kiawe* grows well where rainfall is low but only where there is a water table supplied by high rainfall areas in the upper inland mountain ranges. *Kiawe* is found in higher densities along water courses and, when found in valleys, tends to congregate along the valley bottom where there is likely to be a permanent supply of sub-surface water (Simpson 1977). In montane areas, *kiawe* tends to inhabit dry valleys in the rain shadow of large mountains with rainfall up to 60 inches (Solbrig and Bawa 1975).

Water use by *kiawe* in Hawai'i has not been reported. In Kenya, water use efficiency of Peruvian *kiawe* was estimated to be 690 kg or 183 gallons H₂O/kg dry matter/day (Kaarakka and Johannsson 1992). Estimates of water use efficiency in other *Prosopis* species vary widely from 345 kg or 91 gallons H₂O/kg dry matter/day in *P. chilensis* to 710 kg or 188 gallons H₂O/kg dry matter/day in *P. juliflora* (Felker et al., 1983; Chaturvedi et al. 1988). Thus, the range of water use efficiency in *kiawe* and other *Prosopis* species suggests that *kiawe* is capable of transpiring much greater amounts of water when compared to other native and non-native tree species in Hawai'i (i.e. *M. polymorpha*, *E. saligna*, and *F. uhdei* described earlier) due primarily to its ability to extract water from the water table. In the leeward valleys of the island of O'ahu, the ability of *kiawe* to extract large but unknown quantities of groundwater from the valley floors through transpiration was reported almost 40 years ago (Takasaki 1971). Water use by *kiawe* in the coastal zone is one component of a five-year study (2009 to 2014) currently being conducted by researchers from the University of Hawai'i at Mānoa along the west coast of the island of Hawai'i (EPSCoR 2010).

Transpiration losses from plants growing in and around the margin of the Honu'apo Estuary complex are unknown. It is likely that the numerous non-native *kiawe* trees that line the margins of the wetland have tapped into the phreatic or ground water layer that is the source of the fresh water springs and seeps

discharging into the estuary. These trees function as pumps and can transpire a significant volume of water. During site investigations a count of *kiawe* trees growing at or lower than the banks of the estuary with a diameter at breast height equal to or greater than three inches was performed. A total of 173 *kiawe* trees within this size range were inventoried in order to estimate the cumulative transpiration loss of all trees. However, due to a significant amount of uncertainty with respect to the dry weight of the trees and other variables necessary to compute losses, it is not possible to provide an accurate transpiration estimate for the *kiawes*. Basic water budgeting supports the theory that the removal and replacement of *kiawe* with drought tolerant native vegetation that does not mine the phreatic zone would result in increased fresh water inflows via the existing seeps and springs.

2.4.4 Water Level and Quality

The quality of water in the estuary is a function of inputs of organic and inorganic substance around the complex, atmospheric inputs, ground water volume and quality, and the ambient quality of the ocean. Several water quality data collection and analysis efforts have been conducted on the estuary. A review of the available results finds no anomalies and that quality of the various parameters sampled appears to be 'normal' and within expected concentrations and levels (Bruland et al. 2010). In general, water quality is not degraded and the daily exchange between the ocean and estuary appears to keep ambient conditions in a condition to support healthy aquatic species. Water quality bacteria levels may be elevated intermittently due to turtle feces. However, if the number of turtles using the estuary for resting prior to human habitation of the area was equal to or greater than present, the background bacteria level will be similar.

The complex contains numerous *kiawe* trees growing around it that may increase nitrogen levels in the surrounding soil and waters due to the tree's ability to fix nitrogen. Ongoing research of the effect *kiawe* have on the nitrogen cycle in ground water is being conducted by University of Hawai'i researchers. Based on samples collected, nitrogen concentration in the estuary does not appear to be greater than normal background.

Pressure Transducer and Salinity Measurements

Pressure transducers are devices used in hydrologic investigations to record depth of water. Two pressure transducers were installed in the estuary to record water elevation above known reference elevations at 15 minute intervals. They were installed on November 5, 2010 and downloaded on January 27, 2011. Figure 2-2 depicts the locations of the transducers, or stage measuring locations. One of the transducers (PT1) was placed along the edge of the estuary in its main water body near one of the four shoreline springs. This device is fitted with a salinity probe that measures and records salinity in ppt every 15 minutes in addition to water depth. The second transducer (PT2) was placed in a backwater pool that has no surface water connectivity to the estuary. A third transducer was deployed near the County's maintenance shed near the Whittington Beach Park access road to record atmosphere pressure, which is necessary to correct the two water transducer's measurements to account for barometric pressure.

The two in-water pressure transducers' data was downloaded, processed, and analyzed. Figure 2-4 through Figure 2-8 are plots of the data collected at PT1 and PT2. A correlation between the 24 hour high and low water levels and the tides was found at PT1. A slight time lag between the occurrence of the diurnal maximum and minimum tide and the water level was observed. For the sample period salinity concentrations showed a correlation with the tide flux, with maximum and minimum concentrations

occurring approximately one hour after the maximum and minimum daily tides. Salinity ranged from a maximum of 33.2 ppt to a minimum of 0.07 ppt, with a mean of 18.5 ppt. PT1 was installed in the estuary on the small channel that drained the four measured springs. The data shows that the springs dilute the seawater flooding into the estuary near their point of discharge at all tide levels. Temperature values showed the same correlation as salinity to the tide fluxes. Water temperatures ranged from 85° F to 65° F with a mean of 77.5° F. The maximum occurred at the daily high tide and the minimums at low tides. This indicates that inflows from the springs, whose temperature is assumed to be moderately constant at 65° F, has an effect on the water temperature of the estuary in and along the channel draining the four springs. The data from PT1 was used in the design process to define the wetted perimeter of the estuary at the maximum and minimum water surface elevations in the estuary and subsequently compute water volume in the estuary at and between the two extremes.

PT2 was used to record water level in a backwater pool that has no surface water connection to the estuary. This transducer was fitted with a temperature probe but not fitted with a salinity probe. During field visits salinity was measured on three days at three tide levels, with an average of 0.4 ppt or fresh water. Review of the water level data set shows water level fluxes daily, correlated to the tide flux. There is an approximately 12-hour lag between the response at PT2 and the 24-hour maximum high and low tides. This is likely due to the fact that the water flow is subsurface and that the hydraulic conductivity between the estuary and the backwater pond is low. The diurnal flux of water at the pond may also be explained by water use of *kiawe* in the vicinity of the pool. During the afternoon hours when air temperature is at daily maximum, water use by *kiawe* is likely at a daily maximum, resulting in a lowering of the ground water table that maintains the pool. At night the *kiawe* trees stop photosynthesizing and transpiring, which may increase the local ground water level and the surface level of the pool. Similar to PT1, the data and information collected at PT2 will be used in the design phase of the estuary enhancement/restoration plan.

Discrete Salinity Measurements

Salinity measurements were collected using the YSI sonde at numerous locations in the estuary. Measurements were made from the shoreline and by wading into the estuary and placing the probe in the water for one minute. The objectives were to determine if a salinity gradient occurs across the estuary and to locate the seeps and springs. Seeps and springs would be evident if salinity values at discrete locations in the estuary were lower than surrounding waters, indicating dilution by fresh water. This effort revealed that the salinity in the estuary ranges from sea water concentration of 35 ppt in the main body of the estuary under maximum and minimum tides to between 35 ppt and 18 ppt near the shoreline springs following low tides. The measured values around the estuary indicate that there no large pockets of fresh water in the estuary, and that areas with lower salinity concentrations are isolated to the immediate vicinity of the fresh water springs.

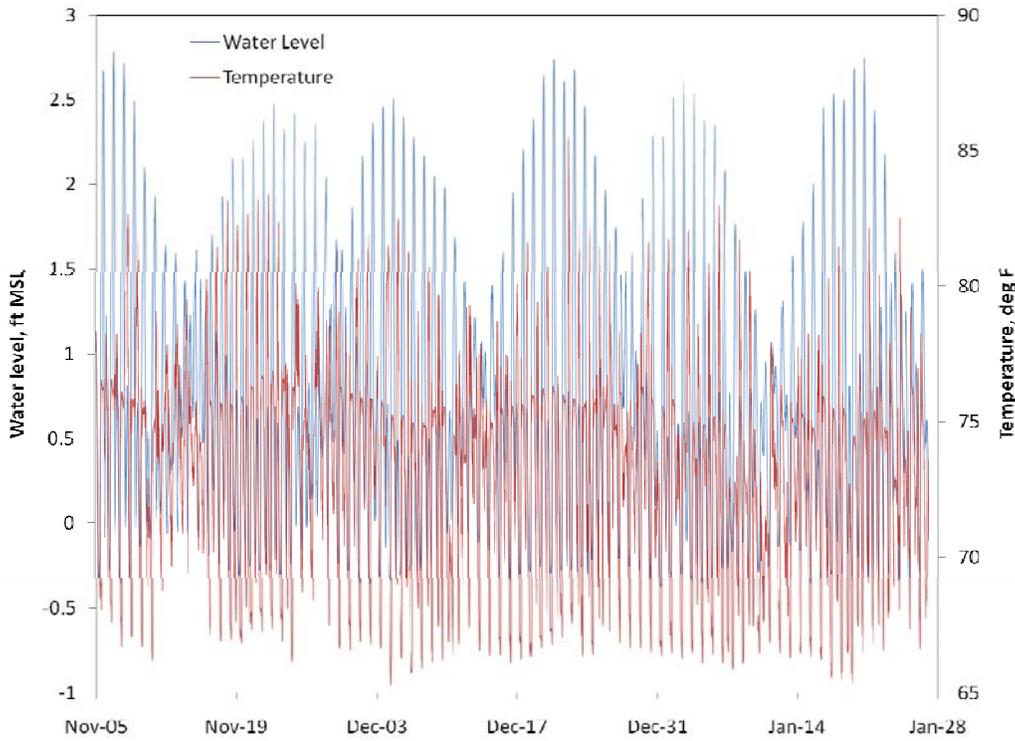


Figure 2-4. PT1 Water Level-Temperature vs. Time

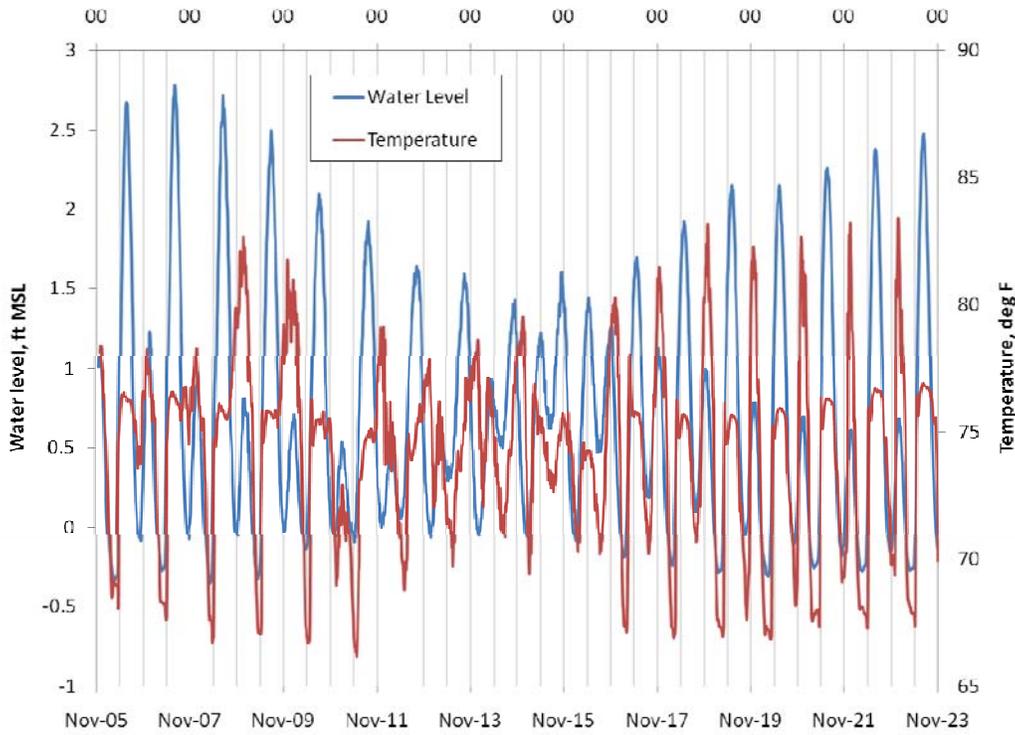


Figure 2-5. PT1 Water Level-Temperature vs Time

Plot depicts two weeks of data that reveals tidal control on water surface elevation in estuary.

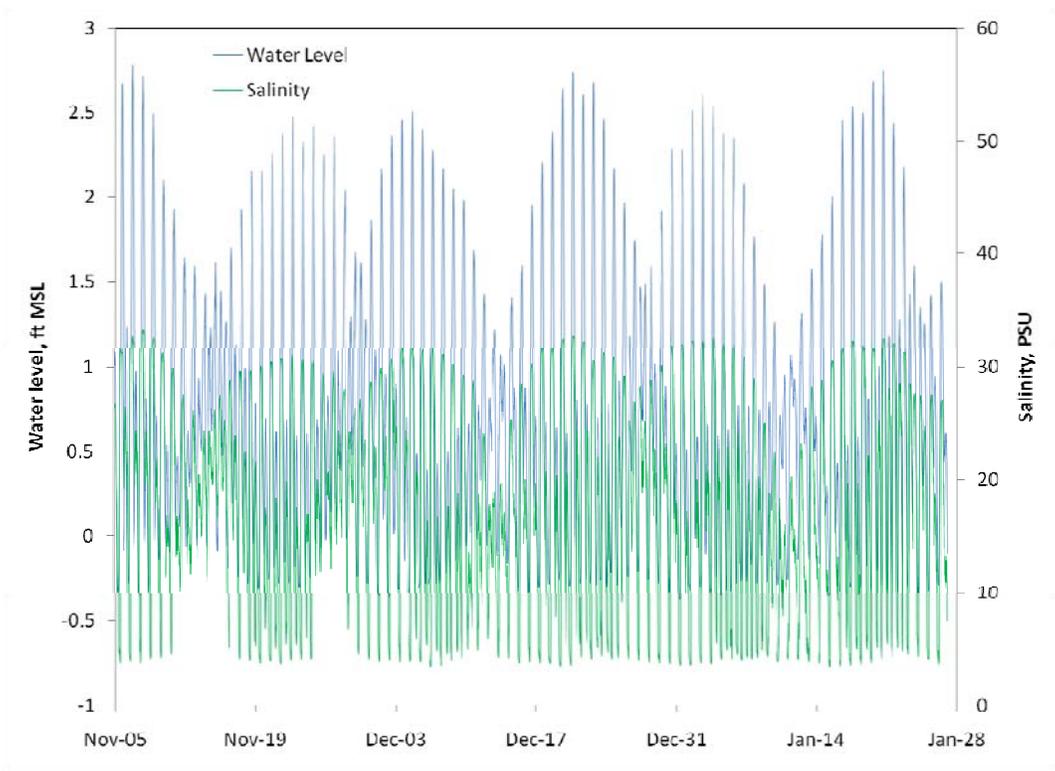


Figure 2-6. PT1 Water Level-Salinity vs Time

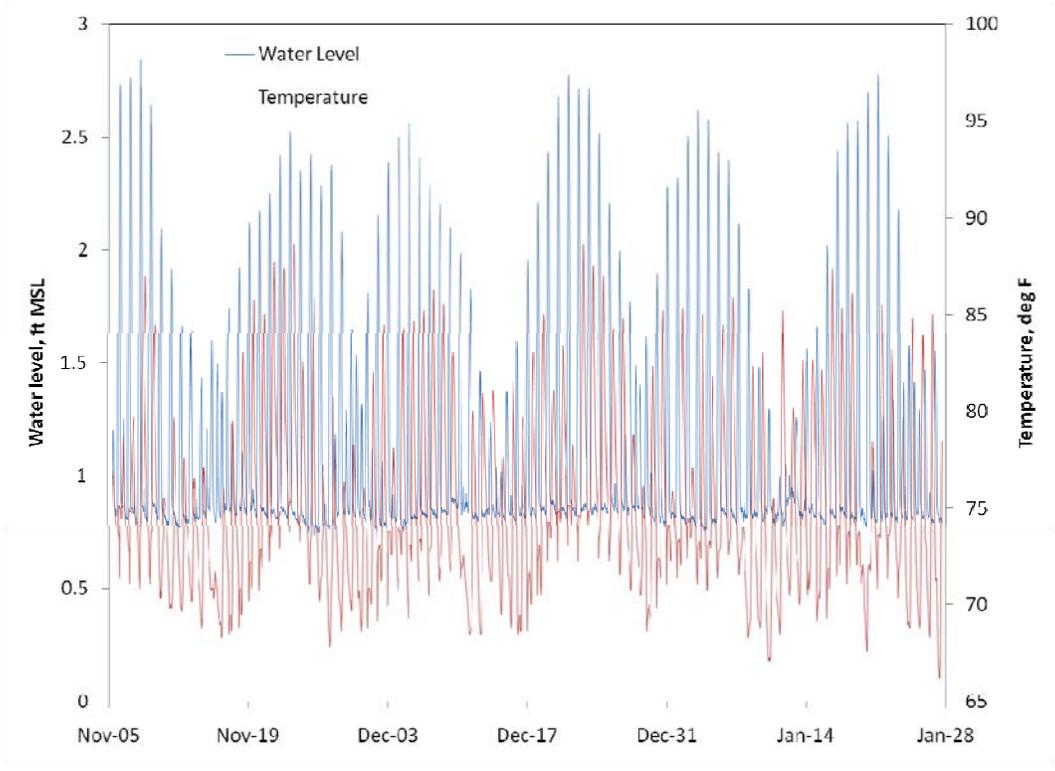


Figure 2-7. PT2 Water Level-Temperature vs Time

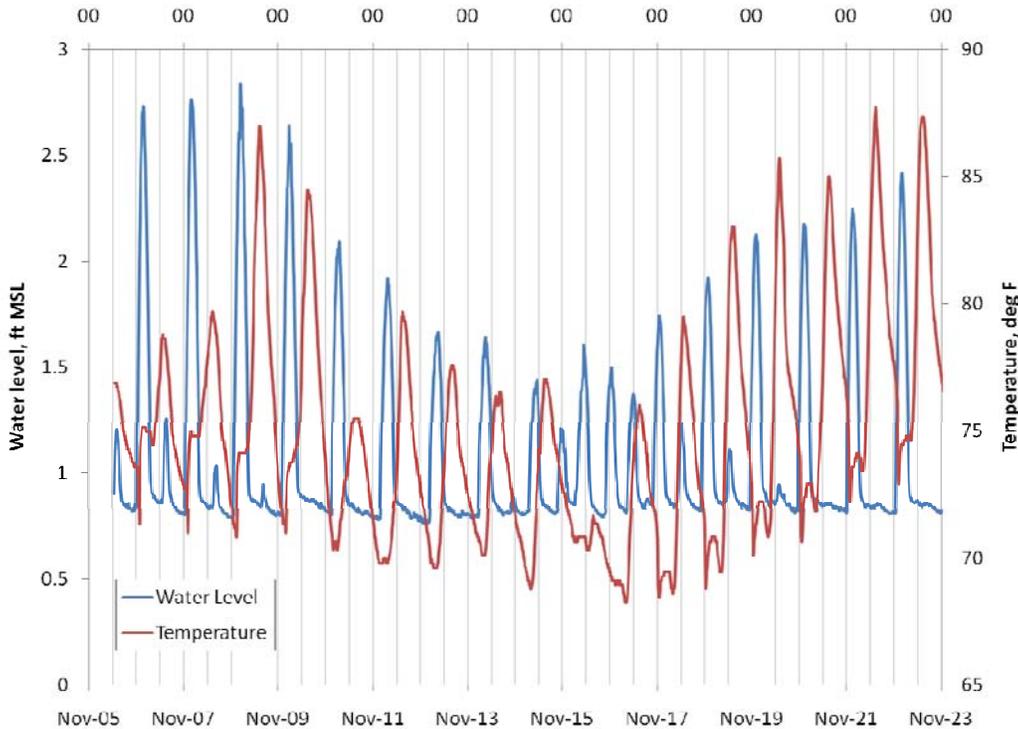


Figure 2-8. PT2 Water Level-Temperature vs Time

Other Water Quality Parameters

Other water quality parameters measured during field investigations include: temperature, pH, conductivity, dissolved oxygen (DO) and turbidity. Measurements were made at random locations and at locations where salinity was measured. A review of these data did not reveal values that would indicate water quality concerns. The data were not collected to establish baseline conditions, and thus are snapshots of water quality at the time they were measured. As a result no statistical analysis was conducted. However, it is likely that there are diurnal fluxes in temperature, DO, and turbidity. Temperature in the main body of the estuary likely fluxes with daily temperature, and reaches a maximum in the late afternoon. Turbidity in the estuary appears to be controlled by mixing induced by wind-generated turbulence, and is likely greatest during late afternoon under trade wind weather patterns. DO may follow a diurnal pattern as well, as a function of plant respiration and aquatic organism use.

2.4.5 Air Quality

In general the presence of the almost constant trade winds is noted as the reason for high air quality over the Hawaiian Islands. It is common near the shoreline to have salt spray carried along with the sea breeze. The air quality at Honu'apo Park and the adjacent airshed is to a large degree a function of the atmospheric circulation. On the island of Hawai'i the gas plumes of Kīlauea volcano erupt from active vents: Halemaumau Crater, Pu'u 'Ō'ō vent, and along the coastline when intermittent lava flows from the East Rift zone enter the ocean. The plumes create a blanket of vog that can envelop the island. Vog mostly affects the Kona coast on the west side of the island since the prevailing trade winds blows the vog to the southwest and southern winds, which then blow it north up the Kona coast toward Kohala. When

winds shift and blow towards the south, the vog plume is carried over the Ka‘ū District impacting Honu‘apo.

2.4.6 Noise

The types of activities conducted at the park rarely involve the use of mechanical equipment that would generate high decibel levels. County DPR maintenance staff periodically mow the grass and use excavators, however, the noise is within acceptable levels and occurs infrequently. The ambient noise level generated at the site originates from human conversations, radios and amplified music, waves washing the shoreline, and wind blowing through and around objects. As a comparison, the noise level of normal human conversation heard at a distance of 1.5 m [5 ft] is 60 decibels (dBA). Vehicular traffic enters and leaves the park at various intervals during the day. Noise generated from this traffic is estimated to produce 70 dBA as heard at distance of 7.6 m [25 ft], which is within normal traffic background levels. Overall, the noise levels generated from the park are minimal.

2.5 Ecological Features

2.5.1 Vegetation

There are two distinct vegetation zones within the project area: wetlands and the uplands directly adjacent to the wetland area. The coastal strand community is found *makai* of the estuary, towards the ocean. A species list is found in Appendix B.

Wetland Plant Community

The dominant overstory and understory plant species in the wetlands of Honu‘apo Estuary are *kiawe* (mesquite, *Prosopis pallida*) and seashore paspalum (*Paspalum vaginatum*), respectively, both non-native invasive species. Other prevalent non-native and invasive grass species within the wetland area include California grass (*Urochloa mutica*) and *manienie* (Bermuda grass, *Cynodon dactylon*). Native plant species present within the wetland area include *makaloa* (*Cyperus laevigatus*), *milo* (*Thespesia populnea*), and *‘ākulikuli* (sea purslane, *Sesuvium portulacastrum*). The native *‘aka‘akai* or *nānaku* (Giant bulrush, *Schoenoplectus tabernaemontani*) is found in the intertidal and palustrine zones near the fresh water seeps and springs.

Upland Plant Community

The uplands directly adjacent to the wetland area are dominated by non-native invasives including: *haole koa* (*Leucaena leucocephala*), Guinea grass (*Panicum maximum*) and *kiawe* (*Prosopis pallida*), with other dry shrubland species such as Christmas berry (*Schinus terebinthifolius*), java plum (*Syzigium cumini*), and sourbush (*Pluchea odorata*).

Coastal Strand Plant Community

The coastal strand vegetation community is located between the shoreline and estuary and is dominated by native plants adapted to an environment of sea spray including: *naupaka kahakai* (beach naupaka, *Scaevola taccada*), *‘ilima* (*Sida fallax*), *pa‘u o hi‘iaka* (*Jacquemontia ovalifolia*), *pōhuehue* (beach morning glory, *Ipomoea pes-caprae brasiliensis*), *‘ākulikuli* (sea purslane, *Sesuvium portulacastrum*), *nehe* (*Melanthera integrifolia*), and *kipukai* (seaside heliotrope, *Heliotropium curassavicum*).

2.5.2 Fish and Wildlife

Honu'apo Estuary is habitat for a diversity of native and endemic fish and wildlife. Species lists are found in Appendix B.

Terrestrial Mammals

Terrestrial mammals found in the park area include introduced wild and feral species including feral cats (*Felis catus*), feral dogs (*Canis familiaris*), pigs (*Sus scrofa*), goats (*Capra aegagrus hircus*), mongoose (*Herpestes javanicus*), mice (*Mus musculus*), and rats (*Rattus rattus*). There is a feral cat colony that is actively maintained by local residents. There is anecdotal evidence that the endangered 'ōpe'ape'a (Hawaiian Hoary bat, *Lasirus cinereus semotus*), the only native terrestrial mammal in Hawai'i, occasionally occurs in the Honu'apo area.

Birds

There are three endemic native waterbirds that are listed under the Endangered Species Act (ESA) (Hawaiian stilt, *Ae'ō*, *Himantopus mexicanus knudseni*; Hawaiian coot, 'Alae ke'oke'o, *Fulica alai*; and Hawaiian duck, *Koloa moali*, *Anas wyvilliana*) that may be found at the estuary. The Hawaiian ducks that have been sighted at the estuary are believed to be hybrids. Several migratory waterbirds, protected under the Migratory Bird Treaty Act (MBTA), may utilize either the land or marine environments near the estuary including: 'akekeke (Ruddy turnstone, *Arenaria interpres*); hunakai (Sanderling, *Calidris alba*); 'ulili (Wandering tattler, *Heteroscelus incanus*); kioea (Bristle-thighed curlew, *Numenius tahitiensis*); and kolea (Pacific golden plover, *Pluvialis fulva*). The native 'auku'u (black-crowned night heron, *Nycticorax nycticorax hoactli*) resides in the area.

The seabird black noddy or *noio* (*Anous minutus melanogenys*) is frequently seen flying in and out of refuges in the rocky coastal cliffs of the area. In addition, the white-tailed tropic bird (*Phaethon lepturus dorotheae*) has been observed at Honu'apo, along with the endangered 'io (Hawaiian hawk, *Buteo solitarius*) (NPS 2006). Non-native birds found at Honu'apo include the northern cardinal (*Cardinalis cardinalis*), Japanese white-eye (*Zosterops japonicus*), spotted dove (*Streptopelia chinensis*), zebra dove (*Geopelia striata*), and common barn owl (*Tyto alba*). There are no native forest birds found near the wetland or that are known to travel through the surrounding areas.

Aquatic Species

The estuary provides important spawning and nursery habitat for a large number of native fishes. A reef area located at the mouth of the estuary is naturally protected by a breakwall of *pāhoehoe* lava and provides prime habitat for juvenile fishes and other marine life (Lamson 2010). Local residents recall that the estuary used to provide habitat for *pāpio* (juvenile trevally (*ulua*), *Caranx ignobilis*).

Native fish species that have been recorded in Honu'apo Estuary include 'o'opu (*Eleotris sandvicensis*), 'ōpae huna (*Palaemon debilis*), the threatened naniha goby (*Stenogobius hawaiiensis*), 'ama'ama (striped mullet, *Mugil cephalus*), āholehole (Hawaiian flagtail, *Kuhlia sandvicensis*), Hawaiian shrimp goby (*Psilogobius mainlandi*), and yellowfin goatfish (*Mulloidichthys vanicolensis*). Recorded crustaceans include snapping shrimp (*Alpheus* sp.) and feeble shrimp ('ōpae huna, *Palaemon debilis*).

The threatened *honu* (green sea turtle, *Chelonia mydas*) is known to frequent Honu'apo Estuary. The endangered honu'ea (hawksbill sea turtle, *Eretmochelys imbricata*) has been recorded in Honu'apo Bay, and nearby nesting sites include Kawa'a, Kamehame, and Punalu'u. The endangered 'ilio holo i ka uaua

(Hawaiian monk seal, *Monachus schauinslandi*) is frequently observed utilizing the bay and the beach near the estuary.

Insects

A candidate insect species for listing under the ESA, the orange-black Hawaiian damselfly (*Megalagrion xanthomelas*), has been seen at Honu‘apo Estuary near freshwater seeps.

2.6 Land Use and Infrastructure

The Honu‘apo Estuary is found within Honu‘apo Park on the coast in the Ka‘ū District of southern Hawai‘i Island. The closest town, Nā‘ālehu, lies three miles southwest of the park. The population of the town was listed at 919 in the 2000 census. Honu‘apo Park and the surrounding lands are dominated by open space. Except for the limited number of houses in the immediate area, and one resort, much of the area is either used for cattle grazing or has been left undeveloped.

Honu‘apo Park is 225 acres of mostly undeveloped land that offers unspoiled vistas of the coast and Mauna Loa, and provides unique habitats for marine and near-shore flora and fauna (Townscape 2010). The southernmost portion of the property contains limited facilities including: a parking lot, picnic tables, shelters and public restrooms. This area is maintained as a community park, “Whittington Beach Park”, and is in close proximity to the estuary and Honu‘apo Bay. It is one of only two developed County Beach Parks in the Ka‘ū District. Whittington Beach Park is used primarily by local residents for fishing, camping, picnicking and parties.

Townscape Inc. recently completed a *Resource Management Plan for Honu‘apo Park* that provides guidance to help protect and restore the important natural and cultural resources of the property while providing recreational and educational opportunities (Townscape 2010). Plans to supplement recreational and educational opportunities include developing a new coastal park section with vehicle-accessible campgrounds, a multiuse pavilion, interpretive displays, and a native plant garden. Improvements to the Whittington Park section are also proposed. The plans call for protecting cultural resources and archaeological areas by limiting vehicular access in areas rich in native Hawaiian sites. Plans for protection of natural resources include preservation and restoration of native vegetation and shoreline habitats.

2.7 History and Culture

At least five archaeological studies have been conducted within Honu‘apo Park. Evidence of habitation in this area of the Ka‘ū District dates back to as early as the 15th century. Two Archeological Inventory Surveys (AIS) have been completed, one in 2004 and a second in 2009, which identified eighty-eight sites with over 200 archaeological features, most in the northern portion of the park.⁷ Sixty-five of these sites were considered significant under State Historic Preservation criteria and include the remains of the Kamala‘i *heiau* (place of worship), pre-contact burial and ceremonial complexes, habitation sites, salt basins and petroglyphs. The studies also indicated that waste fill disposal during the sugar plantation era likely covered many other archaeological sites, particularly around the estuary. The estuary, or fishpond as it is referred to in the 2004 AIS, is recorded as Site Number 22353 and contains eight features (Haun et al. 2004). Under the Significance Assessments and Recommended Treatments section of the 2004 AIS the

⁷ The Haun et al. (2004) report was submitted and approved by the State Historic Preservation Division (SHPD) in 2006. The Rechtman Consulting (2009) report was submitted to SHPD in 2010 and has not yet been reviewed.

fishpond was considered significant based on criteria for evaluating archeological sites established by the State Historic Preservation Division (SHPD) and the features were recommended for preservation. As a result, a Restoration Plan detailing how preservation would be done needs to be prepared and submitted to SHPD for review and approval. The 2009 AIS does not include the area of the estuary/fishpond and its recommendations do not have a direct impact on the proposed wetland restoration activities.

Historic structures from the sugar plantation era are basically gone. There are some concrete foundation remains of the warehouses and pier, but all other evidence has been destroyed by the tsunamis that have occurred over the years. The only other historic structure was a clubhouse and Japanese-style garden constructed in the 1950's on the northern side of Honu‘apo Estuary. That building was also destroyed by a tsunami, but garden structures (bridge and debris) remain.

2.8 Regulatory Context

2.8.1 Jurisdiction and Management Authority

Multiple organizations and agencies have jurisdiction and management authority for activities related to wetland restoration at Honu‘apo Estuary.

- *County of Hawai‘i, Department of Parks and Recreation:* The County DPR is the managing entity of Honu‘apo Park. The County DPR provides equipment, maintenance of existing park facilities, consultation and advice.
- *County of Hawai‘i, Planning Department:* The County Planning Department has community-wide planning initiatives (e.g., Ka‘ū Community Development Plan) for the area. The Planning Department is also responsible for implementing the CZM program for the county.
- *State of Hawai‘i.* The State owns the land on which Honu‘apo Park is situated. The land was set aside to the County of Hawai‘i for Estuarine Land Conservation and Public Recreation purposes by Executive Order No. 4164 (March 30, 2006). Under the Hawai‘i Organic Act of 1900 and the Admissions Act of 1959, the State of Hawai‘i claims jurisdiction over the submerged lands of the main Hawaiian Islands (MHI) from 0-3 nautical miles. This includes Honu‘apo Estuary.
- *DLNR, Division of Conservation and Resources Enforcement.* The Division of Conservation and Resources Enforcement (DOCARE) is responsible for DLNR enforcement activities. The division, with full police powers, enforces all State laws and rules involving State lands, State Parks, historical sites, forest reserves, aquatic life and wildlife areas, coastal zones, Conservation districts, State shores, as well as county ordinances involving county parks. The division also enforces laws relating to firearms, ammunition, and dangerous weapons.⁸
- *U.S. Fish and Wildlife Service:* The USFWS Conservation Partnerships Program provides technical and financial assistance to Ka ‘Ohana on wetlands restoration planning and management.
- *National Oceanic and Atmospheric Administration:* NOAA provides technical and funding assistance to Ka ‘Ohana on wetlands restoration planning and management. Restoration activities need to be consistent with the terms of the Coastal and Estuarine Land Conservation Program, a NOAA program that provided funds to purchase the park property (see Section 3.7 in Townscape 2010).

⁸ Enforcement is inherently difficult in Ka‘ū since DOCARE, the regulating offices for fishing violations, is located an hour and a half away from Honu‘apo in either direction.

- *Pacific Coast Joint Venture and Hawaii Wetland Joint Venture*: PCJV/HWJV is a partnership of Federal, State, and local players that work collaboratively to protect wetland habitat for recovery of waterbirds, migratory birds, and shorebirds. The joint venture provides technical and funding assistance to Ka 'Ohana on wetlands restoration planning and management.
- *Ka 'Ohana O Honu'apo*: Ka 'Ohana has a formal Memorandum of Understanding with the County DPR to care for, restore, and manage Honu'apo Park.

It is anticipated that wetland restoration work would be accomplished primarily by Ka 'Ohana and partners including NOAA, USFWS, State and County governments, and the PCJV/HWJV with the securing of additional funding. Ka 'Ohana and a variety of State and County agencies would be involved in the implementation of the remainder of the Resource Management Plan for the park.

2.8.2 Land Classification and Zoning

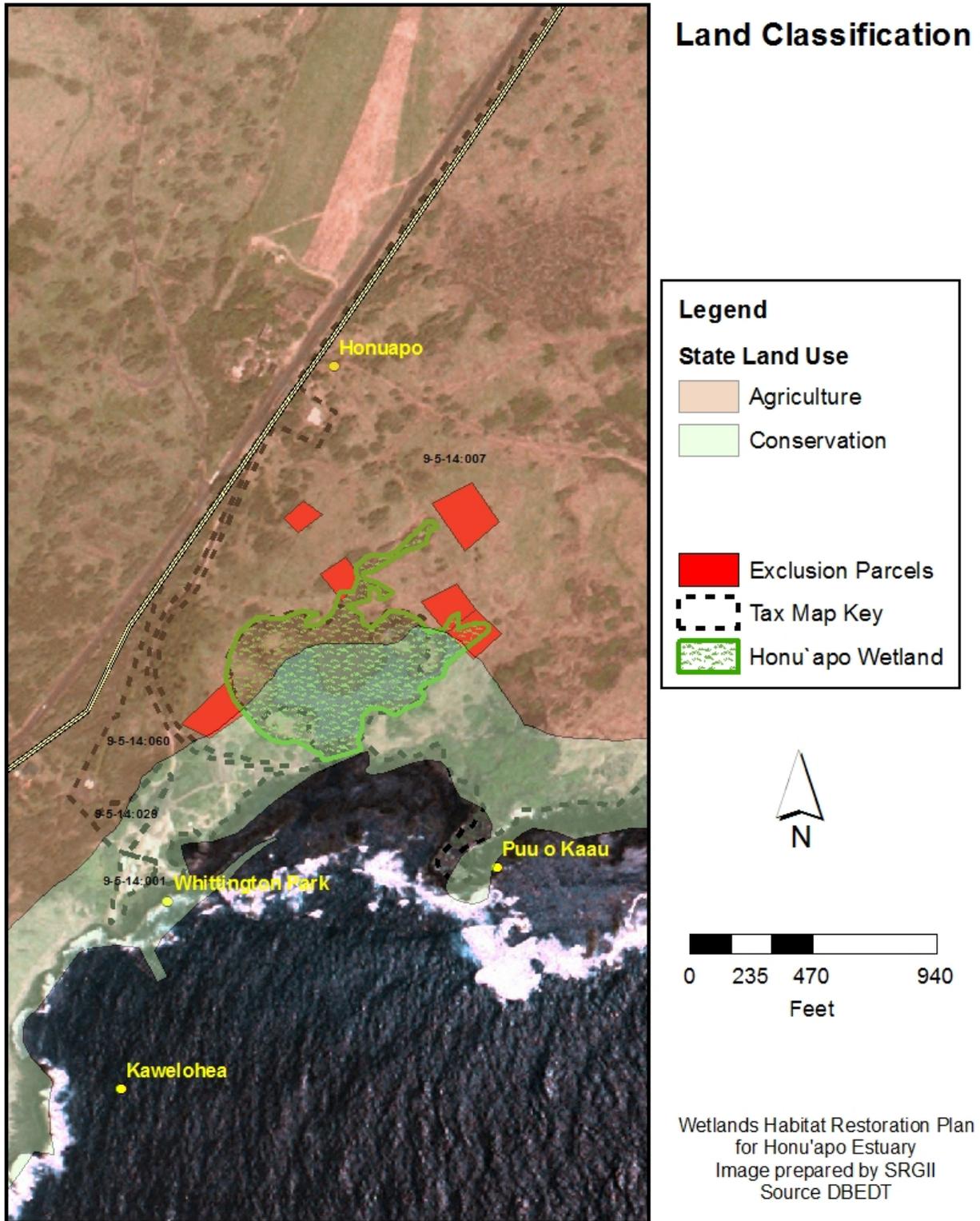
All lands in Hawai'i are classified into one of four districts for land use management purposes: Urban, Rural, Agriculture, and Conservation. The wetland and surrounding area is within the Agricultural District and the Conservation District (Resource Subzone) (Figure 2-9). Permitted land uses and activities within Conservation District subzones are restricted and generally require a Conservation District Use Permit from the Department or the Board of Land and Natural Resources (Section 6.2). The wetland and surrounding area is zoned as Agricultural District (A-20) (20-ac minimum lot size) under the Hawai'i County Zoning Code (HCC Chapter 25), which identifies permitted land uses.

The entirety of Honu'apo Park is within the Special Management Area (SMA) boundary, which extends up to the Hawai'i Belt Road in this area. SMAs are designated under Hawaii Revised Statute 205A as part of the Hawai'i CZM Program. Through their respective SMA permit systems, the Counties assess and regulate development proposals in the SMA for compliance with the CZM objectives and policies and SMA guidelines (Section 6.2). In general, SMAs include lands extending inland from the coast that are placed under special development control to avoid permanent losses of valuable resources and the foreclosure of management options, and to ensure that adequate public access to public beaches, recreation areas, and natural reserves is provided.

2.8.3 Exclusion Parcels

There are five exclusion parcels and one school grant parcel within Honu'apo Park, which are excluded from the park property (Figure 2-9).

Figure 2-9. Land Classification



2.9 Community Input

2.9.1 Community Knowledge, Attitudes, Use and Impacts

As a graduate student in Tropical Conservation Biology and Environmental Science at the University of Hawai'i, Hilo, Megan Lamson conducted a one year biological and social monitoring project at Honu'apo Bay (Lamson 2010).⁹ The project, conducted over the course of a lunar year (November 2008–November 2009), had two main goals: to provide a contemporary baseline for the nearshore species utilizing Honu'apo Bay and to evaluate human use and attitudes about the area. The study provides important information detailing species composition and potential conservation tools in the nearshore waters of Honu'apo Bay. Having good data on the current biomass, diversity and species richness and composition of the bay is essential to future planning efforts. Honu'apo Estuary, the subject of the current wetland restoration efforts, is directly connected to the bay through tidal exchange, provides an input of freshwater, and has been and continues to be an important nursery for fish species found in the bay's nearshore waters.

The research sought to answer two socio-cultural research questions: (1) *How are humans affecting marine resources (by extractions)?*; and (2) *What are community attitudes towards conservation and what do Ka'ū residents recommend for conservancy of the area?* By linking biological and socio-cultural data, Lamson demonstrates how protecting the rich species assemblage in the nearshore waters supports multiple objectives including maintenance of biological diversity, support for sustainable recreational and subsistence fishing, and upholding cultural traditions. Lamson draws parallels between modern community-based stewardship of marine resources and traditional Hawaiian fishing practices that were rooted in knowledge of and coordination with ocean patterns, an in-depth knowledge of species' reproduction cycles, and the social construct based on *ahupua'a* management and the *kapu* system.¹⁰ She suggests that implementing a community-based management model that draws on traditional cultural values and management practices, and has community support, will aid in protecting Honu'apo's resources for future generations.

The socio-cultural monitoring was conducted in and about Whittington Beach Park, the shoreline access for fishers to Honu'apo Bay. Social monitoring involved recording human-use patterns along the shoreline at Honu'apo (by observation from a distance), conducting informal interviews with local residents, and randomly distributing a survey to community members. Data was collected throughout the project period. The study was designed to assess how local residents utilize resources at Honu'apo Bay, with a focus on fishing (i.e. targeted fish species and preferred times, methods), and gather information about how they felt about Honu'apo and its preservation.

A total of 210 human-usage records were collected during the approximate year long survey, 136 on weekdays and 74 on weekends or holidays. Activities observed at Honu'apo included camping, picnicking, dog walking, snorkeling/swimming, and routine park maintenance. In addition, nearly half of the human-use observations documented fishing using a variety of methods including polefishing,

⁹ See original text for full details of the study, including biological and socio-cultural methods, results and discussion. This text summarizes the key points, with an emphasis on the socio-cultural component.

¹⁰ "In old Hawai'i, each *ahupua'a*, or traditional land division, from the highest mountain ridge (*mauka*) to the ocean (*makai*) was under the authority of a distinct *konohiki*, or resource manager. These *konohiki* could enforce *kapu* (restriction) systems of fishing closures for certain species that were dependent on seasonal and lunar reproduction schedules, and would encourage keeping the *ko'a* (fishing grounds) clean within their *ahupua'a*" (Lamson 2010; see original text for citations).

shoreline gathering, thrownetting, spearfishing, and lay/gillnetting. Collection of ‘opae (shrimp, *Palaemon* spp.), a‘ama crabs (Sally lightfoot crab, *Grapsus tenuicrustatus*), hā‘uke‘uke (Helmit urchins, *Colobocentrotus atratus*) and ‘opihi (limpets, *Cellana* spp.) was observed along the shoreline. The region is also known for access to limu (algae) and ula (spiny lobsters, *Panulirus* spp.).

A total of 174 social surveys were completed between April 2009 and November 2009.¹¹ Surveys were distributed at a variety of community events, at the beach park, at Ka ‘Ohana O Honu‘apo meetings and to personal contacts. Most common activities at Honu‘apo included (in descending order) walking, picnicking, swimming, family parties, and turtle watching. Extractive activities, in the form of fishing (rod/reel and pole) and shoreline gathering, were also identified by survey participants. The survey data support the human-use observations that showed polefishing and shoreline gathering as the most commonly observed fishing methods. No commercial fishing is conducted at Honu‘apo, however fishers indicated that they fish for sharing, subsistence, recreation, and culture and tradition.

Study results provide a baseline for the nearshore species utilizing Honu‘apo Bay and demonstrate that fishers engage in shoreline fishing and gathering on a daily basis. Detailed information on the current biomass, diversity, species richness and composition of the bay is an integral and essential first step in protecting its resources. Data provides information on how humans are affecting marine resources by extractions, including preferred fishing methods (polefishing, spearfishing, thrownet), targeted species (e.g., *Myripristis* spp., *menpachi*; *Kyphosus* spp., *nenue*; *Acanthurus triostegus*, *manini*; *Kuhlia xenura* and *Kuhlia sandvicensis*, ‘āholehole; *Carangid* spp., *pāpio*; and *Chlorurus* spp. and *Scarus* spp., *uhu*), and favored fishing times. Twenty-nine targeted resource species were identified at Honu‘apo Bay and data showed moderate fishing pressure along the shore.

Although there have been changes over time in intensity of fishing, efficiency of technology, and regulations and enforcement, it is not clear whether the fishing pressure at Honu‘apo currently exerts a negative influence on the stocks. Both fishers and the general public indicated their perception that there are generally *less* marine resources (in terms of use or availability) at Honu‘apo now as compared to the past. Specific observations included “*less limu*”, “*less fish*”, and “[*the*] *fish are smaller*”. Data indicate that Honu‘apo Bay is an important area for juvenile fishes, and the part of the estuary was used in the past as a fishpond, providing a managed nursery environment for fish species. With marine resources facing increasing pressure worldwide, Lamson (2010) argues that sustainable resource management “must now account for these substantial changes, and reflect of the multifaceted needs of the fisheries, the human residents, and the marine resources”.

The survey was also designed to gauge community and fisher attitudes towards conservation, and to gather recommendations about conservation planning for the Honu‘apo area, with an emphasis on marine resources. Over 94% of survey respondents expressed support for conservation efforts along the Ka‘ū

¹¹ “Nearly all of the surveyed population (97.7%, $n = 174$) were Hawai‘i state residents, and most of these were inhabitants of the Ka‘ū District on Hawai‘i Island (75.8%). The majority of the people surveyed had lived in the state for at least two years (89.7%), and over half of them were island residents for over ten years duration (60.3%). The average age of the sample population was 45.7 years and the median was 50 years. There was a roughly even split between the sexes: males (90), females (80), and a handful of undeclared persons (4). However, many (68.4%) of the 57 self-declared fishermen were male. Most of the survey participants were common visitors to the Ka‘ū coastline and Honu‘apo Bay. Survey estimates revealed that the sample population visited each shoreline location at least once a month (Ka‘ū: 72.4%, and Honu‘apo: 55.2%; $n = 174$). Additionally, almost all (94.8%) of the survey respondents were aware that Honu‘apo Bay and Whittington Beach Park were cultural sites along the Ka‘ū coastline ($n = 172$)” (Lamson 2010).

coastline, though specific measures remained disputed. Questions asking what could be done to make sure the natural resources at Honu‘apo Bay are protected elicited a range of general and detailed responses including respecting the site, involving the community, prioritizing conservation, educating the public, and preventing overfishing. Other conservation initiatives that were supported by a majority included creating more protection for fish stocks, building an outreach and public education center, creating walking trails, supporting restoration projects for the Honu‘apo Estuary and the Kaumona fishpond, and participating in a community-stewardship program for Honu‘apo. Of the conservation activities listed in survey, restoration projects for the estuary and fishpond were supported by the largest number of people (over 72%). Lamson notes that since most of the community surveyed was genuinely interested in stewardship, community endorsement and involvement of programs at Honu‘apo can be expected. According to Lamson, maintaining communication with all stakeholders and leading educational awareness projects for both local residents and visitors will be key to securing support for and ensuring success of community-based initiatives.

While the general public felt that better enforcement of the current rules and Marine Protected Area (MPA) designation would help protect Honu‘apo, fishermen supported the idea of establishing a *konohiki* management system rather than better enforcement or designation of Honu‘apo as an MPA. Lamson suggests implementing a community-based management model with a strong foundation in traditional cultural values and management practices, similar to others in the Pacific region. There are several different options including MPAs, Community-based Subsistence Fishing Areas, and Marine Fisheries Management Areas. Such a model could incorporate both terrestrial and marine resources, including the estuary at Honu‘apo.

Although not everyone was in favor of tighter enforcement of fishing regulations, there may be opportunities for community-based organizations to coordinate with DLNR Division of Aquatic Resources (DAR) and DOCARE and help manage local natural resources. Such a system could be informed by traditional practices whereby ocean and shoreline management was the responsibility of those living in the immediate area. In the past, fishing seasons were regulated according to localized resources, regions had their own protocols and chants for fishing practices, and fish gathering places were managed. Management measures for Honu‘apo could include locally-endorsed fishing *kapu*, potentially implemented in coordination with a *konohiki*. *Kapu* might consist of bans on modern and unsustainable fishing methods (e.g., gillnets, spearfishing on SCUBA), could include territorial user’s rights and sea-tenure, and might utilize seasonal closures for targeted resource species. Results from the survey suggest that Ka‘ū community members will endorse management concepts that will lead to the protection of fish stocks at Honu‘apo. Lamson indicates that additional surveys and planning would be required to identify a system that would work for the local community, including fishers. By addressing the common goals of all stakeholders (e.g., fishers, scientists, managers, local residents) to effectively plan, manage, enforce, and share local knowledge of natural resources conservation with other users, Honu‘apo Bay could be a success story from multiple perspectives.

In addition to establishing a marine resource baseline for Honu‘apo Bay, this survey addressed broader issues of natural resource conservation in the Honu‘apo area and presented options for marine resources management. Wetland restoration plans for Honu‘apo Estuary are aligned with the overarching strategy of marine resource conservation in the area. Since the estuary may be a nursery for many of the fish found in marine waters, plans to enhance wetland habitat will support broader ecosystem functioning, including

the linked estuarine-marine environment. On-going monitoring of biological, physical, and socio-cultural parameters in the bay, the estuary, and the park will help demonstrate the benefits of management efforts.

2.9.2 Community Outreach

A series of meetings were held to inform agency partners and community members about the WHRP, and obtain their feedback. In addition, Ka 'Ohana and its project partners have provided input via meetings with SRGII staff and feedback on draft versions of this plan.

- *Community Meeting: Agency Update.* During the course of the project, Ka 'Ohana held a series of meetings to inform local politicians, community leaders, and government agency personnel on project findings and proposed recommendations.
- *Community Presentation: Ka'ū Coffee Festival.* May 14, 2011. Ka 'Ohana attended this event and provided an opportunity for the public and other stakeholders to learn about the wetland restoration plan. Ka 'Ohana staffed a booth and was available to answer questions. Visual aids (poster, hard copy of Draft plan) were available, and written comments were solicited (see Appendix E).
- *Community Meeting: Party in the Park.* May 15, 2011. This event, hosted by Ka 'Ohana, provided an opportunity for the public and other stakeholders to learn about the wetland restoration plan and ask questions of the consultants that developed the plan. A presentation was given, visual aids (poster, hard copy of Draft plan, construction plans) were available, a question and answer session was held, and written comments were solicited (see Appendix E).
- *CZM Program Updates:* The Marine and Coastal Zone Advocacy Council (MACZAC) is a public advisory body established by the Hawai'i State Legislature to identify coastal management problems and to advocate for the Hawai'i CZM Program. The Ocean Resources Management Plan (ORMP) Working Group is an administratively created, multi-agency group of managers and staff tasked with coordinating their agency's implementation of the ORMP. Presentations were given to the MACZAC (May 5, 2011) and the ORMP Working Group (June 2, 2011) to update them on the WHRP.

2.10 Resource Issues

This section provides a general discussion of the issues that the restoration activities are trying to address. These problem areas may be limiting proper function of the wetland. The wetland enhancement design targets each of these problems in an effort to restore functionality (Section 3.0 and Section 4.0).

2.10.1 Regional Wetland Context

Its isolation along the Ka'ū coast, and its unique and somewhat rare wetland habitat, make Honu'apo Estuary a high value location for native flora and fauna. Migratory waterbirds utilize the estuary during winter months and resident birds year round. It is close enough to other wetlands on Hawai'i Island for resident waterbirds such as the Hawaiian coot and the Hawaiian stilt to move between sites for foraging and possibly nesting and chick rearing.

2.10.2 Avian Species

The influx of fresh water at the coastline, originating from precipitation on Mauna Loa dilutes salt water and creates a brackish water environment in the Honu'apo area. Though various species have been observed, the wetland complex does not support substantial waterbird populations. The presence of feral

cats and mongoose in the adjacent Whittington Beach Park and in the larger Honu‘apo Park is believed to be the primary cause of the low number of native bird species utilizing Honu‘apo Estuary. In addition, the non-native vegetation growing in the wetland degrades the habitat by providing cover for predators and limiting ground movement of birds and their access to substrate.

2.10.3 Non-Native Plant Species

Over 30 non-native plant species have been recorded in the Honu‘apo area. Many of these non-natives are considered aggressive invasives with the ability to outcompete native plants for available resources. Of special interest for this project is the elimination or control of seashore paspalum (*Paspalum vaginatum*), *kiawe* (mesquite, *Prosopis pallida*), California grass (*Urochloa mutica*), and Guinea grass (*Panicum maximum*). *Kiawe* is of particular control concern due to its significant use of groundwater (Section 2.4.3). Guinea grass dominates the inland disturbed areas of Honu‘apo Park, and is targeted for control in the *Honu‘apo Park Resources Management Plan* in part to reduce wildfire risk. In general, dense ground cover with high stature vegetation provides cover for predators, is an obstacle to birds walking and foraging, and should be targeted for removal.

2.10.4 Predators

Predators can impact native waterbird populations directly and indirectly. In addition, they may carry diseases that can be transmitted to humans, monk seals, and other species. Fauna at Honu‘apo are covered by the MBTA, the ESA, and the Marine Mammal Protection Act, which protect birds, monk seals and other listed species to varying degrees from human-caused harm. Most dogs at Honu‘apo Park are brought as pets. However, dogs can be a source of stress to bird populations, monk seals and turtles if they are allowed in close vicinity.

Feral cat colonies impact endangered and migratory bird health mainly through predation, competition and transmission of disease. The main disease of concern is toxoplasmosis, which is caused by the parasite *Toxoplasma gondii*. Toxoplasmosis is carried by cats and is passed in their feces. The most dangerous form of the bacteria is the oocysts, the egg encapsulated form, which is not killed when exposed to air or water (fresh or salt). Eggs can be transmitted by exposure to cat feces in the soil, exposure to water carrying the eggs, and ingestion of infected animals. Toxoplasmosis can spread to humans and other animals and has been linked to deaths of Hawaiian monk seals, spinner dolphins, and several species of birds. If toxoplasmosis does not kill animals outright, it can leave them in a weakened state that makes them more vulnerable to predation and other diseases. A study conducted on nearby Mauna Kea between 2002 and 2006 found that at least 37% of feral cats were infected with *T. gondii* (Danner et al. 2007). Although the cats at Honu‘apo are part of a managed trap/ neuter/ release / feed cat colony, the regular feeding of feral cats usually results in attracting more cats to the area as well as enhancing the populations of mongooses and rats. Like cats, mongoose and rats will eat eggs, chicks, and adults of some avian species. In addition, cats and mongoose host fleas, which can also pose a disease risk, especially to humans.

2.10.5 Hydrology

Honu‘apo Estuary is a water body that has a salinity gradient ranging from brackish to sea water. The hydrologic conditions that create this are the result of mixing between fresh water primarily input via ground water and ocean water that impounds the estuary. The volume of fresh water discharging into the estuary via springs and seeps is unknown, however, it is assumed to be relatively high since pockets of

water around the margin of the estuary are brackish, meaning dilution of seawater is occurring. In addition, *kiawe* trees are tapping into the ground water and extracting fresh and brackish water that would otherwise flow into the estuary and dilute the seawater (Section 2.4.4). Removal of *kiawe* trees should increase the volume of fresh water flowing into the estuary, which will enhance ecohydrologic conditions favorable for sustaining native flora and fauna.

2.10.6 Topography

The historic uses of the estuary and surrounding area includes: cattle grazing, cultivation of sugar cane, and manipulation of the topography by plantation managers. Cattle grazing in and around the estuary likely had adverse impacts to the water quality, topography, and vegetation community. Cattle can trample wetland habitat, spread invasive plants, and increase nutrient levels via their feces. During sugar cane operations fill material was intermittently discharged into the estuary, elevating the ground surface and decreasing deepwater and shallow water habitats used by native flora and fauna.

2.10.7 Surrounding Land Use

Maintenance of the natural quality of the wetland area is important for restoration. The relative isolation and undeveloped nature of the area provides a degree of protection. The wetland is directly adjacent to Whittington Beach Park, which is used for a variety of recreational activities. In addition, recreational fishing, including nets, takes place in the estuary and any impacts to fish populations are not well understood (Lamson 2010). Recreational activities must be managed to limit impacts to the wetland (Section 5.4). The wetland restoration must be contextualized as part of the overall Resource Management Plan for Honu'apo Park, which is made easier given the existing community motivation.

3.0 RESTORATION GOALS AND TARGET CONDITIONS

3.1 Restoration Goals

The overall goal of any restoration project should be to achieve a self-sustaining ecosystem that functions within and provides value to its region and/or watershed. This overall goal applies to Honu'apo Estuary, which is a wetland complex that provides habitat to support avian, aquatic, and plant species on the Island of Hawai'i (Section 2.1). Achieving this overall goal requires identifying more specific, measurable goals or objectives crafted in consideration of site-specific and regional needs, opportunities, and constraints. The guiding principle behind the restoration design is to restore habitats through both topographic and ecohydrologic modifications that together sustain wetland functions. This integration of habitat with the underlying geomorphic and hydrologic processes ensures that the designs are sustainable.

Most restoration goals can be grouped into four broad categories: hydrology, biogeochemistry, floral and faunal support, socio-cultural. The first three categories are *function-based* while the fourth is *value-based*. Both types are important to the success of habitat restoration. The function-based and value-based goals provide key processes and societal interests to consider carefully in the context of the opportunities and constraints. The intent is to incorporate as many of them as possible during the development and evaluation of restoration designs, and ultimately, to achieve as many of them as possible in the restoration project.

3.1.1 Function-Based Goals

The following goals are key processes or functions (i.e., “things wetlands do”) to enhance or restore within Honu‘apo Estuary in consideration of the larger region.¹²

Hydrology

- Enhance or restore site hydrology (i.e., proper elevations, slope, tidal channels, freshwater sources) sufficient to establish habitat similar to historic composition or to regional reference sites.
- Establish and maintain hydrological function that supports habitat needs.

Biogeochemistry

- Expose wetland soils to promote biogeochemical cycling of organic and inorganic matter creating conditions favorable for food web productivity (e.g., insects) and to allow waterbirds to access food on and in soils.
- Enhance or restore physical and chemical conditions of water sources (e.g., salinity) to optimize wildlife use and to achieve contaminant concentrations (e.g., nutrients, organic compounds) below State/Federal standards and other published/accepted levels of adverse effect.
- Promote the restoration of pre-existing wetland functions, especially in areas where the systems will serve a significant non-point source pollution abatement function.

Floral and Faunal Support

- Enhance or restore habitat that benefits sensitive species currently using the area, and that encourages nesting/ foraging/ establishment of sensitive species that may have used this area historically (e.g. native and endemic Hawaiian waterbirds, seasonal migratory birds, fishes, turtles).
- Restore habitat enhancing regional or landscape-level “functions” such as resident and migratory bird routes and regional fish populations.
- Enhance and restore habitats using approaches to minimize the presence and influence of non-native, invasive plant species (e.g., California grass and *kiawe*).
- Restore plant communities, with an emphasis on native species, for each habitat type with species abundances, composition, and vertical structure comparable to regional reference sites.
- Achieve abundances and types of vertebrates and invertebrates found associated with each habitat type (in the overall mix) comparable to regional reference sites.

3.1.2 Value-Based Goals

This type of goal is what society or the local community would value about the restored habitat. Support from the local community is critical to the success of large-scale habitat restoration, so it is essential to consider these interests in advancing the restoration of Honu‘apo Estuary.

Capitalize on Education and Research Opportunities

- Provide educational opportunities for young people and visitors.
- Coordinate activities (e.g. monitoring) with local universities (e.g. University of Hawai‘i at Hilo).

Preserve Hawaiian Cultural Values

- Protect richness of cultural and archaeological resources.
- Convey cultural historical information as part of outreach and education.

¹² As described in Section 2.10.1, there are few wetlands on the Island of Hawai‘i for comparison. Regional reference sites include those throughout the main Hawaiian Islands.

Provide Broad-Based and Environmentally Sensitive Recreation and Access

- Allow for passive recreational and educational uses.
- Maintain wetland as a natural habitat that is aesthetically pleasing.
- Protect open space and scenic vistas.

Protect, Enhance, and Restore Habitat and Species in Consideration of Regional Resources and Conditions

- Protect endangered plant and animal species (restoration).
- Take climate change into account in the restoration design (sea level rise).
- Support recovery plans of various resource agencies for rare, threatened, and endangered species.
- Provide an open-ocean connection through the estuary outlet.
- Consider the regional importance of wetlands relative to other sites on the Island of Hawai'i and in Hawai'i.
- Preserve, enhance, restore, and create habitat area for shorebirds and waterbirds.

Implement a Project Compatible with or Benefiting Surrounding Land Uses

- Consider impacts and constraints to adjacent landowners and uses (e.g. Whittington Beach Park, *kuleana* parcels (parcels awarded under the Land Commission Award)).
- Provide adequate buffer areas (i.e., native habitat) to protect wetlands and to minimize impacts to adjacent landowners and uses.

Maximize Implementation of Protection, Enhancement, and Restoration Activities

- Provide a financial plan for the restoration project.
- Obtain required permits to support implementation of the restoration project.
- Consider how individuals outside Ka 'Ohana and participating sponsors will perceive the restoration project to gain support.

3.1.3 Alignment with Other Initiatives

As part of Federal and State efforts, Hawai'i has conducted statewide planning efforts aimed at protecting ocean and coastal resources, wetlands, and native species. This section demonstrates how some of these broader initiatives correlate to the goals of this WHRP for Honu'apo Estuary.

Hawai'i Ocean Resources Management Plan

In addition to meeting general wetland restoration goals, this WHRP will also assist the State in implementing all three Perspectives of the *Hawai'i Ocean Resources Management Plan* (2006), 7 of 10 Management Goals and 15 of 28 Strategic Actions (Table 3-1).

Hawaii Coastal Nonpoint Pollution Control Program Management Plan

The *Hawaii Coastal Nonpoint Pollution Control Program Management Plan* contains a set of management measures, including those for the protection and restoration of wetlands, with the overarching goal of protecting Hawai'i's coastal waters from nonpoint source pollution (Table 3-2) (HCZMP 1996).

One of the key functions of a healthy wetland is to process nonpoint source pollutants, both by bioremediation and filtering. Since Honu'apo Estuary is located along the coast, with no direct surface channel inputs, the wetland restoration has not been designed specifically to address nonpoint source pollutants. However, overland flow and nonpoint source pollutants contained in the runoff and routed into

the estuary will be remediated and filtered. Restoration plans call for vegetation planting and fill removal, which are expected to improve the wetland's capacity for biofiltration.

Table 3-1. ORMP Perspectives, Goals, and Strategic Actions Addressed

ORMP Perspectives, Goals, and Strategic Actions	Expected Outcomes
Perspective 1. Connecting Land and Sea	
<p>Goal 1. Improve coastal water quality by reducing land-based sources of pollution and restoring natural habitats.</p> <ul style="list-style-type: none"> - <u>Strategic Action 1.</u> Reduce soil erosion from upland forest ecosystems and conservation lands. - <u>Strategic Action 2.</u> Reduce pollutant loads from residential, agricultural, and commercial land uses in priority watersheds. - <u>Strategic Action 3.</u> Restore and protect wetlands, streams and estuaries. 	<p>During the planning process, natural resource problems and opportunities to address these problems within and adjacent to the planning area including the watershed were identified. Wetlands improve water quality by filtering sediments and removing contaminants. Restoration of the estuary will enhance these functions.</p>
<p>Goal 2. Protect beaches, wetlands, and coastal communities from shoreline erosion and other coastal hazards.</p> <ul style="list-style-type: none"> - <u>Strategic Action 3.</u> Encourage appropriate coastal-dependent development that reduces risks from coastal hazards and protects coastal and cultural resources. 	<p>Wetlands protect shorelines from erosion due to waves and currents, and restoration will enhance this function. This plan includes recommendations for monitoring indicators of climate change and managing shoreline uses to protect natural and cultural resources.</p>
Perspective 2. Preserving our Ocean Heritage	
<p>Goal 2. Improve the health of coastal and ocean resources for sustainable traditional, subsistence, recreational, and commercial uses.</p> <ul style="list-style-type: none"> - <u>Strategic Action 1.</u> Strengthen and expand marine protected area management. - <u>Strategic Action 2.</u> Develop ecosystem-based approaches for nearshore fisheries management. - <u>Strategic Action 3.</u> Establish and institutionalize approaches for restoring, operating, and preserving Hawaiian coastal fishponds and salt ponds. - <u>Strategic Action 4.</u> Improve enforcement capacity and voluntary compliance with existing rules and regulations for ocean resource protection. - <u>Strategic Action 5.</u> Enhance the conservation of Hawaii's marine protected species, unique habitats and biological diversity. 	<p>This plan integrates the results of the community knowledge and attitudes survey regarding marine conservation and long-term stewardship for Honu'apo Bay (Section 2.9.1). This information focuses on ecosystem-based approaches for nearshore fisheries management. Honu'apo Estuary functions as a resting ground for marine protected species (i.e. green sea turtle) and may function as a nursery for native fish species. A companion archaeological and cultural resources survey identifies areas for protection and enhancement including fishpond features.</p>
<p>Goal 3. Enhance public access and appropriate coastal dependent uses of the shoreline.</p> <ul style="list-style-type: none"> - <u>Strategic Action 1.</u> Enhance and restore existing public shoreline access and scenic vistas. - <u>Strategic Action 2.</u> Establish new shoreline areas for public and appropriate coastal dependent uses. 	<p>Honu'apo Estuary is bordered by Whittington Beach Park, which has recently been enhanced for public use and enjoyment by the County and Honu'apo Park. Additional improvements to the park are planned (Townscape 2010). This provides an opportunity for public education and outreach about appropriate shoreline uses. The plan includes recommendations for access, education, and outreach (Section 5.4 and Section 5.5).</p>
<p>Goal 4. Promote appropriate and responsible ocean recreation and tourism that provide culturally informed and environmentally sustainable uses for visitors and residents.</p> <ul style="list-style-type: none"> - <u>Strategic Action 2.</u> Promote responsible and sustainable ocean-based tourism. 	<p>Recreational activities are guided by NOAA's Coastal and Estuarine Land Conservation Program. Though not a focus of this plan, tourism will be addressed in Ka 'Ohana's outreach program, which emphasizes conservation of Ka'ū's natural and cultural treasures (Section 5.5).</p>

ORMP Perspectives, Goals, and Strategic Actions	Expected Outcomes
Perspective 3. Promoting Collaboration and Stewardship	
<p>Goal 1. Apply integrated and place-based approaches to the management of natural and cultural resources.</p> <ul style="list-style-type: none"> - <u>Strategic Action 1.</u> Develop integrated natural and cultural resources planning process and standardized tools. - <u>Strategic Action 2.</u> Build capacity for community participation in natural and cultural resources management. 	<p>Ka 'Ohana's Executive Director Lehua Lopez-Mau, a Native Hawaiian Cultural Anthropologist, is on the planning committee. In addition, there are biologists and managers with expertise in marine, wetlands, terrestrial, and recreational resources. Ka 'Ohana, a community non-profit, is a driving force behind planning for Honu'apo Park and the wetland restoration. The plan specifically targets ways to involve the community in the habitat restoration, monitoring, and long-term stewardship of Honu'apo Estuary (Section 5.1).</p>
<p>Goal 2. Institutionalize integrated natural and cultural resources management.</p> <ul style="list-style-type: none"> - <u>Strategic Action 2.</u> Monitor and evaluate ORMP implementation. 	

Table 3-2. Hawaii Coastal Nonpoint Pollution Control Program Wetland Management Measures

Management Measure	Management Practice
Protection of Wetlands and Riparian Areas	
<p>Protect from adverse effects wetlands and riparian areas that are serving a significant nonpoint source pollution abatement function and maintain this function while protecting the other existing functions of these wetlands and riparian areas as measured by characteristics such as vegetative composition and cover, hydrology of surface water and ground water, geochemistry of the substrate, and species composition.</p>	<ul style="list-style-type: none"> - Consider wetlands and riparian areas and their polluted runoff control potential on a watershed or landscape scale. - Identify existing functions of those wetlands and riparian areas with significant polluted runoff control potential when implementing management practices. Do not alter wetlands or riparian areas to improve their water quality function at the expense of other functions. - Conduct permitting, licensing, certification, and non-regulatory nonpoint source pollution control. - Use appropriate pretreatment practices such as vegetated treatment systems or detention or retention basins to prevent adverse impacts to wetland functions that affect pollution abatement from hydrologic changes, sedimentation or contaminants.
Restoration of Wetlands and Riparian Areas	
<p>Promote the restoration of the pre-existing functions in damaged and destroyed wetlands and riparian systems in areas where the systems will serve a significant nonpoint source pollution abatement function.</p>	<ul style="list-style-type: none"> - Provide a hydrologic regime similar to that of the type of wetland or riparian area being restored. - Restore native plant species through either natural succession or selected planting. - Plan restoration as part of naturally occurring aquatic ecosystems.

Hawaii's Comprehensive Wildlife Conservation Strategy

The development of a Comprehensive Wildlife Conservation Strategy allows states to participate in the State Wildlife Grant program administered by USFWS. The program funds efforts by states and partner organizations to address species with the greatest conservation need. *Hawai'i's Comprehensive Wildlife Conservation Strategy* presents strategies for long-term conservation of native terrestrial and aquatic species and their habitats (Mitchell et al. 2005). Several species of flora and fauna that utilize Honu'apo Estuary are found on Hawai'i's list of species of greatest conservation need. Website: <http://www.state.hi.us/dlnr/dofaw/cwcs/index.html>.

U.S. Pacific Islands Regional Shorebird Conservation Plan

In an effort to improve waterbird habitat management in Hawai'i and the Pacific, USFWS, with input from other organizations, developed the *U.S. Pacific Islands Regional Shorebird Conservation Plan* (Engilis and Naughton 2004). The plan describes: species of importance and the type of habitat they use; habitat status; threats and management; and conservation priorities. Wetlands and tidal flats are habitats that support the highest diversity and density of shorebirds. Website: <http://www.fws.gov/shorebirdplan/RegionalShorebird/RegionalPlans.htm>.

Recovery Plan for Hawaiian Waterbirds

The *Draft Revised Recovery Plan for Hawaiian Waterbirds: Second Draft of Second Revision* addresses four species of Hawaiian waterbirds: the Hawaiian duck or koloa maoli (*Anas wyvilliana*), Hawaiian coot or 'alae ke'oke'o (*Fulica alai*), Hawaiian common moorhen or 'alae 'ula (*Gallinula chloropus sandvicensis*), and Hawaiian stilt or ae'o (*Himantopus mexicanus knudseni*), all listed as endangered (USFWS 2005). It provides habitat requirements, and details recovery information including goals, objectives, criteria for downlisting and delisting, and recovery actions. Website: <http://www.fws.gov/pacificislands/recoveryplans.html>.

Pacific Coast Joint Venture Hawai'i Strategic Plan for Wetland Conservation in Hawai'i

The *Strategic Plan for Wetland Conservation in Hawai'i* establishes the framework for the Hawai'i State component of the PCJV (Henry 2006). The plan describes: national, regional and state-wide avian conservation plans; existing habitat protection within Hawai'i, focusing on wetland ecosystems; natural and cultural resources in Hawai'i; and habitat and population goals for Hawai'i. It is intended to be a conservation plan for waterbirds and wetlands of Hawai'i but was designed to address more species and broader ecosystem management since wildlife species and habitats cannot be managed in isolation. Website: <http://pcjv.org/hawaii/publications/HWJVStrategicPlan.pdf>.

Ka 'Ohana 'O Honu'apo

The WHRP will also assist Ka 'Ohana in meeting the major goals the organization has set for the next ten years:

1. Restore, conserve, and protect the ecosystems and wetlands of the Honu'apo Estuary as a viable habitat for endangered and other native plants and animals.
2. Establish a safe and usable community park at Honu'apo with camping sites, picnic tables, showers, restrooms, BBQ pits, a parking area, a hiking trail, and native landscaping.
3. Establish environmental educational programs about the Honu'apo wetlands and estuary for children, families, and tourists.
4. Maintain awareness among Hawai'i's citizens and tourists of the need for cultural protection and preservation of the area along the southern coast of Hawai'i Island known as Honu'apo.

3.2 Target Conditions

This section describes the target species, habitat conditions, and hydrological parameters for the wetland enhancement. In general, the design is targeting biological habitat for avian species, with wading and deep water areas. The ground surface will be manipulated by excavating in selected areas. Hydrological conditions will target restoration of freshwater input and creation of deep water in areas of lower salinity that will also be favorable for fish, turtles, and invertebrates. Invasive plants will be removed and native plants selected for installation will be those used by target avian species.

3.2.1 Birds

Since Honu'apo Estuary is a coastal wetland, with salinity ranging from brackish to sea water concentration, with no pure freshwater pockets, native waterbirds and migratory shorebirds that prefer and are tolerant of water ranging from sea to brackish (i.e., Hawaiian stilt, Hawaiian coot) are being targeted in the restoration design. Control of avian predators, and grading the topography to create favorable physical habitat structure are the key components necessary to restore and enhance avian habitat. With improved habitat conditions and predator control, Honu'apo Estuary may be considered a suitable reintroduction site for the Hawaiian moorhen ('*alae 'ula*, *Gallinula chloropus sandvicensis*) and the Hawaiian goose (*nēnē*, *Branta sandvicensis*).¹³

Native Waterbirds

The native and migratory waterbirds discussed here are protected under the ESA or the MBTA.

Hawaiian duck, Koloa moali, Anas wyvilliana

Both sexes of the *koloa* resemble a dark female mallard, with blue wing bars bordered on both sides by white. Males have darker head and neck feathers. Feet and legs are orange. There is often difficulty in confirming sightings of pure bred *koloa* (*A. platyrhynchos*), and distinguishing purebred *koloa* from *koloa*-mallard hybrids and pure bred mallards is difficult. The Hawaiian duck occupies coastal swamps, freshwater pools, bogs, forest swamps, streams, and marshy areas. They prefer shallow water with nearby dense cover and relatively safe roosting sites (islands). They feed on grass seeds and other vegetation, crustaceans, insects and nematodes. Although there is not currently a captive breeding program, Hawaiian ducks bred in captivity have previously been used for reintroductions in Hawai'i.

The Hawaiian duck is protected under the MBTA and is listed as endangered both federally and by the State. The main threats to this species are: loss of wetlands due to drainage and alien plant encroachment, hybridization with feral mallards, and introduced mammalian predators. Duckling predators include mongooses, cats, dogs, black-crowned night herons, large-mouth bass, bullfrogs, and common mynas.

Hawaiian goose, Nene, Branta sandvicensis

The *nene* is an endemic goose similar in appearance to the Canada goose, except the face, cap and hindneck are black and the cheeks are buff colored. The front and sides of the neck show diagonal black and white striped markings. The *nene* ranges from 21 to 26 inches in length. They have feet that are only half webbed and weak wings, and rarely fly. *Nene* eat both native and introduced plants in grasslands and wetlands. Goslings are flightless for three months, making them vulnerable to predation. *Nene* do not require open water but will utilize it if located nearby.

The *nene* is the Hawai'i state bird and there is a captive breeding program to help the species move towards recovery. The *nene* is protected under the MBTA and is listed as endangered both federally and by the State. The *nene* is categorized as "threatened" on the International Union for Conservation of Nature (IUCN) Red List. It is threatened by habitat loss and introduced predators.

¹³ The last documented sighting of the Hawaiian moorhen on the Island of Hawai'i was prior to 1900 (except for failed reintroduction attempts). Discussions on the possibility of reintroduction of '*alae 'ula* and *nene* would be conducted with USFWS if adequate habitat conditions and predator control are achieved.

Hawaiian coot, 'Alae ke'oke'o, Fulica alai

The 'alae ke'oke'o is solid grayish-black except for its white bill and frontal shield. White undertail feathers are easily seen when the bird is swimming or displaying. The coot nests primarily in fresh or slightly brackish shallow (15–40 inches) water interspersed with robust emergent plants (bulrush, cattail), but may also construct floating nests in open water. They are often seen using deep pools. At Honouliuli on O'ahu, coots have been observed nesting in *makai* (*Bolboschoenus maritimus*) and 'ahu 'awa (*Cyperus javanicus*) (Brimcombe 2003). Hawaiian coots generally feed close to nesting areas. They are omnivorous, feeding on worms, snails, crustaceans, the adults and larvae of aquatic and terrestrial insects, small fish, and perhaps tadpoles. Coots also feed on the seeds and leaves of a variety of aquatic and terrestrial plants including sedges, grasses, and rushes. 'Akulikuli (*Sesuvium portulacum*) is an excellent food source for coot (F. Duvall, pers. comm.). They have been observed feeding on *Bolboschoenus maritimus* (seed heads and leaves), *Cyperus polystachyos* (seed heads and leaves), and *Cyperus javanicus* (Brimcombe 2003). They presumably feed on seed heads and use the stems of *makaloa* (*Cyperus laevigatus*). This species will travel long distances, including between islands, to locate food sources.

The Hawaiian coot is protected under the MBTA and is listed as endangered both federally and by the State. The Hawaiian coot is categorized as "vulnerable" on the IUCN Red List. It is threatened by habitat loss and introduced predators, especially the small Asian mongoose.

Hawaiian moorhen, 'Alae 'ula, Gallinula chloropus sandvicensis

The *alae 'ula* is black on the top portion of its body with dark slate blue below and a white stripe on the flanks. They have a red shield over their red and yellow bill and feet are lobed rather than webbed. The diet of the Hawaiian moorhen varies with habitat but includes algae, grass seeds, plant material, insects and snails. Nesting habitat is restricted to areas of standing freshwater less than two feet deep with dense emergent vegetation. Hawaiian moorhens generally occur in wetlands below 410 feet elevation. Historically they occurred on all of the MHI except Lana'i and Kaho'olawe.

The Hawaiian moorhen is a non-migratory, endemic subspecies of the common moorhen (*Gallinula chloropus*). It is listed as endangered both federally and by the State. It is threatened by habitat loss, introduced predators, avian disease and environmental contaminants.

Hawaiian Stilt, Ae'o, Himantopus mexicanus knudseni

The *ae'o* is slender red-legged shorebird with black upper-parts, white under-parts, and a long black bill. Hawaiian stilts are non-migratory birds, endemic to Hawai'i. Hawaiian stilts are also listed as a species of primary importance in the U.S. Pacific Islands Regional Shorebird Conservation Plan. Although the population is considered stable, it remains at very low levels.

Hawaiian stilts utilize fresh, brackish and saline coastal waters. Hawaiian stilts use little vegetation for nesting or feeding and breed in marshland, mudflats, shallow open water, flooded fields, borders of salt ponds, mangrove swamps, coastal playas and ephemeral wetlands (USFWS 2005). They nest on low relief shorelines and small islands within bodies of water. Nesting occurs from March to August with a peak in May and June. Hawaiian stilts feed primarily on invertebrates, crustaceans, aquatic and terrestrial insects, and small fish. Although chicks leave the nest immediately, the immature birds stay in family groups through the winter and until the next breeding season begins.

The Hawaiian stilt is protected under the MBTA and is listed as endangered both federally and by the State. The Hawaiian stilt is categorized as “vulnerable” on the IUCN Red List. It is threatened by habitat loss and introduced predators, especially the small Asian mongoose.

Black-crowned night heron, 'Auku'u, Nycticorax nycticorax hoactli

'Auku'u reach just over two feet tall, with a wing-span of nearly four feet. The birds have a black cap, bill, and back, dark gray wings, and pale gray undersides. The legs and feet are yellow. The 'auku'u is the most widespread of the native Hawaiian waterbirds. It feeds along shorelines in all types of wetlands on insects, crustaceans, fish, frogs and mice. The black-crowned night heron is protected under the MBTA.

Migratory Waterbirds

Migratory waterbirds are those that stop in Hawai'i on their way to or from breeding grounds.

Ruddy turnstone, 'Akekeke, Arenaria interpres

The 'akekeke is a medium sized shorebird with a variegated russet color pattern on its back, and black and white head, throat, neck and breast. It has short orange legs. The North American breeding population winters in Hawai'i, among other places, and can usually be seen on mudflats and shorelines. They eat crabs, clams, mussels and other crustaceans, aquatic insects and invertebrates as well as carrion and eggs of seabirds like curlews. The ruddy turnstone is protected under the MBTA.

Sanderling, Hunakai, Calidris alba

The hunakai is the smallest of the common shorebirds in Hawai'i, only eight inches from bill to tail. It is a small, light-colored bird with a thin, black bill and black legs. In non-breeding plumage it is white underneath and very pale gray above. Sanderlings winter in warm coastal areas, including Hawai'i, where they inhabit sandy and rocky beaches as well as mudflats. In Hawai'i they feed on mollusks and other aquatic and terrestrial invertebrates found in the shallow mud and water. The sanderling is protected under the MBTA.

Wandering tattler, 'Ulili, Heteroscelus incanus

The 'ulili are slate-gray with yellow legs and a long black bill. During winter they have dark gray feathers on their back and light gray bellies. Wandering tattlers utilize intertidal areas, mudflats, beaches along the coast, and rocky streams. They feed on small fish, aquatic insects, mollusks, crustaceans and other invertebrates. The wandering tattler is protected under the MBTA and is listed as a “species of moderate concern” in the U.S. Shorebird Conservation Plan.

Bristle-thighed curlew, Kioea, Numenius tahitiensis

The kioea is a medium-sized shorebird with a long, downcurved bill. They have brownish underparts, streaked breasts, dark cinnamon underwings, patches on their rumps, and pale blue-gray legs. Bristle-thighed curlews winter in Hawai'i on coral reefs, sandy beaches, intertidal flats, rocky shores and in dense vegetated understory. During winter they undergo a molt that leaves them flightless, making them extremely vulnerable to introduced predators (they are the only shorebird that have a completely flightless period during their molt). In Hawai'i they feed on crustaceans, snails, small fish and the eggs of seabirds. The Bristle-thighed curlew is protected under the MBTA, listed as a “species of high concern” in the U.S. Shorebird Conservation Plan, and categorized as vulnerable on the IUCN Red List. The species is thought to be declining at a moderate rate largely a result of predation on birds while at their wintering grounds in Hawai'i, particularly by cats.

Pacific golden plover, Kolea, Pluvialis fulva

The *kolea* is a yellow and buff mottled shorebird native to Hawai'i. Some pacific golden plovers are found year round in the Northwestern Hawaiian Islands (NWHI), but in the MHI adults are seen between August and May. The habitat of the pacific golden plover while in Hawai'i is extremely varied. Birds may be seen in pastures, coastal salt marshes, mudflats, beaches, mangroves, grassy areas and on roadsides. Pacific golden plovers feed primarily on terrestrial insects such as cockroaches, moths, caterpillars and earwigs. Hawai'i is thought to support a large portion of the world's wintering Pacific golden plover population. The Pacific golden plover is protected under the MBTA and is listed as a "species of high concern" in the U.S. Shorebird Conservation Plan.

3.2.2 Aquatic Animals

The aquatic animals of interest that currently utilize Honu'apo Estuary or the surrounding area include fishes, invertebrates, turtles, and the Hawaiian monk seal. Habitat enhancement may provide better habitat conditions for certain species and increase the frequency of occurrence of others. For example, snapping shrimp (*Alpheus rapax* and *Alpheus rapacida*) and the Hawaiian shrimp burrow goby (*Psilogobius mainlandi*) have a symbiotic relationship whereby a burrow that both share is built by the nearly blind snapping shrimp and protected by the goby. One of the preferred habitats of this pair of species is calm protected areas with silty sand bottoms, though they occur up to depths of 70 feet. Excavated channels that allow passage to perennial pools will provide habitat for the snapping shrimp, gobies, and a host of other fish and invertebrates. Perennial channels will allow free access to deep backwater habitat used by green sea turtles.

Green Sea Turtle, Honu, Chelonia mydas

Honu are the largest hard-shell sea turtle, averaging three feet in length. As adults, green sea turtles are almost exclusively herbivorous and feed primarily on seagrass and algae (*limu*). Green sea turtles utilize three types of habitat: ocean beaches, open ocean and benthic feeding grounds in coastal areas. Female Green sea turtles migrate between foraging areas and nesting beaches. Green sea turtles in Hawai'i nest in the NWHI, but frequent the MHI for a good part of the year feeding on *limu*. The Green sea turtle is listed as threatened both federally and by the State and is listed as "endangered" on the IUCN Red List. It is also protected under the Convention of International Trade in Endangered Species of Wild Fauna and Flora. Threats to the population of Green sea turtles include loss of habitat, harvest of eggs, incidental capture or entanglement in fishing gear, ingestion or entanglement in marine debris, and disease.

Hawksbill Sea Turtle, Honu'ua, Eretmochelys imbricate

Honu'ua is a small to medium sized marine turtle; averaging two and a half feet in length. The Hawksbill sea turtle feeds primarily on sponges, other invertebrates and algae, and is most often associated with the coral reef community. Hawksbill sea turtles frequent rocky areas, coastal reefs, shallow coastal areas and estuaries, and prefer water less than 65 feet deep. They nest in the MHI, predominantly on the Island of Hawai'i. The Hawksbill sea turtle is listed as endangered both federally and by the State and is listed as "critically endangered" on the IUCN Red List. It is also protected under the Convention of International Trade in Endangered Species of Wild Fauna and Flora. Threats to the population of Hawksbill sea turtles include loss of nesting habitat, harvest of eggs and meat, predation, incidental capture or entanglement in fishing gear, and ingestion or entanglement in marine debris.

Hawaiian monk seal, 'Ilio holo i ka uaua, Monachus schauinslandi

The Hawaiian monk seal is named for the folds of skin on their head that look like a monk's hood and because of their mostly solitary nature. Their Hawaiian name, *'Ilio holo i ka uaua*, translated "dog that runs in the sea". The Hawaiian monk seal is one of the rarest marine mammals in the world. Females can be up to 7.5 feet long and 450 lbs, while males can be up to 7 feet long and 375 lbs. Adults have silvery-grey colored backs with lighter creamy coloration on their underside. Additional light patches and red and green tinged coloration from attached algae are common. The back of the animals may become darker with age, especially in males. Monk seal life expectancy is 25-30 years. Hawaiian monk seals spend two-thirds of their time at sea, but haul out on corals, rocks or sand to rest, breed, and give birth. Sandy beaches surrounded by shallow waters are preferred when pupping. They are primarily benthic (bottom) foragers, and eat a variety of prey including fish, cephalopods (octopus and squids) and crustaceans (crabs, lobster, shrimp).

The Hawaiian monk seal is listed as endangered both federally and by the state. It is also protected under the Marine Mammal Protection Act. The population is estimated at fewer than 1,200 individuals and is declining at a rate of 4% annually. Threats include entanglement in and ingestion of marine debris, disturbance and harassment of seals on beaches, habitat loss, starvation, disease, and shark predation.

3.2.3 Vegetation

There is a distinct transition between the wetland and the surrounding upland, with the upland area dominated by plants adapted to the hot, dry, environment at Honu'apo. The wetland enhancement project is focusing on the plant composition in the wetland area, those that are adapted to the hydric soils and regular inundation with salt water in response to tidal fluxes. Planting in adjacent upland areas may be conducted as part of the planned improvements at Honu'apo Park (Townscape 2010). This includes planting and propagation of native coastal strand and drought tolerant plants for landscaping and restoration.

The target vegetation composition for Honu'apo Estuary is one that is dominated by native vegetation, with few, if any invasive species (Table 3-3). Plants with low stature will be favored, since it is more difficult for predators to hide in shorter vegetation. Encouraging landscaping with native species, other species adaptable to the environment, and species suitable for the intended function conserves water, promotes ecological and cultural appreciation, and adequately fulfills the intended buffering, screening, or shading functions without causing undue maintenance problems. This will be achieved through removal of invasive vegetation (Section 4.2), planting of native vegetation (Section 4.4), and maintenance to insure success (Section 5.2).

Table 3-3. Native Plants for Revegetation

Scientific Name	Common Name	Hawaiian Name	On-Site	Height	Habitat Benefit
<i>Schoenoplectus tabernaemontani</i>	Giant bulrush	<i>Aka 'akai</i>	Yes	2.5 ft or taller	Food source, nesting material and shelter for waterfowl
<i>Cyperus laevigatus</i>	Smooth flatsedge	<i>Makaloa</i>	Yes	1-2.5 ft	Food source and shelter for birds
<i>Cyperus javanicus</i>	Marsh cyperus, Java sedge	<i>'Ahu'awa</i>	No ¹⁴	1-3ft	Food source, nesting material and shelter for waterfowl

¹⁴ Widespread around all islands, tolerates brackish water well, tolerates dry periods well.

Invasive Vegetation

Kiawe is being targeted for removal from the wetland margins in order to restore freshwater flow to the wetland. Removal will also reduce roosting sites for cattle egret (*Bubulcus ibis*) that may prey on Hawaiian stilt eggs and chicks. Other invasive plants will be removed from the mudflats to increase foraging habitat. Invasive alien plants, including California grass, can degrade habitat quality by encroaching and choking wetlands. Tall Guinea grass provides cover for predators in areas surrounding the wetland.

Native Vegetation

Native or endemic vegetation planned for this wetland enhancement project includes species that are already on-site, those of short stature, and those wetland plants that are known to provide foraging and nesting resources for target bird species (Section 3.2.1). If the species does not currently occur on-site, only native species known to occur in the local area will be used.¹⁵ The selected species are suitable for soil and water salinity under wetland build out conditions and, once established, do not require long term maintenance. Since tall plants provide cover for predators, removal or mowing of some native plants with tall stature may be necessary for a period of time to help control the predator population.

3.2.4 Predator Control

Predation by feral cats (*Felis domesticus*), mongooses (*Herpestes auro-punctatus*), and rats (*Rattus rattus*) is a serious threat to all waterbirds and sea turtles, and especially to their nests. These animals prey on eggs and chicks. Predator control must be practiced to remove target species and limit the impact of these predators on the waterbird populations. This is particularly important since the target birds are protected by the ESA and MBTA, and knowingly allowing predation is considered take. If the wetland restoration is successful in attracting birds, on-going predator control will prevent the location from becoming a population sink (i.e., birds that come to the wetland from other locations are preyed upon, and overall population declines).

3.2.5 Hydrology

The goal of the hydrologic restoration is to increase fresh water inputs into the estuary. This can be accomplished by removing *kiawe* trees. Removal of this tree should result in increased fresh water inputs via ground water discharged out of seeps and springs into the estuary. Topographic manipulation in the form of removal of vegetative mats and excavation of deepwater channels (<3.0 ft), coupled with increased fresh water, will restore brackish water habitat for avian species that wade in shallow waters or exposed mud flats and birds that exploit brackish water areas.

3.2.6 Anticipating Climate Change

The restoration designs were designed to account for gradual and long term increase in sea levels. Sea level rise will elevate the tidal water levels that determine tidal wetland habitat type, magnify the impact of extreme storm events, and probably shift the coastline *mauka*. The design anticipates the impact of three feet of sea level rise. While uncertainty remains as to future rates of sea level rise because of uncertainty about future carbon emission rates and the oceans' response, it is reasonably certain that three feet of sea level rise from the 1990 level will occur by the end of the 21st century (Vermeer and Rahmstorf 2009; Fletcher 2009).

¹⁵ The coastal strand in nearby Wai'ohinu *ahupua'a* would provide a good example for native plants occurring locally (M. Lansom, pers. comm.)

4.0 RESTORATION DESIGN

This section provides the rationale of the design, commonly referred to as the “basis of design”, for the wetland restoration. Prior to implementation, additional work to secure permits and regulatory agency approval will be necessary. Other components such as grading, grubbing, and vegetation removal and planting may need further refinement as future short- and long-term recommendations are undertaken; discussions between Ka ‘Ohana, its partners, regulatory agencies and the public continue; and the project’s environmental review and approval process are carried forward. The wetland restoration is a component of the overall *Honu‘apo Park Resource Management Plan* (Townscape 2010). Funding requests, permitting, and implementation phasing should be coordinated with other planned activities to the degree possible.

The phases outlined below describe the elements of full restoration. The basis of design uses findings of the site investigations and hydrologic/hydraulic analyses, and background information to develop concept level plans, specifications, and estimates (PSE) of the proposed alternative to restore and enhance the wetland (Appendix C). Specific elements of the plan include grading and grubbing plans to achieve target physical habitat, vegetation removal to enhance biologic habitat and restore hydrologic conditions, and treatments to control avian predators. The PSE has been prepared so that the grading and grubbing, vegetation removal and planting, and predator control options can be distributed to contractors for bids.

Four alternative plans are presented for consideration. Although Full Restoration is desirable, at a minimum, this plan recommends implementation of Moderate Restoration 1. Predator control, especially of feral cats and mongoose, needs to be conducted. Although an option, Moderate Restoration 2 is not recommended. At present it is believed that avian species using the wetland are subjected to constant predation, and the site maybe a biologic sink, meaning birds using it are preyed on, killed, resulting in their depletion from the larger region populations and genetic pool.

1. **No Action.** Under this alternative the Honu‘apo wetland complex would not be subjected to any new actions or management. This alternative is the status quo and the stressors to biological habitat would not be remediated, likely resulting in the continuation of degraded habitat for native flora and fauna and predation on birds using the site.
2. **Moderate Restoration 1.** Under this alternative the only action proposed is control of avian predators. This alternative would result in continuation of the status quo with respect to physical and biological habitat components. As a standalone action, the control of predators would be significant in protecting avian species using the wetland habitat. However, it would not result in full potential of the site and would likely not support large populations of avian species due to the degraded physical and biologic components of the habitat.
3. **Moderate Restoration 2.** This alternative includes actions to restore and enhance habitat form and structure, but does not include control of avian predators. This alternative would enhance the physical and biological habitat components. However, without predator control, birds attracted to the site would be vulnerable to predation, creating a potential for an ecologic sink of avian species. This would be contrary to the objective of increasing resident and migratory bird populations and is not recommended.
4. **Full Restoration.** This alternative includes actions to restore and enhance habitat form and structure, and includes options for the control of avian predators. Under this alternative the full potential of the site would be realized. This alternative was developed so that components could

be phased in over time as funding became available. Each phase would increase habitat productivity and result in incremental increases in habitat quality.

4.1 Phase 1. Predator Control

Predator control inside and around the perimeter of the wetland is necessary for controlling avian predators and reducing bird loss. There are several potential predator control methods including trapping, bait stations and fencing (Table 4-1). Trapping and bait stations are two forms of 'active' predator control that have been used successfully in Hawai'i. There are two basic types of traps, live and lethal. The labor to check the traps varies between the two. Live traps require nearly daily checks to insure caught animals do not suffer. Lethal traps, while less labor intensive, are not recommended where inadvertent taking of pets may occur. They need to operate correctly to prevent injury instead of death to the target predator. Bait stations are a form of ground control where baits (e.g. toxins such as brodifacoum or diphacinone) are laid out in specific areas to poison target pest species. Predator-proof fences are a two phased method to control of predators. The fence is constructed around the area to be protected and predators inside the area are eradicated via trapping and/or bait stations. The second phase prevents predators from returning to the site through the fence design.

All predator control methods need to be conducted until the predator population is completely reduced and the threat to avian species removed, or in perpetuity if predators migrate to the site from areas beyond the predator control area. Conducting predator control for a short period of time and then ceasing it will likely lead to predation on birds that move into the wetlands during the active predator control period. Predator control should be conducted by qualified professionals at times when human presence is minimal and animals are active (i.e. at night, dawn and dusk).

There is currently a feral cat colony in Whittington Beach Park and the cats are fed on a near daily basis. Although feral, they may be considered pets by the person(s) who provides the food. The non-profit group AdvoCATs conducts spay and neuter operations on feral cats living in many of the feral cats colonies across Hawai'i Island, including the one at Whittington Beach Park. The goal of AdvoCATs is to control population growth of feral cats and adopt out kittens and tame adult cats. AdvoCATs does not euthanize cats and their advocacy is in support of cats. Removal of the feral cat colony at Whittington Beach Park may be problematic to the persons' feeding the cats and other members of the community. In general traps used for cats are live traps, and the captured animal is taken to the Humane Society where it is either placed for adoption or euthanized. Trapping of mongoose and rats will most likely not be viewed unfavorably by the public, especially if the predator control is conducted in a discrete and professional manner.

An initial intensive effort would involve removal of cats from the existing Whittington Beach Park colony and cessation of their feeding, and active predator control (i.e. trapping, bait stations) to remove rats and mongoose. After the initial effort, there are two options for long-term predator control at Honu'apo to reduce the pressure on bird species. Option 1 involves on-going trapping and/or baiting control conducted on a schedule to be determined by professionals. Option 2 involves installation of a predator control fence. Cost comparisons are shown in Table 4-2.

Table 4-1. Predator Control Methods

Pros	Cons
Trapping	
<ul style="list-style-type: none"> • Effective method. • Avoids harming native birds if used correctly. • New trap designs do not need to be reset after every individual is trapped. • Visitors to these habitats can see the difference this strategy has made. 	<ul style="list-style-type: none"> • Labor-intensive. • Expense – related to labor. • Potentially unpopular in visible public park setting. • Requires regular testing and maintenance.
Bait Stations	
<ul style="list-style-type: none"> • Targets a greater number of pests than trapping or hunting. • High success rate in targeting pests. • Amount of toxin used is far less than has been used in the past. • Visitors to these habitats can see the difference this strategy has made. 	<ul style="list-style-type: none"> • Labor-intensive. • Expense – related to labor. • Some non-target species can be poisoned from the toxins.
Predator Proof Fences	
<ul style="list-style-type: none"> • All pest species are excluded from the habitat area. • Native fauna translocated into the site are protected and their numbers increase rapidly. • Visitors to these habitats can see the difference this strategy has made. 	<ul style="list-style-type: none"> • High upfront cost to install the fence. • Visual addition to landscape. • Fence will have an opening at estuary mouth. • Constant monitoring of the fence perimeter is required to ensure there are no re-invasions. • The size of any predator-free area can only support a limited population. • Need to allow for access to <i>kuleana</i> parcels.

The recommended predator control fence is manufactured by Xcluder Pest Proof Fencing Company (www.xcluder.co.nz) (Appendix D). The company is based in New Zealand and their predator control fences are considered state-of-the-art with respect to functionality and materials. An Xcluder fence has recently been installed on Kaena Point on the Island of O'ahu. Predators targeted for control by the fence include: cats, dogs, mongoose, rats, and mice. The provisional layout for the fence is depicted on Sheet G-3 in Appendix C, with an estimated total length of 3,200 linear feet. The fence should be fitted with a minimum of three gates, two to allow pedestrian entry (e.g. near the outlet of the estuary and along the north side of the estuary), and one at the *mauka* portion of the estuary to provide for vehicular access. The fence alignment, length, gate structures, and other features are presented in concept design form, and the locations and specifications may change following detailed engineering designs and discussions with owners of exclusion parcels located around the estuary and stakeholders. The cost for the fence indicated in Table 4-2 is an initial order of magnitude estimate, and should be considered provisional. Representatives of Xcluder will conduct a site visit prior to installation in order to prepare final cost estimate for materials and installation.

Table 4-2. Predator Control Cost Comparison

Control Method	Initial Cost (Year 1)	Annual Maintenance and Trapping Cost	Total Cost (20 years)
Xcluder Fence	\$612,500 ¹⁶	\$1,500	\$641,000
Trapping (live) ¹⁷	\$62,160	\$30,240	\$636,720

¹⁶ Cost is provisional and an order of magnitude estimate.

¹⁷ Cost will vary due to predator recruitment to the site following initial predator control efforts.

4.2 Phase 2. Vegetation Removal

The primary objective of the vegetation removal is to remove target invasive species that are currently degrading the wetland habitat. There are two areas of focus – *kiawe* (*Prosopis pallida*) removal to restore freshwater input into the estuary and vegetation removal from intertidal mudflats to improve avian forage habitat. Other non-native vegetation targeted for removal includes California grass (*Urochloa mutica*), Guinea grass (*Panicum maximum*), Koa haole (*Leucaena leucocephala*), Java plum (*Syzygium cumini*), Sourbush (*Pluchea symphytifolia*), and Christmas berry (*Schinus terebinthifolius*). Removal of all non-native vegetation is not recommended in areas where its growth is not significantly impairing habitat due to the effort it would take to prevent the non-native species from recruiting back into the same areas. Appendix C, Sheet G-5 depicts the areas and elevation bands along with species targeted for removal.

4.2.1 *Kiawe*

Kiawe removal will entail removal of all trees in and around the wetland, including those growing in the uplands zone. A count of *kiawe* trees conducted during field assessments of the site identified 173 trees for removal. Removal should also include treatments to prevent resprouting, which can be accomplished by ripping below ground biomass or treating the cut stump with herbicide.

4.2.2 Invasive Wetland Vegetation

Grasses, herbaceous forbs, and shrubs growing on the mudflats that are part of the intertidal habitat will be removed in certain areas as part of the grading efforts. The vegetation will be stripped as part of the grading plan to recontour the topography of the mudflats protruding from the banks of the wetland to make them more suitable for wading birds to forage, and loaf on.

4.3 Phase 3. Topographic Manipulation

The topography of the intertidal zone will be graded to create two habitat types. Forage habitat for use by wading birds will be created on the mudflat areas that are presently covered with high stature ground cover. The ground surface in these areas will be lowered to finished elevations that will result in frequent inundation by MHHW. This is expected to increase productivity of food sources utilized by wading birds and prevent recruitment of invasive plants back onto the mudflats. Deep water pools will also be created by grading. These pools, which remain perennial during all tides and are fed by fresh and sea water, are expected to be favorable to the Hawaiian coot and other diving and dabbling birds. Drawings depicting grading plans and estimates of cut material are included in Appendix C, Sheets C-3 through C-8.

4.4 Phase 4. Revegetation

Existing areas of native wetland plants will be preserved to the extent possible. Grading plans were drawn up with consideration given to existing plant species that are used as food, forage and nesting by the target bird species. In some areas grading will result in removal of native plants in order to create deepwater habitat. Replanting plans list species of plants preferable for native fish and wildlife, specifically Hawaiian and migratory waterbirds. Plants for revegetation efforts were chosen based on several criteria intended to support a native wetland environment that provides suitable habitat primarily for Hawaiian and migratory waterbirds (Section 3.2.3 and Table 3-3.). The re-vegetation plan is shown in Appendix C, Sheet G-6.

5.0 PROJECT MANAGEMENT STRATEGIES

Long-term adaptive management strategies for the wetland are designed to ensure on-going functionality subsequent to restoration and enhancement activities. The management regime should be flexible, interdisciplinary, programmatic, and adaptive to ensure that ecosystem functions and social and economic values are sustained. Without ongoing maintenance, it is likely that many of the gains will be lost. Adaptive management strategies provide guidance on how to alter activities as new information is acquired and operational strategies have been evaluated. Evaluation and revision to the management strategies should be completed at routine intervals to achieve a long-term management strategy that is flexible and adaptive to resource/issue specific site conditions as they evolve.

5.1 Responsibility and Capacity

The ability and capacity of project partners to maintain the enhancement of wetland features is essential to project success. As a partner in park management, part of Ka 'Ohana's role will be to liaison with the county and coordinate on-going community involvement to sustain the benefits of the wetland enhancement project. Types of activities requiring long-term maintenance include: vegetation management, invasive species control, and predator control. As part of its regular park maintenance activities, the County DPR can provide vegetation control in the form of on-going *kiawe* removal and mowing of the upland vegetation (guinea grass). Predator control services will likely be contracted out to a private company. Community members have and will continue to play a key role in the future of Honu'apo Park, including the wetland. Volunteer participation will be needed for on-going wetland maintenance (e.g. work parties) (Section 5.2), monitoring (Section 5.3), and education (Section 5.5).

5.2 Wetland Maintenance

The wetland system has parts and processes that work according to ecological principles. When the ecosystem is working well, it is said to be healthy. It is dysfunctional or unhealthy when relationships involving its different plants and animals become out of balance. For example, when aggressive or fast growing introduced species out-compete, prey on, or come to dominate native species, certain desirable qualities and functions of the ecosystem can decline. An attractive appearance, including healthy looking native plants and wildlife, and good water quality all depend on underlying ecological qualities and functions.

The wetland enhancement project is designed to bring Honu'apo Estuary back into balance by removing invasive plants and animals and improving physical habitat structure and its associated ecological components for desired native species. Maintenance work may be required to promote native species, control or eliminate invasive species, and generally contributes to keeping the wetland attractive with high ecologic and water quality. Maintenance must be performed regularly in order to sustain the site. However, work around or in the pond could affect the endangered waterbirds, their eggs, or habitat and requires a consultation with the USFWS, per ESA Section 7. In general, USFWS is supportive of wetland restoration efforts, but wants to insure that planned maintenance activities are conducted and scheduled so that it has minimal impact on endangered and native species. As bird populations increase at Honu'apo, it will be important to be aware of potential constraints associated with conducting maintenance. For example, the timing and location of certain activities may need to consider nesting.

5.2.1 Vegetation

The use of native species as part of the revegetation component will not require post planting maintenance. Native species will be planted in high soil moisture zones, to eliminate the need for irrigation. The existing organic soils have sufficient levels of nutrients for the native plants, thus alleviating the need for fertilizer and other soil amendments. Post restoration vegetation maintenance will be focused on treatments to prevent recruitment of *kiawe* and California grass. This will be accomplished primarily by physical treatments such as cutting and pulling sprouting plants.

5.2.2 Predator Control

As described in Section 4.1, there are two options for on-going predator control. Option 1, involving trapping, hunting and bait stations will require the services of trained professionals to evaluate the effectiveness of trapping methods and adjust frequency as needed to obtain desired results. Option 2, a predator proof fence, will require routine inspection of the fence to insure its integrity, and monitoring and potentially eradication of predators inside of the fence. Since the fence would have an opening, at the mouth of the estuary, it is possible that predators could circumvent the fence and enter the wetland.

5.3 Wetland Monitoring

As described in the *Honu'apo Park Resources Management Plan* monitoring of human use and biological health of the coastal area, including the estuary, will be the responsibility of Ka 'Ohana as part of a Makai Watch program (Townscape 2010). This section identifies recommended monitoring designed to evaluate the success and failure of the wetland restoration activities. These activities should be incorporated into the planned Makai Watch program. At a minimum, monitoring should be conducted quarterly, with monthly data collection preferred.

- *Vegetation*: Develop transects and conduct photographic monitoring and greenline surveys to measure the success of native plants and potential encroachment of invasive plants.
- *Avian species*: Conduct avian point counts and collaborate with DOFAW to obtain their survey data to measure use of the wetland by native waterbirds and migratory shorebirds. Data on nesting attempts and success (if observed) will be valuable.
- *Aquatic species*: Conduct turtle counts and fish counts to document use of the estuary.
- *Water Quality*: Conduct water quality monitoring for standard parameters (e.g. temperature, salinity, dissolved oxygen, nutrients).
- *Sea Level*: Install a long-term water level logger to monitor changes in sea level, which is an indicator of climate change.

5.4 Public Recreation

Protecting open space and scenic vistas is an important objective of the WHRP. The preservation of aesthetically pleasing coastlines is important culturally, as well as to the Hawaiian economy, which is highly dependent upon tourism.

Recreational activities at Honu'apo Park are considered passive, and in alignment with the goals of the area. Even so, there is a potential for these activities to have a negative impact on the wetland area if not managed. Hiking, bird watching and nature viewing are all compatible activities with the wetland. An educational campaign will help inform people about any limitations necessary to protect the habitat

(Section 5.5). During the active wetland enhancement phase, signage should be placed to alert people about the vegetation plantings in order to minimize disturbance while plants are establishing.

A defined walkway (e.g. nature trail or boardwalk) in conjunction with signage (Section 5.5) could be developed to provide people an opportunity to view the restored wetland. A proposed alignment is shown in Appendix C, Sheet G-3.¹⁸ A walkway could be established whether or not a predator control fence is installed, and could have designated viewing areas / overlooks. Any walkway would need to be compliant with Federal and State standards (e.g. compliant with the American Disabilities Act). Potential drawbacks of a defined walkway include: increasing the possibility of bird disturbance from foot traffic, increasing the possibility of transfer of invasive species into the wetland (e.g. people's shoes carrying seeds from other locations), and additional cost and maintenance.

Fishing is a common activity at Honu'apo, both in the wetland and shoreline areas (Section 2.9.1). Although it is not clear whether the fishing pressure at Honu'apo currently exerts a negative influence on the stocks, there is recognition that some form of community-based stewardship of fishery resources would be beneficial (Lamson 2010). In the wetland area this could include a restriction on the laying of nets, while allowing throw nets. In the future the community might consider a take limit for throw nets (e.g. one 5-gal bucket per person per day). Lamson (2010) provides additional information on potential stewardship opportunities for fishery management at Honu'apo.

It may be necessary to establish and enforce certain rules and prohibitions to ensure that public use of the area does not compromise the restored habitat. For instance, it is anticipated that public access and use will be encouraged in some areas, but discouraged or prohibited in other areas (seasonal or continuous restrictions using fencing) to prevent inadvertent habitat destruction or wildlife disturbance. Enforcement of the prohibition of dogs, cats, or other domestic animals (except for service animals) in County beach parks will assist in resource protection.

5.5 Education

The long-term success of restoration efforts at Honu'apo will depend, in part, on the effectiveness of educating the public about sensitive flora and fauna, identifying recreational activities that limit impacts on natural resources, and building stewardship in the community by involving them in the enhancement, restoration, and management activities. By educating the public, the wetland can benefit in the short- and long-term from volunteer assistance in trash clean-up, invasive species removal, native planting, docent training, water quality sampling, biodiversity monitoring, and area patrolling to dissuade unauthorized or illegal activities. More importantly, by raising awareness and participation of residents and users, particularly children, it is possible to change the behaviors that create the majority of the problems leading to habitat degradation.

In conjunction with the planned improvements to Honu'apo Park (Townscape 2010), the restoration project represents a significant opportunity to increase public access to the coast for recreational purposes and to provide public education on coastal wetland ecosystems, flora, and fauna. The significance of the wetland area and the importance of conservation can be communicated to park visitors through historic,

¹⁸ Public walkways should be designed to minimize disturbance to avian species actively using the site. Final alignment should consider bird activity at the site post-restoration. Management strategies may include limits to the length of walkways or periodic closures due to breeding or rearing periods and the public should be educated about their stewardship role in relationship to the endangered species for which the wetland is home.

cultural, and natural history interpretation. Interpretive signage could be installed to provide environmental information about the wetland and its fauna and flora. This could include information on native plants and Polynesian introductions of cultural historic importance. Identification aides for these and the endangered waterbirds, migratory shorebirds, fishes, invertebrates, and turtles seen at the wetland would enhance the visitor's experience. Ka 'Ohana will have responsibility of designing interpretive and educational displays and managing related educational programs (Townscape 2010).

6.0 NEXT STEPS

6.1 Funding

Restoring and enhancing native wetland habitats and providing public education and environmentally sensitive recreational opportunities are costly endeavors. Nonetheless, preserving open space and restoring wetlands are important for the sustainability and health of the Honu'apo ecosystem. These needs have triggered the development of Federal, State, and private assistance programs that work to protect, enhance, and restore native habitats. Most funding sources prefer projects that achieve multiple goals, such as habitat restoration and education.

As described in Section 1.1, several entities provided funds to acquire the lands to expand Honu'apo Park. Each of these entities has a vested interest in shaping the park's vision and providing funding to implement the planned improvements. As part of its Memorandum of Understanding with the County to assist in the planning, restoration, and management of Honu'apo Park, Ka 'Ohana will play a key role in raising funds for the wetland restoration project, along with other projects identified in the *Honu'apo Park Resource Management Plan* (Townscape 2010). This wetland restoration project requires funding for the various aspects of its implementation, including: permitting and approvals, ecological enhancement and restoration; recreational and educational amenities and programs (Table 6-1).¹⁹ Cost estimates were derived using standard engineering construction cost estimates derived from R.S. Means, solicitation from local contractors and vendors, and comparison to similar built projects. Costs for phases 1, 2, and 4 could be offset by using volunteers and donation of equipment and supplies (Section 6.3).

Table 6-1. Estimated Costs

Phase	Total Cost ²⁰
1. Predator Control	\$641,000 ²¹
2. Vegetation Removal	\$82,000
3. Topographic Manipulation	\$193,000
4. Revegetation	\$48,000
5. Permit Acquisition	\$78,000
Total	\$1,042,000

¹⁹ Costs for recreational and educational programs are not included in this estimate. Type, extent, and cost of work needed to be determined by Ka 'Ohana.

²⁰ Costs are provisional and are subject to change due to escalation and other factors.

²¹ Estimated for 20 years. See Table 4-2 for details.

Although monitoring and adaptive management are critical to the long-term persistence and vitality of protected, enhanced, and/or restored natural resources, there are far fewer grants for maintenance and management activities when compared to those grants established for planning and implementation of these projects. It is important to capitalize on other opportunities for maintenance and monitoring, including researchers from local universities, Federal and State agencies, or volunteers. Table 6-2 and Table 6-3 summarize some of the funding sources that have been identified for various aspects of the project.

Key restoration funding sources will be the National Coastal Wetland Conservation Act and the North American Wetland Conservation Act, grant programs administered by USFWS. Each of these can provide up to \$1 million in Federal funding per application. DOCARE can provide technical support for certain projects as part of the Makai Watch Program.

6.2 Regulatory Requirements for Restoration

A series of Federal, State and County permits and approvals will need to be secured for implementation of construction designs for the planned wetland enhancement at Honu'apo Estuary. These regulatory requirements ensure compliance with all local, State and Federal laws designed to protect natural and cultural resources. It is possible that some of the regulatory steps can be done concurrently with similar permits and approvals identified for the overall park improvements, thereby streamlining the process (Townscape 2010). Project funding and timing of implementation will play a role in determining the suitability of combining the regulatory process. The following agencies have been identified as having jurisdiction over the project, or are otherwise anticipated to have regulatory authority over the project:

- **Federal:** National Marine Fisheries Service (NMFS); NOAA; U.S. Army Corps of Engineers (USACE); USEPA; and USFWS.
- **State:** Department of Business, Economic Development, and Tourism (DBEDT); Department of Health (DOH); DLNR [Division of Aquatic Resources (DAR); Division of Forestry and Wildlife (DOFAW); Office of Conservation and Coastal Lands (OCCL); and State Historic Preservation Division (SHPD)].
- **County:** Department of Parks and Recreation, Department of Planning, Department of Public Works (DPW).

The sequence of securing permits and a specific timeline for permit completion, submission, and review will in part be based on dialogue with each agency. In general, the permits can be prepared concurrently and much of the required information is similar.

6.2.1 Federal

Prior to its implementation, environmental review of the restoration project will be required under the National Environmental Policy Act (NEPA) and/or Hawai'i Revised Statutes (HRS) Chapter 343 (Environmental Impact Statements) (Section 6.2.2). NEPA will be required if the project receives Federal funding.

National Environmental Policy Act

NEPA requires consideration of environmental concerns during project planning and execution of federally funded projects. The Act requires Federal agencies to prepare an Environmental Assessment (EA) or Environmental Impact Statement (EIS) for actions that have the potential to significantly affect

the quality of the human environment, including both natural and cultural resources. NEPA is implemented by regulations issued by the Council on Environmental Quality (40 CFR 1500). A NEPA analysis can have one or more of several outcomes: a determination of categorical exclusion where an action can be categorically excluded from further environmental analysis; the preparation of an EA if the action cannot be categorically excluded or is not a “major federal action”; the EA can result in a “finding of no significant impact”, or in the decision to conduct an EIS because the action has been found to be a major Federal action through the NEPA analysis.

NOAA National Marine Fisheries Service

NOAA NMFS and USFWS share responsibility for implementing the ESA (see details below under USFWS/ESA). Generally, USFWS manages land and freshwater species, while NMFS manages marine and ‘anadromous’ (migrating from the sea to fresh water to spawn) species. In the Honu'apo area, protected species overseen by NMFS include the Hawaiian monk seal, green sea turtle, and hawksbill turtle. The ESA requires NMFS to designate critical habitat and to develop and implement recovery plans for threatened and endangered species.

Sustainable Fisheries Act

The 1996 Sustainable Fisheries Act (Public Law 104-297) (1996 amendments to the Magnuson-Stevens Fishery Management and Conservation Act, 16 U.S.C. 1801 *et seq.*) requires cooperation between Federal and State agencies in achieving Essential Fish Habitat (EFH) goals of habitat enhancement, conservation and protection. EFH is defined as those water and substrates necessary to fish for spawning, breeding, feeding, or growth to maturity. EFH includes waters historically used by fish, and their associated biological communities. The Act requires all Federal agencies to consult with NMFS on all actions, or proposed actions, permitted, funded, or undertaken by that Federal agency, that may adversely affect EFH. Consultation is not required by states or private land owners unless a project is funded, permitted, or authorized by a federal agency and the project may adversely affect EFH.

The restoration activities at Honu'apo Estuary will probably not adversely affect EFH in the long term, but there may be some short-term adverse affects during the construction phase. An EFH consultation can be consolidated with other Federal interagency consultation, coordination, and environmental review procedures such as NEPA, MBTA, Clean Water Act (CWA), or the ESA Section 7 consultation.

National Oceanic and Atmospheric Administration

Since a large part of the funding for the purchase of Honu'apo Park property came from NOAA under the Coastal and Estuarine Land Conservation Program, any wetland restoration activities need to be consistent with the program's final guidelines. As described in the *Honu'apo Park Resources Management Plan*, public access and activities consistent with the conservation purpose of the grant (e.g., resource protection, restoration and enhancement, recreational activities) are allowed (Townscape 2010, including Appendix C).

Table 6-2. Potential Funding Sources

Program Name	Agency	Type	Requirements			Funds Available	Processing Time	Month of Deadline
			Eligibility	Types of Projects	Match Req'd			
<i>Community-based Restoration Matching Grants Program</i>	The Nature Conservancy – Global Marine Team and NOAA - Community Based Restoration Program	Federal	Community-based	Any habitat that will benefit NOAA trust resources (anadromous, estuarine, and marine species and their habitats)	Yes: 50%	\$25,000 to \$85,000	3 months	April
<i>Marine and Anadromous Sportfish Habitat Restoration Grants</i>	NOAA - Community Based Restoration Program Fish America Foundation	Federal	State, local govt., and nonprofits	Locally-driven habitat restoration projects with significant benefits to marine, estuarine or anadromous fisheries resources, particularly sportfish	Yes	\$10,000 to \$75,000	5 months	May
<i>Hawai'i Community Foundation /NOAA Community-Based Coastal Restoration Grant Program</i>	Hawai'i Community Foundation /NOAA Restoration Center	Non-Profit/Federal	Community-based	Conservation activities such as: restoration and protection of coral reef habitat, coastal wetlands and estuaries; addressing and reducing land-based sources of pollution; reducing aquatic invasive species; and restoring traditional cultural infrastructure that benefits coastal communities ecosystems (e.g. fishpond restoration).	Yes: At least 50%	Up to \$80,000	6 months	June
<i>Watershed Protection and Flood Prevention Program</i>	USDA/ Natural Resources Conservation Service (NRCS)	Federal	Local govt.	Watershed management	Appx. 75%	\$650,000 (average)		
<i>Wetlands Reserve Program</i>	USDA/NRCS	Federal	State, local govt., nonprofits, private	Restore and protect farmed wetlands, prior converted wetlands, wetlands farmed under natural condition, certain riparian areas, and eligible buffer areas for landowners who have eligible land on which they agree to enter into a permanent or long-term easement or restoration agreement	Variable	Unknown	60 to 180 Days	Continual - intent to apply must be filed with NRCS office
<i>Regional Wetlands Program Development Grants</i>	US Environmental Protection Agency (USEPA)	Federal	State, tribal, local govt.	Wetland restoration planning/not implementation	25%	\$50,000		April
<i>Five Star Restoration Grant Program</i>	USEPA / National Fish and Wildlife Foundation (NFWF)	Federal	Community-based	Wetlands	Yes	\$20,000 (average)	Unknown	March
<i>Cooperative Endangered Species Conservation Fund</i>	USFWS	Federal	State	Habitat conservation and protection, endangered species monitoring, restoration, management, land acquisition and public education	25% of project cost	\$500 to \$10 million	6 months	Variable -notice on USFWS website
<i>North American Wetlands Conservation Act Standard Grants Program</i>	USFWS	Federal	Nonprofits and private	Support public-private partnerships carrying out projects that involve long-term protection, restoration and/or enhancement of wetlands, wetlands-dependant fish and wildlife and associated upland habitats	At least 50% of project costs	\$75,001 to \$1 million	Minimum of 7 months	March and July
<i>North American Wetlands Conservation Act Small Grants Program</i>	USFWS	Federal	Nonprofits and private	Support public-private partnerships carrying out projects that involve long-term protection, restoration and/or enhancement of wetlands, wetlands-dependant fish and wildlife and associated upland habitats	At least 50% of project costs	Maximum of \$75,000	5 months	October
<i>National Coastal Wetlands Grants Program</i>	USFWS	Federal	State, local govt., nonprofits	Identify, protect, and restore habitats in priority coastal areas	At least 50% of project costs	\$200,000 to \$1 million	Variable	June
<i>Sport Fish Restoration Program (limited to State fish and wildlife management agencies)</i>	USFWS	Federal	State	Restore sport fish populations	At least 25%	Grants	Avg. 8 Days	None
<i>Wildlife Restoration Program (limited to State agencies with lead wildlife management responsibility)</i>	USFWS	Federal	State	Habitat improvement	50%	Grants	Avg. 8 Days	None
<i>State Wildlife Grants Competitive Grants Program</i>	USFWS and Wildlife and Sport Fish Restoration Program	Federal	State	Conservation activities such as research, surveys, habitat and species management, land acquisition, facilities development and monitoring as well as development of habitat mapping, data management and monitoring.	At least 25%	\$300,000 to \$1 million	Unknown	January
<i>Bring Back the Natives</i>	NFWF	Private	State, local govt., nonprofits	Aquatic species benefits	Yes	Project grants	Unknown	January
<i>Native Plant Conservation Initiative</i>	NFWF	Private	State, local govt., nonprofits	Native plants	Yes	\$10,000 - \$50,000	Unknown	Notice on NFWF website
<i>NFWF Matching Grants</i>	NFWF	Private	State, local govt., nonprofits	Fish and wildlife restoration	Yes	\$25,000 - \$75,000 (av)	6 months	June and November
<i>Migratory Bird Conservancy</i>	NFWF / Migratory Bird Conservancy	Federal/Private	Community-based	Wetlands	50%	Grants		June
<i>Coastal Counties Restoration Initiative</i>	NFWF / NOAA / National Association of Counties	Federal/Private	NACo member counties, local govt., nonprofits	Wetlands, marine, estuarine, and anadromous fish habitat	Unknown	\$25,000 to \$100,000	Unknown	February
<i>Environmental Grants Program</i>	Patagonia	Private	Community-based	Variable	Unknown	\$3,000-\$8,000		April and August

Table 6-3. Potential Funding Sources – Additional Details

Program Name	Agency	Website	Res/ Enhmt	Rec/ Ed	Mngt.	Water Qlty	Water Qnty	Anad. Fish	Notes
Community-based Restoration Matching Grants Program	The Nature Conservancy – Global Marine Team and NOAA - Community Based Restoration Program	http://www.habitat.noaa.gov/pdf/RFP%20TNC-NOAA%20CRP%20Partnership%202011.pdf							A focal area of particular interest, though not exclusive or limiting, is native shellfish (bivalve) restoration projects.
Marine and Anadromous Sportfish Habitat Restoration Grants	NOAA - Community Based Restoration Program; Fish America Foundation	http://www.fishamerica.org/grants/	X					X	Emphasis is on using hands-on grassroots approach to restore fisheries habitats.
Hawai'i Community Foundation/NOAA Community-Based Coastal Restoration Grant Program	Hawai'i Community Foundation /NOAA Restoration Center	http://www.hawaicommunityfoundation.org/grants/grants/grant/hcfncaa-community-based-coastal-restoration-grant-program	X			X		X	Funds on-the-ground coastal and marine restoration projects led by community groups and community-based partnerships
Watershed Protection and Flood Prevention Program	USDA/NRCS	http://www.nrcs.usda.gov/programs/watershed/protect-and-prevent.html	X	X			X		
Wetlands Reserve Program	USDA/NRCS	http://www.nrcs.usda.gov/programs/wrp/2011enhancement.html	X						Emphasis on farmed wetlands, prior converted wetlands, wetlands farmed under natural condition, certain riparian areas, and eligible buffer areas
Regional Wetlands Program Development Grants	USEPA	http://water.epa.gov/grants_funding/wetlands/grantguidelines/index.cfm	X		?	X			
Five Star Restoration Grant Program	USEPA / NFWF	http://www.epa.gov/owow/wetlands/restore/5star/	X	X					
Cooperative Endangered Species Conservation Fund	USFWS	http://www.fws.gov/endangered/grants/grant-programs.html	X	X	X			?	Restricted funding to State agencies with which USFWS has a current cooperative agreement for the species involved.
North American Wetlands Conservation Act Standard Grants Program	USFWS	http://www.fws.gov/birdhabitat/Grants/NAWCA/index.shtml	X		X	X		X	Match must be non-Federal in origin
North American Wetlands Conservation Act Small Grants Program	USFWS	http://www.fws.gov/birdhabitat/Grants/NAWCA/index.shtml	X		X	X		X	Match must be non-Federal in origin. Project period should be no more than two years
National Coastal Wetlands Conservation Grants Program	USFWS / Sport Fish Restoration Program	http://www.fws.gov/coastal/coastalgrants/	X		?			X	Restricted to State agencies
Sport Fish Restoration Program (limited to State fish and wildlife management agencies)	USFWS	http://wsfrprograms.fws.gov/subpages/grantprograms/SFR/SFR.htm	X		X			X	Restricted funding to State agencies with lead management responsibility for fish and wildlife resources.
Wildlife Restoration Program (limited to State agencies with lead wildlife management responsibility)	USFWS	http://wsfrprograms.fws.gov/subpages/grantprograms/WR/WR.htm	X		?				Restricted funding to State agencies with lead management responsibility for fish and wildlife resources.
State Wildlife Grants Competitive Grants Program	USFWS and Wildlife and Sport Fish Restoration Program	http://wsfrprograms.fws.gov/Subpages/ToolkitFiles/toolkit.pdf	X	X	X	X		X	Restricted to State agencies. 75% for planning grants and 50% for implementation grants. Education and law enforcements activities may be included if they are a minor portion of the project and critical to success.
Bring Back the Natives	NFWF	http://www.nfwf.org/AM/Template.cfm?Section=Home	X	?					Pre-proposal application required.
Native Plant Conservation Initiative	NFWF	http://www.nfwf.org/AM/Template.cfm?Section=Home	X						Pre-proposal application required.
NFWF Matching Grants	NFWF	http://www.nfwf.org/AM/Template.cfm?Section=Home	X	X	X	X		?	
Migratory Bird Conservancy	NFWF / Migratory Bird Conservancy	http://www.nfwf.org/AM/Template.cfm?Section=Home	X						
Coastal Counties Restoration Initiative	NFWF / NOAA / National Association of Counties	http://www.naco.org/programs/csd/Pages/FiveStar.aspx	X	X	X	X		X	
Environmental Grants Program	Patagonia	http://www.patagonia.com/web/us/patagonia.go?assetid=2927	X	X				X	

U.S. Army Corps of Engineers

The goal of the USACE regulatory program is to protect the nation's aquatic resources. This is accomplished through the issuance of permits for projects that have undergone careful evaluation in light of applicable laws, regulations and policy to insure that authorized actions will not have an adverse impact on the overall public welfare.

The USACE derives its regulatory authority over waters of the United States from the two Federal laws that are central to its regulatory program. Section 10 of the Rivers and Harbors Act of 1899 applies to all navigable waters of the United States and Section 404 of the CWA applies to all waters, including wetlands, which have sufficient nexus to interstate commerce. Waters of the United States include essentially all surface waters such as all navigable waters and their tributaries, all interstate waters and their tributaries, all wetlands adjacent to these waters, and all impoundments of these waters. Any impact to a navigable water or wetland or impact that is connected to navigable waters, including filling, draining or excavating may require a permit from the USACE.

The USACE will make a determination based on the information contained in the project's application packet as to which permit will be issued. There are no prerequisite permits for submitting the Section 10 or Section 404 permit application, although a jurisdictional wetland delineation will likely be required. The level of effort and compliance requirements of the permits is essentially the same. Both permits require preparation of a list of best management practices (BMP) for the construction and post construction phases of the project. The BMP list and specifications will also be used in the CWA Section 401 and 402 permits.²²

Rivers and Harbors Act § 10

Section 10 of the Rivers and Harbors Act of 1899 requires approval prior to the accomplishment of any work in or over navigable waters of the United States, or which affects the course, location, condition or capacity of such waters. Typical activities requiring Section 10 permits are: construction of piers, wharves, bulkheads, dolphins, marinas, ramps, floats, intake structures, and cable or pipeline crossings; dredging and excavation; and artificial reefs.

Clean Water Act Section 404

Section 404 of the CWA requires approval prior to discharging dredged or fill material into the waters of the United States. Activities requiring permits include: deposition (placement) of fill or dredged material in waters of the U.S. or adjacent wetlands; site-development fill for residential, commercial, or recreational developments; construction of revetments, groins, breakwaters, levees, dams, dikes, and weirs; and placement of riprap and road fills.

There are several ways in which activities requiring Section 404 permits can be authorized:

- **Standard permits** can be issued in situations where, after a public notice and comment period, the USACE District Engineer determines that the proposed activity is not contrary to the public interest. USACE issues a public notice within 15 days of receiving a completed permit application. The public notice describes the proposed activity, its location, and potential environmental impacts and invites comments within a specified time period, typically 15 to 30

²² Site specific BMPs are required under CWA, 404, 401 and 402. Regulators require they be developed for the selected alternative, and contain sufficient detail to address specific construction practices that will occur during design implementation.

days. The public at large, as well as interested Federal, State, and local agencies, have an opportunity to comment on the proposed activity.

- **Letters of permission** can be issued in situations where the USACE District Engineer determines the proposed work would be minor, would not have significant individual or cumulative impact on environmental values, and will not encounter appreciable opposition. Concerned fish and wildlife agencies and, typically, adjacent property owners who might be affected by the proposal are notified, but the public at large is not. Section 404 letters of permission can be issued only in cases where, after consulting with certain Federal and State agencies, the USACE District Engineer has previously approved categories of activities that can be authorized by letter of permission procedures.
- **General permits** are often issued by USACE for categories of activities that are similar in nature and would have only minimal individual or cumulative adverse environmental effects. General permits can be issued on a nationwide (“nationwide permit”) or regional (“regional general permit”) basis. A general permit can also be issued on a programmatic basis (“programmatic general permit”) to avoid duplication of permits for state, local or other Federal agency programs. Nationwide Permit 27 Stream and Wetland Restoration Activities.

U.S. Fish and Wildlife Service

USFWS shares responsibility with NOAA NMFS for implementing the ESA. In the Honu'apo area, protected species overseen by USFWS include the Hawaiian stilt and the Hawaiian coot. USFWS also has oversight of the MBTA.

Endangered Species Act

Section 7 of the Endangered Species Act of 1973 requires Federal agencies to ensure that any action authorized, funded or carried out by them is not likely to jeopardize the continued existence of any endangered or threatened species, or result in the destruction or adverse modification of their critical habitat. Section 7 outlines the process for interagency coordination with USFWS and/or NOAA NMFS on a proposed project's potential to affect listed species.

Whether or not the Honu'apo restoration project uses Federal funds, a nexus to Section 7 is made by Section 307 of the Coastal Zone Management Act and the SMA permit requirements. Tasks include development of a species list of Threatened, Endangered and Sensitive species that may be present on the site, a project area wide reconnaissance field survey, and informal consultation with the USFWS. A biological assessment may be required to determine whether formal consultation is necessary, and it may also serve as a basis for a biological opinion.

Migratory Bird Treaty Act

The Migratory Bird Treaty Act of 1918 is the domestic law that affirms or implements the United States' commitment to four international conventions with Canada, Japan, Mexico, and Russia for the protection of shared migratory bird resources. The MBTA governs the taking, killing, possession, transportation, and importation of migratory birds, their eggs, parts, and nests. The take of all migratory birds is governed by the MBTA's regulation of taking migratory birds for educational, scientific, and recreational purposes and requiring harvest to be limited to levels that prevent overutilization. Section 704 of the MBTA states that the Secretary of the Interior is authorized and directed to determine if, and by what means, the take of migratory birds should be allowed and to adopt suitable regulations permitting and governing take. The

Secretary in adopting regulations is to consider such factors as distribution and abundance to ensure that take is compatible with the protection of the species.

The Honu'apo Estuary restoration project will likely include conditions in agency authorizations that protect migratory birds. Such conditions can include conducting work outside the migratory bird nesting season, conducting surveys for migratory birds, maintaining a buffer (e.g. 500 feet) from nesting birds, etc.

6.2.2 State

Department of Business, Economic Development, and Tourism, Office of Planning

Coastal Zone Management Act Section 307

Section 307 of the Coastal Zone Management Act of 1972, as amended (16 U.S.C. 1458(c)), requires the applicant certify that the project is in compliance with an approved State CZM Program. State concurrence with the applicant's certification is required prior to the issuance of permits from the USACE.

The Office of Planning, attached for administrative purposes to DBEDT, is the lead agency for the Hawaii CZM Program. CZM review is required for all projects in the State due to the proximity of all lands to the ocean. The CZM review requires completing an application and demonstrating conformance and compliance with other permits and regulations.

Department of Health

The DOH Clean Water Branch (CWB) protects the public health of residents and tourists who enjoy playing in and around Hawai'i's coastal and inland water resources. The CWB also protects and restores inland and coastal waters for marine life and wildlife. This is accomplished through statewide coastal water surveillance and watershed-based environmental management through a combination of permit issuance, monitoring, enforcement, sponsorship of polluted runoff control projects, and public education. CWB oversees permitting for CWA Section 401 and 402.

Clean Water Act Section 401

A Section 401 water quality certification permit is required and administered by DOH when a Section 404 permit is sought. The permit requires preparation of a water quality monitoring plan, including collection of samples pre-, during and post-construction. The water quality monitoring is expected to follow the USEPA's Seven Step Data Quality Objective Process. The frequency and duration of the sampling will adhere to DOH General Requirements for Monitoring. A determination of the specific water quality constituents to be sampled with the exception of the basic water quality parameters will be made by DOH following their review of the project application and description of construction activities.²³

The Section 401 permit requires a description of historic uses in the watershed in order to determine if dredged materials should be sampled for hazardous materials. If DOH requires sampling of dredged materials, a sampling plan will need to be prepared and samples collected and analyzed. In addition, the Section 401 permit requires a detailed BMP list and the locations for their installation.

²³ Basic parameters include: pH, turbidity, and Total Suspended Solids.

Clean Water Act Section 402

DOH administers CWA Section 402, National Pollutant Discharge Elimination System (NPDES) permits. A NPDES permit is required for construction activities, including clearing, grading, and excavation, that result in the disturbance of one or more acres of total land area. The total land area includes a contiguous area when multiple separate and distinct construction activities may be taking place at different times on different schedules under a larger common plan of development or scale. The Section 402 permit will require preparation of a detailed Storm Water Pollution Prevention Plan and submittal of a General Notice of Intent Form and Form C applications. Site specific BMPs must also be identified in a mitigation plan.

Department of Land and Natural Resources

DLNR is headed by the Board of Land and Natural Resources (BLNR) and manages the State's public lands. Several divisions within DLNR share oversight responsibility for Honu'apo lands, including DAR, DOFAW, OCCL, and SHPD.

DLNR: Board of Land and Natural Resources

Conservation District Use Permit

The use of Conservation District lands is regulated by Chapter 13-5, Hawaii Administrative Rules, "Conservation District" and Chapter 183C, HRS. A Conservation District Use Permit (CDUP) must be secured from the BLNR for certain land uses within the Conservation District.

Hawai'i Revised Statute Chapter 343 (EIS)

The Office of Environmental Quality Control implements the Environmental Impact Statement law, Chapter 343, HRS. Environmental review under HRS Chapter 343 is required for any action that "propose the use of state or county lands or the use of state or county funds, other than funds to be used for feasibility or planning studies for possible future programs or projects that the agency has not approved, adopted, or funded, or funds to be used for the acquisition of unimproved real property; provided that the agency shall consider environmental factors and available alternatives in its feasibility or planning studies; propose any use within any land classified as a conservation district by the state land use commission under Chapter 205; propose any use within a shoreline area as defined in Section 205A-41..." (HRS Chapter 343). Proposed activities at Honu'apo Park, including the wetland restoration and other improvements, will require environmental review. If Federal funding is used for project activities, the environmental analysis would be conducted under NEPA, and would satisfy the conditions of HRS Chapter 343.

DLNR: Division of Aquatic Resources

DAR has as its mission to manage, conserve and restore the State's unique aquatic resources and ecosystems for present and future generations. This agency sets overall water conservation, quality and use policies; defines beneficial and reasonable uses; protects ground and surface water resources, watersheds and natural stream environments; establishes criteria for water use priorities while assuring appurtenant rights and existing correlative and riparian uses and establishes procedures for regulating all uses of Hawai'i's water resources. DAR oversees State laws and rules pertaining to fishing in Hawai'i.

DLNR: Division of Forestry and Wildlife

DOFAW is charged with protecting and managing watersheds, natural resources, outdoor recreation resources, and forest product resources. It is also charged with public education and develops and

manages statewide programs on forest and wildlife resources as well as natural area reserves and trail and access systems. DOFAW currently conducts biannual bird counts at Honu'apo.

DLNR: Office of Conservation and Coastal Lands

OCCL regulates and enforces land use for approximately two million acres of private and public lands that lie within the State's conservation district. OCCL is also responsible for processing conservation district land use requests, developing administrative rules for the conservation district, investigating complaints and violations, and monitoring all CDUP conditions.

DLNR: State Historic Preservation Division

SHPD helps to carry out the responsibilities outlined in the National Historic Preservation Act (NHPA). The division is guided by the Statewide Historic Preservation Plan and the rules and regulations set forth in HRS Chapter 6E. SHPD manages several programs to promote the use and conservation of historic properties. SHPD also reviews proposed development projects to ensure minimal effects of change on historic and cultural assets.

National Historic Preservation Act Section 106

The goal of NHPA is to preserve and protect historical and culturally significant properties. Section 106 of the NHPA requires that the head of any Federal department having authority to license any undertaking shall, prior to the issuance of any authorization, take into account the effect of the undertaking on any district, site, building, structure, or object that is included in or eligible for inclusion in the National Register. Under Section 106 of the NHPA, the agency is required to consult with the State Historic Preservation Officer (an official appointed in each State or territory to administer the National Historic Program) in order to determine a project's potential to impact resources of historic or cultural significance. Consultation with SHPD will be conducted as part of various permit reviews, and specifically for the AIS of the property, and an Archaeological Preservation Plan and a Burial Treatment Plan.²⁴

6.2.3 Local

Department of Parks and Recreation

As the manager of the park, the County Department of Parks and Recreation will likely be the applicant for the permits and approvals outlined in Section 6.2.

Department of Planning

Special Management Area

Hawai'i County Planning Commission Rule 9 is the SMA Rule of the County of Hawai'i. The SMA rule is mostly intended to protect the environmental resources of the coastal area. Within the SMA, "development", as defined in the SMA rules, needs either a "major" permit, which is issued by the Planning Commission, or a "minor" permit, which is issued by the Planning Director. A project needs a major permit if it is valued at over \$125,000, or if the Planning Director determines that it may have a significant environmental or ecological effect in the SMA. This restoration project will require a Major SMA permit. When a Major SMA permit is required, the Rule 9-11 (Special Management Area Use

²⁴ As described in Townscape 2010: Archaeological Inventory Surveys of Honu'apo Park were conducted in 2004 by Haun & Associates and in 2009 by Rechtman Consulting (pending SHPD approval). After approval of the Archaeological Inventory Survey, a Preservation Plan and a Burial Treatment Plan will be developed for Honu'apo Park. The Preservation Plan will be reviewed by SHPD, and the Burial Treatment Plan will be reviewed by SHPD and the Hawai'i Island Burial Council.

Permit Procedures) process is triggered, and an EA or EIS needs to be prepared. The EA is completed as a precursor to the permit, will follow guidelines provided in HRS Chapter 343, and will be reviewed and approved by Hawai'i County Department of Planning. Additionally, an AIS of the property approved by SHPD and an Archaeological Preservation Plan and a Burial Treatment Plan approved by SHPD need to be completed.

As outlined in the *Honu'apo Park Resources Management Plan*, a SMA Permit will need to be secured from the County Planning Department for most of the proposed actions at Honu'apo Park (Townscape 2010). It may be advisable to combine the approvals and permitting for the wetland restoration and the activities identified in the Resources Management Plan.

Department of Public Works

Floodplain Management

Hawai'i County Code Chapter 27 (Floodplain Management) requires conformance with the provisions of the chapter for development permits, including building and grading. The primary purpose is to ensure that the estimated changes to the flood water elevations and the area of the floodway do not exceed flood zones as delineated on Federal Emergency Management Agency Flood Insurance Rate Maps. This task involves writing a report that documents the existing and post construction topography and summarizes the hydraulic variables.

Grading / Grubbing / Stockpiling Permit

Grading (cutting into the earth) of more than 100 cubic yards, and grubbing (mechanical clearing of the surface without cutting into the ground) of more than one acre in a year, require permits from the DPW. Stockpiling permits are required to store material exceeding 500 cubic yards. The Planning Department reviews grading and grubbing permit applications to determine that the proposal is in support of something allowed by zoning. SHPD reviews grading, grubbing and stockpiling permits to ensure that no historic property or burial site are disturbed during the course of land development or alteration activities.

Building Permit

Building permits from the DPW are required to erect a new building or structure (including fences, rock walls and animal shelters over six feet in height; towers and retaining walls). The Planning Department reviews building permit applications to ensure that the building is a permitted use and that it has proper setbacks. A building permit will be needed if a predator control fence over six feet tall and/or a boardwalk is constructed as part of the wetland restoration.

Table 6-4 summarizes the applicable statutes and regulations that would be enforced by the agencies listed above, as well as the anticipated requirements that may be placed on the project, including permits and approvals. General project assumptions related to permitting include: funding sources may include Federal, State, County and private; all earthwork will occur on lands owned by the State of Hawai'i; the land where earthworks will occur is zoned agriculture and conservation and all potential designs will be compatible and conforming uses; earthwork will occur in and along the wetland within the lower reach that is tidally controlled; earthwork will occur on land within the shoreline setback area; and earthwork will include grading and grubbing, excavation, dredging, and fill operations, and will occur on an area greater than one acre.

Table 6-4. Required Permits

Act/Statute/Ordinance	Administering Agency	Permit or Approval	Notes
Federal			
National Environmental Policy Act	Federal Petitioner	EIS or EA	Need depends on funding source. In conjunction with Honu'apo Park Resource Management Plan.
Endangered Species Act Section 7	USFWS / NMFS	Consultation and Approval	
Magnuson-Stevens Fishery Conservation and Management Act (Sustainable Fisheries Act)	NMFS	Consultation and Approval	
Rivers and Harbors Act Section 10	USACE	[or CWA Section 404]	USACE makes determination
Clean Water Act Section 404	USACE	Individual (Standard or Letter of Permission), Nationwide, or General [and/or Rivers & Harbors Act Section 10]	USACE makes determination
Migratory Bird Treaty Act	USFWS	Consultation	
State			
Coastal Zone Management Act Section 307	Hawai'i Office of Planning	Approval	
Clean Water Act Section 401	Hawai'i DOH	Water Quality Certification / Permit	
Clean Water Act Section 402	Hawai'i DOH	National Pollution Discharge Elimination System Permit	
Conservation District Use Permit	Hawai'i DLNR-BLNR	Permit	
Hawai'i Revised Statute Chapter 343 (EIS)	Hawai'i DLNR / County	Approval	In conjunction with Honu'apo Park Resource Management Plan.
National Historic Preservation Act Section 106	Hawai'i DLNR-SHPD	Consultation and Approval. Prepare Archaeological Assessment.	
County			
Special Management Area Hawai'i Revised Statute 205A (Planning Commission Rule 9)	Hawai'i County Planning Department	Permit (<i>Major</i> or <i>Minor</i>)	In conjunction with Honu'apo Park Resource Management Plan.
Flood Ordinance Compliance Hawaii County Floodplain Management Code (HCC Chapter 27)	Hawai'i County Director of Public Works	Approval	
Grading/Grubbing/Stock Piling Erosion and Sedimentation Control (HCC Chapter 10)	Hawai'i County DPW	Permit	
Building Building Code (HCC Chapter 5)	Hawai'i County DPW	Permit	

6.3 Contracting and Construction

A contractor with experience working in and around sensitive waters and that understands that the grading of the site is not typical is preferred. To the extent possible grading, grubbing and other construction phase activities will need to be conducted in a manner that minimizes impacts to the wetland and the desired flora and fauna.

As indicated in Section 6.1, the project design and cost estimates were based on a 'full-cost' scenario, which uses standard construction cost estimating and contractors to conduct all phases of the restoration work. There are potential opportunities for community and in-kind involvement in specific tasks that could both reduce costs and engage the community in the process. Community commitment, as demonstrated through Ka 'Ohana and its volunteers, is strong, and was a primary catalyst for the initial wetland clean-up (Section 1.1). Volunteers could engage in site clearing (e.g., *kiawe* removal), predator control, and replanting efforts. Local nurseries could be used to grow plants for revegetation at reduced rates. Contracting for earthwork with a local company could save costs due to the logistical considerations of the work (e.g., short days and flexible timing due to tides, mobilization based on distance of Honu'apo Park from either Kailua-Kona or Hilo). Any volunteer work would have to be conducted in compliance with applicable permits, safety considerations, liability concerns, and in coordination with the State and County.

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APPENDIX A. ANNOTATED BIBLIOGRAPHY

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Wetlands Habitat Restoration Plan for Honu'apo Estuary

Annotated Bibliography

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Wetlands Habitat Restoration Plan for Honu'apo Estuary: Annotated Bibliography

The following bibliography provides a summary of important journal articles, books, and other reference material that will be used in development of the Wetlands Habitat Restoration Plan for Honu'apo Estuary.

Site Specific Information

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Provides summary of fish species observed during sampling efforts in 2008

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Mitsch, W.J., and J.G. Gosselink. 2007. *Wetlands, Fourth Edition*. John Wiley & Sons, Inc., Hoboken, New Jersey.

This is a general text with information on all aspects of wetland ecology and conservation.

Muller, J. G., Y. Ogneva-Himmelberger, S. Lloyd and J. M. Reed. 2010. Predicting Prehistoric Taro (*Colocasia esculenta* var. *antiquorum*) Lo'i Distribution in Hawaii. *Economic Botany* 64(1): 22-33.

Discusses the potential acreage of artificial wetlands created by prehistoric Hawaiians for taro cultivation. This information could help managers determine the amount of previously existing waterbird habitat.

Wetland Restoration Information and Techniques (including example projects)

AMEC Earth and Environmental, Inc. 2006. Final Report: Ormond Beach Wetland Restoration Site-Wide Soil/Surface Water Investigation. Prepared for Aspen Environmental Group. San Diego.

This report summarizes the physical and chemical characteristics of the soils and waters within the Ormond Beach wetland restoration project area. The work was conducted to help wetland restoration planners determine any constraints placed on restoration project by soils and waters found at the site.

Bartoldus, C. C. 1994. EPW: a procedure for the functional assessment of planned wetlands. Water, Air, and Soil Pollution 77: 533-541.

Describes a rapid assessment procedure which documents and highlights differences between a wetland assessment area and planned wetland based on their capacity to provide six functions: shoreline bank erosion control, sediment stabilization, water quality, wildlife, fish (tidal, non-tidal stream/river, and non tidal pond/lake), and uniqueness/heritage.

Brimacombe, K. 2004. ANNUAL REPORT II: Applied Research on Use of Native Plants for Coastal Wetland Restoration on O'ahu. May 2002 - May 2003. Botany Department, University of Hawai'i Manoa. Honolulu.

Brown, S. C. 1998. Remnant seed banks and vegetation as predictors of restored marsh vegetation. Canadian Journal of Botany 76: 620-629.

Authors studied the seed banks and the remnant vegetation at restoration sites to determine their degree of similarity to the vegetation that developed following restoration of wetland hydrology.

Davis, M. M. 1994. Decision sequence for functional wetlands restoration. Water, Air and Soil Pollution 77: 497-511.

A decision sequence is presented for wetland restoration projects to help achieve functional replacement. This methodology incorporates site selection and design features for specified wetland functions into three phases of a project planning decision sequence. The fast phase, site selection, situates a wetland where there is the potential to perform a function. Phases two and three, the incorporation of functional design features into design criteria and project plan development, focus on the optimization of the functional capacity of a site.

Interagency Workgroup on Wetland Restoration. 2003. An Introduction and User's Guide to Wetland Restoration, Creation, and Enhancement. Interagency Workgroup on Wetland Restoration (National Oceanic and Atmospheric Administration, Environmental Protection Agency, Army Corps of Engineers, Fish and Wildlife Service, and Natural Resources Conservation Service).

This document introduces non-technical readers to the basics of wetland projects including planning, implementing, and monitoring, and directs interested persons to documents and resources specific to a particular region or wetland type. The text gives information on wetlands, background on the practice of restoration, and information on the process involved in undertaking a wetland project. The appendices provide resources for finding additional information and advice on restoration, creation, and enhancement projects. This document is not a scientific paper. It is designed specifically for individuals, community groups, municipalities, or others who have little or no experience in the restoration field.

Natural Resources Conservation Service. 2010. Conservation Practice Standard: Wetland Restoration (Ac.) Code 657. September.

Provides standards for wetland restoration. The conservation practice standard contains information on why and where the practice is applied, and it sets forth the minimum quality criteria that must be met during the application of that practice in order for it to achieve its intended purpose(s).

Natural Resources Conservation Service. 2010. Conservation Practice Standard: Wetland Enhancement (Ac.) Code 659. September.

Provides standards for wetland enhancement. The conservation practice standard contains information on why and where the practice is applied, and it sets forth the minimum quality criteria that must be met during the application of that practice in order for it to achieve its intended purpose(s).

Rauzon, M. and D. Drigot. 2001. Invasive red mangrove eradication in a Hawaiian wetland, waterbird responses, and lessons learned. *Eradication of Island Invasives: Practical actions and results achieved*, New Zealand.

Discusses the results of a mangrove control program and resulting colonization of wetland by Hawaiian stilts.

Sprecher, S. W. and Schneider, C. B. 2000. *Wetlands Management Handbook*. ERDC/EL SR-00-16, U.S. Army Engineer Research and Development Center, Vicksburg, MS.

Guidance developed for Army land managers on basic ecological and regulatory issues that must be considered in wetlands protection and management.

Turner, R. E., E. M. Swenson and J. M. Lee. 1994. A rationale for coastal wetland restoration through spoil bank management in Louisiana, USA. *Environmental Management* 18(2): 271-282.

The rationale and outline of an implementation plan for restoring coastal wetlands in Louisiana is presented. The rationale for the plan is based on reversing the consequences of documented cause-and-effect relationships between wetland loss and hydrologic change.

Xiong, S., M. E. Johansson, F. M. Hughes, A. Hayes, K. S. Richards and C. Nilsson. 2003. Interactive effects of soil moisture, vegetation canopy, plant litter and seed addition on plant diversity in a wetland community. *Journal of Ecology* 91: 976-986.

The authors carried out a factorial experiment to examine how groundwater availability (low and high sites with intermediate or rare flooding), vegetation canopy, leaf litter and seed availability interacted to determine the species richness of a productive wet grassland community in Wicken Fen National Nature Reserve, Cambridgeshire, UK.

Water Quality

Bruland, G. 2010. EPA Region IX Wetland Program Development Grant Final Report. Assessment and Monitoring of the Water Quality and Habitat Functions of Natural, Restored, and Created Wetlands of the Hawaiian Islands. University of Hawaii Manoa. Honolulu.

This report describes a series of wetland and water quality investigations conducted under the EPA Wetland Program Development Grant. Honu'apo (referred to as Honoapu and Honuapo in the report) is one of the wetlands that was included for some of the studies conducted. Some data on conditions at Honu'apo are provided.

Bruland, G. L. and R. A. MacKenzie. 2010. Nitrogen Source Tracking with $\delta^{15}\text{N}$ Content of Coastal Wetland Plants in Hawaii. Journal of Environmental Quality 39: 409-419.

The authors compared $\delta^{15}\text{N}$ values from different herbaceous wetland plants across 34 different coastal wetlands from the five main Hawaiian Islands and investigated relationships of $\delta^{15}\text{N}$ with land use, human population density, and surface water quality parameters (i.e., nitrate, ammonium, and total dissolved N).

Fabricius, K. E. 2005. Effects of terrestrial runoff on the ecology of corals and coral reefs: review and synthesis. Marine Pollution Bulletin 50: 125-146.

This paper reviews and evaluates the current state of knowledge on the direct effects of terrestrial runoff on (1) the growth and survival of hard coral colonies, (2) coral reproduction and recruitment, and (3) organisms that interact with coral populations (coralline algae, bioeroders, macroalgae and heterotrophic filter feeders as space competitors, pathogens, and coral predators). The responses of each of these groups are evaluated separately against the four main water quality parameters: (1) increased dissolved inorganic nutrients, (2) enrichment with particulate organic matter, (3) light reduction from turbidity and (4) increased sedimentation.

Serrano, L. and M. E. DeLorenzo. 2008. Water quality and restoration in a coastal subdivision stormwater pond. Journal of Environmental Management 88(1): 43-52.

This study examined the interaction between land use and coastal pond water quality in a South Carolina residential subdivision pond.

Waterbird Information

Allen, A. W. 1985. Habitat Suitability Index Models: American Coot. U.S. Fish and Wildlife Service Biological Report 82(10.115): 26.

This document develops a habitat suitability index for American coot (*Fulica americana*) in order to enable managers to determine habitat needs for impact assessments and habitat management.

Allen, G. R. and A. L. Lum. 1972. Seasonal abundance and daily activity of Hawaiian stilts (*Himantopus himantopus knudseni*) at Paiko Lagoon, O'ahu. Elepaio 32(12): 111-117.

Provides information on Hawaiian stilt behavior and abundances.

Banko, W. E. 1988. History of endemic Hawaiian birds. Part I. Population histories-- species accounts. Freshwater birds: Hawaiian stilt Ae'ō. Cooperative National Park Resources Study Unit, University of Hawai'i at Manoa. Honolulu.

Provides information on distribution and natural history of Hawaiian stilt.

Berger, A. J. 1967. The incubation period of the Hawaiian stilt. Auk 84: 130.

Provides information on distribution and natural history of Hawaiian stilt.

Bildstein, K. L., T. Bancroft, P. J. Dugan, D. H. Gordon, R. M. Erwin, E. Nol, L. X. Payne and S. E. Senner. 1991. Approaches to the conservation of coastal wetlands in the western hemisphere. Wilson Bulletin 103(2): 218-254.

This paper (1) briefly describes coastal wetland avifauna, (2) discusses the threat of global warming on coastal wetlands, (3) uses several Western Hemisphere wetlands as site-specific examples of development pressures facing these habitats, and (4) provides synopses of nongovernmental and governmental approaches to wetland conservation.

Brawley, A. H., R. S. Warren and R. A. Askins. 1998. Bird use of restoration and reference marshes within the Barn Island Wildlife Management Area, Stonington, Connecticut, USA. Environmental Management 22(4): 625-633.

This paper discusses the use of restored wetlands by native waterbirds in Connecticut.

Browne, R. A., C. R. Griffin, P. R. Chang, M. Hubley and A. E. Martin. 1993. Genetic divergence among populations of the Hawaiian duck, Laysan duck, and mallard. Auk 110(1): 49-56.

Discusses speciation within the Hawaiian ducks

Conant, S. 1988. Saving endangered species by translocation: Are we tinkering with evolution? BioScience 38(4): 254-257.

Discusses potential impacts of translocation of birds from one location to another.

DesRochers, D. W., S. R. McWilliams and J. M. Reed. 2010a. Evaluating if Energy and Protein Limit Abundance of Hawaiian Moorhen. Journal of Wildlife Management 74(4): 788-795.

The authors conducted an assessment to determine whether there was evidence that energy or protein might limit numbers of the tropical, endangered Hawaiian moorhen (*Gallinula chloropus sandvicensis*). They compared observed numbers of moorhen at 15 O'ahu wetlands with predicted numbers based on measured energy and protein in food plants and abundance of these food plants in each wetland and on estimates of energy expenditure of moorhen. Hawaiian moorhen on O'ahu did not appear to be limited by energy, nor did they appear to select sites based on energy or protein, in contrast to many studies relating animal numbers to energy in nonbreeding situations. Consequently, we suggest that researchers and managers explore other potentially limiting factors for Hawaiian moorhen.

DesRochers, D. W., M. D. Silbernagle, A. Nadig and J. M. Reed. 2010b. Body Size, Growth, and Feather Mass of the Endangered Hawaiian Moorhen (*Gallinula chloropus sandvicensis*). Pacific Science 64(2): 327-333.

Body mass is a central piece of data required for many avian studies in which researchers are interested in evaluating body condition or calculating energetic carrying capacity. Body mass and feather mass for adults and body mass for three subadult age classes are provided for the Hawaiian subspecies of Common Moorhen (*G. c. sandvicensis*). Other body size measurements, including tarsus length, shield bill length, shield width, and wing cord length also are presented.

Engilis, A. and T. K. Pratt. 1993. Status and population trends of Hawaii's native waterbirds, 1977-1987. Wilson Bulletin 105(1): 142-158.

Provides background information on Hawaiian waterbirds.

Hawai'i Audubon Society. 1997. *Hawai'i's Birds*. Honolulu, HI, Hawai'i Audubon Society.

Field guide for Hawaiian birds.

Johnson, O. W., A. J. Bennett, L. Alsworth, III, L. A. Bennett, P. M. Johnson, J. R. Morgart and R. J. Kienholz. 2001. Radio-tagged Pacific golden-plovers: the Hawaii-Alaska link, spring destinations, and breeding season survival. Journal of Field Ornithology 72(4): 537-546.

This paper discusses the movement patterns of koea between Alaska and Hawai'i.

Mitchell, C., C. Ogura, D. Meadows, A. Kane, L. Strommer, S. Fretz, D. Leonard and A. McClung. 2005a. 'Alae 'Ula or Hawaiian Moorhen (*Gallinula chloropus sandvicensis*). Hawaii's Comprehensive Wildlife Conservation Strategy. Honolulu, HI, As submitted to the National Advisory Acceptance Team, Dept. of Land and Natural Resources.

Describes distribution, habitat use, and life history traits of the moorhen.

Mitchell, C., C. Ogura, D. Meadows, A. Kane, L. Strommer, S. Fretz, D. Leonard and A. McClung. 2005b. 'Alae ke'oke'o or Hawaiian Coot (*Fulica alai*). Hawaii's Comprehensive Wildlife Conservation Strategy. Honolulu, HI, As submitted to the National Advisory Acceptance Team, Dept. of Land and Natural Resources.

Describes distribution, habitat use, and life history traits of the Hawaiian coot.

Morrison, M. L. 2002. *Wildlife Restoration: Techniques for Habitat Analysis and Animal Monitoring*. Washington, D.C., Island Press.

This text reviews information on wildlife restoration techniques and monitoring needs.

Pyle, R. L. and P. Pyle. 2009a. *Black-crowned night heron *Nycticorax nycticorax**. The Birds of the Hawaiian Islands: Occurrence, History, Distribution, and Status. Honolulu, HI, Bishop Museum. Version 1 (31 December 2009).

Provides information on natural history of the Black-crowned night heron.

Pyle, R. L. and P. Pyle. 2009b. *Black-necked stilt *Himantopus mexicanus**. The Birds of the Hawaiian Islands: Occurrence, History, Distribution, and Status. Honolulu, HI, Bishop Museum. Version 1 (31 December 2009).

Provides information on natural history of the Hawaiian stilt.

Pyle, R. L. and P. Pyle. 2009c. *Common moorhen Gallinula chloropus*. The Birds of the Hawaiian Islands: Occurrence, History, Distribution, and Status. Honolulu, HI, Bishop Museum. Version 1 (31 December 2009).

Provides information on natural history of the common moorhen in Hawai'i.

Pyle, R. L. and P. Pyle. 2009d. *Hawaiian Coot Fulica alai*. The Birds of the Hawaiian Islands: Occurrence, History, Distribution, and Status. Honolulu, HI, Bishop Museum. Version 1 (31 December 2009).

Provides information on natural history of the Hawaiian coot.

Pyle, R. L. and P. Pyle. 2009e. *Hawaiian Duck Anas wyvilliana*. The Birds of the Hawaiian Islands: Occurrence, History, Distribution, and Status. Honolulu, HI, Bishop Museum. Version 1 (31 December 2009).

Provides information on natural history of the Hawaiian duck.

Pyle, R. L. and P. Pyle. 2009f. *Pacific golden plover Pluvialis fulva*. The Birds of the Hawaiian Islands: Occurrence, History, Distribution, and Status. Honolulu, HI, Bishop Museum. Version 1 (31 December 2009).

Provides information on natural history of the kolea in Hawai'i.

Pyle, R. L. and P. Pyle. 2009g. *Ruddy turnstone Arenaria interpres*. The Birds of the Hawaiian Islands: Occurrence, History, Distribution, and Status. Honolulu, HI, Bishop Museum. Version 1 (31 December 2009).

Provides information on natural history of the Ruddy turnstone in Hawai'i.

Pyle, R. L. and P. Pyle. 2009h. *Wandering tattler Tringa incanus*. The Birds of the Hawaiian Islands: Occurrence, History, Distribution, and Status. Honolulu, HI, Bishop Museum. Version 1 (31 December 2009).

Provides information on natural history of the Wandering tattler in Hawai'i.

Ritter, M. W. 1993. Rapid colonization of a human-made wetland by Mariana Common Moorhen on Guam. Wilson Bulletin 105(4): 685-687.

Provides information on use of a constructed wetland by moorhen in Guam.

Shallenberger, R. J. 1977. An ornithological survey of Hawaiian wetlands. Vol 1 and 2. Contract DAOW 84-77-C-0036. U.S. Army, Engineer District. Honolulu, HI.

Historical data on waterbirds in Hawaiian wetlands.

Swedberg, G. E. 1967. The koloa: a preliminary report on the life history and status of the Hawaiian duck (*Anas wyvilliana*). Honolulu, Department of Land and Natural Resources.

Natural history and behavior of the Hawaiian duck.

USFWS. 2000. Avian botulism strikes Kealia Ponds, Maui. 'Elepaio 60(8): 81.

Article on impacts of avian botulism on waterbirds.

USFWS. 2005. Draft Revised Recovery Plan for Hawaiian Waterbirds, Second Draft of Second Revision. U.S. Fish and Wildlife Service. Portland, OR.

This second draft revised recovery plan addresses four endangered species of Hawaiian waterbirds: the Hawaiian duck or koloa maoli (*Anas wyvilliana*), Hawaiian coot or 'alae ke'oke'o (*Fulica alai*), Hawaiian common moorhen or 'alae 'ula (*Gallinula chloropus sandvicensis*), and Hawaiian stilt or ae'o (*Himantopus mexicanus knudseni*).

van Riper, C., III and J. M. Scott. 2001. Limiting factors affecting Hawaiian native birds. Studies in Avian Biology 22: 221-233.

This paper discusses the major impacts to native Hawaiian birds, including habitat loss, hunting, predation by introduced predators, and disease. It emphasizes need for control/removal of invasive herbivores and invasive predators for preventing extinction of the avifauna.

Work, T. M., J. L. Klavitter, M. H. Reynolds and D. Blehert. 2010. Avian Botulism: A Case Study in Translocated Endangered Laysan Ducks (*Anas laysanensis*) on Midway Atoll. Journal of Wildlife Diseases 46(2): 499-506.

This paper describes an outbreak of avian botulism in a translocated population of Laysan duck and addresses possible management activities to avoid wildlife diseases from impacting translocated species.

Wetland Plants – General Information

Asquith, A. no date. Alternative Plant List for Restoration in Gulch 2. Provided to SRGII 2 pp.

Provides a list of native plants to use in stream restoration projects on Kauai, which may also be applicable to other wetland restoration projects.

Erickson, T. A. and C. F. Puttock. 2006. Hawai'i wetland field guide: an ecological and identification guide to wetlands and wetland plants of the Hawaiian Islands. Honolulu, Bess Press Books.

This book provides general background information on Hawaiian wetlands, and photographs of common wetland plants along with detailed descriptions for identification.

Wagner, W. L., D. R. Herbst and S. H. Sohmer. 1990. *Manual of the Flowering Plants of Hawai'i*. Honolulu, Bishop Museum Press.

The definitive key to plants in the Hawaiian Islands.

Invasive Plants – Information, Impacts and Control Methods

Demopoulos, A. W. J. and C. R. Smith. 2010. Invasive mangroves alter macrofaunal community structure and facilitate opportunistic exotics. Marine Ecology Progress Series 404: 51-67.

The authors conducted a case study of 2 *Rhizophora mangle* habitats in Hawai'i, comparing habitat parameters and macrofaunal community structure in introduced mangroves and nearby control sandflats at a similar tidal elevation.

Ferriter, A. and D. Clark. 1997. Brazilian pepper management plan for Florida. The Florida Exotic Pest Plant Council's Brazilian Pepper Task Force. City of Sanibel.

Information on control of Christmasberry, *Schinus terebinthifolius*.

Greenfield, B. K., N. David, J. Hunt, M. Wittmann and G. Siemering. 2004. Aquatic Pesticide Monitoring Program. Review of Alternative Aquatic Pest Control Methods For California Waters. San Francisco Estuary Institute. San Francisco. Retrieved from www.sfei.org/apmp/reports/PestAlternatives_field.pdf.

This review evaluates aquatic pest control methods that may serve as alternatives to registered chemical pesticides. These alternatives include biological, mechanical, and physical control methods, as well as preventive measures. The review also discusses chemicals not registered as pesticides, including phosphorus-binding agents, acetic acid, and Aquashade.

Johnson, D. 2010. Invasive plant Best Management Plan reference list. aliens-l@indab.iucn.orgpp.

Email with list of references pertaining to Invasive Plant BMPs

King County Department of Natural Resources and Parks. 2006. Best Management Practices. Fragrant Water Lily (*Nymphaea odorata*) Nymphaeaceae. from <http://dnr.metrokc.gov/weeds>.

This online brochure provides control and management tips for invasive freshwater aquatic plants (specifically water lily, but some methods may apply to other species).

Mayence, C. E., D. J. Marshall and R. C. Godfree. 2009. Hydrologic and mechanical control for an invasive wetland plant, *Juncus ingens*, and implications for rehabilitating and managing Murray River floodplain wetlands, Australia. Wetlands Ecology and Management DOI: 10.1007/s11273-010-9191-1: 14.

Paper discusses factors that most impacted germination and survival of an invasive wetland species in order to determine best control methods to use to prevent spread of the plant in flood plains.

Motooka, P., L. Ching and G. Nagai. 2002. Herbicidal Weed Control Methods for Pastures and Natural Areas of Hawaii. Weed Control. WC-8, Nov. 2002. Cooperative Extension Service, College of Tropical Agriculture and Human Resources, University of Hawai'i. Honolulu, HI. Retrieved from www.ctahr.hawaii.edu/oc/freepubs/pdf/WC-8.pdf.

This text provides an overview of the various methods of weed control available in Hawai'i, an in depth discussion of herbicide application methods, and approved herbicides that may be used in Hawai'i.

Motooka, P., L. Castro, D. Nelson, G. Nagai and L. Ching. 2003. Mesquite *Prosopis juliflora* (Sw.) DC. Weeds of Hawai'i's Pastures and Natural Areas; An Identification and Management Guide. Honolulu, HI, College of Tropical Agriculture and Human Resources, University of Hawai'i at Manoa.

Provides information on control of kiawe.

Mueller-Dombois, D. 1996. Watershed impairment by an alien grass on Windward Oahu. Tech. Rep. 96-01. Hawai'i DLNR Aquatic Resources Division. Honolulu, HI.

Information on impacts of invasive grasses in Hawai'i.

PEIR (Pacific Ecosystems at Risk). 1999, April 2009. *Urochloa mutica* (Forssk.) T.Q. Nguyen, Poaceae. from http://www.hear.org/Pier/species/urochloa_mutica.htm.

This online article provides information on the distribution, habitats, and control of California grass (*Urochloa mutica*, or *Brachiaria mutica*).

Shluker, A. D. and HI DLNR, DAR. 2003. State of Hawai'i Aquatic Invasive Species Management Plan, Final Version - September 2003. Prepared by A.D. Shluker, The Nature Conservancy of Hawai'i, for The Hawai'i Department of Land and Natural Resources, Division of Aquatic Resources. Honolulu HI.

The purpose of this State of Hawai'i Aquatic Invasive Species (AIS) Management Plan is to act as a tool in which to help enhance the coordination of current management efforts, identify remaining problems areas and gaps, and recommend additional actions which are needed to effectively address AIS issues in Hawai'i. The focus of this plan is the identification of feasible, cost-effective management practices to be implemented by State, Federal, county, nongovernmental, private, and volunteer entities for the environmentally sound prevention and control of aquatic invasive species in a coordinated fashion.

Spencer, D. F. 2003. Impacts of Aquatic Weeds in Water Use and Natural Systems. 2003 Proceedings of the California Weed Science Society 55: 32-36.

This article discusses the importance of aquatic plants for fish and invertebrate species found in wetlands, and reviews the negative impacts associated with excessive growth of aquatic plants.

State of Washington Department of Ecology. No Date. Non-native Invasive Freshwater Plants: Fragrant Water Lily (*Nymphaea odorata*). from <http://www.ecy.wa.gov/programs/wq/plants/weeds/aqua005.html>.

This brochure provides ideas on methods to control an invasive wetland plant, Fragrant water lily, which may be applicable to other invasive wetland plants.

Twilley, R. R. and J. W. Barko. 1990. The growth of submersed macrophytes under experimental salinity and light conditions. Estuaries 13: 311-321.

Information on impacts of hydrological conditions on growth of aquatic plants. May be useful in restoration of wetland species by controlling growth patterns.

Virginia Department of Conservation and Recreation. 2008. Marsh Invader! How to identify and combat one of Virginia's most invasive plants: Phragmites. from http://www.dcr.virginia.gov/natural_heritage/documents/phragmitescontrolbooklet_final2008.pdf.

This brochure provides ideas on methods to control an invasive wetland plant, Phragmites, which may be applicable to other invasive wetland plants.

Predators – Information, Impacts and Control Methods

Hansen, H., S. C. Hess, D. Cole and P. C. Banko. 2007. Using population genetic tools to develop a control strategy for feral cats (*Felis catus*) in Hawai'i Wildlife Research 34: 587-596.

Feral cat control ideas.

Hess, S. C., H. Hansen and P. C. Banko. 2007. Ecology of an invasive predator in Hawai'i. Managing Vertebrate Invasive Species: Proceedings of an International Symposium, Fort Collins, CO.

Discusses impacts of feral cats on Hawaiian birds.

Seto, N. W. H. and S. Conant. 1996. The effects of rat (*Rattus rattus*) predation on the reproductive success of the Bonin petrel (*Pterodroma hypoleuca*) on Midway Atoll. Colonial Waterbirds 19(2): 171-185.

Information on impacts of rats on waterbirds in Hawai'i.

Smucker, T. D., G. D. Lindsey and S. M. Mosher. 2000. Home range and diet of feral cats in Hawaii forests. Pacific Conservation Biology 6(3): 229-237.

Information on cat behavior in Hawai'i.

Snetsinger, T. J., S. G. Fancy, J. C. Simon and J. D. Jacobi. 1994. Diets of owls and feral cats in Hawaii. Elepaio 54(8): 47-50.

Discusses feral cat dietary composition.

Stone, C. P. and S. J. Anderson. 1988. Introduced Animals in Hawaii's Natural Areas. Proceedings of the Thirteenth Vertebrate Pest Conference (1988). Vertebrate Pest Conference Proceedings Collection. University of Nebraska, Lincoln. Retrieved from <http://digitalcommons.unl.edu/vpcthirteen/28/>.

Information on invasive mammals in Hawai'i.

USGS. 2000. Does your cat eat birds? 'Elepaio 60(8): 78.

Information on cat behavior in Hawai'i.

Climate and Hydrology

Blumenstock, D. I. and S. Price. 1967. Climates of the states: Hawai'i. Climatology of the United States. Washington, D.C., U.S. Department of Commerce: 27.

Provides description of the weather patterns, climatic statistics, and summary of meteorological variables for the Hawaiian islands.

Cao, G., T. W. Giambelluca, D. E. Stevens, and T. A. Schroeder. 2007. Inversion variability in the Hawaiian trade wind regime. Journal of Climate 20: 1145-1160.

Technical discussion describing the vertical shifts and transient nature of the trade wind inversion and how it impacts rainfall frequency and magnitudes in the Hawaiian islands. Provides good description of how trade wind persistence is tied to position of north Pacific anticyclone (high pressure) and how it controls rainfall distribution.

Chen, Y.-L. and A. J. Nash. 1994. Diurnal variation of surface airflow and rainfall frequencies on the island of Hawaii. Monthly Weather Review 122: 34-56.

Chu, P.-S. and H. Chen. 2005. Interannual and interdecadal rainfall variations in the Hawaiian islands. Journal of Climate 18: 4796-4813.

Statistical analysis and summary of amount of rainfall that occurs yearly and every ten years across the Hawaiian islands.

Giambelluca, T. W., M. A. Nullet, and T. A. Schroeder. 1986. Rainfall atlas of Hawai'i: Report R76. Honolulu, Department of Land and Natural Resources: 267.

Compilation of maps depicting isohyetal lines of the mean rainfall amounts for monthly and yearly periods. Includes discussion of how the mean values were computed. Maps are provided for all of the main Hawaiian islands.

Kodama, K. and G. M. Barnes. 1997. Heavy rainfall over the south-facing slopes of Hawaii: Attendant conditions. Weather and Forecasting 12: 347-367.

Technical discussion describing the metrological variables that result in heavy rainfall on the south facing / leeward sides of the main Hawaiian islands. Provides specific case studies of several events that were extreme with respect to rainfall magnitudes.

Lau, L. S. and J. F. Mink. 2006. Hydrology of the Hawaiian Islands. Honolulu, University of Hawai'i Press.

Comprehensive discussion of all aspects of the hydrologic cycle with description and examples of occurrence affecting the cycle in the Hawaiian islands. Good introduction to the hydrology of the islands, with specific examples and narrative from around the islands.

Roy, S. S. and R. C. Balling Jr. 2004. Analysis of Hawaiian diurnal rainfall patterns. Theoretical and Applied Climatology 79: 209-214.

Technical paper on how rainfall rates and time of occurrence varies between day and night. Provides statistical summary of rainfall amounts at select locations for day and night time periods.

U.S. Department of Agriculture. 2004. Hawai'i (Big Island) Digital Orthophoto Mosaic.

Remotely sensed image acquired from high resolution satellite that has been spatially adjusted to depict accurate rendering of the island's surface.

Policy

Army Corps of Engineers. 2000. Final Notice of Issuance and Modification of Nationwide Permits. Federal Register 65(47): 12818-12899.

The Corps of Engineers (Corps) issued 5 new Nationwide Permits (NWP) and modified 6 existing NWP to replace NWP 26 which expired on June 5, 2000. The Corps is also modifying nine NWP general conditions and adding two new NWP general conditions. The new NWP general conditions will increase protection of designated critical resource waters and waters of the United States within 100-year floodplains.

Downing, D. M., C. Winer and L. D. Wood. 2003. Navigating through clean water act jurisdiction: a legal review. Wetlands 23(3): 475-493.

Discusses CWA policy.

NOAA. 2003. Coastal and Estuarine Land Conservation Program Final Guidelines. Office of Ocean and Coastal Resource Management, National Ocean Service, National Oceanic and Atmospheric Administration.

These guidelines establish the eligibility, procedural, and programmatic requirements for participation in the Coastal and Estuarine Land Conservation Program (CELCP), authorized by the FY 2002 Appropriations Act.

Public Outreach

Gutrich, J., D. Donovan, M. Finucane, W. Focht, F. Hitzhusen, S. Manopimoke, D. McCauley, B. Norton, P. Sabatier, J. Salzman and V. Sasmitawidjaja. 2005. Science in the public process of ecosystem management: lessons from Hawaii, Southeast Asia, Africa and the US Mainland. Journal of Environmental Management 76: 197-209.

This paper discusses integration of science and public input and values in cooperative management of watersheds.

APPENDIX B. SPECIES LISTS

The following tables contain species lists for the Honu'apo Estuary and surrounding area. Lists are included for: (1) mammals and reptiles, (2) birds, (3) fish, (4) invertebrates, and (5) plants. The lists were compiled from various plans, studies and reports. It is recognized that this list may be incomplete due to the lack of comprehensive floral and faunal surveys. There are, to date, no scientifically-verified sightings of listed endangered plants anywhere in the project area.

The lists reflect the most current and available scientific information (e.g., presence on a particular property, scientific names²⁵, regulatory status). The standard references used included:

American Ornithologists Union. 2000. *The A.O.U. Check-list of North American Birds, Seventh Edition*. <http://www.aou.org/aou/birdlist.html>.

Hoover, J.P. 1998. *Hawai'i's Sea Creatures: A Guide to Hawai'i's Marine Invertebrates*. Mutual Publishing, Honolulu. 366 pp.

McKeown, S. 1996. *A Field Guide to Reptiles and Amphibians in the Hawaiian Islands*. Diamond Head Publishing, Los Osos, CA. 172 pp.

Randall, J.E. 1996. *Shore Fishes of Hawaii*. Natural World Press, Oregon. 216 pp.

Staples, G.W. and R.H. Cowie. 2001. *Hawai'i's Invasive Species*. Mutual Publishing and Bishop Museum Press, Honolulu. 116 pp.

Tinker, S.W. 1991. *Fishes of Hawaii*. Hawaiian Service, Inc. Honolulu. 532 pp.

Wagner, W.L., Herbst, D.R. and S.H. Sohmer. 1990. *Manual of the Flowering Plants of Hawai'i*. Vols 1 & 2. Bishop Museum Press, Honolulu. 1853 pp.

Whitaker, J.O. Jr. 1996. *National Audubon Society Field Guide to North American Mammals*. Alfred A. Knopf Press, New York. 937 pp.

Yamamoto, M.N. and A.W. Tagawa. 2000. *Hawai'i's Native and Exotic Freshwater Animals*. Mutual Publishing, Honolulu. 200 pp.

The following information is included for each species (where applicable): scientific name, common name, Hawaiian name, regulatory status (e.g., endangered/threatened at the Federal or state level), origin (e.g., endemic, native, introduced), and whether or not the species is considered invasive. Those species that are protected or regulated under Federal or State laws are of particular concern to resource management efforts, including those protected under the Endangered Species Act and the Migratory Bird Treaty Act. A species is listed as invasive if it meets the criteria for invasive as defined in Executive Order 13112 of February 3, 1999 - Invasive Species (Federal Register: Feb 8, 1999 (Volume 64, Number 25)) as being "an alien species whose introduction does or is likely to cause economic or environmental harm or harm to human health."

²⁵ For example, edits have been made to some species names to reflect the most current and available scientific information. Names in parentheses are older or synonymous scientific names that may be found in the source reports.

Information Sources for Species Lists:

1. Bruland, G.L., R.A. MacKenzie, A.R. Henry, and C.R. Ryder. *Assessment and Monitoring of the Water Quality and Habitat Functions of Natural, Restored and Created Wetlands of the Hawaiian Islands*. EPA Region IX Wetland Program Development Grant Final Report. 2010.
2. Department of Land and Natural Resources, Division of Forestry and Wildlife. State Waterbird Survey Database. Hawaiian and Migratory Waterbirds Recorded at Honuapo, Hawai'i 1990-1995
3. Lamson, M. 2010. *One Year at Honu'apo Bay. A Social and Biological Monitoring Project in SE Hawai'i (Ka'u)*. MS Thesis. Tropical Conservation Biology and Environmental Science, University of Hawai'i-Hilo.
4. Sustainable Resources Group Intn'l, Inc. 2010-2011. Field Surveys in support of the *Wetlands Habitat Restoration Plan for Honu'apo Estuary*.
5. Townscape, Inc. 2010. *Honuapo Park Resource Management Plan*. Prepared for Hawai'i County Finance Department.
6. Waterbird and Seabird Count at Honuapo, Hawai'i 08-08-01, 11:30a – 12:00n (Eden, Ramona, Kim)

Mammals and Reptiles

Scientific Name	Common Name	Hawaiian Name	Regulatory Status	Origin	Invasive
Mammals					
Marine					
<i>Monachus schauinslandi</i>	Hawaiian monk seal	<i>'Ilio holo i ka uaua</i>	Endangered (US)	Endemic	
Terrestrial					
<i>Canis familiaris</i>	Feral dog			Introduced	
<i>Felis catus (F. domesticus)</i>	Feral cat			Introduced	X
<i>Herpestes javanicus (H. auropunctatus)</i>	Small Indian mongoose			Introduced	X
<i>Lasiurus cinereus semotus</i>	Hawaiian hoary bat	<i>'Ope'ape'a</i>	Endangered (US)	Endemic	
<i>Mus musculus (M. domesticus)</i>	House mouse			Introduced	
<i>Rattus rattus</i>	Roof rat			Introduced	X
<i>Sus scrofa</i>	Feral pig			Introduced	X
Reptiles					
<i>Chelonia mydas</i>	Green sea turtle	<i>Honu</i>	Threatened (US)	Migratory	
<i>Eretmochelys imbricate</i>	Hawksbill sea turtle	<i>Honu'ea</i>	Endangered (US)	Migratory	

Birds

Scientific Name	Common Name	Hawaiian Name	Regulatory Status	Origin	Invasive
Birds					
				Status**	
<i>Anas acuta</i>	Northern Pintail*	<i>Koloa mapu</i>		Visitor, common migrant to Hawai'i	
<i>Anas clypeata</i>	Northern Shoveler	<i>Koloa moha</i>		Visitor, common migrant to Hawai'i	
<i>Anas wyvilliana</i>	Hawaiian Duck	<i>Koloa moali</i>	Endangered (US)	Endemic	
<i>Anous minutus melanogenys</i>	Black Noddy	<i>Noio</i>		Endemic	
<i>Arenaria interpres</i>	Ruddy Turnstone	<i>'Akekeke</i>		Visitor, common migrant to Hawai'i	
<i>Buteo solitarius</i>	Hawaiian Hawk	<i>'Io</i>	Endangered (US)	Endemic	
<i>Calidris alba</i>	Sanderling	<i>Hunakai</i>		Visitor, common migrant to Hawai'i	
<i>Cardinalis cardinalis</i>	Northern Cardinal			Introduced	
<i>Fulica alai</i>	Hawaiian Coot	<i>'Alae ke'oke'o</i>	Endangered (US)	Endemic	
<i>Geopelia striata</i>	Zebra Dove			Introduced	X
<i>Heteroscelus incanus</i>	Wandering Tattler	<i>'Ulili</i>		Visitor, common migrant to Hawai'i	
<i>Himantopus mexicanus</i>	Hawaiian Stilt	<i>Ae'o</i>	Endangered (US)	Endemic	
<i>Numenius tahitiensis</i>	Bristly-thighed Curlew	<i>Kioea</i>		Visitor, common migrant to Hawai'i	
<i>Nycticorax nycticorax</i>	Black-crowned Night-Heron	<i>'Auku'u</i>		Resident native	
<i>Phaethon lepturus</i>	White-tailed Tropicbird*	<i>Koa'e kea</i>		Native	
<i>Pluvialis fulva</i>	Pacific Golden-Plover*	<i>Kolea</i>		Visitor, common migrant to Hawai'i	
<i>Streptopelia chinensis</i>	Spotted Dove			Introduced	
<i>Tyto alba</i>	Barn Owl			Introduced	
<i>Zosterops japonicus</i>	Japanese White-eye			Introduced	X

*Listed as a priority species under North American Wetlands Conservation Act (limited range, regional population declines); **Pyle, RL. 1997. Checklist of the birds of Hawaii – 1997. Elepaio 57(7):129-138.

Fish

Family	Scientific Name	Common Name	Hawaiian Name	Regulatory Status	Origin	Invasive
Fish						
Eleotridae	<i>Eleotris sandwicensis</i>	Sleeper fish	<i>O'opu 'akupa</i>		Endemic	
Gobiidae	<i>Psilogobius mainlandi</i>	Hawaiian shrimp burrow goby			Endemic	
Gobiidae	<i>Stenogobius hawaiiensis</i>	Goby	<i>O'opu naniha</i>		Native	
Kuhliidae	<i>Kuhlia spp.</i>				Endemic	
Kuhliidae	<i>Kuhlia sandwicensis</i>	Hawaiian flagtails	<i>'Aholehole</i>		Endemic	
Mugilidae	<i>Mugil cephalus</i>	Striped mullet	<i>'Ama'ama</i>		Native	
Mugilidae	<i>Valamugil engeli</i>	Kanda mullet			Introduced	
Mulloidichthys	<i>Mulloidichthys vanicolensis</i>				Native	
Poeciliidae	<i>Poecilia spp.</i>				Introduced	
Tetradontidae	<i>Arothron hispidus</i>	Stripedbelly puffer	<i>'O'opu hue</i>		Native	

Invertebrates

Phylum	Class/Common Group	Scientific Name	Common Name	Hawaiian Name	Origin	Invasive
Invertebrates						
Arthropoda	Insecta, damselfly	<i>Megalagrion xanthomelas</i>	Orange-black Hawaiian damselfly		Endemic	
Arthropoda	Palaemonidae	<i>Palaemon debilis</i>			Native	
Arthropoda	Rock crabs	<i>Grapsus sp.</i>				
Arthropoda	Shrimps	<i>Palaemon debilis</i>	Feeble shrimp	<i>'Opae huna</i>	Indo-Pacific	
Arthropoda	Snapping shrimp	<i>Alpheus sp.</i>			Native	

Plants

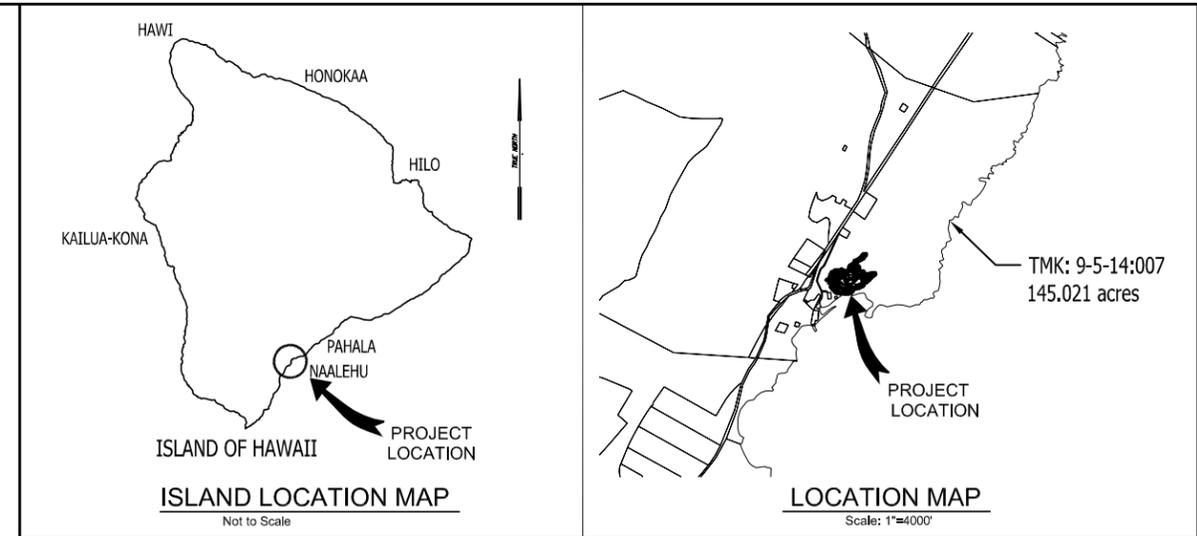
Scientific Name	Common Name	Hawaiian Name	Regulatory Status	Origin	Invasive
Plants					
<i>Chloris barbata</i> (<i>C. inflata</i>)	Swollen fingergrass	<i>Mau'ulei</i>		Introduced	X
<i>Cocos nucifera</i>	Coconut	<i>Niu, lolani</i>		Polynesian Introduction	
<i>Cynodon dactylon</i>	Bermuda grass	<i>Manienie, mahiki</i>		Introduced	
<i>Cyperus laevigatus</i>		<i>Makaloa</i>		Native	
<i>Dactyloctenium aegyptium</i>	Beach wiregrass			Introduced	
<i>Distichlis spicata</i>	Salt grass			Introduced	
<i>Eleusine indica</i>	Wiregrass, goosegrass	<i>Manienie ali'i</i>		Introduced	X
<i>Fimbristylis cymosa</i> (<i>F. pycnocephala</i>)	Button fimbristylis	<i>Mau'u 'aki'aki</i>		Native	
<i>Heliotropium curassavicum</i>	Seaside heliotrope	<i>Nena, kupukai</i>		Native	
<i>Ipomoea pes-caprae</i> ssp.	Beach morning glory	<i>Pohuehue</i>		Native	
<i>Jacquemontia ovalifolia</i> <i>sandwicense</i>		<i>Pa'u-o-hi'iaka, kakuaohi'iaka</i>		Endemic	
<i>Leucaena leucocephala</i> (<i>L. glauca</i>)		<i>Koa haole, ekoa, lilikoa</i>		Introduced	X
<i>Melanthera integrifolia</i>		<i>Nehe</i>		Native	
<i>Panicum maximum</i>	Guinea grass			Introduced	X
<i>Paspallum vaginatum</i>	Seashore paspallum			Introduced	X
<i>Pithecellobium dulce</i>	Madras thorn, Manila tamarind	<i>'Opiuma</i>		Introduced	X
<i>Pluchea symphytifolia</i> (<i>P. odorata</i>)	Sourbush, Hairy fleabane			Introduced	X
<i>Portulaca oleracea</i>	Pigweed, common purslane	<i>'Akulikuli kula</i>		Introduced	
<i>Portulaca pilosa</i>	Portulaca	<i>'Akulikuli</i>		Introduced	
<i>Prosopis pallida</i>	Algaroba, mesquite	<i>Kiawe</i>	Noxious Weed (US)	Introduced	X
<i>Scaevola sericea</i> (<i>S. taccada</i>)	Beach naupaka	<i>Naupaka, Naupaka kahakai</i>		Native	
<i>Schinus terebinthifolius</i>	Christmas berry	<i>Wilelaiki</i>		Introduced	X
<i>Schoenoplectus tabernaemontani</i>	Giant bulrush	<i>'Aka 'akai</i>		Native	
<i>Sesuvium portulacastrum</i>	Sea purslane	<i>'Akulikuli</i>		Native	
<i>Sida fallax</i>		<i>'Ilima</i>		Native	
<i>Sporobolus virginicus</i>	Beach dropseed grass, seashore rushgrass	<i>'Aki'aki</i>		Native	
<i>Syzygium cumini</i>	Java plum	<i>Palama</i>		Introduced	X
<i>Thespesia populnea</i>		<i>Milo</i>		Native	
<i>Urochloa mutica</i>	California grass			Introduced	X

APPENDIX C. RESTORATION PLAN DRAWINGS

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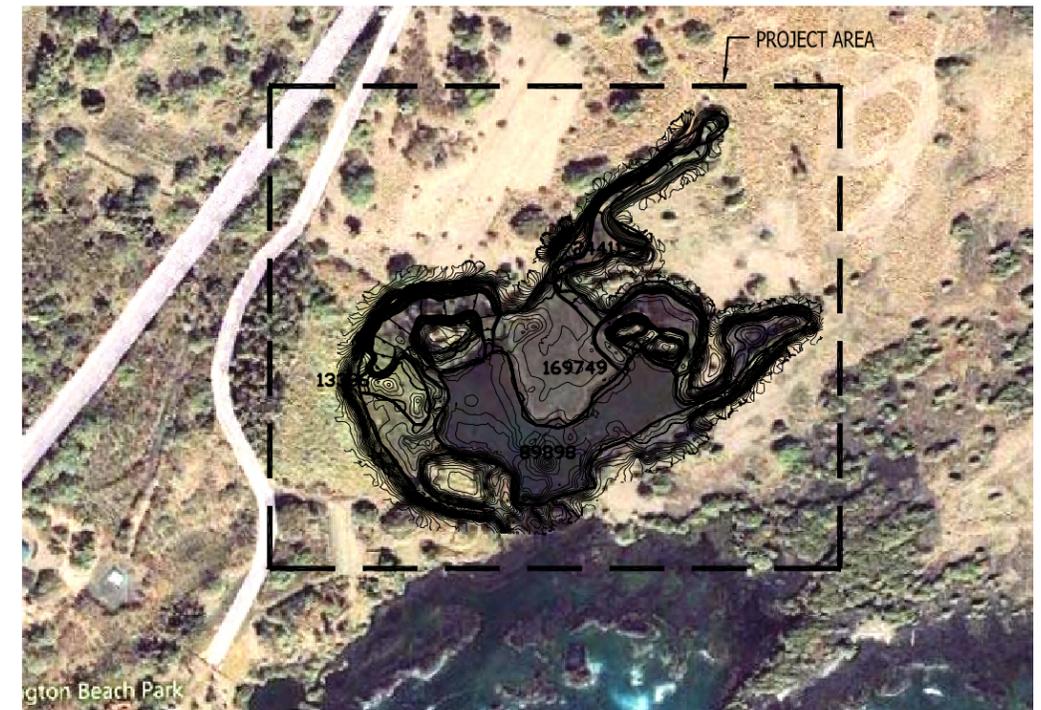
Wetlands Habitat Restoration Plan for Honu'apo Estuary

Whittington Beach Park to Honu'apo Park, Ka'ū District, Island of Hawai'i



INDEX OF DRAWINGS

	Drawing Number	SRGII NO.	Title
GENERAL CONTRACTOR	G-1	HA 12691	Title Sheet, Vicinity and Location Map, and Index to Drawings
	G-2	HA 12692	General Note, Symbols and Abbreviations
	G-3	HA 12693	General Plan
	G-4	HA 12694	Wetland Types
	G-5	HA 12695	Vegetation Removal Plan
	G-6	HA 12696	Re-Vegetation Plan
	G-7	HA 12697	Vegetation Removal & Re-Vegetation Notes
CIVIL ENGINEER	C-1	HA 12698	Existing Conditions-Remedial Action
	C-2	HA 12699	Existing Conditions-Remedial Action
	C-3	HA 126910	Deep Water Plan # 1
	C-4	HA 126911	Deep Water Plan # 2
	C-5	HA 126912	Deep Water Plan # 3
	C-6	HA 126913	Cross-Section Location Map
	C-7	HA 126914	Cross Sections 1 to 3
	C-8	HA 126915	Cross Sections 4 to 6
	C-9	HA 126916	Hardscape Mitigation Plan



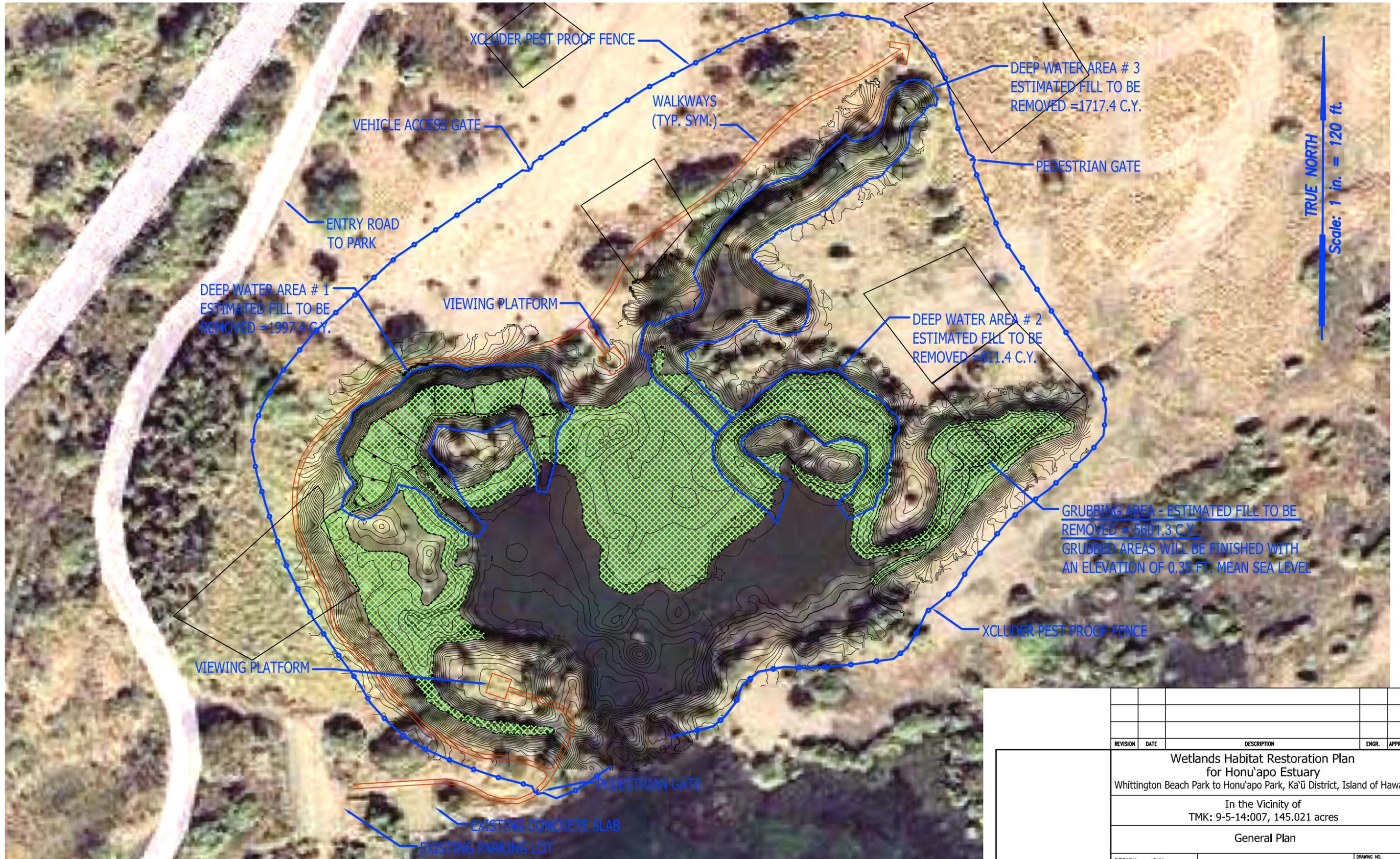
VICINITY/PROJECT SITE MAP

Wetlands Habitat Restoration Plan

1"=400' scale

REVISION	DATE	DESCRIPTION	ENGR.	APPROVED

Wetlands Habitat Restoration Plan for Honu'apo Estuary Whittington Beach Park to Honu'apo Park, Ka'ū District, Island of Hawai'i	
In the Vicinity of TMK: 9-5-14:007, 145.021 acres	
Title Sheet, Vicinity and Location Map, and Index to Drawings	
DESIGN: CHK DRAWN: CHK CHECKED: APH DATE: 04-15-11	DRAWING NO. G-1 SHEET 1 OF 16 SHEETS
JOB NO. 00 - 1154	FILE ___ DRAW ___ FOLDER ___ NUMBER ___



TRUE NORTH
Scale: 1 in. = 120 ft.

DEEP WATER AREA # 1
ESTIMATED FILL TO BE
REMOVED =1997.4 C.Y.

VIEWING PLATFORM

DEEP WATER AREA # 2
ESTIMATED FILL TO BE
REMOVED =811.4 C.Y.

GRUBBING AREA - ESTIMATED FILL TO BE
REMOVED = 5601.3 C.Y.
GRUBBED AREAS WILL BE FINISHED WITH
AN ELEVATION OF 0.35 FT. MEAN SEA LEVEL

VIEWING PLATFORM

PEDESTRIAN GATE

EXISTING CONCRETE SLAB
EXISTING PARKING LOT

GENERAL PLAN

Honu'apo Wetlands Restoration
1"=120' scale
Contour Interval = 0.35 foot



REVISION	DATE	DESCRIPTION	ENGR.	APPROVED

Wetlands Habitat Restoration Plan
for Honu'apo Estuary
Whittington Beach Park to Honu'apo Park, Ka'u District, Island of Hawai'i
In the Vicinity of
TMK: 9-5-14:007, 145.021 acres

General Plan

DESIGN: CHK
DRAWN: CHK
CHECKED: APH
DATE: 04-15-11

DRAWING NO.
G-3
SHEET **3**
OF **16** SHEETS

JOB NO. **00 - 1154** FILE ___ DRAW ___ FOLDER ___ NUMBER ___

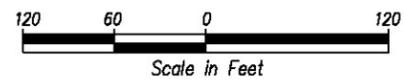


TRUE NORTH
Scale: 1 in. = 120 ft.

LEGEND

A	SUBTIDAL	2.07 AC. (0.84 HECTARES)
B	INTERTIDAL	4.57 AC. (1.85 HECTARES)
C	PALUSTRINE	1.35 AC. (0.55 HECTARES)
D	UPLAND ZONE	3.51 AC. (1.42 HECTARES)
		TOTAL: 11.5 AC. (4.66 HECTARES)

Existing Wetland Types
Honu'apo Wetlands Restoration
1"=120' scale
Contour Interval = 0.35 foot



REVISION	DATE	DESCRIPTION	ENGR.	APPROVED

Wetlands Habitat Restoration Plan
for Honu'apo Estuary
Whittington Beach Park to Honu'apo Park, Ka'u District, Island of Hawai'i
In the Vicinity of
TMK: 9-5-14:007, 145.021 acres

Existing Wetland Types

DESIGN: CHK	DRAWING NO. G-4
DRAWN: CHK	
CHECKED: APH	
DATE: 04-15-11	
JOB NO. 00 - 1154	FILE — DRAW — FOLDER — NUMBER —

SHEET **4**
OF **16** SHEETS

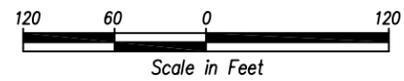


Vegetation to be Removed
within this Boundary:

- Urochloa mutica*
- Panicum maximum*
- Prosopis pallida*
- Leucaena leucocephala*
- Syzgium cumini*
- Pluchea symphytifolia*
- Schinus terebinthifolius*

TRUE NORTH
Scale: 1 in. = 120 ft.

Vegetation Removal Plan
Honu'apo Wetlands Restoration
1"=120' scale
Contour Interval = 0.35 foot



REVISION	DATE	DESCRIPTION	ENGR.	APPROVED

Wetlands Habitat Restoration Plan
for Honu'apo Estuary
Whittington Beach Park to Honu'apo Park, Ka'u District, Island of Hawai'i

In the Vicinity of
TMK: 9-5-14:007, 145.021 acres

Vegetation Removal Plan

DESIGN: CHK	G-5	DRAWING NO.
DRAWN: CHK		SHEET 5
CHECKED: APH		OF 16 SHEETS
DATE: 04-15-11		
JOB NO. 00 - 1154	FILE	DRAW
	FOLDER	NUMBER

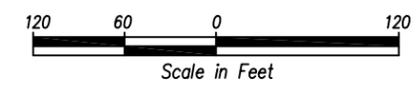


TRUE NORTH
Scale: 1 in. = 120 ft.

LEGEND

-  Schoenoplectus sp. 3,851 SF.
-  Cyperus laevigatus 10,040 SF.
-  Cyperus javanicus 25,879 SF.

Re-Vegetation Plan
Honu'apo Wetlands Restoration
1"=120' scale
Contour Interval = 0.35 foot



REVISION	DATE	DESCRIPTION	ENGR.	APPROVED

Wetlands Habitat Restoration Plan
for Honu'apo Estuary
Whittington Beach Park to Honu'apo Park, Ka'u District, Island of Hawai'i

In the Vicinity of
TMK: 9-5-14:007, 145.021 acres

Re-Vegetation Plan

DESIGN: CHK
DRAWN: CHK
CHECKED: APH
DATE: 04-15-11

DRAWING NO.
G-6
SHEET **6**
OF **16** SHEETS

JOB NO. **00 - 1154** FILE ___ DRAW ___ FOLDER ___ NUMBER ___

Vegetation Removal:

1. Trees, shrubs, and grasses to be removed will be delineated on the site via flagging, paint, or other methods to identify individual plants or areas for removal. The contractor is responsible for acquiring the services of a botanist to inventory the site and delineate plants to be removed.
2. Native, endemic, or plants to remain will be delineated on the site via flagging, paint, or other methods to identify individual plants or areas to remain. The contractor is responsible for acquiring the services of a botanist to inventory the site and delineate plants to be protected.
3. Removal shall be conducted to the extent possible that minimizes damage to topography and native vegetation.
4. The contractor is responsible for establishing skid trails, and ingress and egress points to work site.
5. All above ground plant material shall be removed after it is cut, treated with herbicide, and/or ripped. Herbicide application and leave in place is not acceptable.
6. The contractor is responsible for disposing all cut, removed, and discarded plant materials. All removed vegetation shall be disposed of at an approved location.
7. No removed vegetation will be allowed to be permanently disposed of at any portions of Honu'apo Park.
8. The contractor will be responsible for removal of all above ground biomass of trees and shrubs targeted for removal. Stumps and roots shall be removed or treated with an approved herbicide to prevent re-growth. Stumps and roots can remain in place only if treated to prevent regrowth.
9. The contractor is responsible for adhering to all applicable General Notes.

Special Notes:

10. California grass will be removed in all areas where it is present. Preferred method is to brush cut stems flush with ground surface and spray remaining plant material with approved herbicide. Herbicide applicator is required to hold all applicable permits and licenses required by State of Hawaii for applicators. Herbicide should not come in contact with open water areas to the extent possible.
11. Guinea grass growing in areas outside of limits of excavation of deep water habitats will be removed. Guinea grass growing up to an elevation of 6 ft MSL'. Guinea grass is presently found around perimeter of wetland; objective is to clear it from banks of wetland up to elevation 6 ft MSL. Preferred method is to brush cut stems flush with ground surface and spray with approved herbicide remaining plant material. Herbicide applicator is required to hold all applicable permits and licenses required by State of Hawaii for applicators. Herbicide should not come in contact with open water areas to the extent possible.

Planting Notes:

12. Milo trees growing on small island in west section of wetland to be removed. Caution should be used to prevent damage to *Sesuvium portulacum* growing on same island feature.
13. All species indicated on planting plan are native and/or endemic to the Hawaiian Islands.
14. Plants shall be ordered from nursery prior to grubbing and grading with sufficient lead time to allow plants to grow to installation size.
15. Planting holes shall be excavated with a diameter of 2 times the plant pot diameter.
16. Depth of planting holes shall be a depth equal to thickness of planting pot.
17. Hole will be backfilled with excavated soil; no soil amendments will be added to planting hole.
18. Plants shall be installed as depicted on planting plan at elevation that allow roots access to soil water. Supplemental irrigation will not be provided.

Plant Removal List			
<i>Species Name</i>	Common Name	Plant Type	Plant Count or Area (ft2)
<i>Urochloa mutica</i>	California Grass	Grass	1100 ft2
<i>Panicum maximum</i>	Guinea Grass	Grass	135224 ft2
<i>Prosopis pallida</i>	Kiawe	Tree	173
<i>Leucaena leucocephala</i>	Koa Haole	Tree	115*
<i>Thespesia populnea</i>	Milo Tree	Tree	250 ft2
<i>Syzygium cumini</i>	Java Plum	Tree	23*
<i>Pluchea symphytifolia</i>	Sourbush	Shrub	38*
<i>Schinus terebinthifolius</i>	Christmas berry	Tree/Shrub	37*

* Plant count is approximate, actual number to be verified by contractor.

Plant Installation List for Re-Vegetation				
Quantity	Latin Name	Common Name	Size	Notes
2000 ea	<i>Cyperus laevigatus</i>	Makalo	4 in. pot	Install along margins of deepwater habitats in elevations between 0.7 - 1.05 ft MSL.
3000 ea	<i>Cyperus javanicus</i>	'Ahu 'awa	4 in. pot.	Install along margins of deepwater habitats and locations invasive grasses were removed in elevations between 1.05 - 2.05 ft MSL.
500 ea	<i>Schoenoplectus sp.</i>	Aka 'akai	1 gallon pot	Install in deepwater areas in elevations between 0.35 - 0.7 ft. MSL

REVISION	DATE	DESCRIPTION	ENGR.	APPROVED

Wetlands Habitat Restoration Plan for Honu'apo Estuary Whittington Beach Park to Honu'apo Park, Ka'u District, Island of Hawai'i			
In the Vicinity of TMK: 9-5-14:007, 145.021 acres			
Vegetation Removal & Re-Vegetation Notes			
DESIGN: CHK		DRAWING NO. G-7	
DRAWN: CHK		SHEET 7	
CHECKED: APH		OF 16 SHEETS	
DATE: 04-15-11		JOB NO. 00 - 1154	
FILE ___ DRAW ___ FOLDER ___ NUMBER ___			



Figure 3. Looking northeast into dry arm of wetland complex, located in the northeast section of the wetland. Area is covered in dense seashore paspalum grass that appears to be growing on fill comprised of fine sediments and organic material. The slopes and flat area above the grassy area contains a high density of kiawe trees. Kiawe trees will be removed to increase fresh water inputs into wetland. The grass will be removed and the ground elevation lowered to enhance habitat for wading birds.



Figure 2. Looking south from north edge of wetland towards outlet. Plants transition from California grass in foreground to native and non-native wetland species at lower elevations. Vegetation will be removed and area will be excavated to create open deepwater habitat for native birds. Vegetation shown, including kiawe trees, are targeted for removal to restore fresh water inputs via springs in the area and improve habitat.



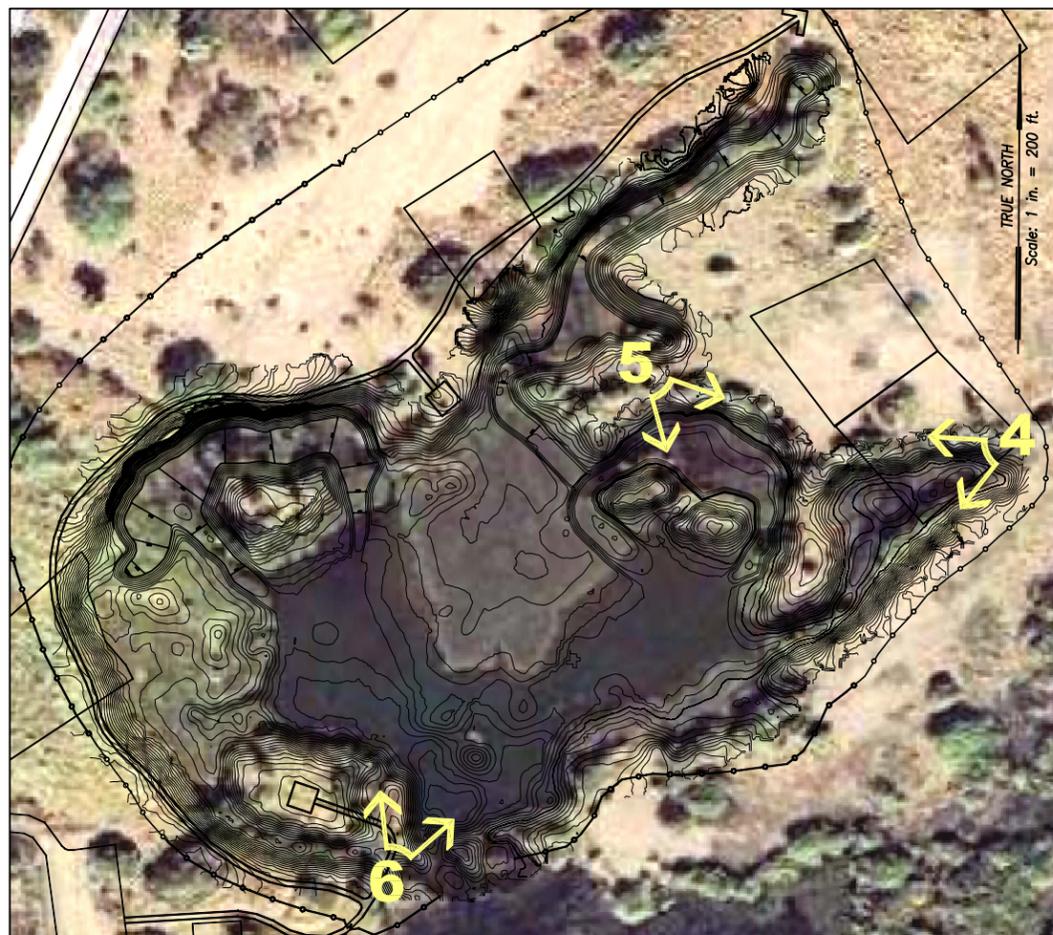
Figure 1. Looking northeast from west edge of estuary at filled in estuary zone covered with mixed vegetation. Grass along channel in image is seashore paspalum (*Paspalum vaginatum*) growing on mudflat slightly higher than mean tide level. Grass prevents wading birds from using area for foraging. Grass will be removed and ground surface lowered to create topography that will be submerged by flooding tides and provide foraging habitat for wading birds.



EXISTING CONDITIONS
 Honu'apo Wetlands Restoration
 1"=200' scale
 Contour Interval = 0.35 foot

REVISION	DATE	DESCRIPTION	ENGR.	APPROVED

Wetlands Habitat Restoration Plan for Honu'apo Estuary Whittington Beach Park to Honu'apo Park, Ka'u District, Island of Hawai'i					
In the Vicinity of TMK: 9-5-14:007, 145.021 acres					
Existing Conditions-Remedial Actions					
DESIGN:	CHK	C-1 SHEET 8 OF 16 SHEETS	DRAWING NO.		
DRAWN:	CHK				
CHECKED:	APH				
DATE:	04-15-11				
JOB NO.	00 - 1154	FILE	DRAW	FOLDER	NUMBER



EXISTING CONDITIONS
 Honu'apo Wetlands Restoration
 1"=200' scale
 1"=Contour Interval = 0.35 foot



Figure 6. Looking northeast from estuary outlet at large grass flat protruding into estuary water body. Grass is comprised of two species, seashore paspalum (*Paspalum vaginatum*) and salt grass (*Distichlis spicata*). Both are dense and of heights that make it difficult for birds to forage on insects in soil substrate. Grass cover on flat area will be removed to an elevation that exposes underlying mud/rock layer to create forage habitat for wading birds. Finished elevation is expected to be submerged daily by flooding tides to prevent regrowth of vegetation.



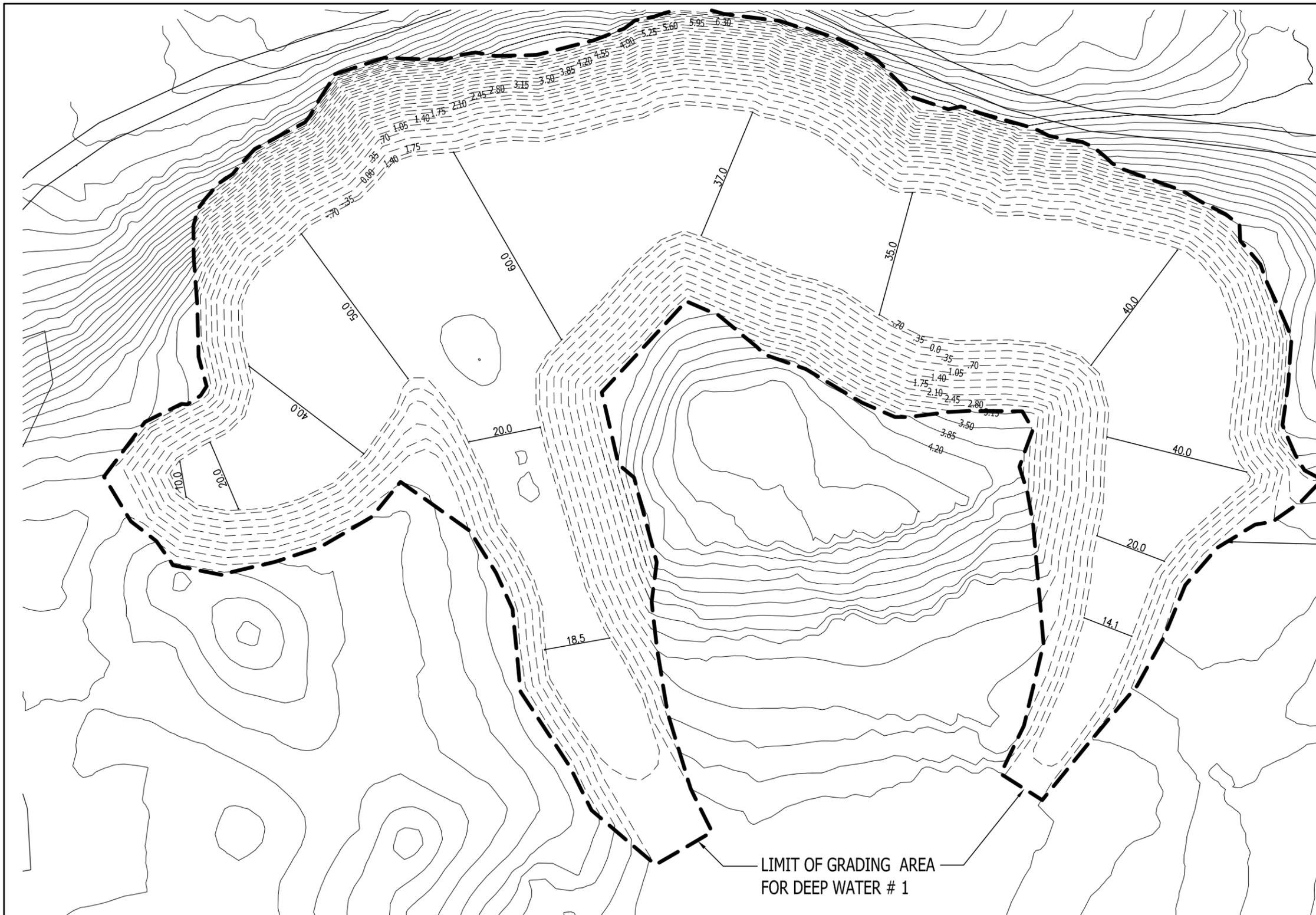
Figure 4. Looking west down southeast arm of estuary complex at channel that is submerged during high tide. Dense stands of seashore paspalum grass are growing adjacent to the channel creating dense cover that prevents birds from foraging. Kiawe and other non-native trees and shrubs can be seen encroaching over the grass. Area will be graded to remove grass and ground elevation will be lowered, resulting in frequent flooding by mean tide to create foraging habitat.



Figure 5. Looking south over backwater area east of two islands in estuary that is used by green sea turtles for basking and resting. The flat areas adjacent to the open water are covered with dense seashore paspalum, which reduces open water area. In the foreground, a stand of California grass grows over an area where freshwater springs discharge into the estuary. Other plants are non-native and are degrading habitat structure. Grass and non-native plants will be removed and elevation of backwater area lowered so that area is ponded during all tides.

REVISION	DATE	DESCRIPTION	ENGR.	APPROVED

Wetlands Habitat Restoration Plan for Honu'apo Estuary Whittington Beach Park to Honu'apo Park, Ka'u District, Island of Hawai'i				
In the Vicinity of TMK: 9-5-14:007, 145.021 acres				
Existing Conditions-Remedial Actions				
DESIGN:	CHK	C-2 SHEET 9 OF 16 SHEETS	DRAWING NO.	
DRAWN:	CHK			
CHECKED:	APH			
DATE:	04-15-11			
JOB NO.	00 - 1154	FILE	DRAW	FOLDER
				NUMBER



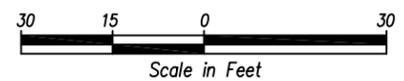
TRUE NORTH
Scale: 1 in. = 30 ft.

DASHED LINES REPRESENT FUTURE TOPOGRAPHY.
SOLID LINES OUTSIDE LIMITS OF GRADING
REPRESENT EXISTING/FUTURE (UNCHANGED)
TOPOGRAPHY.

- LEGEND**
- EXISTING TOPOGRAPHY
 - PROPOSED TOPOGRAPHY
 - CHANNEL WIDTH
 - LIMITS OF GRADING
 - CONTOUR INTERVAL - .35 FEET ELEVATION
 - EXCAVATION ESTIMATE - 1997.4 CUBIC YARDS

LIMIT OF GRADING AREA
FOR DEEP WATER # 1

DEEP WATER PLAN #1
Honu'apo Wetlands Restoration
1"=30' scale
Contour Interval = 0.35 foot



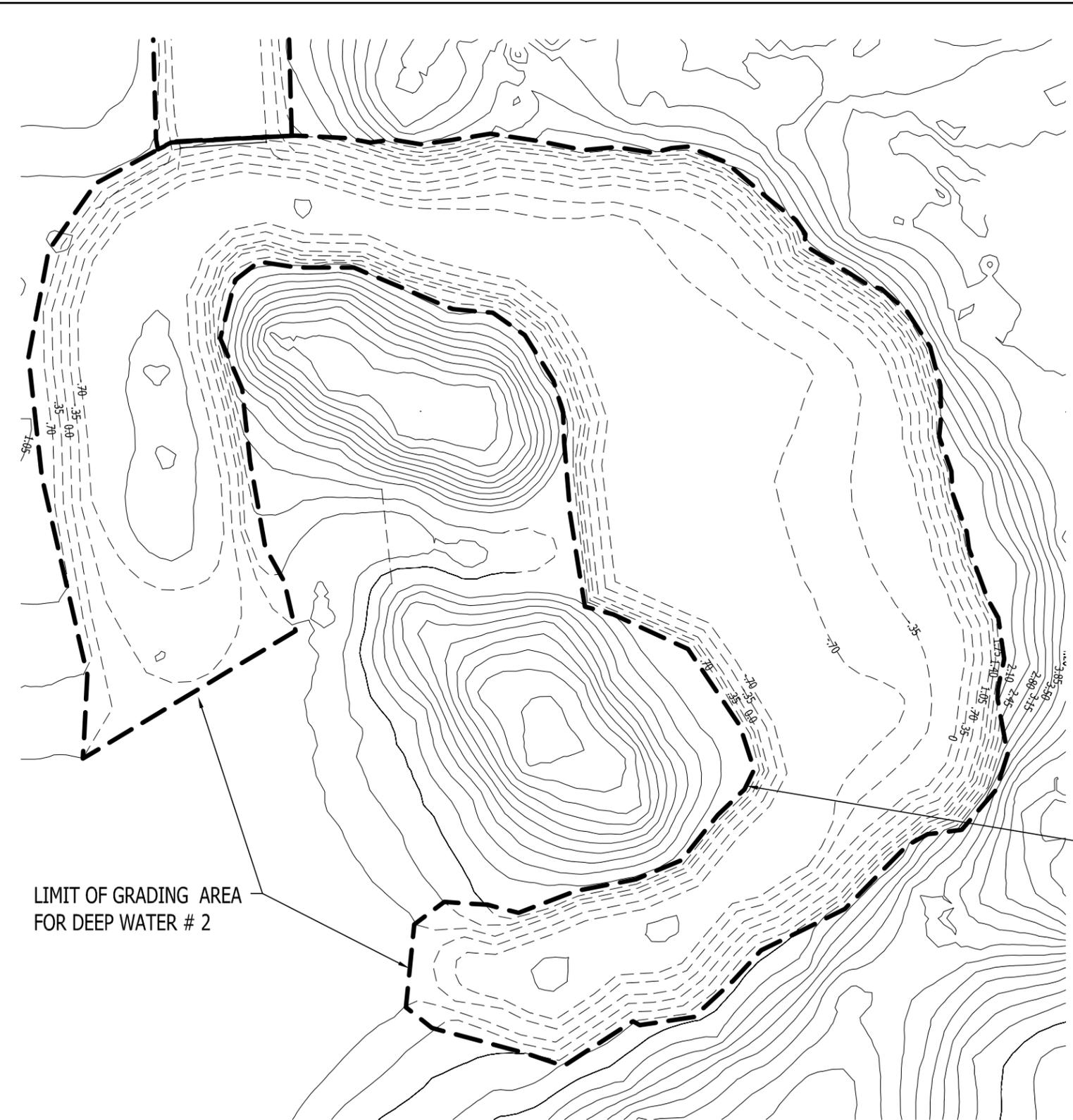
REVISION	DATE	DESCRIPTION	ENGR.	APPROVED

**Wetlands Habitat Restoration Plan
for Honu'apo Estuary**
Whittington Beach Park to Honu'apo Park, Ka'u District, Island of Hawai'i

In the Vicinity of
TMK: 9-5-14:007, 145.021 acres

Deep Water Plan #1

DESIGN: CHK	C-3	DRAWING NO.		
DRAWN: CHK		SHEET 10		
CHECKED: APH		OF 16 SHEETS		
DATE: 04-15-11				
JOB NO. 00 - 1154	FILE	DRAW	FOLDER	NUMBER



LIMIT OF GRADING AREA FOR DEEP WATER # 2

DASHED LINES REPRESENT FUTURE TOPOGRAPHY. SOLID LINES OUTSIDE LIMITS OF GRADING REPRESENT EXISTING/FUTURE (UNCHANGED) TOPOGRAPHY.

TRUE NORTH
Scale: 1 in. = 30 ft.

LEGEND

EXISTING TOPOGRAPHY	
PROPOSED TOPOGRAPHY	
CHANNEL WIDTH	30.0
LIMITS OF GRADING	
CONTOUR INTERVAL	.35 FEET ELEVATION
EXCAVATION ESTIMATE	- 811.4 CUBIC YARDS

DEEP WATER PLAN # 2
Honu'apo Wetlands Restoration
1"=30' scale
Contour Interval = 0.35 foot



REVISION	DATE	DESCRIPTION	ENGR.	APPROVED

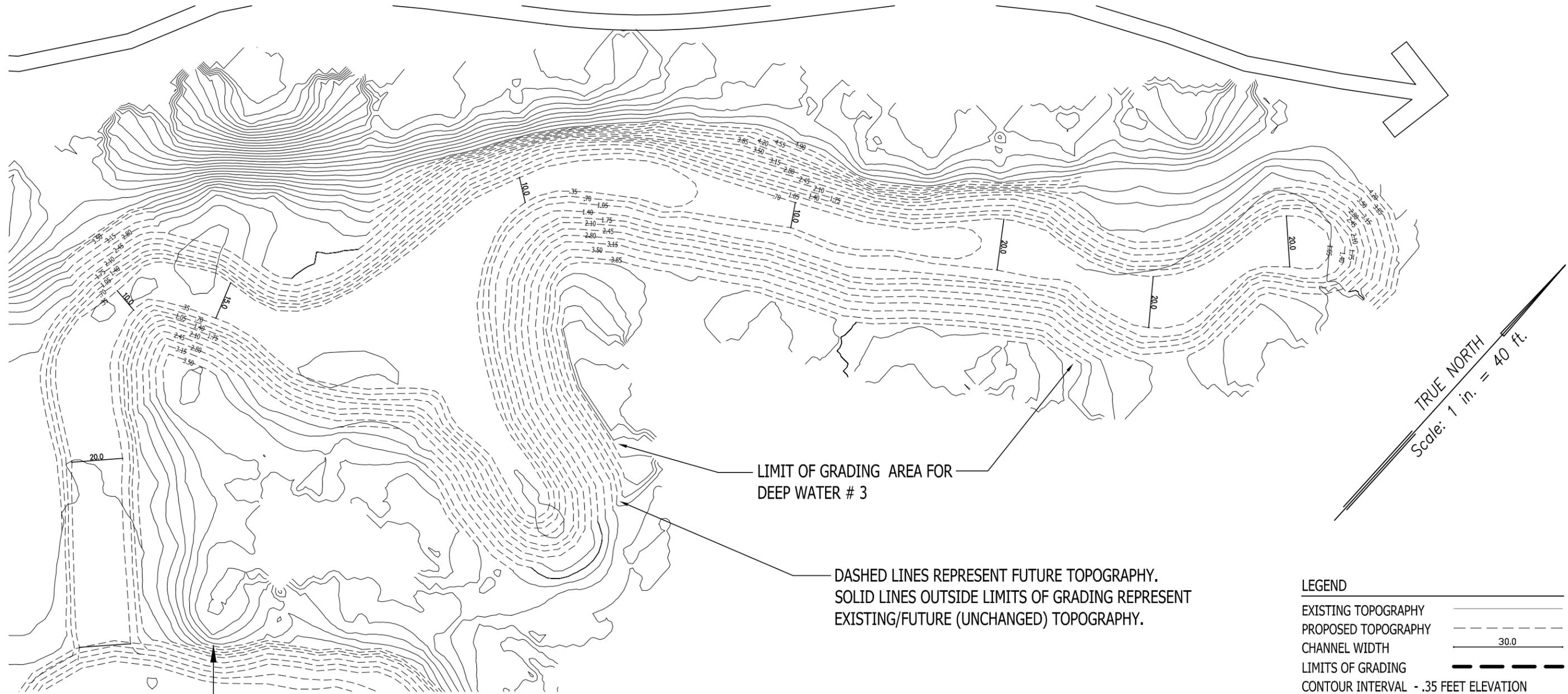
Wetlands Habitat Restoration Plan
for Honu'apo Estuary
Whittington Beach Park to Honu'apo Park, Ka'u District, Island of Hawai'i

In the Vicinity of
TMK: 9-5-14:007, 145.021 acres

Deep Water Plan #2

DESIGN: CHK	DRAWING NO. C-4
DRAWN: CHK	
CHECKED: APH	
DATE: 04-15-11	
JOB NO. 00 - 1154	FILE ___ DRAW ___ FOLDER ___ NUMBER ___

SHEET **11**
OF **16** SHEETS



LIMIT OF GRADING AREA FOR DEEP WATER # 3

DASHED LINES REPRESENT FUTURE TOPOGRAPHY. SOLID LINES OUTSIDE LIMITS OF GRADING REPRESENT EXISTING/FUTURE (UNCHANGED) TOPOGRAPHY.

DEEP WATER # 2 BOUNDARY

DEEP WATER PLAN # 3
 Honu'apo Wetlands Restoration
 1"=40' scale
 Contour Interval = 0.35 foot



LEGEND

EXISTING TOPOGRAPHY ————
 PROPOSED TOPOGRAPHY - - - - -
 CHANNEL WIDTH ———— 30.0 ————
 LIMITS OF GRADING - - - - -
 CONTOUR INTERVAL - .35 FEET ELEVATION
 EXCAVATION ESTIMATE - 1717.4 CUBIC YARDS

REVISION	DATE	DESCRIPTION	ENGR.	APPROVED

Wetlands Habitat Restoration Plan
for Honu'apo Estuary
 Whittington Beach Park to Honu'apo Park, Ka'u District, Island of Hawai'i

 In the Vicinity of
 TMK: 9-5-14:007, 145.021 acres

Deep Water Plan #3

DESIGN: CHK	DRAWING NO. C-5
DRAWN: CHK	
CHECKED: APH	
DATE: 04-15-11	
JOB NO. 00 - 1154	FILE ___ DRAW ___ FOLDER ___ NUMBER ___

SHEET **12**
 OF **16** SHEETS



TRUE NORTH
 Scale: 1 in. = 120 ft.

DEEP WATER AREA # 1

DEEP WATER AREA # 3

DEEP WATER AREA # 2

GRUBBING AREA - ±3.4 ACRES

Cross-Section Location Map
 Honu'apo Wetlands Restoration
 1"=120' scale
 Contour Interval = 0.35 foot



REVISION	DATE	DESCRIPTION	ENGR.	APPROVED

Wetlands Habitat Restoration Plan
 for Honu'apo Estuary
 Whittington Beach Park to Honu'apo Park, Ka'u District, Island of Hawai'i

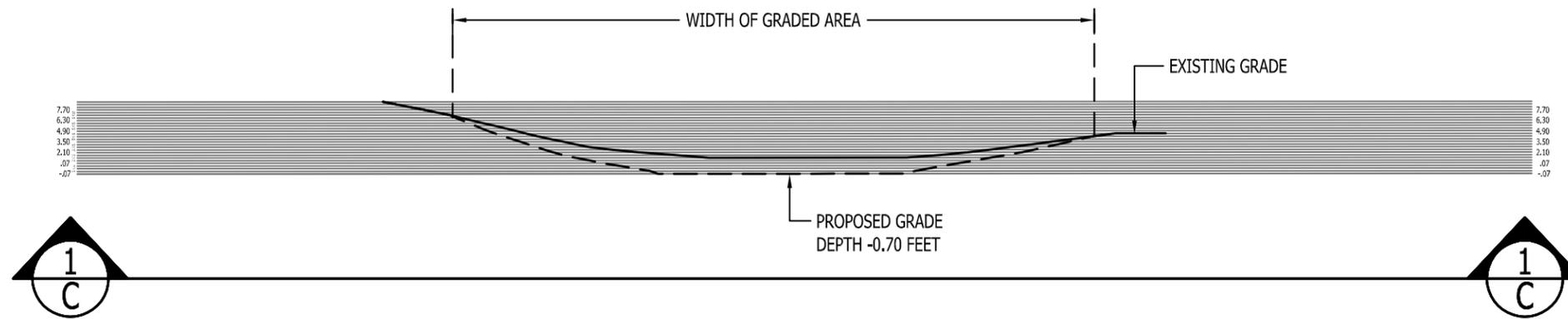
In the Vicinity of
 TMK: 9-5-14:007, 145.021 acres

Cross-Section Location Map

DESIGN: CHK
 DRAWN: CHK
 CHECKED: APH
 DATE: 04-15-11

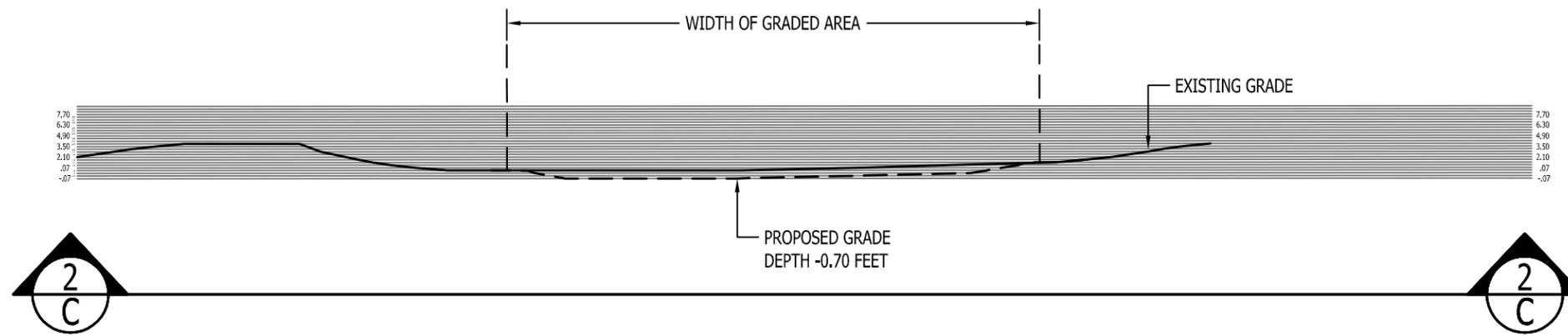
DRAWING NO.
C-6
 SHEET **13**
 OF **16** SHEETS

JOB NO. **00 - 1154** FILE ___ DRAW ___ FOLDER ___ NUMBER ___



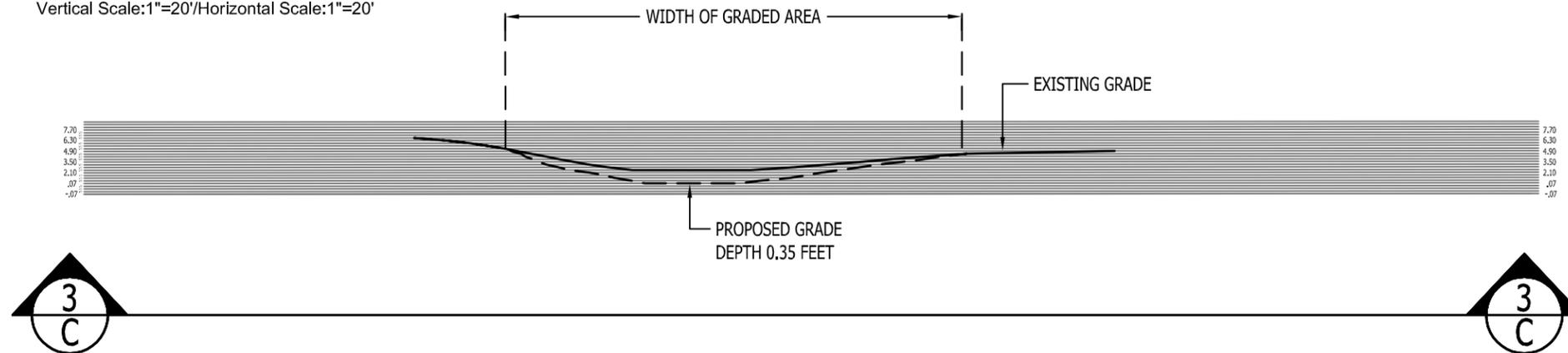
Section 1 - Deep Water Area # 1

Vertical Scale: 1"=20'/Horizontal Scale: 1"=20'



Section 2 - Deep Water Area # 2

Vertical Scale: 1"=20'/Horizontal Scale: 1"=20'



Section 3 - Deep Water Area # 3

Vertical Scale: 1"=20'/Horizontal Scale: 1"=20'

Cross-Sections 1 TO 3
 Honu'apo Wetlands Restoration
 1"=20' scale
 Contour Interval = 0.35 foot



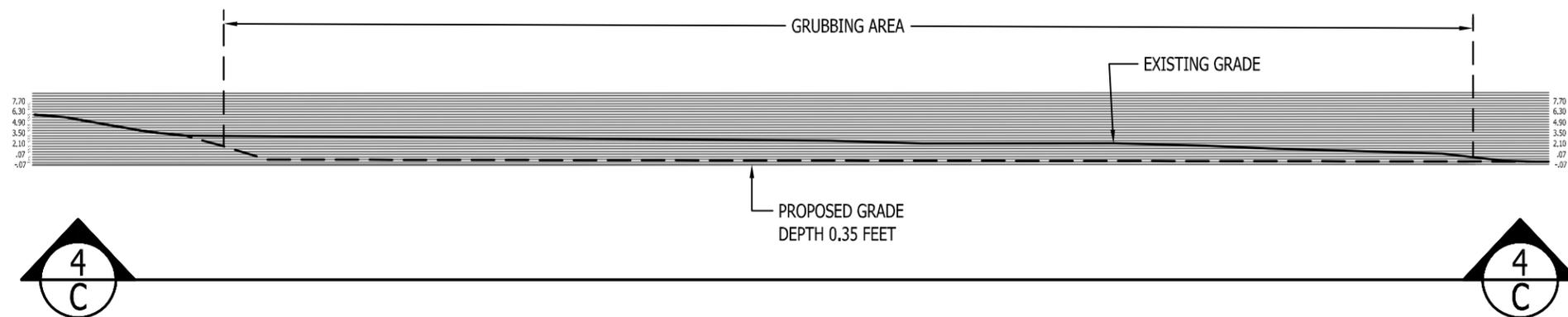
REVISION	DATE	DESCRIPTION	ENGR.	APPROVED

Wetlands Habitat Restoration Plan
for Honu'apo Estuary
 Whittington Beach Park to Honu'apo Park, Ka'u District, Island of Hawai'i

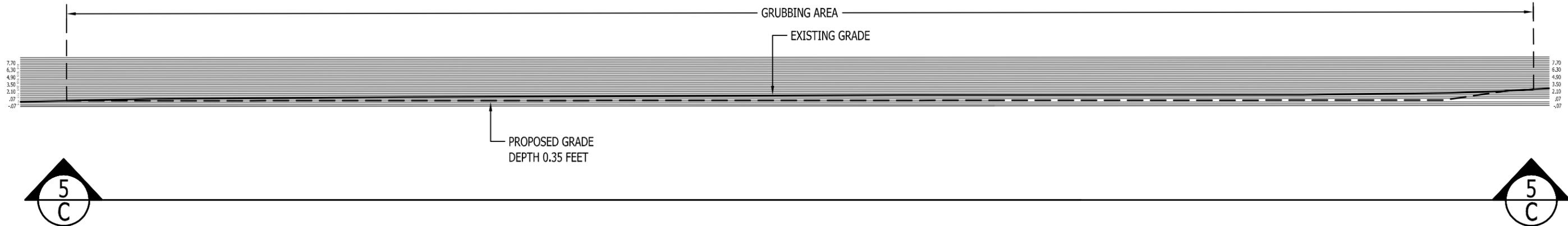
 In the Vicinity of
 TMK: 9-5-14:007, 145.021 acres

Cross-Sections 1 TO 3

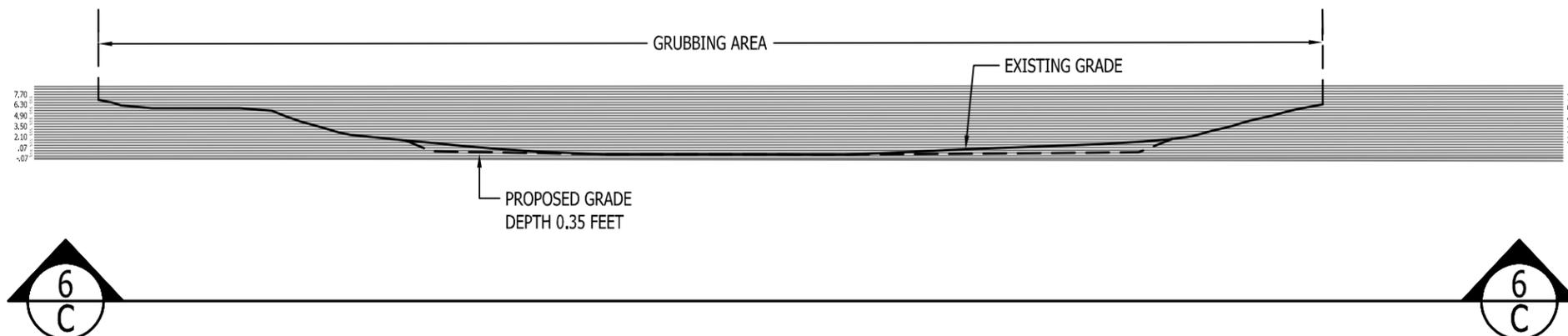
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DRAWN: CHK	
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DATE: 04-15-11	
JOB NO. 00 - 1154	FILE ___ DRAW ___ FOLDER ___ NUMBER ___



Section 4 - Grubbing Area # 1
Vertical Scale: 1"=20'/Horizontal Scale: 1"=20'



Section 5 - Grubbing Area # 2
Vertical Scale: 1"=20'/Horizontal Scale: 1"=20'



Section 6 - Grubbing Area # 3
Vertical Scale: 1"=20'/Horizontal Scale: 1"=20'

Cross-Sections 1 TO 3
Honu'apo Wetlands Restoration
1"=20' scale
Contour Interval = 0.35 foot



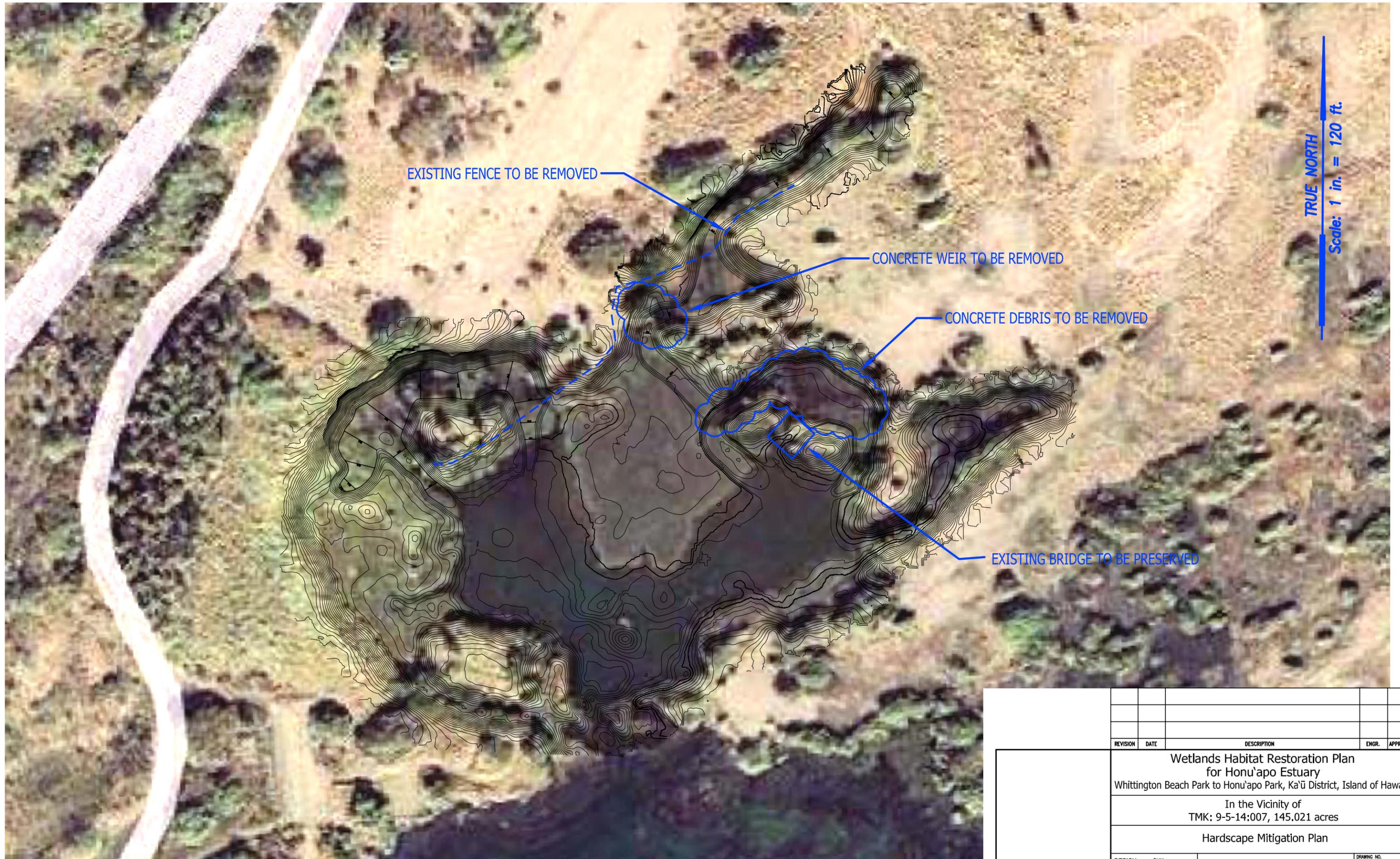
REVISION	DATE	DESCRIPTION	ENGR.	APPROVED

Wetlands Habitat Restoration Plan
for Honu'apo Estuary
Whittington Beach Park to Honu'apo Park, Ka'u District, Island of Hawai'i

In the Vicinity of
TMK: 9-5-14:007, 145.021 acres

Cross-Sections 4 TO 6

DESIGN: CHK	C-8	DRAWING NO.		
DRAWN: CHK		SHEET 15		
CHECKED: APH		OF 16 SHEETS		
DATE: 04-15-11				
JOB NO. 00 - 1154	FILE	DRAW	FOLDER	NUMBER



EXISTING FENCE TO BE REMOVED

CONCRETE WEIR TO BE REMOVED

CONCRETE DEBRIS TO BE REMOVED

EXISTING BRIDGE TO BE PRESERVED

TRUE NORTH
Scale: 1 in. = 120 ft.

Hardscape Mitigation Plan
Honu'apo Wetlands Restoration
1"=120' scale
Contour Interval = 0.35 foot



REVISION	DATE	DESCRIPTION	ENGR.	APPROVED

Wetlands Habitat Restoration Plan
for Honu'apo Estuary
Whittington Beach Park to Honu'apo Park, Ka'u District, Island of Hawai'i

In the Vicinity of
TMK: 9-5-14:007, 145.021 acres

Hardscape Mitigation Plan

DESIGN: CHK
DRAWN: CHK
CHECKED: APH
DATE: 04-15-11

DRAWING NO.
C-9
SHEET **16**
OF **16** SHEETS

JOB NO. **00 - 1154** FILE ___ DRAW ___ FOLDER ___ NUMBER ___

APPENDIX D. XCLUDER PEST PROOF FENCE INFORMATION

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Fence Design:

Xcluder® “Kiwi” fence:

The most common, but by no means only, fence type that we build is the Xcluder® “Kiwi” fence design (Figures 1, 2 & 3). The construction of the Xcluder® “Kiwi” fence is usually based on a 2 m high post and wire “farm-fence” framework, and this design is what we would recommend at your site. This fence is designed to exclude ALL pest animals from the area to be protected (rats, cats and mongoose) and the basic configuration and dimensions of the Xcluder® “Kiwi” fence have been proven to be very successful at excluding all target pests. Examples of this design are seen in New Zealand at the Maungatautari Ecological Island Trust in the Waikato and Shakespear Peninsula, Auckland (Figures 2 & 3). A variant of this design has been used at Kaena Point, Hawaii.

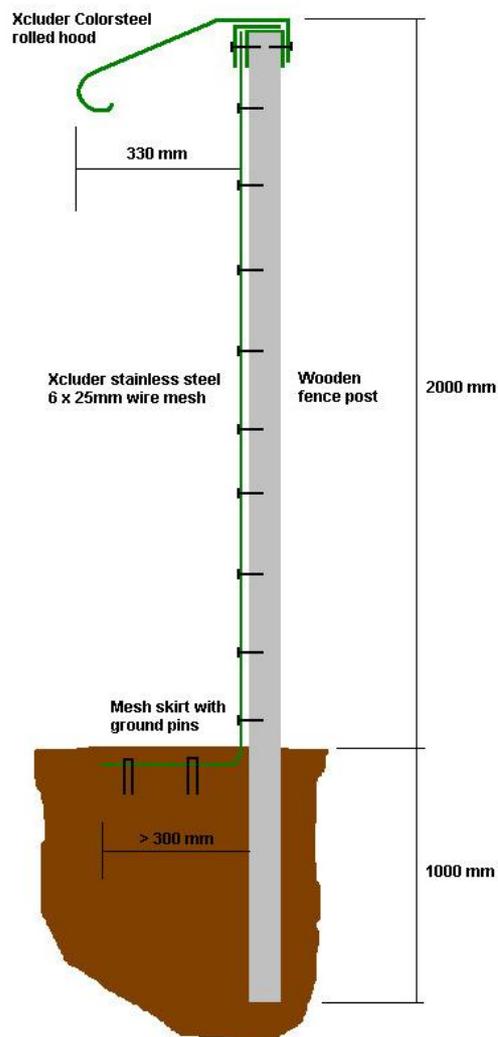


Figure 1: Basic profile and image of the Xcluder® “Kiwi” fence design.



Figure 2: Xcluder's® "Kiwi" pest-proof fence at Wairakei International Golf Course.



Figure 3: Xcluder's® "Kiwi" pest-proof fence at Shakespear Peninsula, Auckland.

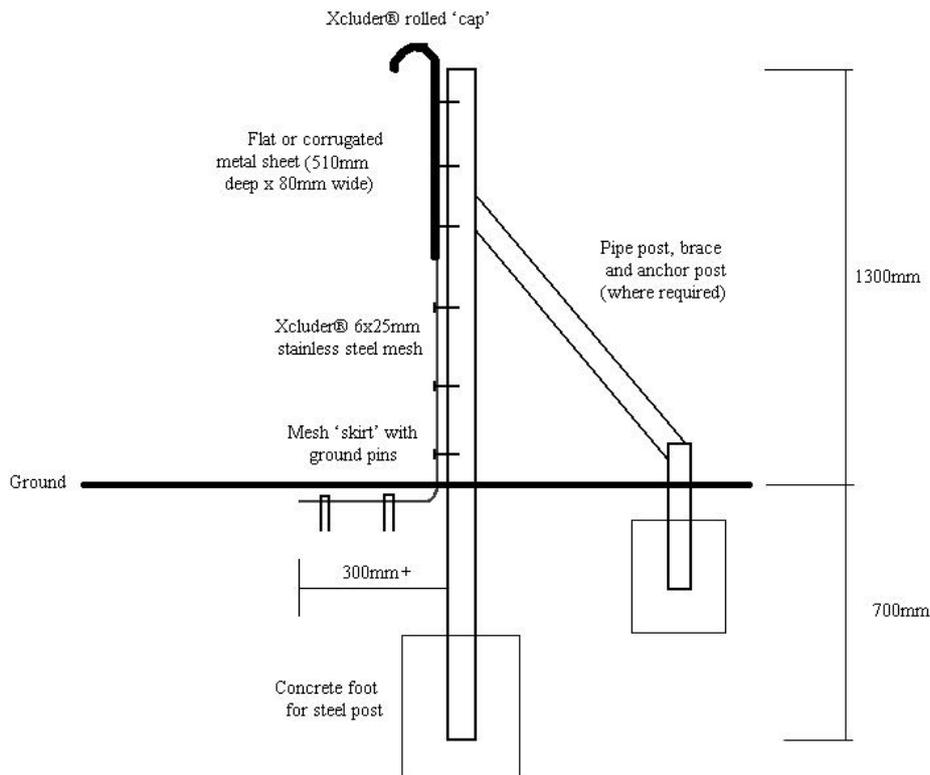


Figure 4b: Profile of an Xcluder® “10-pest” fence with steel framework and bracing.

Typical material Specifications for Xcluder® Fence Designs:

Fence posts:	Timber: H5 and H4 treated Landscape grade 135mm posts and 185mm strainers; or Steel: 50mm diameter hot dipped galvanized or anodised aluminium posts with bracing.
Supporting wires:	2.5 mm hi-tensile ss304L stainless steel wire.
Mesh:	Xcluder® 6 x 25 mm ss316 “marine grade” welded mesh (or larger aperture if mouse exclusion is not required).
Horizontal mesh joint:	Karaka green 50 x 3 mm Al flat bar and 50 x 25 x 3 mm Al channel.
Hood:	Karaka green ZRX-grade double-painted roofing iron.
Fastenings/fixings:	Aluminium and stainless steel screws, rivets and wire ties.

Fence and Product Life Expectancy:

Xcluder® provides standard warranties of up to 5 years on fence workmanship and materials quality. In addition, we use several well-known materials in our fences that have recognized life expectancy and quality specifications.

All timber posts used by Xcluder® are ground treated in accordance with the ISO9002 MP 3640 1992 standard, and consequently can be expected to have an effective life equal to posts used in a typical farm permanent fence. In many situations we use higher post treatment strengths (e.g. H5 instead of H4 treatment) for added longevity.

It is recommended at many Hawaiian sites that the base fence base should be constructed using anodised aluminium posts and stays, at approximately 2m linear spacing along the fence length. Stays should be used where required, and on average every 4 posts. Using anodised aluminium protects the base fence from coastal corrosion influences and termite attack.

The Xcluder[®] hood is made of zinc-alum Colorsteel[®], the same material that is used for roofing iron in New Zealand. The Colorsteel manufacturers produce several grades of their product. Greater amounts of aluminium are used for material that is used in corrosive environments such as those close to the sea. The independent BRANZ appraisal of Colorsteel (BRANZ Appraisal Certificate No. 303 (1994) states that Colorsteel can be reasonably expected to have “a serviceable life of 15 years in severe corrosion environments, and 50 years in moderate exposure environments.” The manufacturers of Colorsteel offer a grade of Colorsteel, “Maxx”, which has significantly longer lifespan than the conventional product when exposed to salt laden coastal winds. In environments where corrosion may be extreme, Xcluder[®] makes its hood sections out of higher specification Colorsteel, aluminium and, on occasions, stainless steel to increase fence longevity.

Xcluder[®] uses **stainless steel mesh** coated with a green PVC coating for all of its “all-pest” fences. We have an exclusive supplier of high quality marine grade (“316”) stainless steel mesh. Research suggests that 316 stainless steel mesh is likely to have a lifespan at least double that of zinc-aluminium coated mesh and perhaps as much as six times the lifespan of zinc coated (galvanised) wire, especially in corrosive environments. On the basis of the data available we expect the 316 stainless to have a lifespan in excess of 30 years on corrosive sites (e.g. exposed to salt-laden winds), and substantially longer on non-corrosive sites.

All of our ancillary fence components, such as steel posts, hood brackets, pedestrian and vehicle gates, and watergate structures, are sealed in hot-dip zinc galvanising or are made of aluminium. The zinc coating applied meets the approved New Zealand industry standard, NZS 4680. (Note that this standard refers to the quality of the zinc application process, it does not convey a guarantee of lifespan). For very corrosive areas we offer anodized aluminium brackets, gates and fittings in addition to posts.

Xcluder[®] use metallurgists to test all new product and provide technical support and information to verify the quality and expected longevity of the products we use, and to warn of product incompatibilities. We have a large amount of comparative data on the performance of various materials used in pest fence applications and use this data to assist with materials selection.

Fences are designed so that sections or materials can be replaced without having to completely strip large parts of the fence. In the event that one small section of fence is damaged or needs replacing, that small section of material can easily be replaced without compromising the rest of the fence.

Construction Precision:

Construction precision is as important as the fence design and the quality of construction materials when it comes to producing an effective pest-proof fence. There can be no gap wider than 7mm if juvenile mice are to be excluded.

To ensure every fence built is completely pest proof, Xcluder[®] has developed a rigorous quality control programme for our staff and any contractors working on our fence lines. Each fence we construct is built to detailed specifications and is rigorously inspected repeatedly through the period of construction. At the conclusion of construction our fences are independently inspected for their workmanship and their pest-proof standard and we are happy to offer such inspection as a condition of contract completion.

Xcluder® Fence Components:

For a pest fence to be fully effective and for pest eradication to be achieved the constructed fence must be 100% effective at excluding all target pests around its entire perimeter. Waterways, drains, gates, and abutting fences must all be made pest-proof. Xcluder® have designed, developed and tested specialised components to accompany its base fence designs:

Xcluder® water gates:

Xcluder® have developed pest-proof watergate designs (see Figure 5 for an example) for permanently flowing streams that open under high or flood flows and close again when flow returns to normal levels. The principle behind the watergate operation is that the gate only opens when water flow is beyond the swimming capabilities of pests such as Norway rats. On-site inspection of waterways is usually required to determine if or how many water gates will be required at a proposed site.



Figure 5: Xcluder® swinging water gates mounted in concrete box culverts.

Pest proof culvert screens:

Whenever an Xcluder® pest proof fence is built across the face of a hill all water runoff from above the line of the fence must be captured in water tables and channelled away from or under the fence. Runoff cannot be allowed to flow through the fence itself because the turbulence generated as water passes through the mesh can create unacceptable erosion. Xcluder® has developed several culvert screens (Figure 6) to manage the water flow through under-fence culverts in a pest proof manner.



Figure 6: Xcluder[®] culvert screens. Conventional screen (left) and culvert cube (right) to carry larger water volumes and /or deal with channels which carry debris which may block a conventional screen.

Xcluder[®] pedestrian, vehicle and automated gates:

Xcluder[®] has developed a selection of fail-safe, pest-proof pedestrian (Figure 7) and vehicle access gate systems (Figure 8) that cannot be left open or ajar by careless operators. The gate systems available range from small pedestrian cages for landowners to large scale public access pedestrian cages, and from manually operated to fully automated double vehicle gate systems.



Figure 7: Xcluder[®] public entry pedestrian double gate system (left); view of single person entry cage from inside the fence (right).



Figure 8: Xcluder manual vehicle gate (top) and automated vehicle gate (bottom).

Xcluder[®] abutting fence junctions:

There are many situations where subdivisional farm fences must adjoin the pest fence and this can provide easy access for some pests to reinvade a pest free area. Xcluder[®] has developed a variety of techniques that enable abutting fences to be rejoined without increasing the likelihood of pest invasion (Figure 9). Abutting fence junctions are not likely to be required at your site.



Figure 9: Xcluder® abutting fence “A-frame”

Remote electronic surveillance:

Xcluder’s® Remote Electronic Surveillance System provides 24 hour a day reporting of any fence breach caused by tree fall etc and reports any vehicle, pedestrian or water gate left open. We see remote surveillance as an essential monitoring tool, especially where the risk of tree fall is a threat to fence integrity and/or where there are likely to be frequent gate openings (e.g. on auto and maintenance gates). Recent research has demonstrated that pest animals are likely to detect and use fence breaches within a relatively short time of the breach occurring (Connolly *et al.* 2009; Speedy *et al.* 2008). Therefore, it is essential for fence integrity that an effective breach detection system is used.

The system comprises a number of remotely (solar) powered devices (Figure 10) that send ‘real-time’ messages about the status of gates or sectors of fence via the mobile phone network. Gates are monitored using standard security switches and fence sectors are monitored by continuously measuring voltage on a conventional electrified fence wire that travels the length of the fence. When a tree or branch falls on the fence and ‘shorts’ it, alarm messages are sent. Typically, the fence monitoring wire passes through ‘earth rings’ and is positioned far enough above the top of the fence to ensure that almost any tree or branch that falls on the fence is detected by the wire. At most sites we find that surveillance will be an essential component of the project success.



Figure 10: Xcluder[®] electronic surveillance wire and remote solar powered monitoring device on a section of fence at Maungatautari, New Zealand.

Livestock protection:

Although not required for pest exclusion, we recommend that if any livestock are present, 2 electric fence wires be mounted on the outside of the fence at 250mm and 900mm above ground, to protect the fence from livestock and pigs. Examples of electric outriggers can be seen in Figures 3 and 10. It is not expected this will be required for your fence.

Earthworks required:

Xcluder[®] normally uses a standard farm-track/roading earthworks prescription for protecting the fence base from erosion and providing a stable long-term base. This prescription has been demonstrated to be highly effective in a variety of terrain and soil types and is briefly summarized below:

On steeper fence sections, across gullies and through areas of scrub and trees a 4 to 5m wide fence platform is usually formed using a digger. Platform formation requires clearing of small trees and vegetation. A platform of this width is necessary to accommodate the fence, provide room on the outside of the fence for a vehicle to pass for fence inspections, and room on the up-hill side for the construction of a water table to trap and channel all runoff (see Figure 11). Surface water runoff tends to bounce off the mouse proof (6mm x 25mm) mesh that we use causing accelerated erosion; for this reason we must prevent water flowing through the line of the base of the fence in any concentrated way by mounding the fence platform, creating water tables, and drawing surface runoff under the fence through screened culverts. The longer and steeper the section of fence, the greater the number and frequency of cut-out culverts that will be required.

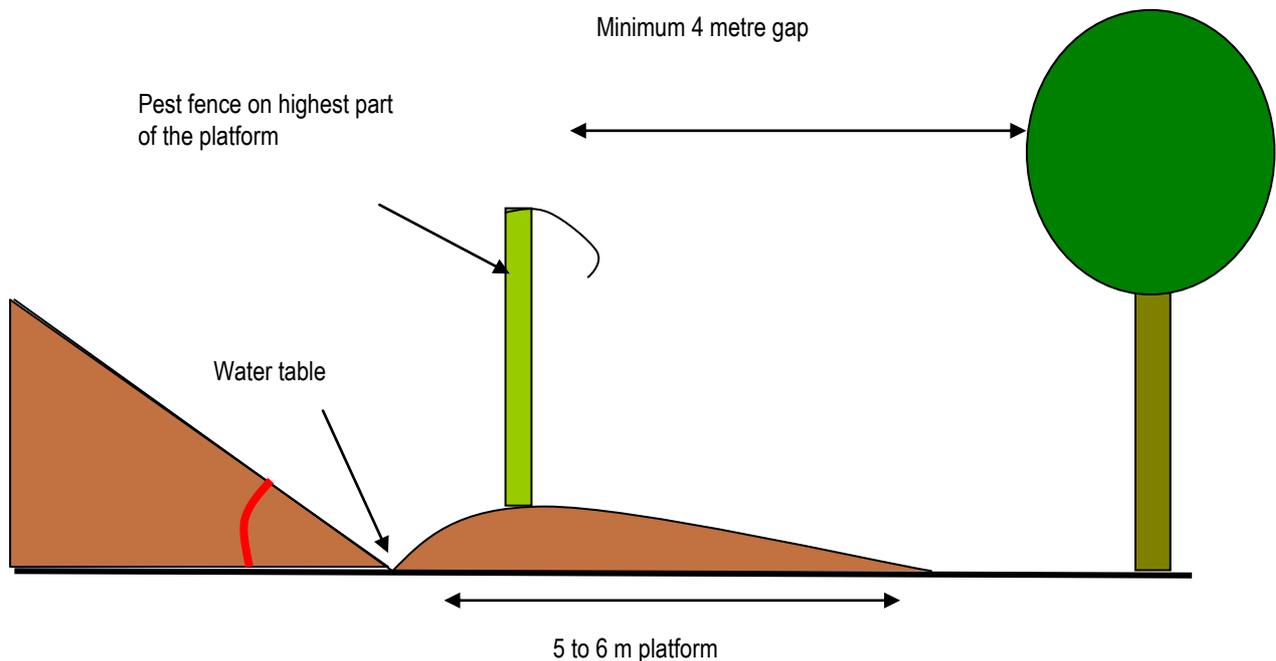


Figure 11: Diagram of standard fence platform used on steeper sections of pest proof fence.

Indicative costing:

The following notes summarise our indicative costs per metre to build a pest proof fence on Oahu, Hawaii:

Our costing assumes the following:

- This pricing has been compiled without a site visit and little knowledge of the site. We suggest that the best way to gain a more accurate costing for the site would be to look at background information, maps etc, then visit and walk the proposed line(s). Xcluder's fencing Manager and General Manger will be in Hawaii from 22 March to early April, and either could visit your site to more accurately determine the logistics and cost of fencing.
- Xcluder® would undertake all of the proposed fencing work and gate installation, including the provision of all labour and supply of all materials.
- For your site we would recommend the construction of a 'kiwi' fence which should be constructed to withstand coastal influences including wind and salt. We would recommend the use of anodized steel poles and stainless steel components, similar to that recently constructed at Kaena Point (Figure 12). A lower cost option would be to substitute the anodised steel poles for galvanised poles, but there would be a subsequent reduction in longevity.
- Any earthworks required would need to be discussed with local earthmoving contractors with knowledge and experience of the area.
- Pricing is based on the mesh purchasing price and current exchange rate on 2 March 2011. Materials prices (and therefore total fence cost) will remain subject to change at time of contracting.



Figure 12: Xcluder 'kiwi' fence, constructed with anodised aluminium components at Kaena Point, Oahu.

- Excluded from this costing are any costs associated with:
 - gaining appropriate permits, consents or approvals to undertake earthworks or construct the fence;
 - accommodation and food;
 - travel to and from Hawaii;
 - shipping of materials to site. Note: we recently shipped 1 km of materials to Hawaii via container for approx US\$5,000.
- The indicative cost per lineal metre for a fully installed 'kiwi' fence, including material cost, would range from a low-spec fence costing **US\$250/m** to a full hi-spec fence cost of up to **US\$500/m**.
- For comparison, the recent construction of a pest-proof fence at Kaena Point, Hawaii, was in the region of US\$430/m. This fence was constructed using hi-spec materials and due to its relatively short length and difficult accessibility resulted in a greater cost per metre.
- The indicative cost of a fully installed '10 Pest' fence, (which would not keep cats out of the site, and has not been tested against mongoose) including material cost, would range from a low-spec fence costing **US\$175/m** to a full hi-spec fence of up to **US\$225/m**.

References:

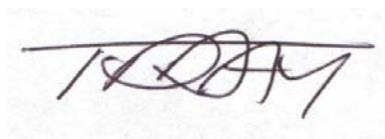
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I trust that this document provides you with some of the background information and indicative pricing you require for now.

We will be in Hawaii from 22 March until early April and there may be an opportunity for either myself or our Fencing Manager to visit your site to discuss the project and options in more detail if appropriate. Alternatively we could meet you at the Kaena Point project site during that period.

Please do not hesitate to contact me if you require further information about any aspect of your proposed project.

Best regards,



Dr Tim Day

APPENDIX E. PUBLIC COMMENTS

Written Public Comments from: Ka'u Coffee Festival, Saturday, May 14, 2011, at Pahala Community Center and Meeting on Sunday, May 15, 2011 at Honu'apo Park

Verbal Public Comments from Public Meeting on Sunday, May 15, 2011 at Honu'apo Park

DRAFT HONU'APO WETLANDS HABITAT RESTORATION PLAN

Written Public Comments from:
Ka'u Coffee Festival, Saturday, May 14, 2011, at Pahala Community Center
and
Meeting on Sunday, May 15, 2011 at Honu'apo Park

The following are written comments received from individuals who filled out a comment sheet with two questions: What is your opinion and/or comments about this Plan?, and How should Ka 'Ohana improve or change this draft Plan?

WHAT IS YOUR OPINION AND/OR COMMENTS ABOUT THIS PLAN?

1. Sounds good so far
2. I think it is well thought out and well-planned
3. Predator control is key
4. Needs more input...perhaps a few more meetings
5. Knowing how very important this is I feel we should start yesterday. Putting together programs to raise funds should start now.
6. Sounds great. I think structures (swale diversion channels) above estuary would help to protect estuary
7. Seems like effort went into keeping it simple for maintenance and replanting natives. I am very concerned with herbicides being sprayed near the pond.
8. I like the plan, except for the fence. I feel that it would be torn down by some of our ohana.
9. Better than nothing
10. Excellent, concise report.
11. Great, approve. Would like to see move forward wetlands and re-vegetation and cultural center and especially the need for fencing to protect the eco system from predators.
12. This plan will bring restoration and a home for bird life. And a place for enjoyment for the community.
13. Fence (yes) and bike path
14. Fence blocks beautiful view - use active predator control.
15. Active predator control – yes
16. Yes to plan
17. Predator proof fence rather than trap and kill.
18. You can only restore the habitat with the fence. One look at the conservatory forest up above will convince you.
19. No to the fence. I favor wetlands restoration
20. Name it the "Honu'apo Bird Sanctuary." Use as an outdoor classroom
21. I would choose implementing restoration for the place
22. Keep up the good work
23. I would definitely like to see native plants and bird habitat there.
24. In favor of removing alien vegetation and planting endemic and native plants, restore etc. hydrologic regime. Reservations on fencing.
25. Cool ideas. Sounds like some interesting proposals – can you get some corporate or private funding?
26. Love it! Such an important thing to bring back to way it was – look forward to seeing the birds!
27. Always improve the eco-system
28. I think it is a positive and doable. This plan has my support.
29. The plan is excellent. Yes for the fence

30. Mostly great – a few reservations about removing windbreak trees. This is a special place that should be kapu! Habitat destruction is the biggest threat to Hawaiian flora and fauna.
31. Prefer [active] predator control – yes
32. This is a very necessary plan. Please provide any resources and/or assistance to put this into action.
33. Great plan.
34. If tastefully done?? Fence is OK with myself.
35. Great plan with the fence.
36. Yes, I agree with restoration of the estuary. It is a tough choice between the fence and trap & kill. I need time to think about the loss of the view.
37. I agree with it. Rather than fences, the predators must be killed?

HOW SHOULD KA'OHANA IMPROVE OR CHANGE THIS DRAFT PLAN?

1. Make changes if something doesn't seem to be working
2. At this point I don't think it needs changing.
3. Add swell to prevent run-off from mauka!!! Add predatory fence around estuary!!!
4. Show expanded horizons and put more emphasis on reaching out to the eco preservation lovers worldwide not just in Ka'u
5. I think your plan is excellent and minor changes can be incorporated as needed.
6. Maybe once every month or every other month have a booth set up with drawings of what it would look like with restoration – maybe a board down at Park?
7. Aloha
8. Keep reviewing the process but good job so far.
9. I'm not sure about changing the plan because Honu'apo need this...
10. Fence. Bike path.
11. Educate people about it.
12. I choose the fence design
13. Plan OK
14. I have a plan to restore the springs.
15. I would go to improve local and migratory bird habitat.
16. N/A
17. Fence is questionable both in cost and looks. Why not do restoration of wetland and wait on fence. See how it goes as far as birds surviving.
18. Cost to benefit could be interesting. Fencing would be better than trapping? If it is cost effective.
19. Start now not later.
20. Not needed at this time.
21. Keep on keeping on. Mahalo.
22. Let Hawaiian kuleana families become involved as stewards with the plan and including cultural (and environmental) education/participation so community may embrace for local Ka'u youth. Also ask local talent for input and help
23. A kapu (fishing and taking) system – to maintain control of marine resources.
24. Perhaps a simple handout to describe the plan.
25. Give the county parks guys new t-shirts.
26. Your community would know the best
27. Not sure. Have not had enough time to really think about it.

KA'U RESIDENTS = 29

OTHER [Visitors to Ka'u] = 4

DRAFT HONU'APO WETLANDS HABITAT RESTORATION PLAN

WHRP Public Comment Meeting
Sunday, May 15, 2011, 1:30 PM to 3:00 PM
Honu'apo Park

Verbal Comments from Questions and Answers (following a presentation by Andy Hood and Kristin Duin from Sustainable Resources Group, Intn'l, Inc., Lehua Lopez-Mau, E.D., Ka 'Ohana O Honu'apo, and J Rubey, Pacific Coast Joint Venture Program):

What are the costs involved?

~\$400,000 to \$500,000 (without an anti-predator fence), including costs to excavate, restore springs and remove alien plants (e.g., kiawe).

What is the tidal range here at the estuary?

2.91' MHHT (high tide)

-0.9' MLLT (low tide)

~around 2.5' range during the study

15% (salinity at high tide)

Are there (will there be) differences in tidal ranges with global climate change?

That research was not monitored here.

But sea level rise is happening elsewhere in the Pacific.

With this current plan, tidal range from sea rise should not affect bird habitat.

What is the depth of the pond now and before the plantation era?

Now—5 to 5.5 feet deep in spots, some areas less than 1 foot in low tide.

This is a young geologic site so you hit bedrock fairly quickly if you dig more than a few feet.

No information about how deep it was before the plantation era.

How will you prevent re-silting/sedimentation after restoration?

No plans have been made to do that yet.

Can you create channels to prevent run-off [into the wetlands] from storm events and flooding?

Not in this plan.

What will be the physical changes to the kuleana parcels?

No work will be done (removal of invasive species/planting of native, excavation) without permission.

Did you find any toxins in the water-quality tests?

No testing was done for toxins (for this plan), but in the tests conducted just prior to the sale of the land to the state in 2004, no toxins were noted.

There are no registered sites (with EPA or the state) with pollutants on this property.

Are you going to remove all the mud in the pond?

No

Are there any burial sites?

Two archaeological surveys have been done, the most recent was completed summer, 2010. There are nine unique features within the estuary. One was prehistoric—a wall by the channel, some are historic—like the remains of a Japanese garden planted close to the estuary during the plantation era by residents of the manager's house. It is likely that much, if not all, of the old Hawaiian sites have been destroyed by sugar industry activities and by earthquakes and tsunamis.

Will there be any areas around here to plant native plants?

Besides the appropriate native plants planned for bird habitat, the Park's General Resources Management Plan includes a "Discovery Garden" of Native Hawaiian plants (to be located at the end of the Mill Ditch Road) for educational purposes.

How does the Ala Kahakai trail fit into the Plan? Will there be access?

Everything north of the Mill Ditch Road will be wilderness. Existing trails will be left the way they are now.

Comment

It would be nice to have a designated AKT point at Honu'apo.

If you are going to remove non-native plants, which native plants will you plant for the birds?

Makaloa, Akulikuli, aku'awa, and at least 3 more appropriate for bird habitat.

Are there any examples of a successful restoration project over decades in Hawai'i?

Yes, lots of projects. The range of success is from very good to failure. Restoration projects are labor intensive, even for moderate restorations. This plan does not include heavy continued maintenance requirements.

Are your environmental objectives viable in the long haul?

Yes, because we hope the salt water [which will poison alien and exotic plants] will help maintain the native plants [those that can tolerate brackish water].

However, there needs to be some continued maintenance [predator control, weed control, etc.] to ensure success.

What is the ecological value [of the wetlands and estuary]?

Historically, Hawai'i had 113 different endemic species of birds, now we have only 35. In the 2010 *State of the Birds* report, "...among the 42 native and endemic species of the Hawaiian Islands, only 1 is not considered to be of conservation concern.. ..it was identified that 93% of Hawaiian species are in danger." There were more than 30+ water bird species, now there are only 6 left and of those, the Hawaiian stilt, the Hawaiian coot, the Hawaiian moorhen, the nene, and the Hawaiian duck were all seen in the past at Honu'apo. Creating a native bird "sanctuary" at Honu'apo could entice those birds back and help to recover their species.

There are also numerous fish, marine, and seaweed species at Honu'apo that would all benefit from wetlands restoration.

Can you put a sign in the Park to warn people about the dangers of the strong currents out here?

(As soon as certain permits and approvals are in place), yes.

Comments

I'm concerned that removing the kiawe trees will lead to more winds in the Park and wind breakers like the kiawe are important.

The reason this area looks the way it does is because it was grazed by cattle. If you don't have grazers, what grows (the invasive species) will create a region of heightened fire threats.

[End of meeting.]