Waiulaula Watershed Management Plan

June 2009

Mauna Kea Soil and Water Conservation District
Kamuela, Hawaii

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Acronyms

ac.	acres
ALISH	Agricultural Lands of Importance to the State of Hawaii
ASEA	Aquifer Sector Area
BMP	best management practice
CDP	community development plan
CDUA	Conservation District Use Application (DLNR)
CDUP	Conservation District Use Permit (DLNR)
CES	University of Hawaii's Cooperative Extension Service
cfs	cubic feet per second
CNPCP	Hawaii Coastal Nonpoint Pollution Control Program
CREP	Conservation Reserve Enhancement Program
CWDA	DOH's Critical Wastewater Disposal Areas
CWRM	Hawaii Commission on Water Resource Management
CZM	coastal zone management
DAR	DLNR's Division of Aquatic Resources
DEM	digital elevation model
DHHL	Department of Hawaiian Homelands
DLNR	Hawaii Department of Land and Natural Resources
DOA	Hawaii Department of Agriculture
DOBOR	DLNR's Division of Boating and Ocean Recreation
DOH	Hawaii Department of Health
DOT	Hawaii Department of Transportation
DPW	Hawaii County Department of Public Works
DWS	Hawaii County Department of Water Supply
EA	environmental assessment
eFOTG	NRCS's electronic Field Office Technical Guide
EIS	environmental impact statement
EMC	event mean concentration
EPA	US Environmental Protection Agency
ER	enrichment ratios
FIRM	Flood Insurance Rate Map
FIS	Flood Insurance Study
ft/d	feet per day (movement of groundwater)
FUDS	Formerly Used Defense Sites
GIS	geographic information system
gpd	gallons per day
HAR	Hawaii Administrative Rules
HBS	Bishop Museum's Hawaii Biological Survey
HCC	Hawaii County Code
HRS	Hawaii Revised Statutes
HWMO	Hawaii Wildfire Management Organization

LCC	large capacity cesspool
LID	Low Impact Development
LSB	University of Hawaii's Land Study Bureau
LUC	Hawaii Land Use Commission
LUPAG	Hawaii County General Plan Land Use Pattern Allocation Guide
MG	million gallons
mgd	million gallons per day
MKSWCD	Mauna Kea Soil and Water Conservation District
MSD	marine sanitation device
MV	mass-volume (curve)
N	nitrogen
NARS	Hawaii Natural Area Reserve System
NH4	ammonium
NPDES	National Pollutant Discharge Elimination System (permit)
NRCS	USDA's Natural Resources Conservation Service
N-SPECT	Nonpoint Source Pollution and Erosion Comparison Tool
OSDS	onsite disposal system
P	phosphorus
SCAP	CWRM's Stream Channel Alteration Permit
SLH	Session Laws of Hawaii
SMA	Special Management Area (permit)
TBD	to be determined
TMK	tax map key
TN	total nitrogen
TP	total phosphorus
TSS	total suspended solids
UIC	Underground Injection Control (line or program)
USACOE	US Army Corps of Engineers
USCG	US Coast Guard
USDA	US Department of Agriculture
USFWS	US Fish and Wildlife Service
USGS	US Geological Survey
UST	underground storage tank
UXO	unexploded ordnance
WWMP	Waiulaula Watershed Management Plan

Chapter 1: Introduction

The Waiulaula Stream watershed encompasses over 18,000 acres in the South Kohala District on Hawaii Island. The streams within this watershed flow more frequently than any other stream system in West Hawaii, creating important habitat for the native aquatic species. The nearshore waters of Kawaihae Bay, into which Waiulaula flows, provide an important nursery ground not only for the native stream fishes but also for species important to the marine recreational, subsistence, and commercial fisheries. The upper reaches of the streams also provide water for both domestic and agricultural use.

The watershed supports a variety of land and water uses, ranging from agriculture to urban to commercial to conservation. The South Kohala District which encompasses this watershed has experienced tremendous population and residential growth over the past 20 years. Much of this growth has occurred within the watershed. No studies have been done on the impacts of this cumulative and ongoing development on the riparian, stream, and coral reef habitats, and stream and coastal water quality. However, it is generally agreed that the water quality within the watershed remains good. Through the Waiulaula watershed management project, the Mauna Kea Soil and Water Conservation District seeks to be proactive in the management of this important watershed, focusing on the prevention of pollution rather than waiting until there is a water quality problem downstream that requires a potentially expensive and difficult restoration effort.

1.1 Document Overview

This watershed management plan addresses both EPA's 9 key elements for watershed-based plans and the applicable management measures for Hawaii's coastal nonpoint pollution control program (CNPCP). Chapter 2 describes the natural and socio-cultural resources of the watershed. Chapter 3 provides water quality and biological data for the watershed, as well as estimations of pollutant loads. Chapter 4 describes the threats to the water quality of the watershed, and Chapter 5 outlines goals, objectives and recommended actions that address these threats. Chapter 6 details the implementation program, while Chapter 7 describes the monitoring plan to measure effectiveness of implementation efforts.

1.2 Watershed Management Plan Purpose and Process Used

The Mauna Kea Soil and Water Conservation District (MKSWCD) took the lead role in developing the Waiulaula Watershed Management Plan (WWMP), with significant stakeholder involvement and community input. MKSWCD is a quasi-state agency established in 1955 under Chapter 180, Hawaii Revised Statutes (HRS). Five volunteer directors administer the MKSWCD programs. The MKSWCD takes available technical, financial and educational resources and focuses them to meet the needs of the local land users for the conservation of soil, water and other related environmental resources. MKSWCD has a proven track record in developing and implementing watershed management plans. Prior to initiating the Waiulaula watershed planning effort, the MKSWCD was responsible for the Pelekane Bay watershed management effort. In 2005, the MKSWCD received a contract from the Hawaii Department of Health (DOH) supported with Section 319(h) funding to develop the WWMP.

The MKSWCD directors have been responsible for overseeing the project. The directors who have been involved since the beginning of this effort include: Jim Frazier; David Fuertes; Pete Hendricks;

Robby Hind; Ken Kaneshiro; Brad Lau; Chris Robb; and Jim Thain. Carolyn Stewart was hired as the watershed coordinator. She has 20 years of experience in watershed planning and polluted runoff control. John Pipan, the Hawaii Association of Conservation Districts conservation specialist, and Margaret Fowler, office manager, also contributed significantly to the project. Two University of Hawaii graduate students – Katie Gaut and James Tait – conducted their thesis work in the Waiulaula watershed, providing information beneficial to the watershed planning effort.

Other project partners include: Hawaii Department of Health (DOH), US Environmental Protection Agency (EPA), USDA's Natural Resources Conservation Service (NRCS), US Geological Survey (USGS), US Army, Hawaii Department of Land and Natural Resources (DLNR), Commission on Water Resources Management (CWRM), Hawaii County Department of Public Works, Hawaii County Department of Water Supply, University of Hawaii, Parker Ranch, Kohala Watershed Partnership, Waimea Outdoor Circle, Starbucks, Cornell University, Parker School, Hawaii Preparatory Academy, Queen Emma Land Co., FR Cattle Co., and Mauna Kea Beach Resort.

This watershed planning process has been a 4-year effort to develop relationships, educate residents of the watershed on water quality issues, and seek community help to identify contributing pollution sources in the watershed and recommend specific actions needed to effectively control sources of pollution. While a watershed advisory group was initially formed in December 2005 to provide input into the watershed management planning efforts, the MKSWCD found that attendance was generally low. There are many community organizations and committees already in existence, and people were not interested in attending yet another meeting. Instead, the MKSWCD decided to meet with existing organizations and committee and seek input that way.

Presentations were made at the following community meetings:

April 18, 2006	REEFTALK public presentation at Thelma Parker Library
December 20, 2006	Waimea Community Development Plan (CDP) Committee
March 1, 2007	Waimea Community Association
June 1, 2009	Watershed Public Event at Kahilu Theatre

In addition, there were numerous one-on-one meetings and site visits with land owners, land users, government personnel, school teachers, individuals, and other stakeholders to seek background information and to identify and discuss potential implementation projects. A community stream cleanup was held on April 12, 2008, and watershed personnel helped Parker School teachers and students with several additional stream cleanups. Presentations were made at the local schools about the watershed, and the MKSWCD regularly participated in local community events, such as festivals and fairs.

Chapter 2: Watershed Description

2.1 Physical and Natural Features

2.1.1 Watershed Boundaries

A watershed is the land area that drains water to a stream, river, lake or ocean. These drainage areas are normally confined by topographic divides, such as ridgelines. Hawaii's watersheds tend to be small, in comparison to Mainland systems, short in length, and steep. On the geologically-young island of Hawaii, watersheds also tend to display simple stream networks with few tributaries and have shallow, often poorly-defined channels.

The Waiulaula watershed is located in South Kohala, on the northwest coast of Hawaii Island. According to the watershed layer in the Hawaii State Geographic Information System (GIS), this watershed stretches from the tops of Kohala Mountain and Mauna Kea, flowing down into inner Kawaihae Bay near the Mauna Kea Beach Resort, a distance of less than 15 miles. As delineated using the island's 10-meter Digital Elevation Model (DEM), this watershed encompasses an area of about 32,000 acres or 50 square miles (Figure 1).

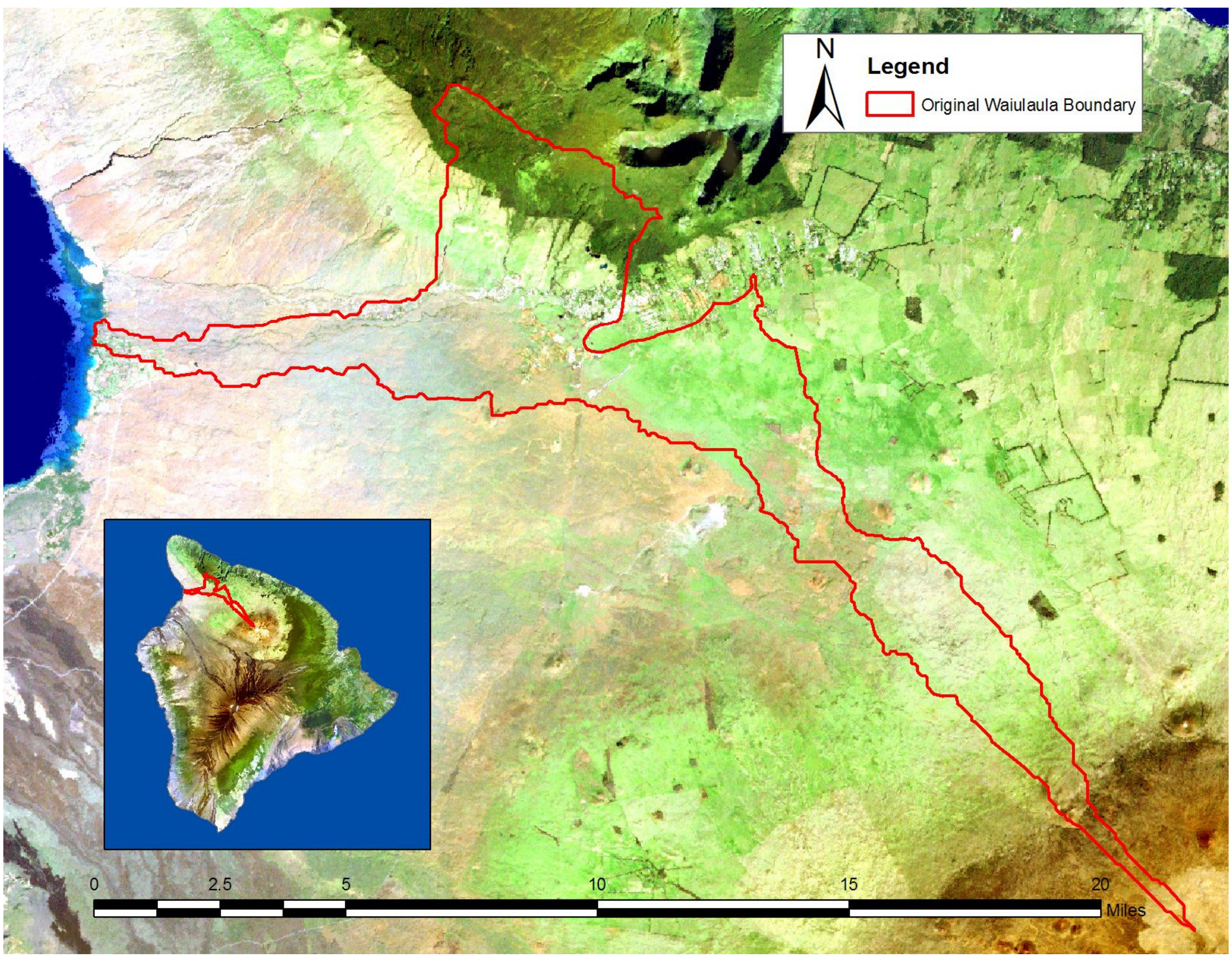
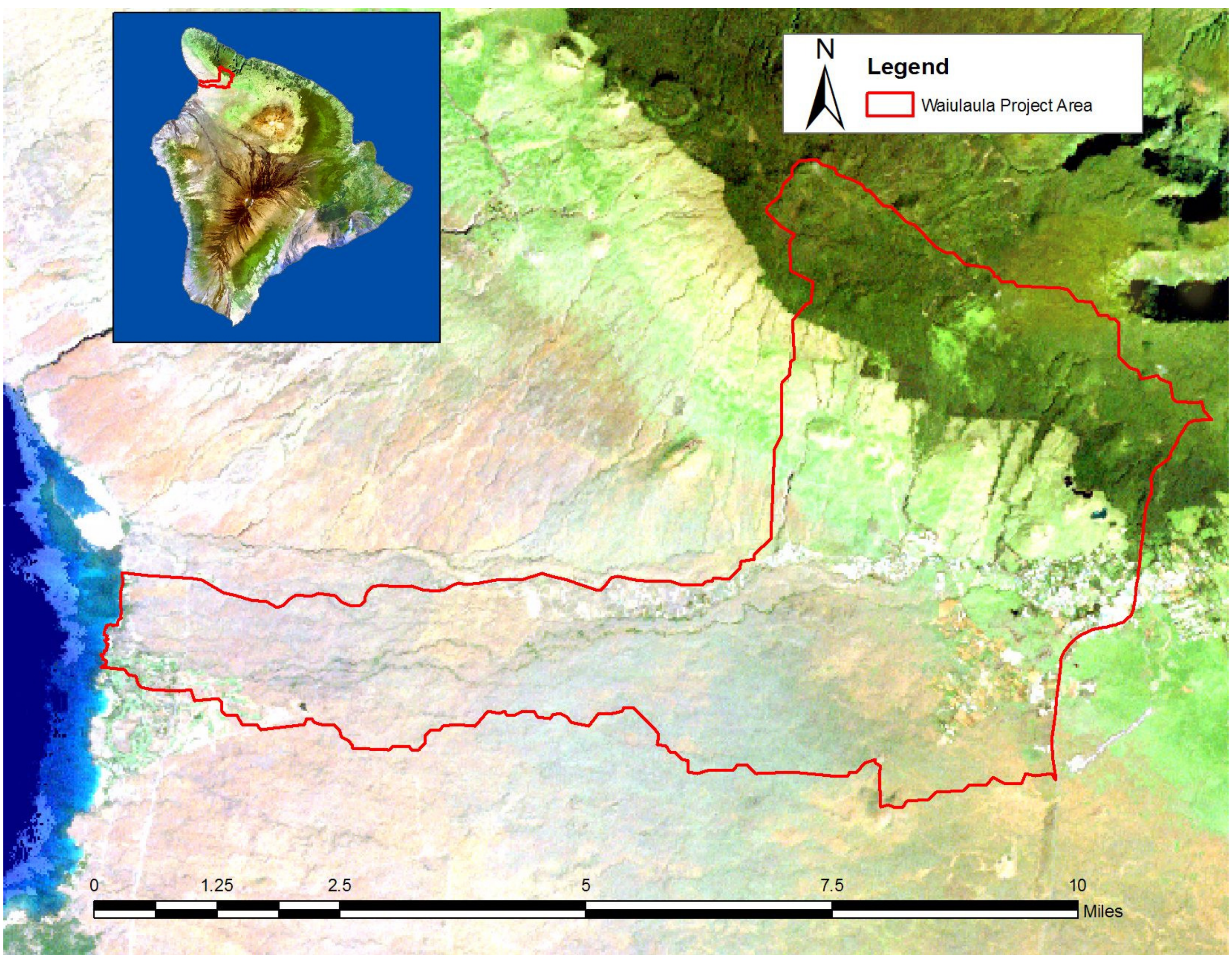


Figure 1: Original Watershed Boundary

As the Mauna Kea Soil and Water Conservation District (MKSWCD) began examining the watershed more closely, there were questions raised about the fate of runoff from the Mauna Kea "leg" of the watershed. It appears that runoff from this section of the watershed does not get into the stream systems of the watershed, but rather collects in the broad, flat plain of the Mauna Kea – Kohala saddle. Because the watershed boundary data would be used in the N-SPECT model to help determine pollutant loading and estimate load reductions, it was important to ensure that the MKSWCD was using appropriate watershed boundaries.

Because the MKSWCD was concerned that using the existing watershed boundary would skew modeling results, render the N-SPECT outputs meaningless, and lead the MKSWCD to focus its resources to implement management measures in an area in which it would be unable to demonstrate significant pollutant load reductions, the MKSWCD revised the watershed boundaries for the purposes of this watershed management project. For the purposes of this WWMP and project, the upper Mauna Kea boundary follows Mamalahoa Highway, thereby eliminating the Mauna Kea "leg." The revised watershed boundary encompasses an area of 18,370 acres or 28.7 square miles (Figure 2).

Figure 2: Revised Watershed Boundary



2.1.2 Hydrology

The hydrology of the Waiulaula watershed is very complex. "Overall, the base-flow characteristics of streams are controlled by the distribution of ground water, which, in turn, is controlled by the local geologic setting and climatic conditions. Dike-impounded and perched ground-water bodies are typical sources of perennial discharge that sustain streamflow at higher elevations" (Tribble 2008 p. 13). In the Waiulaula watershed, a low-permeability layer not far below the ground surface is likely causing a perched waterbody that forms the bog that provides the water for the streams. The watershed's hydrology is further complicated by high permeability geologic formations that cause base-flow to disappear from some places within streams, only to reappear further downstream. Withdrawals of water from the upper reaches of several primary streams for domestic and agricultural uses also reduce the natural flow of water downstream. At this time, the streams are generally perennial in their upper reaches but only flow in the lower reaches during storm events.

Surface Water Resources

The natural surface water resources in the watershed are limited to streams and the upland montane bogs that feed them. The upper elevations of the Waiulaula watershed comprise ohia mixed shrub and ohia/olapa montane wet forest types. These bogs form in areas where low permeability soil hinders drainage, causing standing water to accumulate. Hawaii Island bogs are characterized primarily by sedges, sphagnum moss, and low-stature ohia of varying density (Cuddihy and Stone 1990). While these wet forests are unique plant communities and will be described under Section 3.1.9., they serve as natural sponges that store water for slow release into Kohala Mountain's various stream systems.

Waikoloa Stream near headwaters

The primary tributaries of the Waiulaula watershed are Waikoloa and Keanuiomano streams, both of which originate at over 4,000-ft. elevation on Kohala Mountain and flow relatively parallel to one another until they join in a series of braided channels at about the 1,440-ft. elevation to form Waiulaula, which terminates in the ocean in Kawaihae Bay (Figure 3). Keanuiomano originates from two smaller intermittent tributaries, Waiaka Gulch (which becomes Lanikepu Stream) and Haleaha Gulch, as well as Kohakohau Stream, which is considered perennial. It is called Keanuiomano stream below the 2,200-ft. elevation. Two additional intermittent streams join Keanuiomano just below this elevation -- Ouli Gulch and Mamaewa Gulch (which includes Momoualoa Gulch upslope). A small intermittent tributary of Kohakohau stream is Oolamakapehu Gulch. (See Figure 4.)

Waikoloa Stream has no tributaries. While, historically, Waikoloa Stream has been considered perennial, "it is unclear whether [it] is now intermittent, with perhaps some occasional permanent pools downstream of Waimea, because of … numerous diversions and reservoirs" upstream (Englund *et al*. 2002). The *Hawaii Stream Assessment* (CWRM 1990) classifies Waikoloa Stream as intermittent with year-round flow in the upper reaches and intermittent flow in the lower sections.

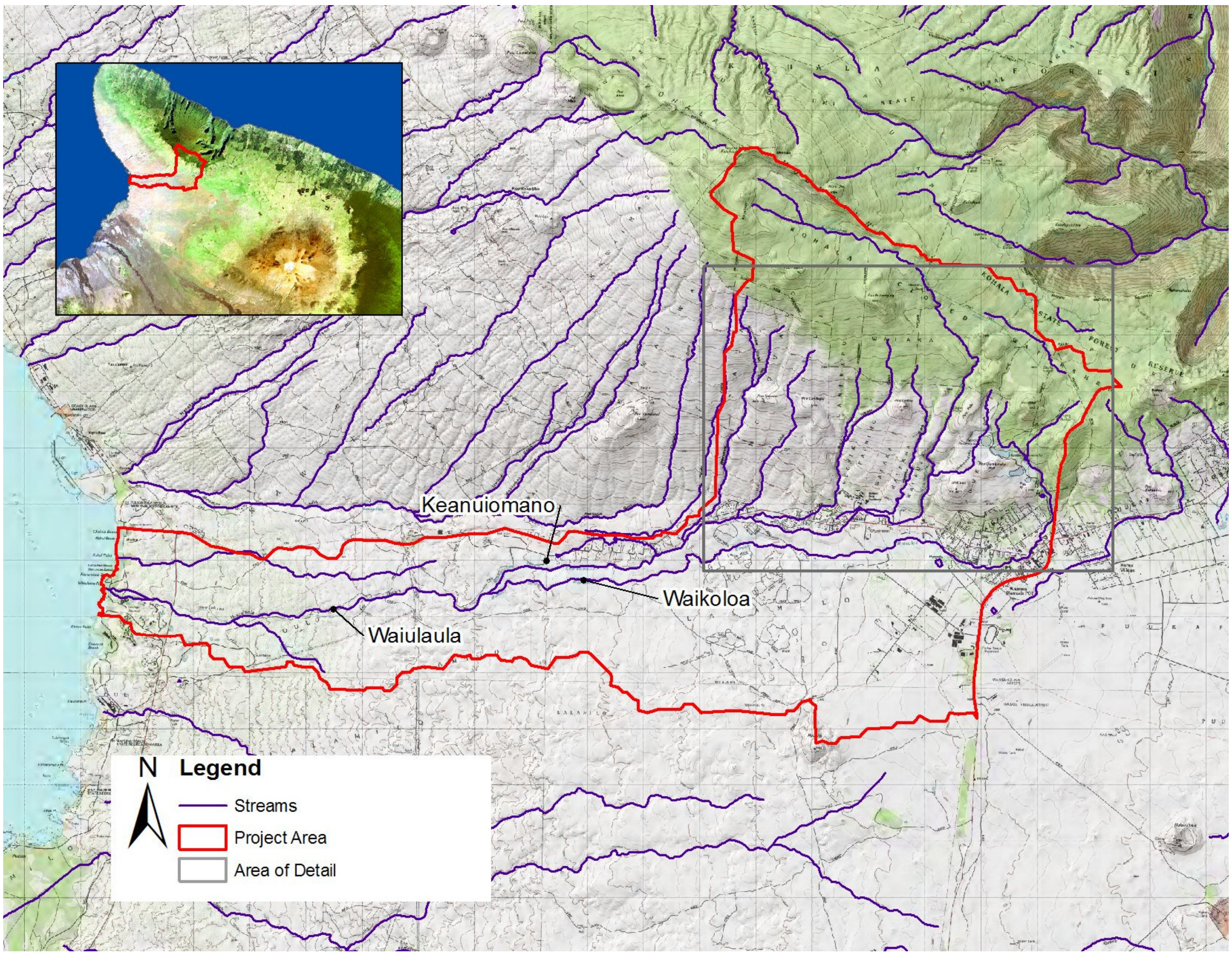


Figure 3: Overview of Streams in the Watershed

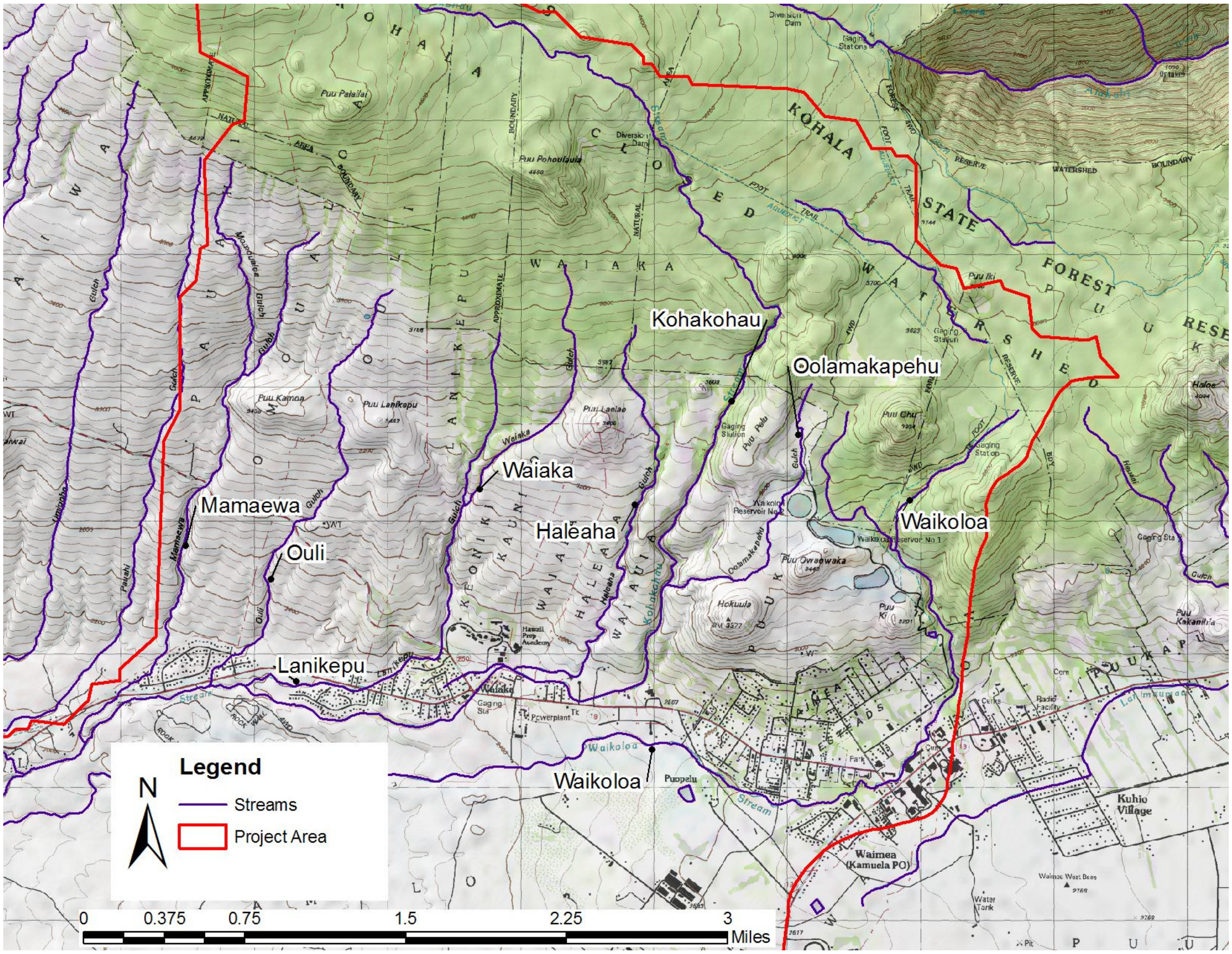


Figure 4: Upper Tributaries of Watershed

The average annual daily flow at Waikoloa and Kohakohau, the only streams that are currently gauged, is 9.13 cubic feet per second (cfs) and 10.43 cfs, respectively. The gauge on Waikoloa Stream near the Marine Dam (USGS gauge number 16758000) provides real time data accessible via the Internet. The gauge on Kohakohau Stream (USGS gauge number 16756100) has a water stage recorder from which data must be downloaded periodically. Maximum instantaneous flow recorded at Waikoloa Stream was 3,390 cfs in 1958. Data available for Kohakohau Stream since 1998 indicate a maximum instantaneous flow of 1,860 cfs recorded in 2005. During storm events, the stream level and flow can increase rapidly, demonstrating the flashiness of Hawaiian streams. There is a significant lag time between peak flow at the upper stream gauge (3,460-ft. elevation) and the lowest stream gauge (sea level), a distance, following the stream channels, of less than 12 miles.

In 2005, the Hawaii Commission on Water Resource Management (CWRM) adopted surface water hydrologic units and a coding system for Hawaii's watersheds, after a review of the *Hawaii Stream Assessment* (CWRM 1990), *State Delineation of Watersheds* (GDSI 1994), and *Refinement of Hawaii Watershed Delineations* (GDSI 1999). The majority of hydrologic unit boundaries closely match drainage basin boundaries (CWRM 2005). The surface water hydrologic unit code is a unique combination of four digits (CWRM 2005). The first digit identifies the island and the following three digits the specific hydrologic unit. A Hawaiian geographic name or local geographic term is also used. The Waiulaula watershed is identified as Waikoloa 8161. According to CWRM's *Water Resource Protection Plan* (2008), the Waikoloa surface water hydrologic unit encompasses 51.96 square miles (less with our revised boundaries), 11 diversions, 4 gauges, and 2 active gauges. See 3.2.4. below for more detailed information.

Groundwater Resources

Groundwater on Hawaii Island occurs as both a freshwater basal lens floating on denser underlying seawater near the coast and as high-level aquifers further inland impounded by lower permeability rocks. Generally, the source of freshwater in the higher elevations is groundwater recharge from infiltration of rainfall and fog drip, as well as irrigation water. The island's subsurface geology controls the movement and occurrence of groundwater (Bauer 2003). Unfortunately, this has not been as well studied as the superficial geology. In the Waiulaula watershed, it is likely that lava flows from Mauna Kea overlay earlier flows from Kohala Mountain, affecting the local presence and movement of groundwater. (See Section 3.1.8 "Geology.")

Tribble (2008) explains the hydrology of groundwater in Hawaii:

> The porosity and permeability of an aquifer affect the shape of the freshwater lens and how water flows through the aquifer. "Porosity" is the percentage of a geologic formation (sediment or rock) that consists of small pores or spaces that can contain water, and "permeability" is a measure of the ease with which water can flow through a geologic formation. Effective porosity reflects the volume of an aquifer that consists of interconnected spaces through which water can flow. All other factors being equal, a zone of high effective porosity results in higher rates of ground-water flow than does a zone of low effective porosity. The permeability of an aquifer is typically described in terms of its "hydraulic conductivity" (K), which accounts for both the permeability of a geologic formation and the fluid properties of the water flowing through it. Typical K values range from less than 0.1 ft/d (feet per day) for low-permeability volcanic dike rocks to more than 10,000 ft/d for some types of highly permeable limestone. All other factors being equal, high-permeability aquifers have higher rates of ground-water flow and lower water-table levels, and low permeability aquifers have lower rates of ground-water flow and higher water-table levels. (p. 5,8).

As a rule, groundwater normally moves from higher elevations to lower elevations and from locations of higher pressure to locations of lower pressure. The groundwater or hydraulic gradient expresses the slope of the groundwater level or water table and is a measure of the change in groundwater head over a given distance, generally expressed in feet per mile. The hydraulic gradient influences the direction and rate of groundwater flow. Bauer (2003) reports that "[n]ormal ground-water gradients range from less than one foot per mile to greater than 3 ft. per mile in South Kohala in the Lalamilo/Ouli area. Generally, steeper ground-water gradients either reflect higher rainfall and recharge or lower hydraulic conductivity" (p. 21). He goes on to say:

> The steep ground-water gradient between Ouli 1 and 2 wells… may be attributed to the lower hydraulic conductivity associated with denser and typically thicker hawaiite lavas (and possibly mugearite, if indeed, the bottom of these wells penetrates into Kohala lavas). Because of the arid conditions of South Kohala, the steep gradient … may be the result of low hydraulic conductivity of the lavas rather than from direct recharge by rainfall. However, an influx of high-

level ground-water from the Waimea-Kamuela region could be enough to increase the ground-water gradient (p. 21-22).

The Kohala Aquifer Sector Area (ASEA) includes the Hawi (80101), Waimanu (80102) and Mahukona (80103) aquifer system areas (see Figure 5), with an estimated total sustainable yield of 154 million gallons per day (mgd) (DWS 2006). A portion of the Waiulaula watershed, including the headwaters of all its streams, falls within the Mahukona aquifer system area. The southern portion of the Waiulaula watershed falls within the Waimea aquifer system (80301) in the West Mauna Kea ASEA. In addition, water from the Waimanu aquifer system area is transmitted via the Upper Hamakua Ditch and pipelines to Waimea to provide agricultural water for the Lalamilo farmers.

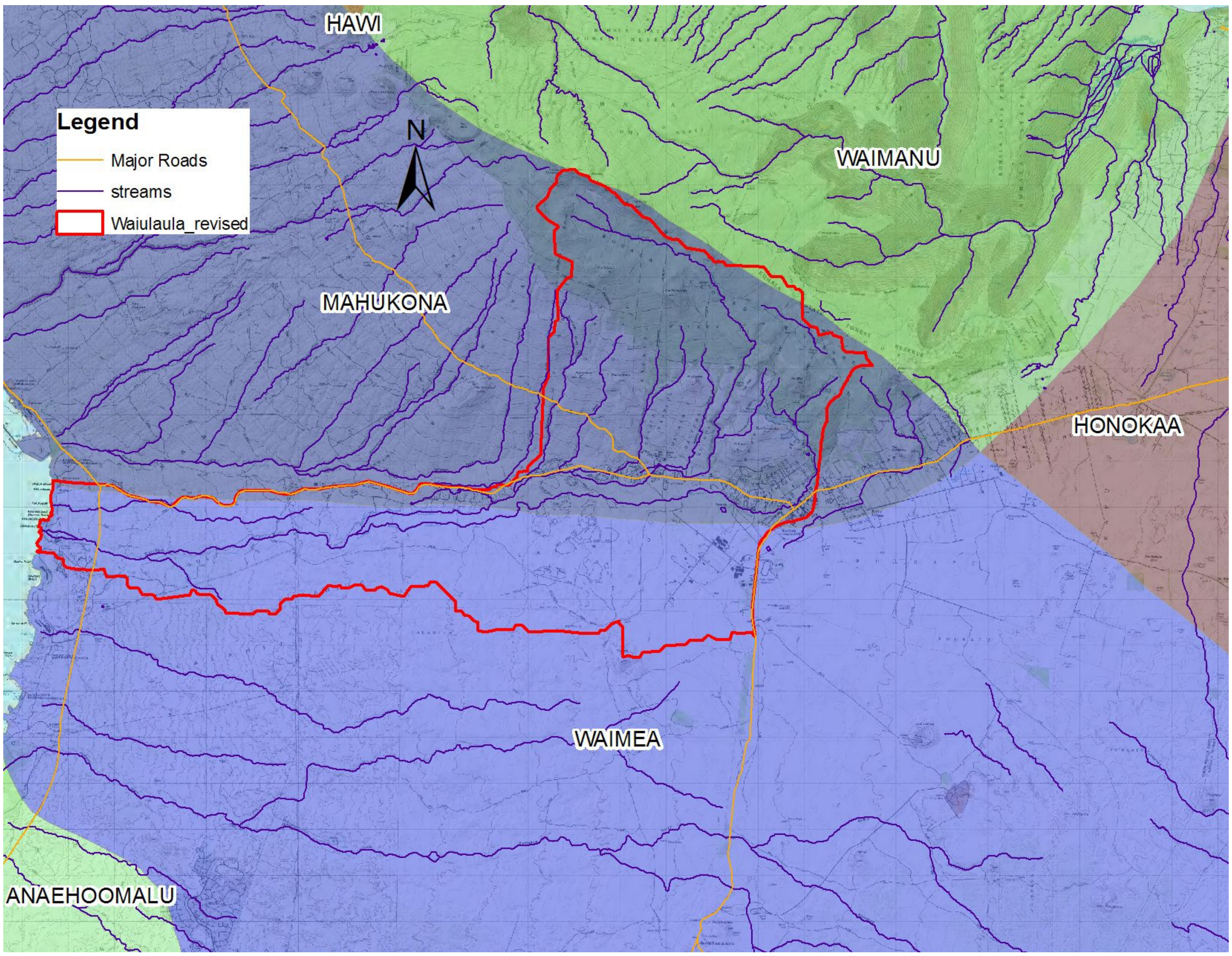


Figure 5: Groundwater Aquifers

In response to competition for water resources in the early 1990s and the lack of basic water level data, CWRM initiated a groundwater monitoring program in 1991. Since then, CWRM has taken groundwater elevation measurements from 40 public and private wells and test holes throughout the North and South Kona and South Kohala districts, including from two within the Waiulaula watershed (Ouli 1 and 2). Bauer (2003) summarizes the results of this program through 2002. In addition, USGS has measured water levels regularly since 1975 in one well, Kawaihae W-3 (well 6147-01; USGS

200132155471101), located at the edge of the Waiulaula watershed at the 982-ft. elevation along Kawaihae Road.

2.1.3 Climate and Precipitation

Because of the steepness of Hawaii's watersheds, their climates vary considerably by elevation. The upper elevations of the Waiulaula watershed are typically wet and cool, while the coastline is hot and arid. The watershed is typically affected by a regular pattern of orographic cloud formation and precipitation. During typical trade wind weather, the wind blows from the northeast direction and rising moist air cools, forming clouds over the top of Kohala Mountain. The cooled clouds drop moisture in the form of rain and fog drip, keeping these upper, forested elevations wet.

Fog drip is the direct interception of water from clouds or fog by vegetation. "Fog drip is likely an important contribution to the hydrologic budget in Hawaii's forested areas frequently enveloped in clouds. This is especially true when there is little or no precipitation occurring" (CWRM 2008). According to the *Kohala Mountain Watershed Management Plan* (KWP 2007), this fog drip is a consistent characteristic of the windward Kohala Mountain slopes above 2,500-feet.

Bog on Kohala Mountain

The clouds formed by the typical trade wind weather rarely make it to the leeward and *makai* reaches of the watershed. These areas are typically dry and receive most of their moisture during Kona storms and localized convection events during the winter months (November to March). Drought conditions in the watershed in recent years have exacerbated the dry conditions in the lower watershed. According to DLNR's Commission on Water Resources Management, severe drought conditions affected North Hawaii or Kohala in 1996, 1998-1999, and 2002-2003, and 2007-2008.

The *Rainfall Atlas of Hawaii* (Giambelluca *et al*. 1986) contains monthly and annual rainfall maps for each island, which generally serve as the standard isohyet maps for use in estimating precipitation across a watershed (Figure 6). Annual rainfall in the watershed varies from about 120 inches in the upper elevations to 7 inches at the coast. In Waimea, the rainfall is highly variable, ranging between 20 and 60 inches per year.

There are two rain gauges in the watershed that are part of the National Weather Service Hydronet: KUUH1 Kamuela Upper; and KMUH1 Kamuela 1. With recent technological improvements, there are more and more weather stations being established within the watershed by individuals. Many of these can be found on the Weather Underground (www.wunderground.com). However, as a more recent phenomenon, these stations provide current and very recent weather data, but not historical.

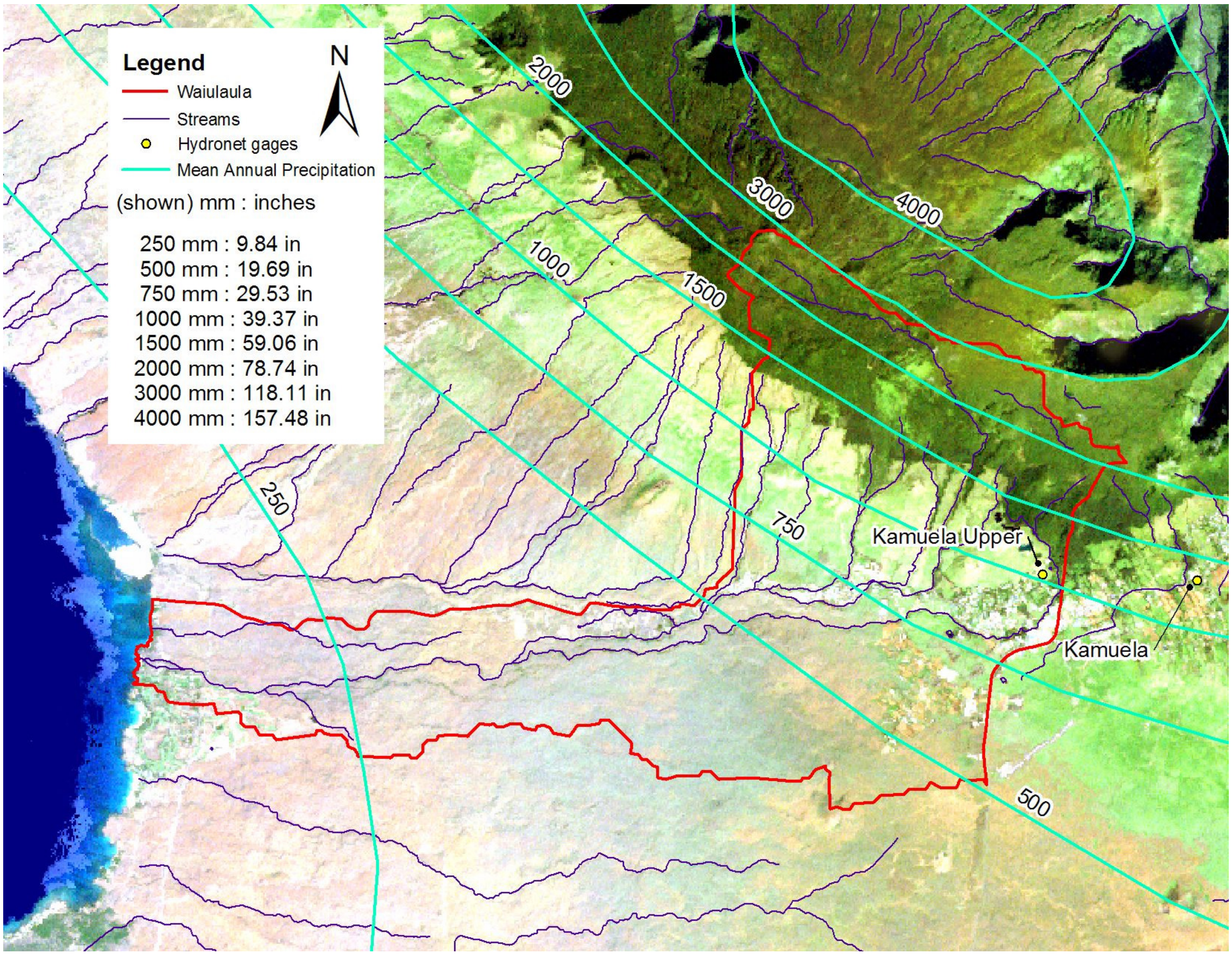


Figure 6: Annual Precipitation

As noted above, trade winds dominate the watershed area. It is during winter months that the major storms occur and the heaviest rains fall. The storms may blow in from any direction but are typically from the south, southwest, or southeast (Kona storms). Mumuku, fierce gusts of wind from the northeast, also blow in the watershed.

Temperatures in the watershed can also be highly variable and dependent on elevation, weather and time of year. Temperatures at higher elevations are typically cooler, while the coast enjoys year-round averages of 70 to 87ºF. In the Waimea area, average temperatures range from 55ºF to 75ºF. According to DHHL (2002), "the extreme minimum temperature recorded at Waimea is 34 ºF, while the extreme maximum temperature is 90 ºF" (p. 4-1).

2.1.4 Flood Plains

Flooding has been identified as a problem in the Waiulaula watershed. Flooding of downtown Waimea and of roads crossing streams has been a particular concern. In 2004, a 25-year storm event led to flooding of downtown Waimea when Waikoloa Stream jumped its banks, and to the closure of Waiaka bridge, Kawaihae Road, and Queen Kaahumanu Highway because of high water. In addition, the pipelines transmitting water from the water treatment plant to Waimea were badly damaged, leaving Waimea without potable water for several days. While flooding has been a reality for decades in Waimea, it has become an even more significant problem as more and more development occurs within flood prone areas.

Photo by Carolyn Wong photo by Rosemary Alles

2004 Waimea Flood

FEMA has developed Flood Insurance Rate Maps or FIRMs for Hawaii Island. Figure 7 shows the flood hazard rating map for the Waiulaula watershed. Zone A is the flood insurance rate zone that corresponds to the 1% annual chance floodplains that are determined in the Flood Insurance Study (FIS) by approximate methods of analysis. This translates into the 100-year floodplain. Zone X500 corresponds to the 500-year floodplain. There is one small area within Waimea town that falls into Zone X500.

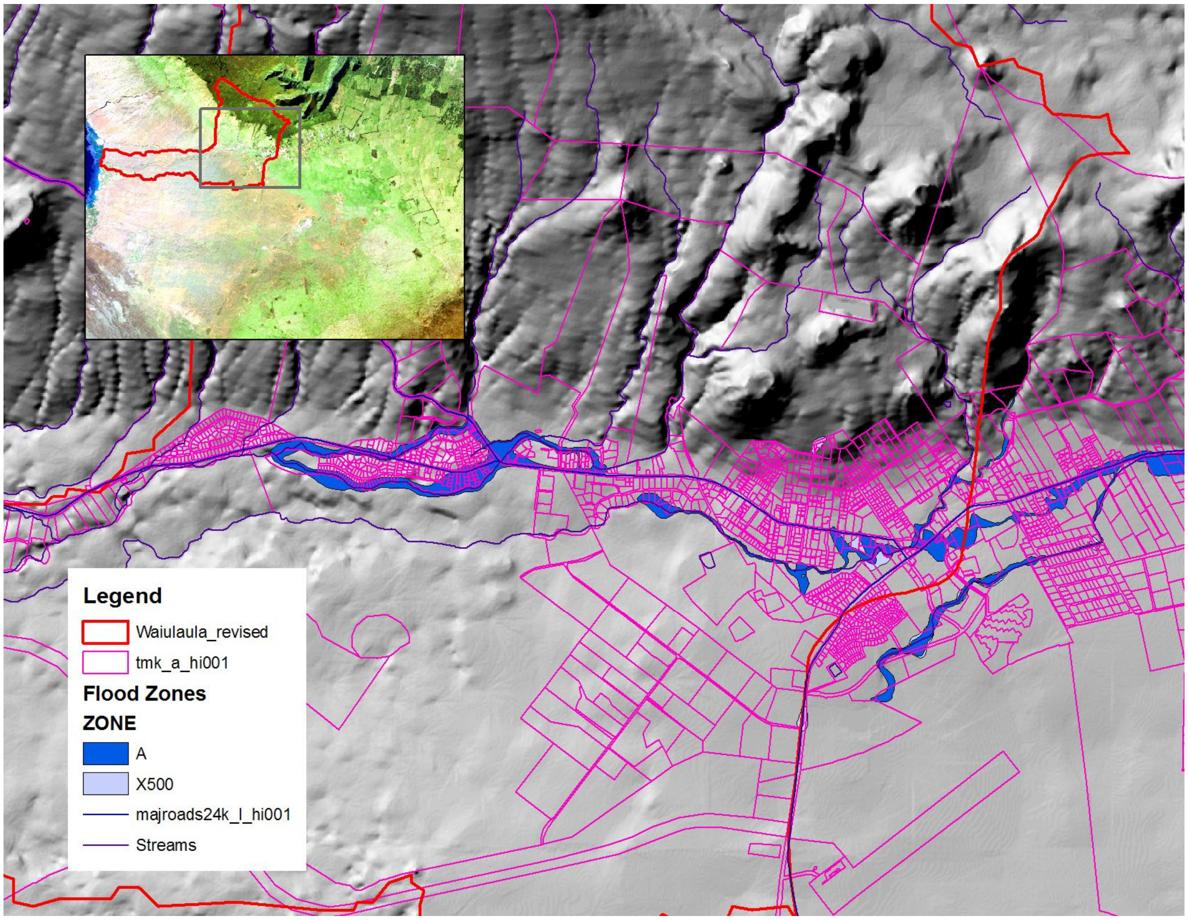
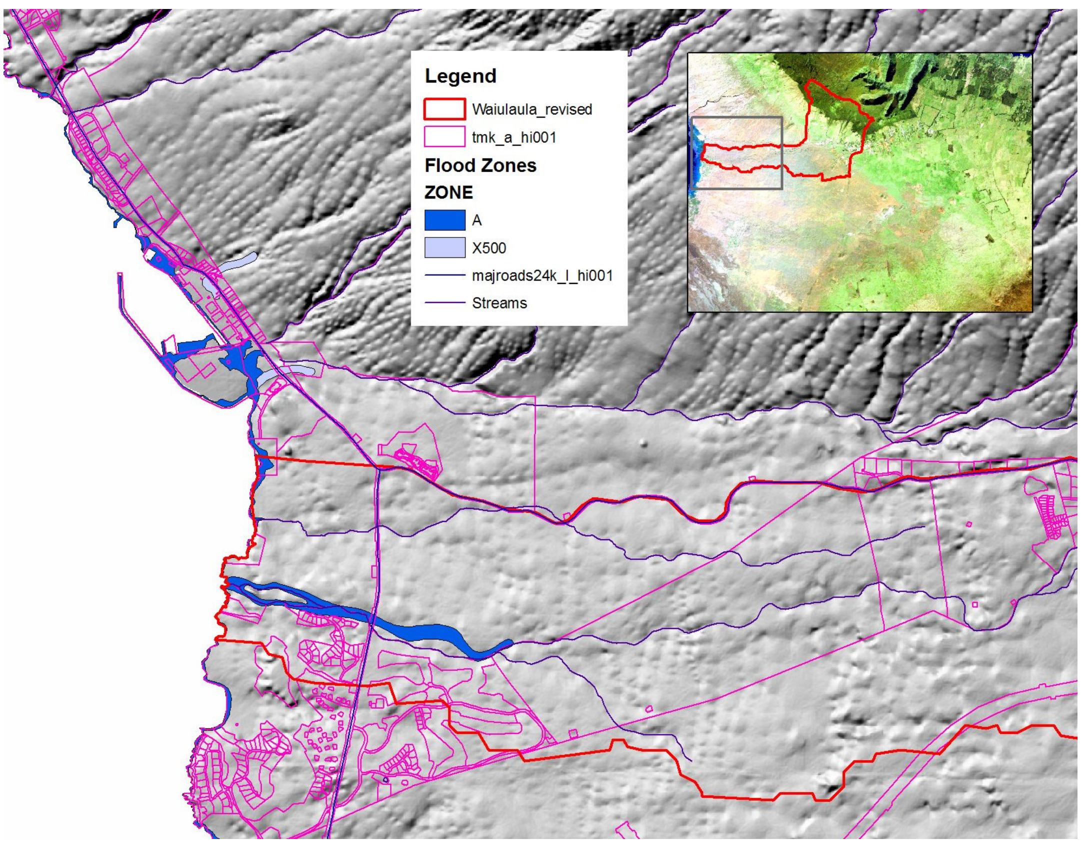


Figure 7: Flood Insurance Rate Maps for Waimea (above) and the coast (below)



2.1.5 Riparian Areas

Most of the streams within the Waiulaula watershed do not have adequate vegetated buffers. While fully vegetated, connected riparian corridors exist in the upper reaches of many of the streams, extensive riparian vegetation generally disappears outside of the conservation district. The pockets of vegetation that exist at lower elevations often comprise invasive species, such as Christmas berry (*Schinus terebinthifolius*), that tend to grow into the stream, impeding stream flow and reducing habitat for aquatic species.

2.1.6 Dams

There are five structures considered dams in the Waiulaula watershed. Three of the reservoirs above Waimea are considered dams because of the heights of the reservoir walls impounding water. There are two dams impounding water in streams, described below. Based on inventoried storage (<1000 acre-feet) and height data (<40 ft.), these dams are considered small.

Marine Dam: The Marine Dam is a diversion dam in Waikoloa Stream at 3,460 ft. elevation, built during World War II by the United States Engineering Department to supply water for a new military encampment of several thousand Marines that was being established in Waimea. Built in 1943, the 5-ft. high Marine Dam captured stream water into a 12-inch lightweight steel clamp-on pipeline. In 1966, the steel pipeline was replaced by a more durable 18-inch ductile iron pipe. A still basin and a cleanout were also added. The Marine Dam still serves its original function today and is the major source of drinking water for the South Kohala Water System.

In 1997, the Marine Dam was officially designated an "American Water Landmark" by the American Water Works Association Water Landmark Award Committee. To receive the Landmark status, the facility must be at least 50 years old and of significant value to the community. The community has always called it the "Marine Dam" in reference to those who were served by this facility. This is the first neighbor island facility to receive this designation.


Marine Dam (left) and Kohakohau Dam (right)

Kohakohau Dam: Planning for the development of Kohakohau Dam started in the mid-1960s, and, by 1975, it was supplying water to Waimea and the surrounding area. This diversion dam is located on Kohakohau Stream at the 3,470-ft. elevation. The dam is approximately 5-ft. high at the sides and 10-

ft. high in the middle and about 45-ft. long. With development pressures along the Kohala and Waikoloa coasts, there was a major push to expand Kohakohau Dam to increase its capacity. This would have required inundation of additional lands in the Kohala watershed. While strong community opposition slowed progress on the Konokohau Dam expansion project, the 1970s discovery and development of potable groundwater in the Lalamilo area eased pressure to expand Kohakohau Dam to create a larger impoundment area.

2.1.7 Topography and Elevation

The Waiulaula watershed extends from the 5,260-ft. elevation on Kohala Mountain to sea level over a distance of 8.5 miles, if measured as a straight line from headwater to estuary. The upper elevations are generally steeply sloped and bisected by deep gulches. From about 2,500-ft. in elevation, the terrain is rugged but more gently sloped. (See Figure 8.)

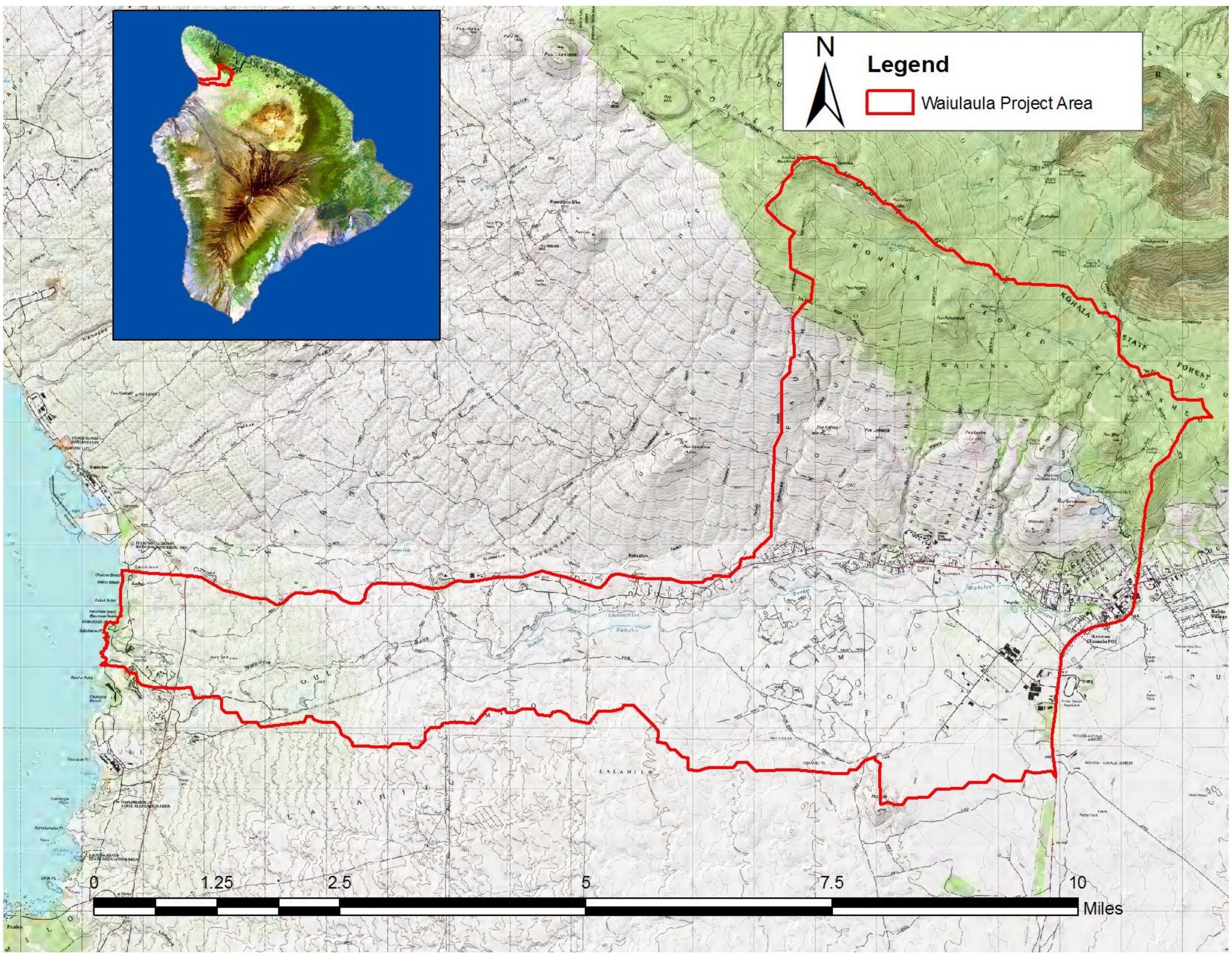


Figure 8: Topography of the Watershed

2.1.8 Geology and Soils

The Waiulaula watershed is located in the saddle between Kohala Mountain and Mauna Kea, where the Mauna Kea lavas ponded against the older Kohala dome (Clark 1986). As a result, the lands of the watershed comprise the geological substrates of both mountains.

Kohala is the oldest of the five volcanoes on the Hawaii Island, emerging above sea level more than 500,000 years ago. It last erupted about 120,000 years ago in the late Pleistocene era (USGS HVO website: http://hvo.wr.usgs.gov/volcanoes/kohala/). "The last eruptions were moderately explosive and formed a series of large cinder cones that stud the Kohala Mountain surface above Waimea" (Macdonald *et al.* 1983: p. 353). Kohala Mountain is now considered extinct and in a transition between post-shield and erosional stages of its life cycle. In contrast to the highly eroded valleys of the windward side of Kohala Mountain, erosion has made little headway on the leeward side (Macdonald *et al.* 1983).

Mauna Kea, the tallest mountain on Hawaii Island, is in the post-shield phase and considered dormant. It last erupted about 4,500 years ago. The oldest exposed lava flows on the mountain are about 250,000 years old. Mauna Kea's last eruptions were more explosive than those of the shield-building phase, with viscous magma containing more gas, and produced widespread ash deposits downwind of the mountain. The fertile soils in Waimea are a result of these ash deposits.

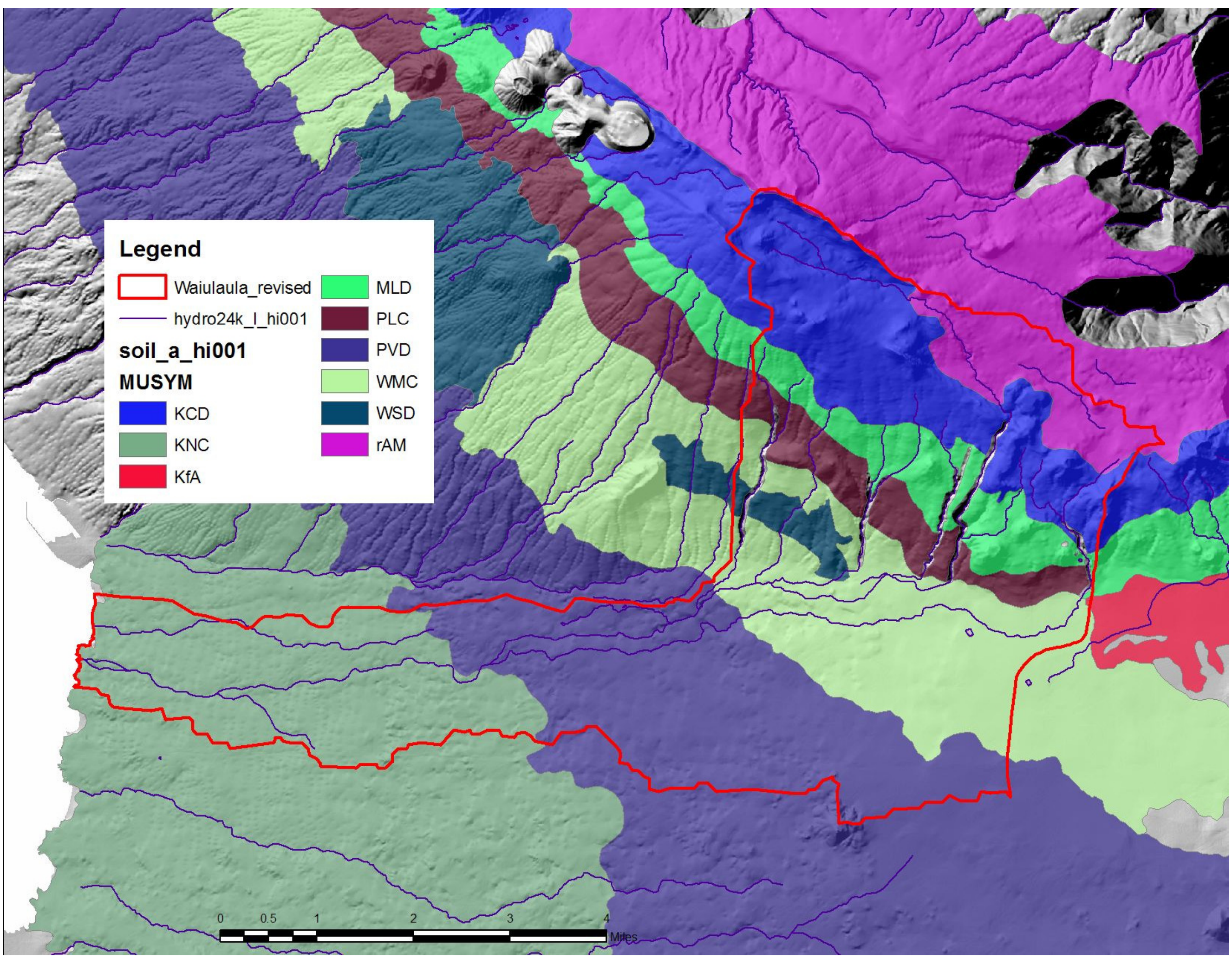


Figure 9: Soil Types in the Watershed

The watershed's geology has implications for both soil types and hydrology, as noted above. The geological substrate consists of lava flows of several volcanic series. The predominate soil types in the watershed are listed below and shown in Figure 9. Figure 10 shows the soil erodibility. Soil erodibility is an estimate of the soil's ability to resist erosion, based on the physical characteristics of the soil.

- Amalu (rAM) – poorly drained; 3-35% slopes; meets hydric criteria;
- Kahua (KCD) – silty clay loam, somewhat poorly drained; 6-20% slopes;
- Maile (MLD) – well drained silt loams that formed in volcanic ash; 6-20% slopes; moderately rapid permeability, slow runoff, slight erosion hazard;
- Palapalai (PLC) – well drained silt loams that formed in volcanic ash; 6-12% slopes; moderately rapid permeability, slow runoff, slight erosion hazard;
- Waimea (WMC) – well drained very fine sandy loam that formed in volcanic ash; 6-12% slopes; moderately rapid permeability, slow runoff, slight erosion hazard;
- Waimea (WSD) – well drained extremely stony very fine sandy loam that formed in volcanic ash; 12-20% slopes; moderately rapid permeability, medium runoff, moderate erosion hazard;
- Puu Pa (PVD) – well drained extremely stony very fine sandy loam that formed in volcanic ash; 6-20% slopes; moderately rapid permeability, medium runoff, moderate erosion hazard; and
- Kawaihae (KNC) – somewhat excessively drained extremely stony very fine sandy loam; 6-12% slopes; moderate permeability, medium runoff, moderate erosion hazard;

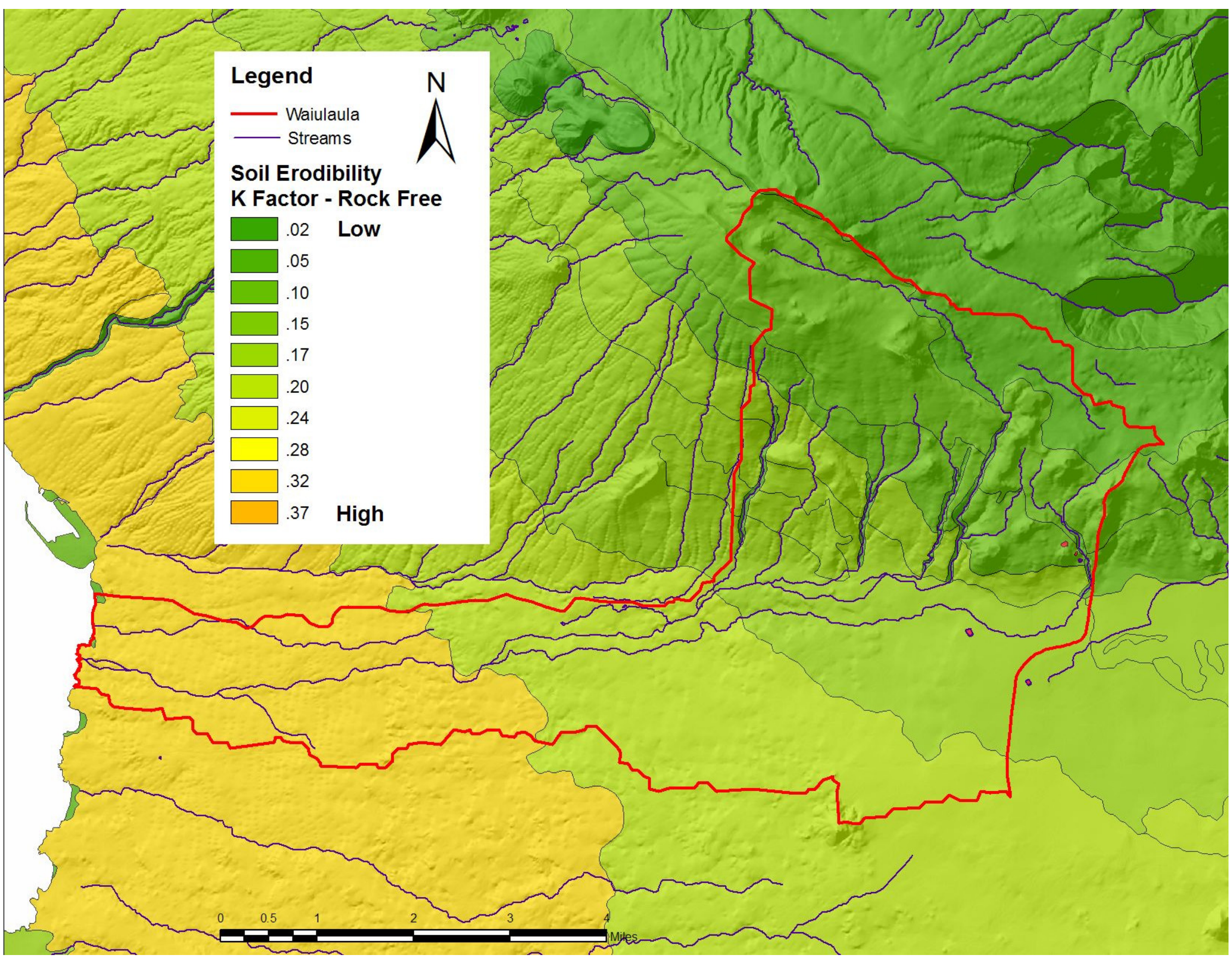


Figure 10: Soil Erodibility

2.1.9 Vegetation

The Waiulaula watershed comprises several broad types of vegetation: forest, grassland, scrub/shrub and cultivated land. With the exception of the forested headwaters, much of the watershed's vegetation has been altered over time. In fact, McEldowney (1983) found that nearly 75% of the vegetation in the area surveyed was composed of introduced grass species.

The forested section of the watershed primarily encompasses wet, predominantly native ohia rainforest, more specifically an Ohia/Olapa Montane Wet Forest. Ohia (*Metrosideros polymorpha*) and Olapa (*Cheirodendron* spp.) comprise the upper canopy, reaching 15 to 30 ft. in height. According to McEldowney (1983), this upper canopy is usually "accompanied by native subcanopy trees (3 to 6 m tall), native shrubs (1 to 3 m tall), a herbaceous layer composed of saplings, native and introduced herbs, grasses, sedges, rushes, and ferns (<1 m tall) and numerous epiphytic ferns and bryophytes" (p. 410). Plant surveys of the Puu o Umi Natural Area Reserve found that the

> [c]ommon associated species in the canopy of the ohia/olapa forest included kawa`u (*Ilex anomala*), kolea (*Myrsine sandwicensis* and *M. lessertiana*), alani (*Pelea clusiifolia* and other species) and hapu`u (*Cibotium glaucum* and *C. chamissoi*)…. Uluhe ferns were often codominant. Shrub species included alani, pukiawe, pu`ahanui, na`ena`e, `ohawai (*Clermontia* spp.), manono (*Hedyotis terminalis* and *H. hillebrandii*), and pilo (*Coprosma pubens* and *C. ochracea*). Native ferns included ho`i`o (*Athyrium sandwichianum*), akolea (*Athyrium microphyllum*), *Dryopteris* spp., *Asplenium* spp., `ae (*Polypodium pellucidum*), `ama`u (*Sadleria pallid* and *S. souleyetiana*), and pala`a (*Odontosoria chinensis*). The ground cover was moss-dominated by Sphagnum sp., especially in poorly drained areas, but ground cover also included `ala`alawainui, and *Cyrtandra paludosa*. Maile (*Alyxia oliviformis*) was sometimes abundant (DLNR 1989; p. 7-8).

Bog-like communities are also found in the forested watershed, primarily containing dwarfed forms of trees and shrub species found in the neighboring forests and moss hummocks mixed with grasses, sedges and rushes. According to KWP (2007), "It is believed that bogs develop on poorly drained areas where clay soil formation impedes drainage, causing accumulation of perched water on top of the clay, thereby drowning out root systems of woody plants." (p. 25)

Alien plant species have also become established in the native rainforest on Kohala Mountain. Once established, these weedy plants can compete with native species for nutrients and water, and have the potential to alter the native ecosystem. Known invasive plants in the forested section of the watershed include broomsedge (*Andropogon virginicus*), kahili ginger (*Hedychium gardnerianum*), yellow ginger (*Hedychium flavescens*), *Melastoma candidum*, banana poka (*Passiflora tarminiana*), fountain grass (*Pennisetum setaceum*), blackberry (*Rubus argutus*), palm grass (*Setaria palmifolia*), fireweed (*Senecio madagascarensis*), *Tibouchina herbacea*, *Clidemia hirta*, and *T. urvelliana* (KWP 2007).

McEldowney (1983) describes the eight major plant communities that currently dominate the unforested sections of the region (Figure 11), most of them being open grass or grass and shrub communities used for cattle grazing.

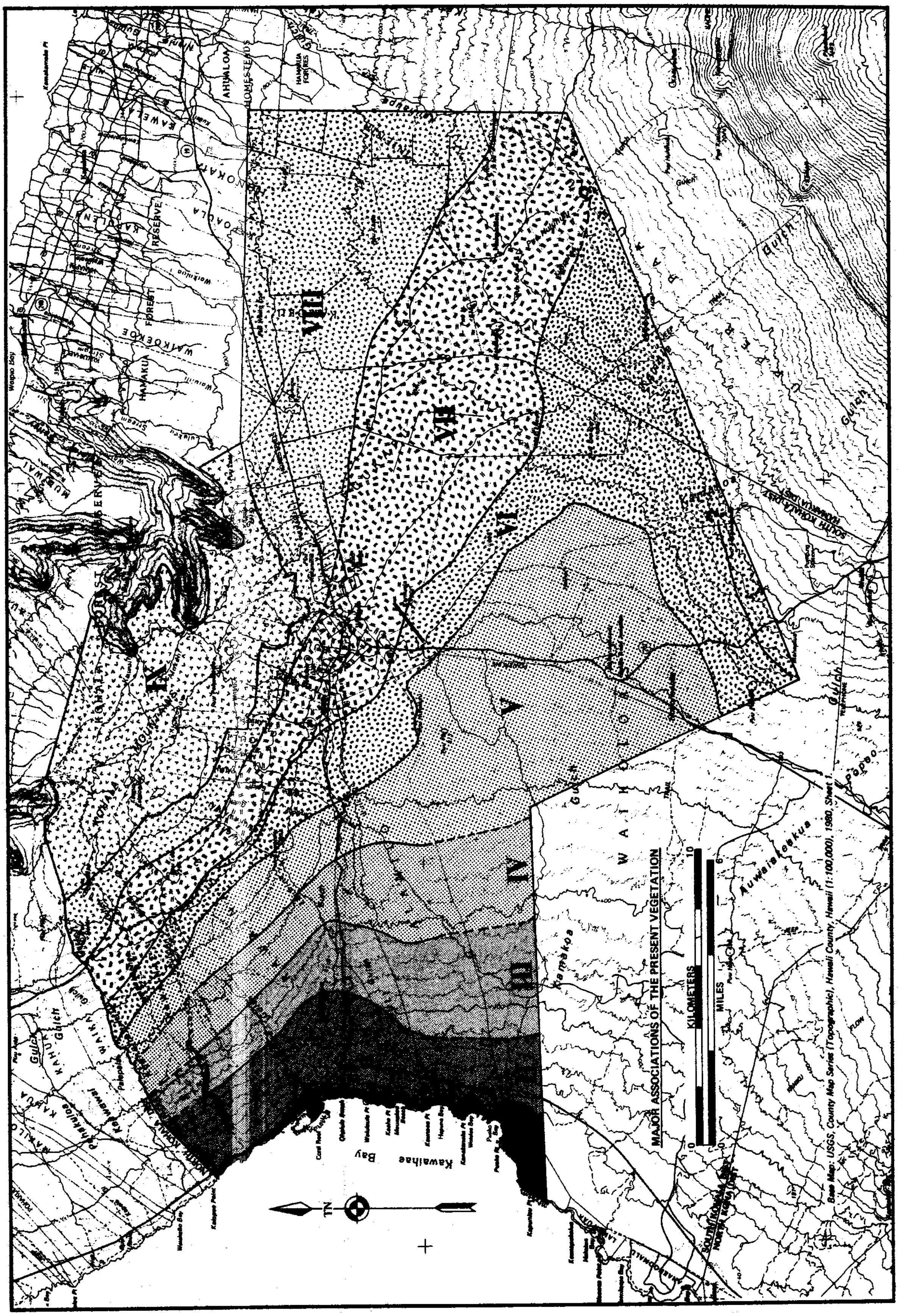


Figure 11: Zones of Major Communities of Present Vegetation (McEldowney 1983)

Zones I through III occur below the 1,500-ft. elevation. This landscape is dominated by grasses (primarily introduced buffel grass (*Cenchrus ciliaris*), fountain grass (*Pennisetum setaceum*), and native pili grass (*Heteropogon contortus*)) and thickets of kiawe trees (*Prosopis pallida*). There is also a significant proportion of bare land. This area is generally used as open range, its use dependent entirely on forage growth following seasonal or episodic rainfall. It is extremely susceptible to wildfires, which burn through this area with increasing frequency. The primary grass species are all well-adapted to fire.

The kiawe tree *(Prosopis pallida*) is an introduced species. It can desiccate an area, using all available water by tapping groundwater with its deep root system. This species is generally killed by intense fires, although a small proportion of the trees will survive if the bases are partially protected.

Zones IV through VI fall between 1,500 to 3,600-ft. in elevation. According to McEldowney (1983), these intermediate vegetation types are "basically unimproved pastures receiving little or no management" (p. 410). These zones comprise mixed grass and shrub communities containing naturalized introduced species – buffel grass (*Cenchrus ciliaris*), fountain grass (*Pennisetum setaceum*), guinea grass (*Panicum maximum*), Bermuda grass (*Cynodon dactylon*), and Natal redtop grass (*Melinis repens*) – and some scattered native shrubs (*e.g.*, ilima (*Sida* sp.), akia (*Wikstroemia pulcherrima*)). "The higher percentage of bare ground is ephemerally covered by numerous annual herbs following both seasonal and intermittent concentrations of rainfall" (McEldowney 1983, p. 410).

Fountain grass is beginning to dominate the intermediate corridor. "Usually avoided by cattle [and even feral goats], this stiff-bladed bunch grass increases in dominance following periodic fires" (McEldowney 1983, p. 409). It has the ability to form monotypic stands which increase the fire fuel load of dry lowland regions and, when dry, are highly flammable. The plant is extremely fire-resilient, benefiting from fire at the expense of more palatable, non-fire-hardy grasses.

Zones VII and VIII are wetter zones above the 3,600-ft. elevation, dominated by kikuyu grass (*Pennisetum clandestinum*). Kikuyu grows as a dense mat; therefore, it provides better protection against soil erosion. There are scattered pockets of native tree species, primarily in inaccessible gulch areas. Because this part of the watershed normally receives greater amounts of annual rainfall, it is less susceptible to fire. These zones are best suited for grazing and have been subjected to agricultural management practices.

Along the fringe of many of the watershed's streams, there is greater occurrence of vegetation, supported by the relatively steady source of water. In the upper elevations of pasture land (above 3,600-ft. elevation), this riparian vegetation comprises a greater proportion of native species, mostly due to its inaccessibility to grazing because of its location in gulches. In some locations in the central elevations, the vegetation often grows within the stream channel itself (comprising mostly of Christmas berry (*Schinus terebinthifolius*) and other non-natives), making access to the stream difficult and causing debris to get caught on the vegetation during storm events, increasing the potential for flooding. Kiawe trees fringe some reaches of the stream in the lower elevations.

Char (2002) noted plants that prefer a wetter habitat in shallow water and small mudflats in the riparian zone of the DHHL's proposed Lalamilo Residential Homestead Lots (about 2,500-ft. elevation).

“These include several members of the sedge family (Cyperaceae) such as `aka`akai or great bulrush (*Schoenoplectus lacustris*), kyllinga (*Kyllinga brevifolia*) *Caarex longii*, *Fimbristylis dichotoma*, and *Cyperus haspan*; also found here are scattered clumps of bog rush (*Juncus ensifolius*). Other plants found along the water’s edge include honohono (*Commelina diffusa*), marsh purslane (*Ludwigia palustris*), knotweed (*Persicaria glabra*), elephant grass (*Pennisetum purpureum*), and jungle rice (*Echinochloa colona*). All nine fern species found during this study are associated with moist shaded stream banks” (p. 6). Similar plants are likely found in areas of standing water and mud in other parts of the watershed.

Obviously, it is difficult to know exactly how human pressures altered the distribution and composition of the native plant communities. But, generally, historical accounts document a series of human impacts on the environment of the watershed. The early Hawaiians altered the lands by developing large, irrigated agricultural systems. The sandalwood (*Santalum paniculatum* or iliahi) trade of the early 19th century drastically altered the landscape as the slopes were denuded of sandalwood trees. With the arrival of European settlers and whaling ships, the cattle industry was born, and cattle grazed down shrub and tree species and the land was fenced for livestock. Trees were also harvested for firewood.

Fire has been a major threat to maintaining a healthy ecosystem in the watershed, and the changing composition of vegetation in the watershed has contributed to an increased fire hazard. Fire contributes to the erosion problem by stripping the land of vegetation. Without vegetation to hold the soil in place, it is subject to both wind and water erosion. Fire also can render to soil hydrophobic, which increases water repellency, surface runoff and erosion.

2.1.10 Wildlife

The Waiulaula watershed is home to a number of native wildlife, occupying aerial, terrestrial, and aquatic environments. These species play a vital role in the ecological processes within the watershed, as well as hold cultural significance to the Hawaiian people.

Of the avian species, the watershed houses a handful of native birds. A wildlife survey done as part of the EIS for DHHL's Lalamilo Residential Project (DHHL 2002) revealed nine species of birds. Of the nine, only one species, the Pacific Golden Plover or kolea (*Pluvialis fulva*), was native. *P. fulva* is migratory and makes its home in Hawaii during the months of August to April, where they feed on insects. Although not observed in this survey, it is expected that the native Short-Eared Owl or Pueo (*Anas wyvilliana*) resides in the region. The pueo is widespread on Hawaii Island and often hunts during the day in pastures on the leeward side of the island.

Beyond the mid-regions of the watershed, which the Lalamilo survey covered, lay the upper reaches of the watershed atop Kohala Mountain. While no formal surveys have been made specifically within the Waiulaula watershed, mountain-wide surveys have encountered many other native avian species that could potentially reside within the watershed. The endangered and endemic Hawaiian Goose or Nene (*Branta sandvicensis*) has been spotted on Kohala mountain. Other native avian species that have been known to reside on Kohala Mountain are the forest birds ‘elepaio (*Chasiempis sandwichensis*), ‘amakihi (*Hemignathus virens*), ‘apapane (*Himatione sanguinea*), and ‘i’iwi (*Vestiaria coccinea*). These birds inhabit the closed canopy ‘ohi’a and ‘olapa forests on top of Kohala Mountain above an elevation of 4,000 feet, where they are free of diseases transmitted by mosquitoes (KWP 2007). Also established on Kohala mountain is the endangered Hawaiian duck (*Anas wyvilliana*) (USFWS 1999). The endangered Hawaiian Hawk or i'o (*Buteo solitarious*) can also be found nesting in ohi'a forests. All these birds perform a number of important roles within the ecosystem, such as seed dispersal and pollination of native plants from the nectarivorous 'amakihi, 'apapane, and i'iwi, pest control of insects by the insectivorous kolea and 'elepaio, and rodent control by the pueo and i'o.

The Hawaiian hoary bat or 'Ope'ape'a (*Lasiurus cinereus semotus*) is the only native mammal of the Hawaiian Islands. This endemic species is federally-protected under the endangered species list. The insectivorous bats have been spotted near Kawaihae and Honokaa, with some reported sightings in Waimea.

Aquatic species play extremely important ecological roles within the watershed. Their presence or absence is often used as an indicator of stream and watershed health. In the Waiulaula watershed, surveys of Waikoloa and Keanuiomano streams conducted in 1992 by DLNR's Division of Aquatic Resources (DAR) and in 2002 by Bishop Museum's Hawaii Biological Survey (HBS) revealed many of the watershed's unique and native fish and aquatic macro-invertebrates. In these surveys, no federally-threatened or endangered native aquatic animals were found. Nevertheless, these aquatic species are important members of a fragile trophic food web that is important to the dynamics and health of the streams. The HBS survey of the middle reaches of Waikoloa and Keanuiomano streams found that, of the species surveyed, the percentage of native species was 64% and 62% respectively. These high percentages reflect the relatively undisturbed and healthy conditions of these aquatic habitats (Englund *et al*. 2002).

The aquatic insects surveyed have important trophic roles as collectors, grazers, and predators. Collector-gatherer invertebrate species are filter feeders that consume passing particulate organic matter, effectively absorbing nutrients in the water. Native collector species found in the HBS and DAR surveys include the endemic prawn Opae'oeha'a (*Macrobrachium grandimanus*) and the endemic true flies under the order Diptera, *Forcipomyia hardyi*, *Chironomus sp,* and *Orthocladius grimshawi*. Invertebrate grazers feed on benthic algae and are responsible for maintaining healthy levels of algae. Grazers identified in this survey include the endemic true flies of the Ephydridae family, *Scatella bryani* and *Scatella clavipes*. The survey also found many native predacious invertebrates that prevent the overabundance of other invertebrates in the ecosystem. These predatory organisms were primarily the dragonflies such as the endemic *Pinao* (*Anax strenuous*) and the indigenous Common Green Darner (*Anax junius*) and Wandering Glider (*Pantala flavescens*).

The 1992 DAR survey also revealed a few species of native fish in the Waiulaula watershed. These fish were the O'opu nakea (*Awaous guamensis*), O'opu alamo'o (*Lentipes concolor*), and O'opu nopili (*Sicyopterus stimpsoni*). The O'opu have amphidromous life cycles in which adults reside in freshwater pools, migrate utilizing the intermittent stream flows, and mate in the headwaters. Eggs are deposited on rocks, hatch into larvae, and the larvae travel down the stream to the sea. Post-larval o'opu migrate back up a stream in response to freshets, restarting the lifecycle. In addition to the cultural significance of the once-plentiful o'opu as a traditional food source, the o'opu are important members of the trophic community. The indigenous o'opu nakea is omnivorous and feeds on filamentous algae as well as invertebrate species. And, the endemic o'opu alamo'o and nopili feed primarily on algae on the surface of rocks. These fish help control the overabundance of algae and invertebrate species.

2.1.11 Exotic and Invasive Species

Alien and invasive species of plants and animals are tremendous problems in Hawaii, both from environmental and economic standpoints. Every year, new non-native species are introduced into the islands. The majority of the plants in the Waiulaula watershed are considered exotic and/or invasive species. These are described above in Section 3.1.9.

Much of the animal life in the watershed is also introduced. The problems caused by introduced species is well-documented: KWP (2007), SPREP (2000), Atkinson (1977), Giffen (1977), Smith (1985), DLNR (1989), Cuddihy and Stone (1990), Staples and Cowie (2001), Stone (1985).

Introduced cattle, goats, and pigs can be very destructive in their habitats. Pigs destroy areas of native forest, introduce weed species, and serve as vectors for disease. Improper management of domesticated cattle and feral goats can lead to damage to the environment through over-grazing. Other small mammals, such as rats (*Rattus rattus* and *Rattus exulans*), mice (*Mus musculus*) and mongoose (*Herpestes javanicus*), prey on native birds and feed on fruit, seeds, flowers, stems and roots of native plants. Introduced bird and insect species, of which there are many, compete with native ones for food sources and introduce new diseases.

Some of the most problematic species include:

Fireweed (or Madagascar ragwort, *Senecio madagascariensis*)
Fireweed was discovered in the early 1980s in pastures on Kohala Mountain. It invades pastures, disturbed areas, and roadsides, and is toxic to livestock when eaten. It is spread by wind, shoes, vehicles and animals. It is considered very invasive and is on the Hawaii State Noxious Weed List.

Fountain grass (*Pennisetum setaceum*)
DLNR has designated fountain grass as one of Hawaii's most invasive horticultural plants, and Hawaii Department of Agriculture has designated it a noxious weed. Fountain grass is native to Africa and was introduced to Hawaii as an ornamental plant. It poses a major fire threat to the Waiulaula watershed because it provides an excellent fuel for wildfire and is fire-adapted. It degrades the quality of pasture lands and is not palatable to cattle.

Freshwater stream fishes
Numerous fish and invertebrate species imported through the aquarium fish trade have become established in Hawaiian streams after being released into these natural environments. Introduced species have contributed to the decline in endemic stream species, through competition, predation, and introduction of parasites and diseases.

2.2 Socio-Cultural Resources

2.2.1 Land Use Zones (State and County)

State Land Use Districts

The Hawaii Land Use Law, Chapter 205, Hawaii Revised Statutes (HRS), places all lands in the State into four districts: Urban, Agricultural, Rural and Conservation. Lands in the Conservation District are managed by the State, and the jurisdiction over Rural and Agricultural Districts is shared by the State Land Use Commission (LUC) and counties. The responsibility for zoning within the Urban District is delegated to the counties. Changes to the boundaries can be done by ordinance of the County Council for areas of 15 acres or less. Otherwise, the LUC must approve changes by a 6-3 vote. Only the LUC can take land out of the Conservation District.

In the past, large-scale, urban-style developments have occurred in the Agricultural District, usually designed as a residential development and often surrounding a golf course. However, this use of agricultural lands has virtually halted as a result of the legal decision regarding the Hokulia development in South Kona.[1] As a result, landowners contemplating this type of development in the future will likely request LUC approval for a district boundary amendment to reclassify lands from Agricultural to Rural.

In the Waiulaula watershed, 69.4% of the lands are designated Agriculture, 21.2% Conservation, 0.5% Rural (small farms and low-density residential lots), and 8.9% Urban (Figure 12).

Conservation District

Lands in the Conservation District are managed by the Department of Land and Natural Resources (DLNR) pursuant to Chapter 183C, HRS, and Chapter 13-5, Hawaii Administrative Rules (HAR). Generally, land use is regulated in the conservation district for the purpose of conserving, protecting, and preserving the important natural resources of the State through appropriate management and use to promote their long-term sustainability and public health, safety, and welfare. Lands within the Conservation District are further subdivided into subzones for which Chapter 13-5, HAR, defines specific objectives and types of activities allowed. The conservation lands within the Waiulaula watershed fall within the Protective Subzone, which has the following objective: protect valuable resources in designated areas such as restricted watersheds, marine, plant, and wildlife sanctuaries, significant historic, archaeological, geological, and volcanological features and sites, and other designated unique areas (§13-5-11). Prior to any use of land in the Conservation District, a Conservation District Use Application (CDUA) must be submitted to and approved by the Board of Land and Natural Resources.

Agricultural and Rural Lands

Chapter 205, HRS, delegates the responsibility for zoning within the agricultural and rural districts to the counties. For agricultural lands, however, Chapter 205, HRS, outlines permitted uses of agricultural

[1] *Circuit Court Judge Ibarra ruled in 2003 that Hokulia was an urban project being built illegally on agriculturally-designated lands. He based this conclusion on his findings that the State Land Use Law (Chapter 205, HRS) requires that housing on agricultural lands be related to agricultural use and such agriculture must be economically viable.*

lands classified as “A” or “B” by the Land Study Bureau's land productivity rating system.[2] In Hawaii County, Chapter 25, Hawaii County Code (HCC), regulates zoning and identifies permitted uses and other regulations. Under this ordinance, the State Agricultural District is further subdivided into subzones (agriculture, family agriculture, intensive agriculture, etc.), which the County also refers to as “districts.”

Chapter 205, HRS, states that only the following uses shall be permitted within Rural Districts: low density residential uses (minimum lot size is one-half acre); agricultural uses; golf courses, golf driving ranges and golf-related facilities; and public, quasi-public, and public utility facilities.

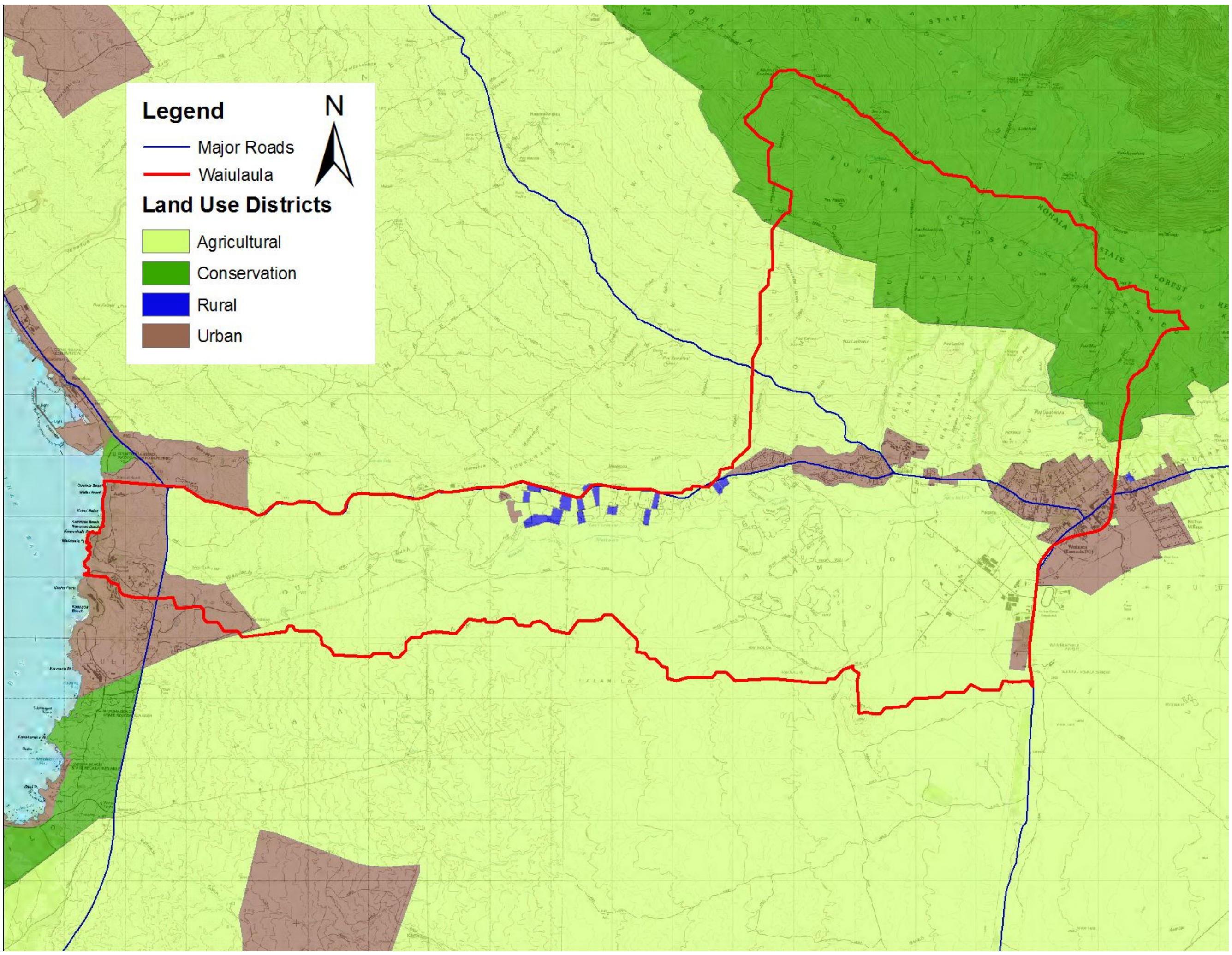


Figure 12: State Land Use Districts

Chapter 205, HRS, also requires that State and county agricultural policies, tax policies, land use plans, ordinances and rules promote the long-term viability of agricultural use of important agricultural lands.

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[2] *The University of Hawaii’s Land Study Bureau (LSB) prepared an inventory and evaluation of the State’s land resources during the 1960s and 1970s. The LSB rated lands, except those in the urban district, in terms of agricultural productivity based on soil properties and productive capabilities (texture, structure, depth, drainage, parent material, stoniness, topography, climate, and rain). A five-class productivity rating system was developed using the letters A, B, C, D, and E, with “A” representing the class of highest productivity and “E” the lowest. There are no class A lands on the island of Hawaii.*

One criterion for designating land as important agricultural lands is lands identified under agricultural productivity rating systems, such as ALISH.

Agricultural Lands of Importance to the State of Hawaii (ALISH): As part of a national effort to inventory important farmlands, the Hawaii Department of Agriculture assessed lands through a rating system for agricultural suitability to produce the Agricultural Lands of Importance to the State of Hawaii (ALISH). This was adopted by the Board of Agriculture in 1977. Three classes of important agricultural lands were identified: (1) Prime – soils with best physical, chemical and climatic properties for mechanized field crops; (2) Unique – lands other than prime for unique high-value crops (coffee, taro, watercress, etc.); and (3) Other – lands needing irrigation or possessing characteristics like seasonal wetness, erodibility that require further management for commercial production. Areas of Prime agricultural lands in the Waiulaula watershed include the Lalamilo farm lots and a band of land *mauka* of Kohala Mountain road (Figure 13).

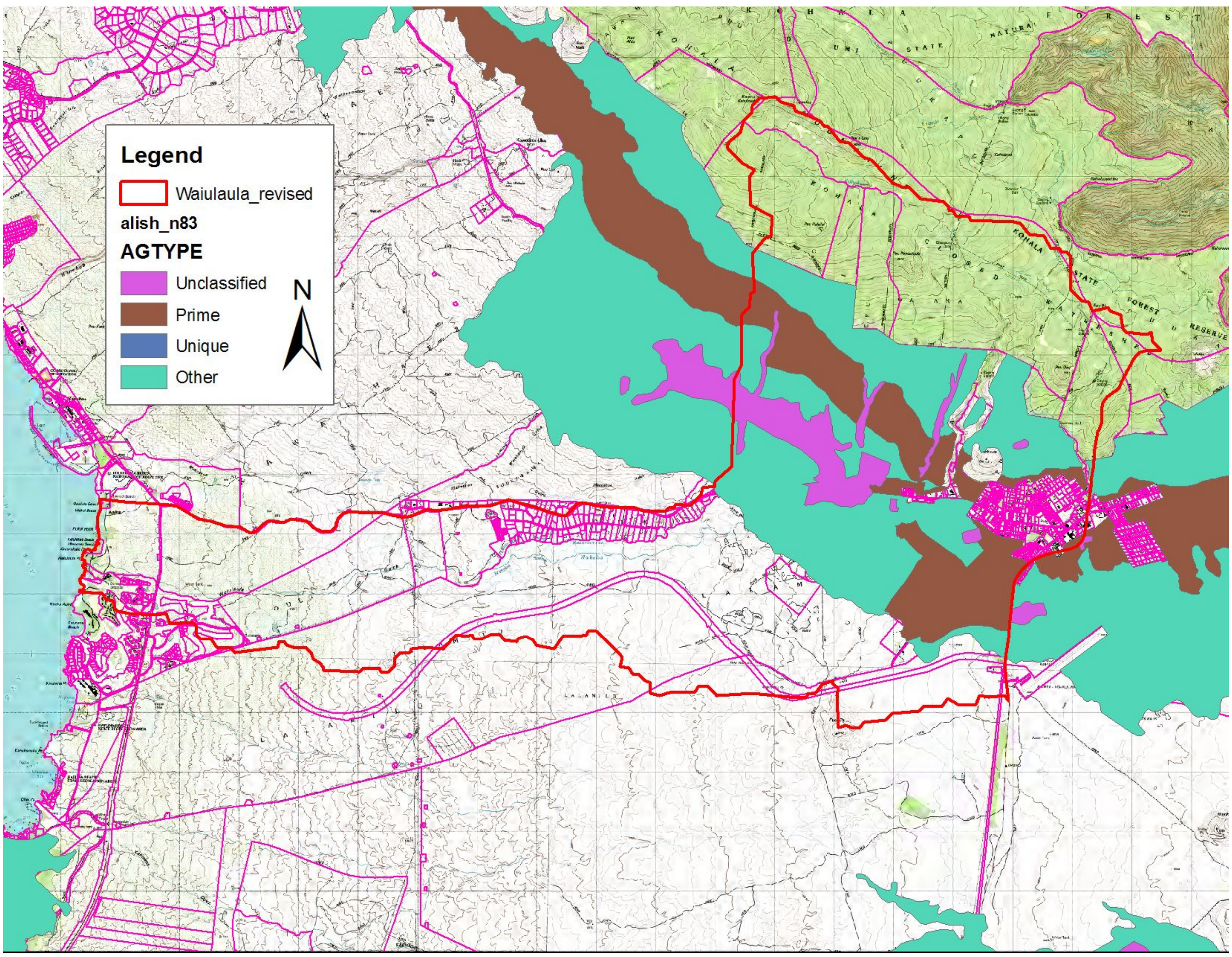


Figure 13: ALISH Agricultural Suitability

General Plan Important Agricultural Lands: Chapter 205, HRS, also mandates counties to identify and map potential important agricultural lands within their jurisdictions. One of the goals of Hawaii County's *General Plan* (2005) is to identify, protect and maintain important agricultural lands on the island of Hawaii. The general plan defines “important agricultural lands” as “those with better potential for sustained high agricultural yields because of soil type, climate, topography, or other factors” (Hawaii County 2005; p. 14-8). In making these determinations, the county included, among other things, data from the 1989 General Plan Land Use Pattern Allocation Guide (LUPAG) maps, the ALISH classification system, and the Land Study Bureau’s (LSB) Soil Survey Report. General Plan Important Agricultural Lands included in the Waiulaula watershed are the Lalamilo farm lots and some areas *mauka* and *makai* of Kohala Mountain Rd (see Figure 16).

Urban District

The urban district is entirely under county jurisdiction, and uses are controlled only by county zoning. All areas on the island, except for federal lands like the national parks and some areas in the conservation district, are zoned (Figures 14 and 15). The Zoning Code, Chapter 25, HCC, lists the permitted uses within each zone, and also the required setbacks, height limits, parking areas for commercial developments, and other controls. Within the Waiulaula watershed, 4% of the land is zoned residential, 0.7% commercial, 1.2% roads, and 1.2% open, while the remaining lands parallel State designations with 71.5% zoned agricultural and 21.2% forest reserve (conservation).

Generally, all development within the County must conform to the policies outlined in its General Plan (2005) and specific community development plans. The county general plan provides a coordinated set of guidelines for decision-making regarding future growth and development and protection of natural and cultural resources. The general plan also guides revisions and updates to the county code. The plan is given the effect of law through adoption by the County Council. Generally, the general plan has policies related to protecting the county’s natural resources and minimizing adverse effects resulting from the inappropriate location, use, or design of sites and structures; protecting wetlands and riparian areas; and designing drainage systems to minimize polluted runoff, retain streambank vegetation, and maintain habitat and aesthetic values.

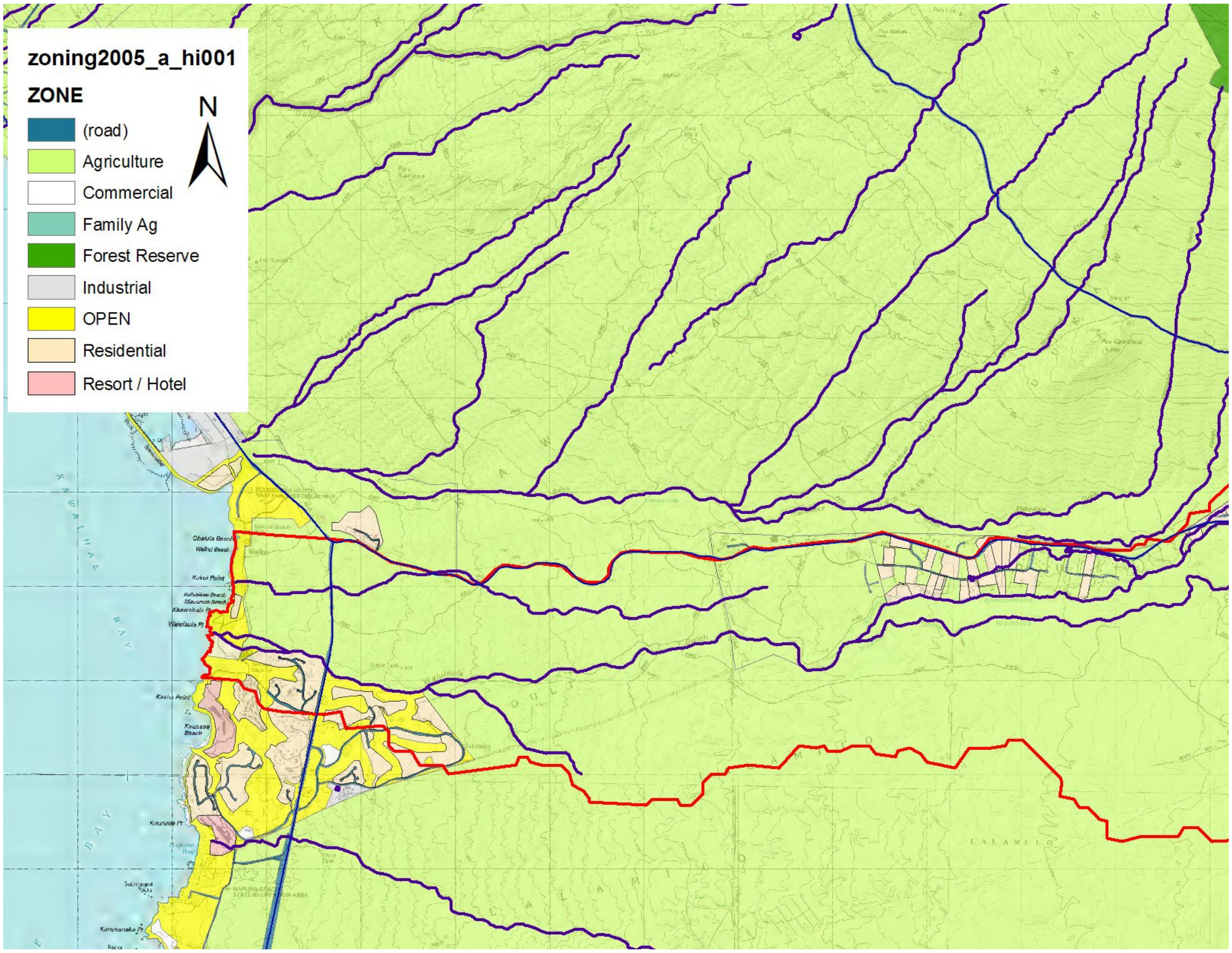


Figure 14: County Zoning – Lower Watershed

The County general plan is implemented through the specific community development plans; budgeting and capital improvement programs guided by the goals, objectives and policies of the general plan and community development plans; county laws amended to be consistent with the intent of the general plan components; and approval or disapproval of developments seeking zoning and other development approvals based on how they support the visions expressed in the general plan. The county planning department prepares an annual report to monitor progress towards achieving general plan goals, objectives and policies. The annual report is submitted to the Mayor and County Council for review. The General plan is subject to periodic review and amendment, as specified by county procedures, with significant opportunities for input by the public.

Hawaii County's 2005 General Plan, outlines policies that will greatly reduce the generation of polluted runoff. The General Plan provides the direction for the future growth of the County. As a policy document, it provides the legal basis for all subdivision, zoning, and related ordinances and will guide revisions to the county code. The General Plan also includes Land Use Pattern Allocation Guide (LUPAG) maps by district that show conservation, agricultural, rural, resort and urban areas, urban expansion areas, and open areas (Figure 16). These serve to guide the location, type, and intensity of different land uses. The LUPAG identifies significant areas of urban expansion within the Waiulaula watershed, particularly in the lower watershed and within Waimea.

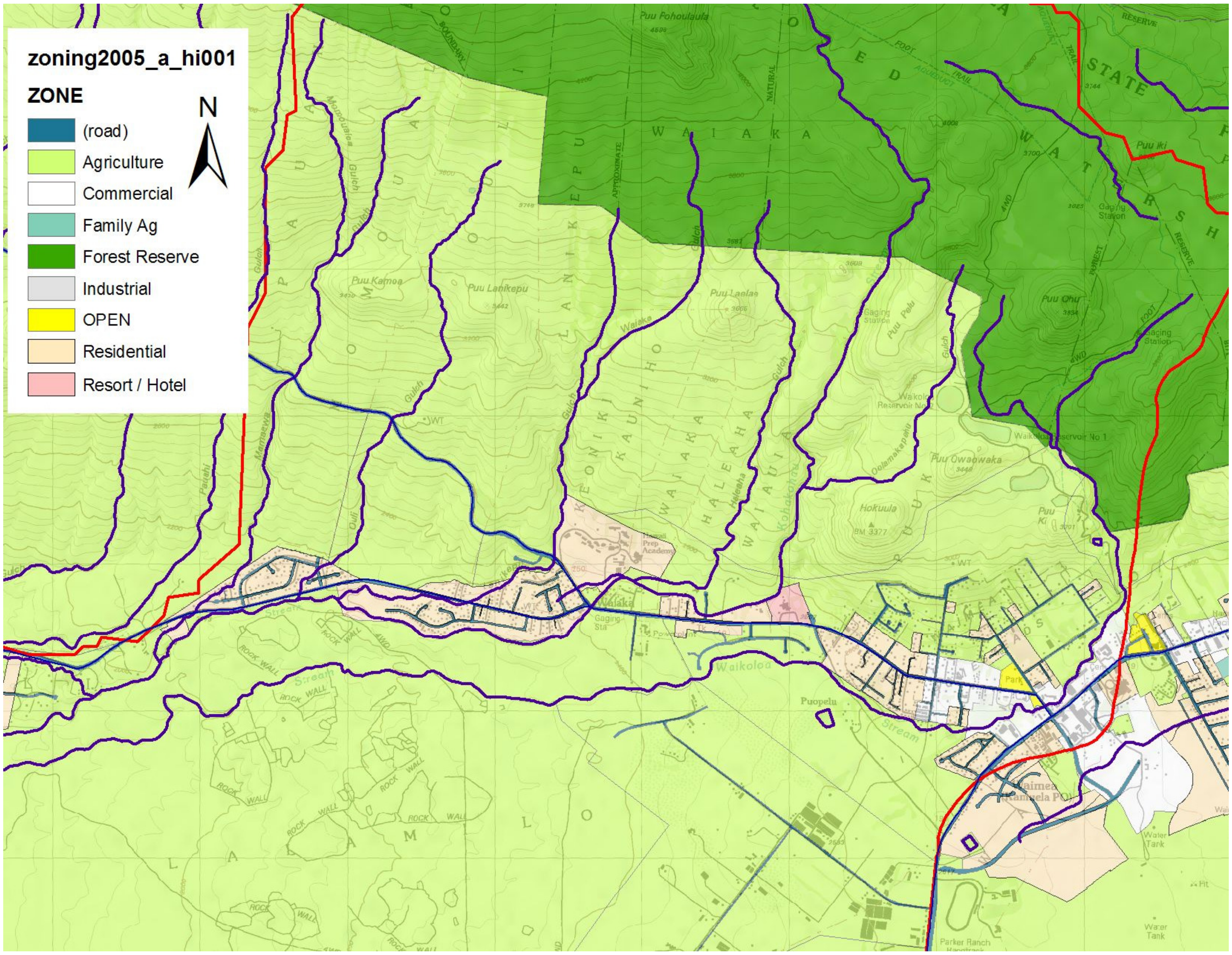


Figure 15: County Zoning – Upper Watershed

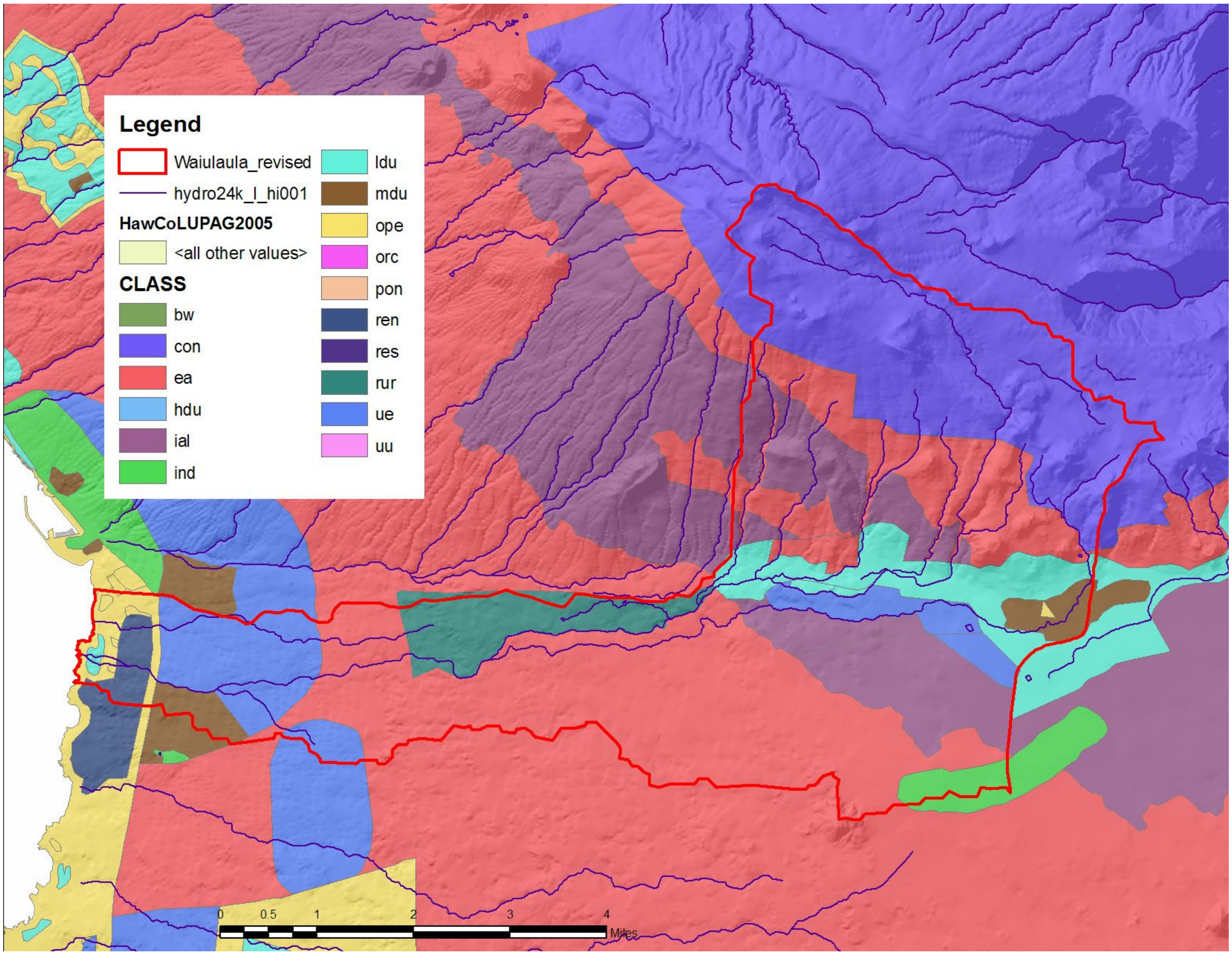


Figure 16: County LUPAG Map

bw	(breakwater)	mdu	Medium Density Urban
con	Conservation	ope	Open Area
ea	Extensive Agriculture	pon	(ponds)
hdu	High Density Urban	ren	Resort Node
ial	Important Ag. Lands	rur	Rural
ind	Industrial	ue	Urban Expansion
ldu	Low Density Urban		

The 2005 General Plan calls for the development of community development plans, which are to be adopted by the Council Council. The South Kohala Community Development Plan (CDP) was developed with significant community input and adopted by the Council on November 20, 2008. It provides a long-term plan with a planning horizon to year 2020, consistent with the General Plan. The South Kohala CDP identifies District-wide policies that address the following priority land use issues: preserve culture/sense of place; traffic and transportation; affordable housing; emergency preparedness; and environmental stewardship and sustainability. It specifically identifies a sub-policy for the District that directs the County to develop or collaborate with other agencies and organizations to develop watershed management programs for the district, as well as water quality monitoring (Hawaii County 2008; p. 52).

The South Kohala CDP includes a Waimea Town Plan, providing general guidelines for the long-range future of Waimea Town. Among the recommendations that are relevant to the Waiulaula watershed management plan are the following:

Strategy 1.1	Protect the pu`u of Waimea.
Strategy 1.5	Expand the Lalamilo Farm lots.
Strategy 2.1	The County should carefully evaluate and condition, as appropriate, any rezoning that would negatively impact important agricultural lands or culturally, visually and environmentally important open space or resources in Waimea.
Strategy 2.2	Work with Parker Ranch to phase the “Parker 2020” Development
Strategy 2.3	Revise the County subdivision regulations and Planning Department policies and enforcement procedures to ensure that agricultural subdivisions are created for agricultural purposes and are not used for rural residential purposes without rezoning.
Strategy 2.4	Amend the County of Hawaii's General Plan “LUPAG” map by reducing the acreage of “Low Density Urban” land in Waimea Town.
Strategy 3.1	Protect Important Agricultural Lands.
Strategy 5.7	Design and construct the Lalamilo connector road.
Strategy 5.8	Work with the State Department of Transportation to resolve the best alignment for the proposed Waimea/Kawaihae Road bypass highway.

2.2.2 Land Cover

Land cover is based on NOAA's Coastal Change Analysis Program (C-CAP) land cover classes. The majority of the watershed (58%) is in grassland, dominated by grammanoid or herbaceous vegetation and not subject to intensive management such as tilling. Evergreen forest, with trees generally greater than 5 meters tall and greater than 20% of total vegetation, accounts for 26% of the land cover. Of the remaining land cover, scrub/shrub and low-intensity developed each account for 5%, bare land 4%, and cultivated land and high intensity developed each 1%.

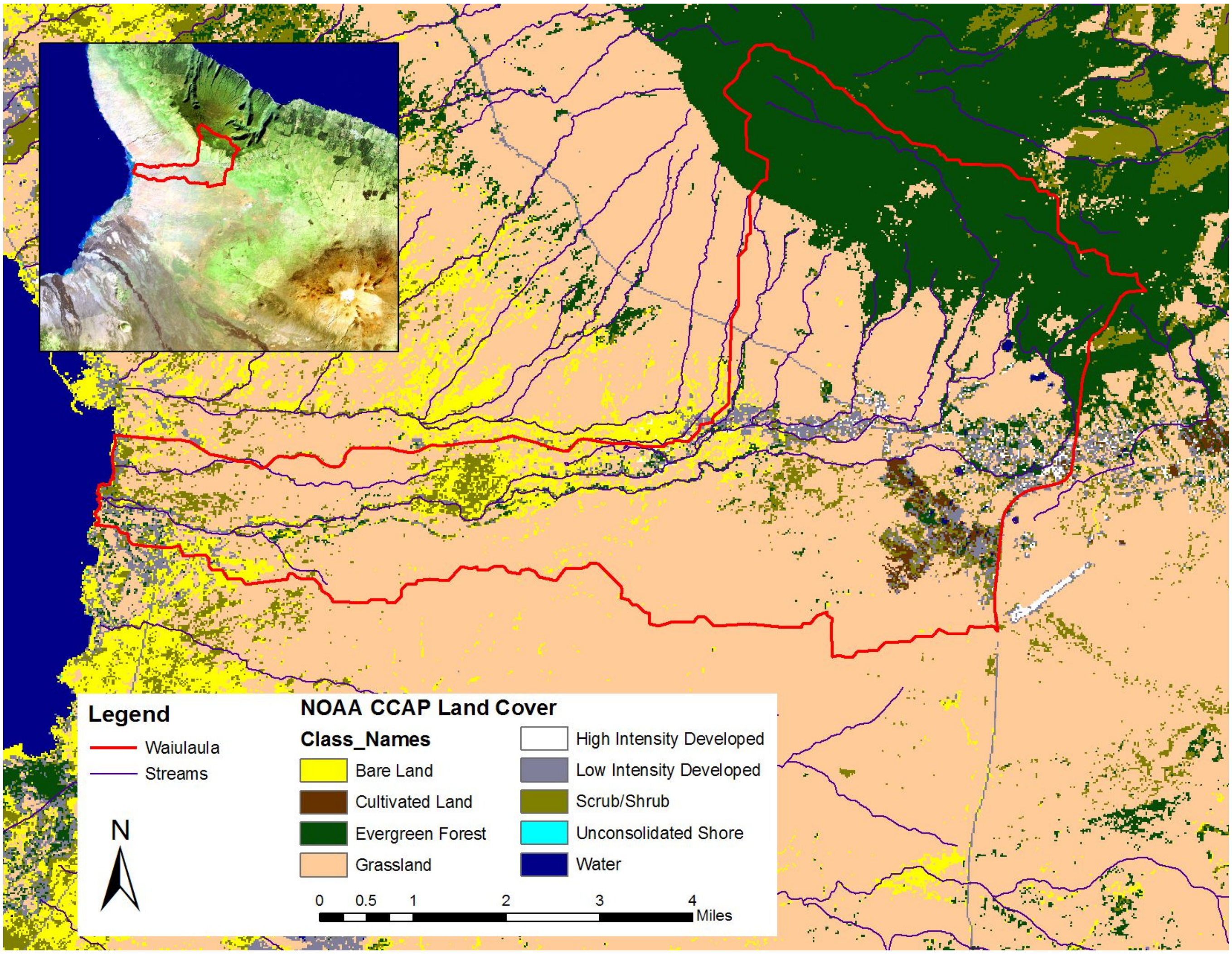


Figure 17: CCAP Land Cover

2.2.3 Population and Local Communities (Demographics)

Waimea is the main population center within the Waiulaula watershed. Waimea is a rural community that developed around the historic Parker Ranch. Residential subdivisions extend down Kawaihae Road, located primarily between Kawaihae Road and Keanuiomano stream to the south. Mauna Kea Beach Resort is a destination resort located near the mouth of the watershed, with a large-scale, high end hotel, restaurants, golf courses, and residential developments. Most of the commercial development in the watershed is concentrated in and around Waimea town center.

The South Kohala District, in which the Waiulaula watershed is located, was the fastest growing district on Hawaii Island from 1980 to 1990 and the second fastest growing district from 1990 to 2000 (Hawaii County 2008). While census data does not provide population information on a watershed basis, it is estimated that Waimea's population in 2000 was over 7,000 people. The South Kohala Community Development Plan estimates (based on building permits issued) that, since 2000, the population of Waimea alone could have increased by about 1,500 people (Hawaii County 2008). There are currently around 2,900 housing units in Waimea. This does not include additional units along Kawaihae Road and at the Mauna Kea Beach Resort.

Many people are employed by the tourism sector. Agricultural operations, both truck crop farms and cattle ranching also employ people within the watershed. Waimea is the home to the headquarters of Canada-France-Hawaii Telescope and W.M. Keck Observatory, numerous public and private schools (Waimea Elementary School, Waimea Middle Public Conversion Charter School, Kanu o Ka Aina Public Charter School, Hawaii Preparatory Academy, and Parker School), and the North Hawaii Community Hospital. Waimea's per capita income is $20,773, based on 2000 census data. Median income is $51,150 for households, $55,822 for families, and $29,750 for non-family households.

2.2.4 Land Uses – Historic and Current

In the Cultural Impact Assessment for the DHHL Lalamilo Residential Development Project, authors McGuire and Haun describe historic land uses in the area. "From ancient times, Waimea has been associated with royalty and chiefly lineages. Waimea was one of the lands which was highly valued by the ali`i (chiefs) and traditional stories indicate they maintained a dominant presence there" (McGuire and Haun 2002, p. 6). Waimea was also a training ground for young chiefly warriors. McGuire and Haun (2002: 8) describe the story of Kekuhaopio, a trainer during the time of Kamehameha, which lists many famous battles either fought in Waimea or fought by Waimea warriors, including a battle between Kamalalawalu of Maui and Lonoikamahakihi from Hawaii in the late 16^{th} to early 17^{th} century that took place in the Waimea area: the battle of Pu`oa`oaka (Pu`uow`owaka Hil). McGuire and Haun also report that a battle occurred at Hoku`ula.

With so many chiefs and warriors coming from Waimea and being trained in Waimea, an extensive agricultural field system was developed that is still evident today. Barrere describes this system:

> It may well have been that during the times of Alapainui and of Kalaniopuu that the cultivating places of Waimea were first expanded to supply the chief's needs while they sojourned there and at Kawaihae. The abandoned cultivated patches, so often attributed to the decrease in the Hawaiian populations, were, in fact, as much the result of this practice of chiefs of traveling about their domains, feeding off the land until supplies were exhausted, then moving off to another. (Barrere in Clark & Kirch 1983: 27, in McGuire and Haun 2002: 9)

Clark (1981) describes an extensive agricultural system within the Waimea area which

> forms a large arc to the north, west, and south of the present-day village of Waimea. It begins on the south flank of Kohala Mountain, a short distance below Puu Laelae, and extends down the slope, onto the Waimea plain west of the village. It then bends to the east, fading out just south of Waimea and west of Kuhio Village.

Clark (1981) notes that this Waimea agricultural system can be subdivided into four field complexes, three of which are contained within the current day Waiulaula watershed:

> Field Complex 1 is located on the Kohala slopes, principally between Lanikepu and Haleaha Gulches on the west and east, respectively. It lies south of Puu Laelae, and north of Keanuiomano and Kohakohau Streams, once they run off the slope and turn to an east-west flow direction. This area is one of comparatively steep slope, and is characterized by a series of terraces and/or terraced field ridges. These features range from 0.5 to 1.5 m. in height and appear to be primarily soil with little or no stone in the retaining faces. The upper portion of the complex is dominated by mildly terraced field ridges, usually comparatively low. These seem most likely to be more of a linchet-type development than

> intentionally constructed ridges. The lower portion of the complex is characterized by the presence of larger terraces with broader and noticeably flatter surfaces behind the soil embankments. The method of construction of these latter features is probably cut-and-fill.
>
> In association with the agricultural fields are a series of water flow channels and at least one set of *auwai*. The water flow channels are found over the entire complex, running down the slope. With one possible exception, they do not appear to divert from a stream flow but, rather, simply begin as small depressions at the upper margins of the fields. The angle of slope would necessitate a very rapid flow, and some of the channels are in comparatively low-lying areas; both conditions would make diversions into fields somewhat difficult. Consequently, it seems most likely that these channels served more a drainage function, diverting water off of rather than onto the fields. Also present, however, is a clearly identifiable auwai set, the main channel of which is diverted from the Kohakohau Stream at approximately 3,000 ft elevation, that feeds a series of fields in the Waiaula land division before emptying into the Haleana Gulch. A historic period irrigation ditch (with a diversion wall of concrete and boulders) is taken off of the east side of the Kohokohau Stream, but its route was not determined.
>
> A few fields may be present immediately east of Kohokohau Stream Gulch, but there are no signs of agricultural activity much beyond it. On the other side, an occasional low terrace, residential structure, or wall can be found beyond the first few hundred meters west of Lanikepu Gulch, but for the most part the field complex proper ends at that point….
>
> Field Complex 2 is situated between Keanuiomano and Kohakohau Streams on the north, and Waikoloa Stream on the south. It is characterized by a set of agricultural fields demarcated by terrace retaining faces, or low ridges of soil and/or stone. The fields average ca. 25 m in width with the long axis oriented northwest by southeast, or perpendicular to the prevailing winds. Associated with the fields is a set of auwai, which diverge from the Kohakohau Stream and angle to the southeast across the complex, draining into the Waikoloa Stream….
>
> Field Complex 3 lies south of Waikoloa Stream and north of Puu Pa. The existing Lalamilo Farm Lots have destroyed much of the eastern end of this complex. The precise western extent has not yet been determined but it appears to incorporate most, if not all, of the Lalamilo Kuleana and Ranch District…. (Clark 1981: 17-19)

The upper Lalamilo fields of the Waimea agricultural complex differ from the Kohala field system "due to the fact that they received supplemental water by means of an extensive and complex irrigation system. Indeed, it is this difference that makes the Waimea agricultural system unique" (Clark 1981: 50).

In 1793, Captain George Vancouver brought Longhorn cattle along with some sheep, and gave them to King Kamehameha as a gift. Kamehameha put a ten-year *kapu* on the cattle, prohibiting anyone from touching or hunting them. From these cattle, large herds eventually multiplied, causing significant damage to the forest on Kohala Mountain. McGuire and Haun (2002) suggest that along with cattle, "other early western visitors introduced goats, horses, a new pig breed, and new vegetable, fruit and plant varieties. Kawaihae and its port became the impetus for the development of trade and commerce. Waimea provided much of the produce, and later on salted beef, to refurbish supplies for foreign ships" (p.18). To harvest the cattle, which all belonged to the Crown, the King hired bullock hunters, like John Palmer Parker. The meat would be salted and brought to Kawaihae. Hides were tanned and tallow was produced from the cattle. All these products were sold to the ships who resupplied in Kawaihae. In 1832, Spanish-Mexican vaquero were brought from California to teach Hawaiians how to manage the wild cattle (Bergin 2004).

Waimea had a reputation for producing fine and durable leather. However, the enterprise of tanning the hides had a noticeable effect on the forest of the area. Haun and McGuire (2002) write:

> ecologically, the tanning business had a negative impact to the landscape. The bark from native trees was used to tan hides. Lyons reports that the "Konohikis demanded high prices for bark gathering permits; and koa and ohia were used more than scarcer trees that made handsomer leather..." Kukui was richest in tannin" (Doyle 1945: 50). Lyons' comment implies there had already been loss of the native forest besides sandalwood. The tanneries no doubt contributed to more loss of the native forest. There were several tanneries in operation during the 1840s and 1850s. One tan works was "under the direction of Chinamen"; one owned by James Fay; and two others were at Waiemi and Pukalani, owned and run by William Burke (Olmsted 1841: 233; Barrera & Kelly 1974: 45; Native Testimony, Waimea Water Rights Case 1914 – 1915). (p. 22)

McGuire and Haun (2002) describe that the sandalwood trade started in the early 1800s. By 1811, King Kamehameha had signed an exclusive agreement with three American entrepreneurs for access to Hawaii's sandalwood resource. In return, Kamehameha received one-fourth of the net profits. As a monopoly of the ali`i, the sandalwood trade grew unabated. Sandalwood was harvested from the slopes of Kohala Mountain and brought down to Kawaihae for shipment, until the supply of trees declined by the early 1840s. The sandalwood harvest had significant environmental impacts on the watershed resources, denuding the forest of sandalwood and causing a major change in the forest ecosystem species composition.

Other agricultural products grown in the Waimea area in the first half of the 19th century included sugar and potatoes. McGuire and Haun (2002) describe that sugar was an industry in Waimea from the mid-1830s until at least 1843. Before this time, sugar cane was grown by Hawaiians for their own consumption at locations around Waimea. The first sugar mill is described as having been established by a Chinese man named Lauki, who had come to Hawaii with Captain Joseph Carter, grandfather of A.W. Carter. The mill was powered by a water wheel using water from Waikoloa Stream. Because of the demand for Irish potatoes and sweet potatoes by those in California involved with the Gold Rush, Waimea farmers began to increase their production and shipping of potatoes to California, along with other agricultural products like vegetables, sugar, molasses and coffee (Kuykendall 1965: 313-314, 321-322). Haun and McGuire (2002) note that this export market lasted only three short years, when the Irish potato market collapsed.

By 1840, there was concern that the great herds of cattle would be diminished because of consistent hunting pressure. So, another *kapu* was placed on the cattle. In 1844, a man named William Beckley was named as konohiki of Waimea, "in addition to his role as manager of the king's and government's cattle (Lyons 1846 in McEldowney 1983: 432). Under his management, more lands were converted to pasturage and holding pens. McEldowney (1983) states that Lyons wrote that Waimea had turned into a "cattle pen." Lyons wrote that "By another unfavorable arrangement 2/3 of Waimea have been converted to a pasture for government herds of cattle, sheep, horses, etc." (Lyons 1846 in McEldowney 1983: 432).

Through the 1840s and 1850s, the government of Hawaii passed new laws that initiated a process called the Mahele in which the land tenure system changed from a feudal system with all land controlled by the king and his chiefs, to a system of private land ownership. With the changes brought about by the Mahele, and in land ownership in Waimea, cattle ranching went through a major transition. Former cattlemen and others began to establish ranching operations. John Palmer Parker purchased the first acres of land that would become Parker Ranch in 1847. Bergin (2004) describes the history of Parker Ranch and its role in the development of Waimea town.

During both World War I and World War II, Parker Ranch supplied the Armed Forces in Hawaii with beef. During World War II, over 20,000 men in the Army and Marines were living at a major encampment located at Puopelu in Waimea. They also used a large area of land between Waimea and Waikoloa as a firing range. Unexploded ordnance from this era remains a problem to this day.

During the war, the farmers in the Waimea area prospered, growing fresh produce for the servicemen living in Waimea. McGuire and Haun (2002) describe that,

> Each farmer leased twenty acres of lands combined between Ranch and Waimea homesteaders. The farmers learned to grow new kinds of vegetables they had never grown before – lettuce, asparagus, celery, and broccoli were especially requested by the servicemen (Nakano 1992: 101). The war helped the Waimea farmers make the shift from tenant farmers to commercial farmers. (p. 44)

Laurance S. Rockefeller constructed the Mauna Kea Beach Hotel in the early 1960s, paving the way for future resorts and hotels to be developed in the region (Hawaii County 2008). In 1975, the Queen Ka'ahumanu Highway was completed, connecting the coastal towns in West Hawaii and enabling further development of the coastline.

During the 1980s, Parker Ranch, under the direction of the last remaining heir, Richard Smart, developed the *Parker Ranch 2020 Plan* to guide the future development of Waimea. He hoped the plan would allow Waimea to expand without losing its village character. In 1992, approval of the plan was granted by the County through the adoption of Ordinance 92-65, which rezoned over 580 acres of land in the Waimea area for commercial, industrial, and residential activities, as well as for community facilities. When Richard Smart died in 1992, he left most of the Ranch assets to the Parker Ranch Trust Foundation. This foundation supports five beneficiaries: North Hawaii Community Hospital, Lucy Henriques Medical Center, Parker School Trust Corporation, Hawaii Preparatory Academy, and the Richard Smart Fund of the Hawaii Community Foundation.

In 1994, Parker Ranch began to revise its plan in response to community concerns and in light of the fiduciary responsibilities of the Parker Ranch Foundation trustees to the beneficiaries. As the cattle industry has become less profitable, the trustees have needed to explore diversification alternatives to generate more stable income for distribution to the beneficiaries. This diversification has included selling Parker Ranch Center and Parker Square, selling land to a developer for the development of condominium homes at HoloHoloKu, and a joint venture with Schuler Homes to develop single-family homes at Luala`i. Figure 18 shows the Waimea Town Center Land Use Map from the *Parker Ranch 2020 Plan*.

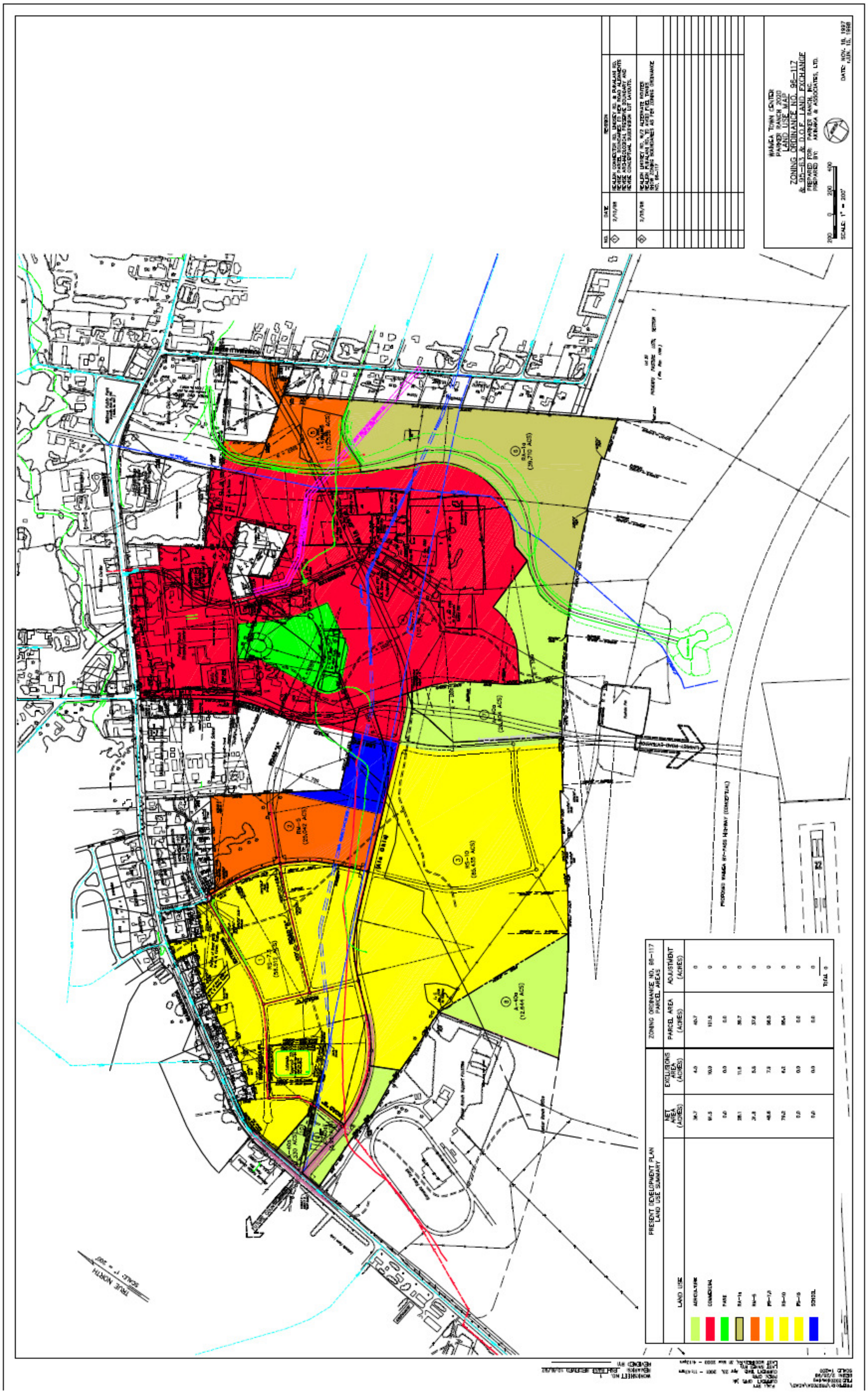


Figure 18: Waimea Town Center Land Use Map – Parker Ranch 2020 Plan

Today, Waimea town is the commercial center of the Waiulaula watershed. There is residential development within Waimea town and along Kawaihae Road. Mauna Kea Beach Resort at the coast comprises hotel and residential developments, and golf courses. There are over 500 acres in cultivated agriculture within the Lalamilo Farm Lots. Much of the remaining watershed is grazed or in a wildland state.

2.2.5 Water Uses – Historic and Current

For years, the presence of an extensive *ʻauwai* (irrigation channel system), has given rise to the possibility that large portions of the Waimea plains were irrigated and cultivated in ancient times. In fact, an important legal case on the water rights of Parker Ranch in the early 1900s led to the production of a detailed map of the *ʻauwai* system on the *kula lands* of Waikoloa Nui, Waikoloa Iki, Lalamilo and Puʻukapu (Kanakanui *et al.*, 1914; Reg. Map No. 2576), which depicts flow of water to, and through many of the fee simple land interests awarded to native tenants in the region (Maly and Maly 2004).

Hawaii County Department of Water Supply (DWS) relies on the streams of Kohala Mountain for its primary source of water. The DWS system draws its water from diversions on Waikoloa and Kohakohau streams. The diversion on Waikoloa Stream was first developed in 1925 and the one on Kohakohau Stream was completed in 1971. Raw water from the streams is stored in 4 reservoirs (2 of which were damaged in the 2006 earthquake and are currently awaiting repairs) with a total capacity of over 150 million gallons (MG) and is treated in the DWS filtration plant.

Use of surface water to supply potable water requires strict adherence to DOH regulations related to treatment and monitoring. The surface water is treated by conventional filtration for odor and color control, and for corrosion control and disinfection, and blended with groundwater before distribution (DWS 2006). According to DWS (2006), the stream diversions currently provide 1.427 mgd. "The *2006 DWS 20-Year Water Master Plan* indicates the estimated capacity of the surface water sources used by the water system to be 1.45 mgd" (DWS (2006), p. 801-15).

During periods of prolonged dry weather or high water usage, the treatment plant cannot process enough surface water sources to meet demand; as a result, DWS has developed a deep well in Waimea, which taps a high-level groundwater source, to supplement surface water sources. The Waimea water system provides about 2.0 mgd to users in Waimea and as far east as Paauilo and west to the Waiemi subdivision on Kawaihae Road.

DWS is currently updating its water use and development plan. A draft of the Hawaii County Water Use and Development Plan Update was completed in December 2006. With the existing DWS filtration plant at capacity, stricter Environmental Protection Agency (EPA) standards for surface water used for domestic consumption, and rapid growth within the North and South Kohala regions taxing water supplies, the county will likely develop more groundwater resources in the very near future to meet the growing demand. Groundwater is also more reliable during periods of drought.

Surface water from outside the Waiulaula watershed is transported into the watershed for use by farmers in the Lalamilo Farm Lots. The Hawaii Department of Agriculture's (DOA) Waimea Irrigation Water System provides irrigation water to farmers in both Puukapu and Lalamilo (Figure 19). Puukapu

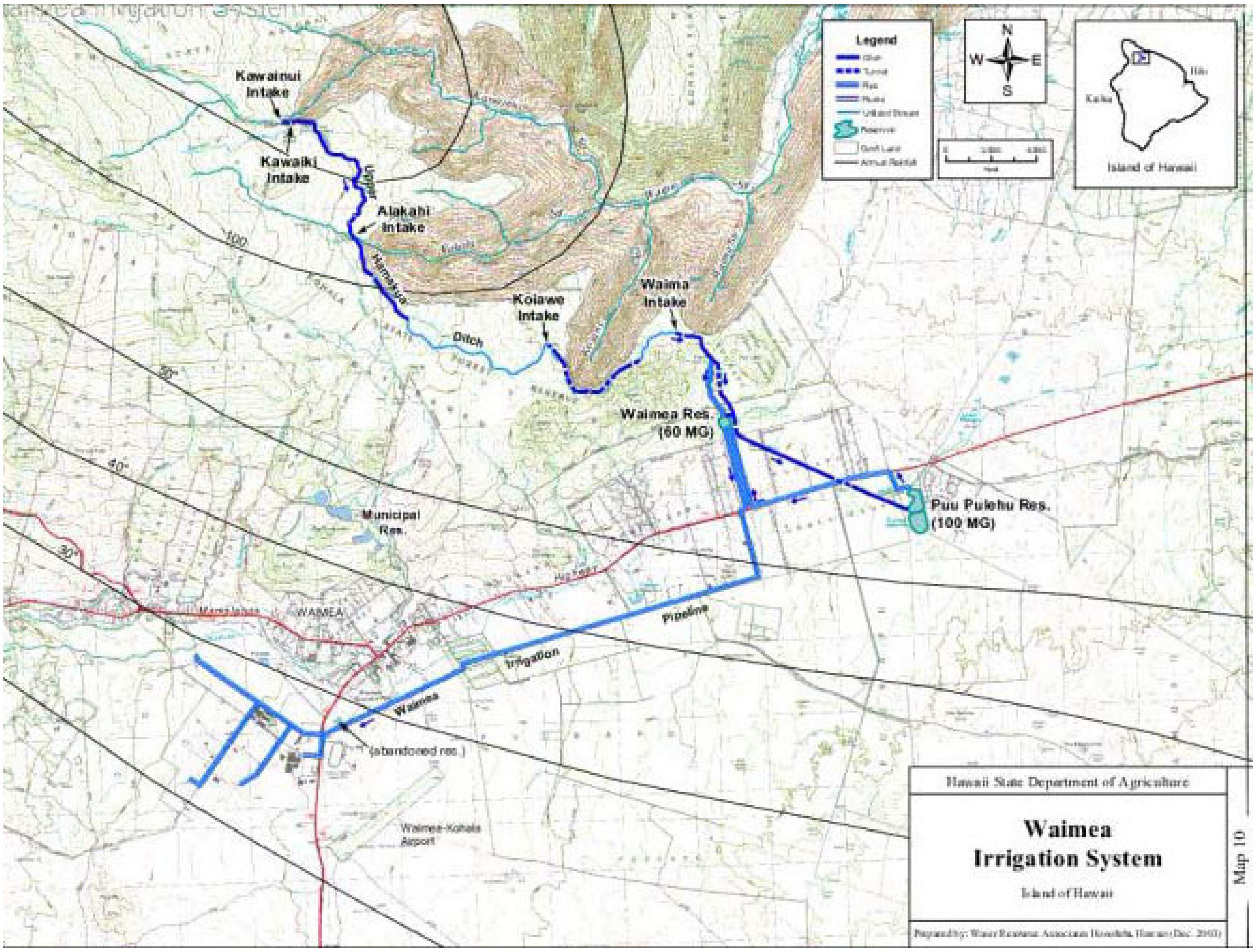


Figure 19: Waimea Irrigation System (taken from HDOA 2003)

farm lots are located on DHHL land east of Waimea town and south of Mamalohoa Highway. The Lalamilo farm lots are situated west of Mamalohoa Highway south of Waimea town, within the Waiulaula watershed at the terminus of the Waimea Irrigation System. Surface water from windward Kohala streams is diverted into the Upper Hamakua Ditch to the system's 60 MG Waimea and 100 MG Puu Pulehu reservoirs (DOA 2004). Puu Pulehu Reservoir water can be transferred to the Waimea Reservoir via a booster pump and connecting pipeline (HDOA 2004). The system then distributes water from Waimea Reservoir to 566 acres of farm land in Puukapu and Lalamilo. According to the DOA website (www.hawaii.gov/hdoa/arm/arm_irrigation), the system currently transports 307.2 MG per year (0.842 mgd). This 15-mile long system suffered considerable damage during the 2006 earthquake to the water intake structures, and conveyance ditches and tunnels. Work continues on repairs to the system.

According to KWP (2007), "Parker Ranch continues to use a water system developed in 1902 to extend water to the Waimea-Waikoloa Plains" (p. 20). Some of the system's supply of approximately 300,000 gallons per day comes from high level intakes within the Waiulaula watershed on Waikoloa and Kohakohau streams. "An extensive system of distribution lines deliver livestock water to Parker Ranch's widely-spread pasture lands in the Waimea area" (KWP 2007: p. 20). Parker Ranch also diverts water from Kohakohau and Ouli streams to fill reservoirs from which water is distributed to tanks and cattle troughs.

2.2.6 Flooding and Flood Control

Flooding has been a chronic problem in the Waimea area. As Waimea has grown over the years, there are greater numbers of structures potentially in harm's way. In 1973, the State proposed channelizing a 1,600-ft. length of Waikoloa Stream as a way to reduce the frequency of flooding in Waimea (DLNR 1973). At the time of the EIS preparation, flooding had occurred at least eight times during the previous 12 years (DLNR 1973). The EIS identified one area prone to flooding as the stream section above Lindsey Road, where flood waters flowed through Waimea Park and sections of the old Hawaii Preparatory Academy (now St. James' Episcopal Church Circle). The State proposed building a concrete-lined channel beginning below the Lindsey Road bridge and ending downstream at a State of Hawaii owned property (Waimea Nature Park), bypassing the meanders of the natural stream and following a straight alignment (Figure 20). The draft EIS stated that "the flood control channel will alleviate the flooding in the area for the 50 year flood event, and may be capable of a 100 year flood capacity" (DLNR 1973; p. 16). It is hoped that through the Waiulaula watershed management project and innovative stormwater management techniques, Waikoloa Stream will never have to be channelized.

Tom Nance Water Resource Engineering prepared a drainage analysis for the DHHL Lalamilo Residential Project EIS "to establish the probable limits of flood inundation and provide greater accuracy for Keanuiomano and Lanikepu Streams (than shown on the FEMA FIRM maps), and to provide an initial flood delineation for Waikoloa Stream" (Nance 2002). To prepare the drainage analysis, an aerial topographic survey with 2-ft. contour intervals was undertaken; the 100-year peak discharge rates for Waikoloa, Keanuiomano, and Lanikepu streams were determined; and the areas subject to flooding by the 100-year storm peaks were computed and mapped.

The 100-year peak discharge rates used for the flood delineations on the FIRM panels for Hawaii Island are based on regression equations developed in 1977. These have not been updated, despite the availability of more streamflow data. To check the validity of the regression equation for leeward streams in light of the data now available, Nance (2002) compared data for four USGS gaging stations in the general vicinity of the project site. Table 1 is taken from DHHL (2002) and compares the 100-year flood peak based on a Log Pearson Type III analysis of the annual flood peaks with the 100-year flood peak computed with the 1977 regression equation.

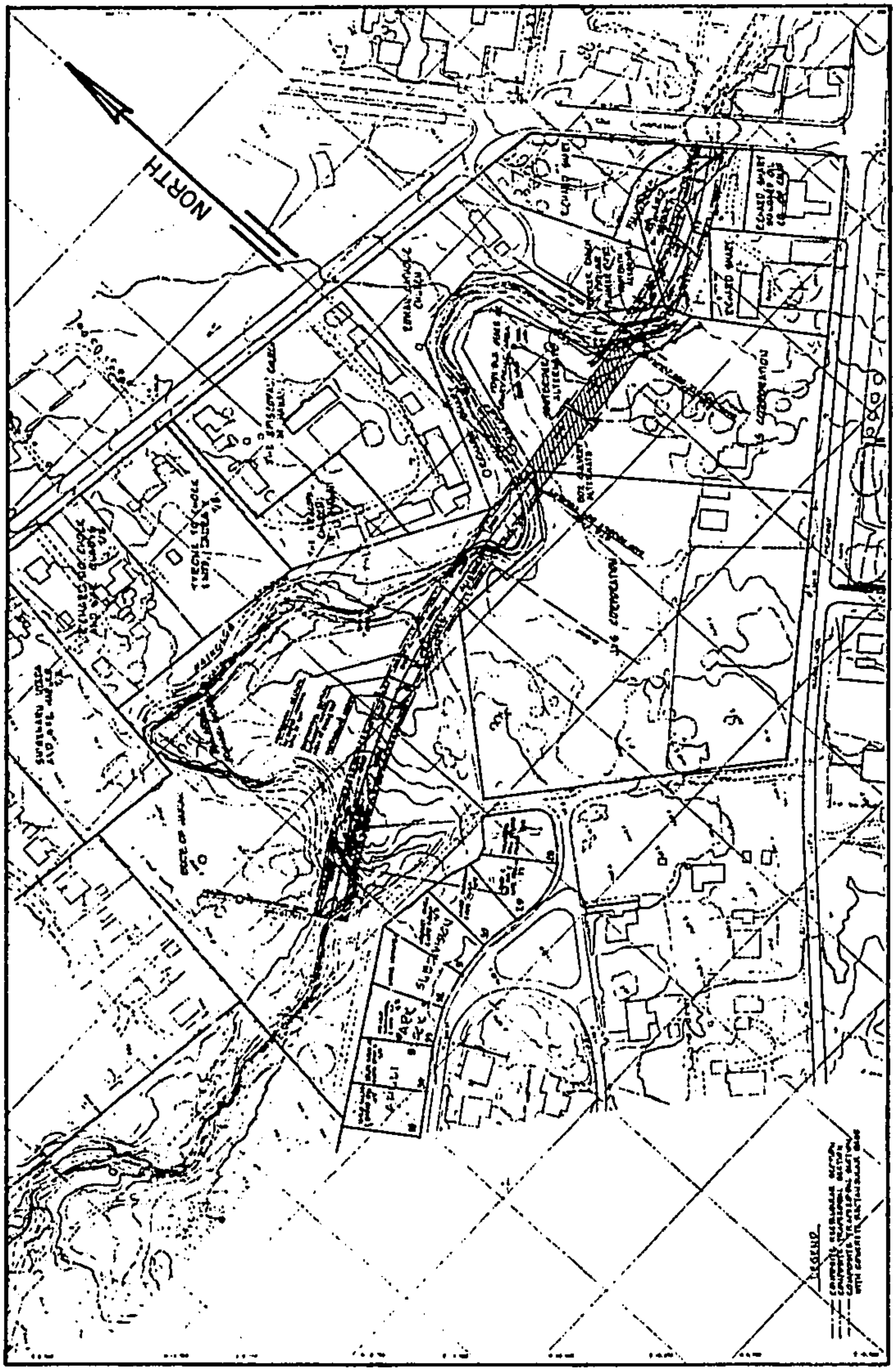


Figure 20: Proposed Puukapu Flood Control Project (Figure 3 from DLNR 1973)

Table 1. Comparison of Computed 100-Year Peak Discharge Rates (Table 11 in DHHL 2002)

	Keanuiomano Stream	Luahine Gulch	Waikoloa Stream	Kohakohau Stream
USGS Gage No.	7565	7558	7580	7560
Elevation of Gaging Station (Feet MSL)	2410	3160	3460	3273
Years of Record	31	33	53	37
Log Pearson Type III Analysis of Annual Flood Peaks:				
M (Log Units)	3.0092	1.9475	2.6779	3.0102
S (Log Units)	0.2936	0.2835	0.3457	0.3057
k_{100} (at skew = -0.05)	2.2895	2.2895	2.2895	2.2895
Q_{100} (CFS)	4801	395	2947	5130
Application of the 1977 Regression Equation:				
DA (Square Miles)	4.30	0.32	1.18	2.51
P_{24-2} (Inches)	6.00	4.40	6.20	6.20
Q_{100} (CFS)	6050	406	2407	4304

The analysis concluded the following:

> The regression equation provides a conservative (i.e., safe) estimate for the Keanuiomano Stream gage. Since this gage is located immediately above the mauka end of DHHL's project site, the regression equation result can be used for this stream.
>
> The regression equation also provides a conservative estimate for Luahine Gulch. This gulch has the same orientation relative to rainfall patterns as Lanikepu Stream and both waterways are normally dry. For this reason, it appears reasonable to use the regression equation for Lanikepu Stream.
>
> The regression equation significantly underestimates peak runoff for the gaging station site on Waikoloa and Kohakohau Streams. However, both these gaging stations are at high elevations in the watershed where the stream channels are relatively deeply dissected. The channel of Waikoloa Stream makai of Waimea Town has less topographic definition. This means that there would be a significant amount of overbank flow during the 100-year flood event, resulting in significant attenuation of the peak discharge rate. In other words, the regression equation is considered to be a reasonable predictor of peak flowrates in the reach of Waikoloa Stream that passes along the south boundary of the project site.
>
> Areas subject to inundation by a 100-year flood were determined for Waikoloa, Keanuiomano, and Lanikepu Streams. For Lanikepu and Keanuiomano Streams, the areas subject to inundation by the 100-year flood are considerably narrower than shown on FEMA Panel 155166 0164D. Waikoloa Stream's inundated area, with the single exception where the flow splits into two channels, is also relatively narrow. The drainage analysis determined that the capacities of the stream channels are generally sufficient to contain most of the flood waters." (DHHL 2002, pp. 4-10 to 4-13)

In 2004, NRCS developed an *Engineering Report for the Waimea Nature Park* (Ulu La`au) that describes alternatives for enhancing stream channel and bank stability, reducing flood-related damage to the Park and improving wildlife and aquatic habitat. It provides detailed hydrologic and hydraulic analyses of the stream reach. The hydraulic analysis determines the peak flood discharge rates at identified stream locations for various storm intensities, associated with recurrence intervals. The peak flood discharges for Waikoloa Stream through the Park were estimated using the existing FEMA analysis. Based on this information, NRCS (2004) estimated that the peak discharge for a 100-year storm at the Park would be 2,600 cfs. NRCS also conducted a hydraulic analysis to determine the characteristics of stream flow in the natural channel and with proposed modifications.

2.2.7 Stormwater Management

In Hawaii County, all urban developments (with very few exceptions) have been mandated to maintain pre-development runoff conditions (Chapter 27, HCC, "Floodplain Management"). Pre- and post-development runoffs are calculated using the County "Storm Drainage Standard." The minimum criteria used for runoff calculations are a 1-hour, 10-year storm event. This requirement inhibits conveyance of development runoff into natural drainage systems. It specifies that stormwater shall be disposed into drywells, infiltration basins or other approved infiltration methods. Chapter 23, HCC, "Subdivision" and Chapter 25, HCC, "Zoning" contain these same requirements.

Hawaii County has historically relied on deep (+20 feet) 5-ft diameter drainage injection wells (or "dry wells") as the primary means of capturing and disposing of urban stormwater runoff because Hawaii Island's geology allows for good lateral and downward percolation. The county allows a maximum disposal rate of 6 cubic-feet-per-second (cfs) of water per dry well (Kuba 2005). Figure 21 identifies the location of many of Waimea's dry wells.

Figure 21: Dry Wells In and Around Waimea

2.2.8 Cultural Resources

The Waiulaula watershed is located in an area that has a very rich cultural history. Table 2.9 of the South Kohala Community Development Plan (Hawaii County 2008) summarizes information on historical and cultural sites within the Waimea area, many of which are in the Waiulaula watershed.

Historical and Cultural Sites in Waimea: Native Hawaiian Sites (Hawaii County 2008)

No.	Site	Structure	Description	Waiulaula watershed
1	Haleino “Women's Heiau”	Heiau	Historical accounts attribute the founding of the heiau to high chiefess Hoapiliahae. It is said that young virgins performed ceremonies at the heiau and learned about the science and practices of healing.	√
2	Heiau built by Makuakua	Heiau	The akua Makuakua observed a rainbow and found the goddess Wao. The two lived at Hoku`ula. Wao returned to the Waimea hillsides to bear children. Thus the hillsides were sacred. A kapu was proclaimed in her honor on the hillsides. The boundary of the kapu area was delineated by rolling stones down the hill. The place where the stones stopped delineated the boundary of the area.	√

No.	Site	Structure	Description	Waiulaula watershed
3	Lalamilo Field System		Identified in 1976 as a veritable treasure of 400+ acres of pastoral lands, house sites, hearths and stone enclosures. The field system was developed by Native Hawaiians prior to contact with western civilization.	√
4	Various agricultural, habitation, religious, and burial sites		Several of these sites are known to exist in the vicinity of various streams, pasture lands, and hillsides of Waimea. Although most have not been surveyed, they have been identified especially in areas that have not been altered by farming or urban development.	√

Historical and Cultural Sites in Waimea: Paniolo Sites (Hawaii County 2008)

No.	Site	Structure	Description	Waiulaula watershed
5	Parker Ranch Race Track	Track built in 1901; Horse Barn (1915); Attendant House and Stallion Barn (1930)		
6	Additional Parker Ranch Structures	Mana Complex (1847); Spencer Home (1875); Manager's House (1885); Kahilu Hall (1918)		√
7	Parker Ranch Slaughter House		Stone wall enclosure that formed Minuke Ole pen. Built in the early 1940s.	√
8	Pukalani Complex	This complex of buildings consists of: Pu`u Hihale Complex, Breaking Pen Stables, Carriage Barn (Surgery Barn), Black Smith Stable, Pukalani Stables	These buildings were essential to Parker Ranch's ranching operations. Possibility of incorporating this complex into a heritage community with a heritage center/museum. Built in the late 1800s.	
9	Breaking Pen		Coffee shack and stone wall enclosure. Built in 1905.	
10	Pu`u Hihale Complex	Viewing lanai (1900); Cowboy Gang Stables (1930, remodeled 1985); Bucking and Grooming Chute (1944)	Stone wall corral with walls 8' high by 6' wide. Cattle branding viewing lanai. Chute built for the Marine Rodeo. Referred to as the "Paniolo Heiau" and is considered the most significant Paniolo historic site in Waimea. Built in the late 1800s.	
11	Waimea Stables	Stone wall that pre-existed the stables by 50-100 years.	Converted to a working corral in 1985. Originally constructed in 1960.	
12	Kemole Corral		Rebuilt often. Originally built in 1930.	
13	Pu`u Kikoni Corral		Rebuilt often. Originally built in 1930.	

No.	Site	Structure	Description	Waiulaula watershed
14	Pu`u Kikoni Dairy Site		Called New Dairy. Built in 1920.	
15	Anna Ranch		Anna Lindsey Perry-Fiske, the last of five generations of Lindseys to run the ranch, died at age 95 in 1995 and left the ranch as her legacy to the people of Waimea.	√
16	Pali Ho`oukapapa Dairy Site	Creamery (late 1800s); Corn Silo (1914); Corral (1920+)	Later became a working corral. Originally built in the late 1800s.	
17	Mana House Complex			
18	Makahalau Complex	Corn Crib and Silo (1914); Cowboy Camp House (1920); Makahalau Stables and Corral (1920); Purebred Bull Barns (1935)	Was once a village like Mana.	
19	Hanaipoe Line Cabin		Became the home for section chief Seichi Morifuji and was kept as a recreational cabin for ranch employees. Built in the 1930s.	
20	Waikii Complex	Corn Silos (1914); Cooking ovens (1915); Large Barn, Corn Crib and Cowboy Stable Barn (1920); Attendant Corral, Homes and Quonset Huts (various dates)	Ovens of both Russian and Portuguese origin.	

Historical and Cultural Sites in Waimea: Homes (Hawaii County 2008)

No.	Site	Structure	Description	Waiulaula watershed
23	Frank Spencer House		Combined styles and the use of Koa wood. Home of Judge Bickerton and served as an early court house and hotel. Associated with several of Waimea's prominent families. Built in 1850.	√
24	Antony Smart House		Original location in Waiemi. Built during the 1830s.	√
25	Purdy House		Built by Harry W.W. Purdy who was one of Waimea's earliest foreign adventurers and a contemporary of John Palmer Parker. Built in 1840.	
26	Old Lindsey House			√
27	Hale Kea (Jacaranda Inn)		Home of A.W. Carter. The oldest part of Hale Kea was built around 1885 and was first used as an Episcopal Church.	v

Historical and Cultural Sites in Waimea: Stores (Hawaii County 2008)

No.	Site	Structure	Description	Waiulaula watershed
28	Kamuela Liquor		Formerly this location was the Wakayama Theater, a gathering place for early Japanese settlers in Waimea.	
29	Chock In		One of the last surviving stores that was built near the turn of the century. Built in 1908.	√

2.2.9 Relevant Authorities/Policies

There are numerous authorities at the county, state and federal levels that regulate potential sources of polluted runoff. Those relevant to land and water use activities within the Waiulaula watershed are summarized below.

Agricultural Lands

The local Mauna Kea Soil and Water Conservation District (MKSWCD) is a major player in the management of agricultural lands because it develops and approves conservation plans which allow agricultural operations to receive an exemption from the county grading ordinances (Chapter 180, HRS). Without an approved conservation plan, agricultural operators are required under Chapter 10, HCC, to get a permit from the Hawaii County Department of Public Works (DPW) for any earthwork.

Significant amounts of land in agriculture are State lands leased to agricultural operators. The Department of Land and Natural Resources (DLNR) Land Division is responsible for leasing these lands under Chapter 171, HRS. One of the lease conditions is that the operator works with the local soil and water conservation district to develop and implement a conservation plan. Pursuant to Act 90, SLH 2003, beginning on January 1, 2010, the authority to manage, administer, and exercise control over any public lands that are designated important agricultural lands pursuant to Section 205-44.5, HRS, will be transferred from DLNR to the State Department of Agriculture (DOA) (Section 171-3(b), HRS).

U.S. Department of Agriculture's Natural Resources Conservation Service (NRCS) usually helps in developing conservation plans to treat existing and potential resource problems and has funding available to assist with the installation of best management practices. NRCS primarily develops plans for operators seeking funding under Federal Farm Bill programs. NRCS's *Hawaii Field Office Technical Guide* (eFOTG) outlines conservation practice standards and specifications.

Chapter 11-21, HAR, "Cross-Connection and Back-Flow Control," administered by DOH, requires that a reduced pressure principal back-flow preventer or air gap separation be installed as part of any piping network in which fertilizers, pesticides and other chemicals or toxic contaminants are injected or siphoned into the irrigation system (§11-21-7(a)(4), HAR).

Pesticides

Under the authority of Chapter 149A, HRS, DOA, Pesticides Branch, is the lead agency for implementing those measures that relate to regulating pesticides. Chapter 4-66, HAR, administered by DOA, relates to the registration, licensing, certification, record-keeping, usage, and other activities related to the safe and effective use of pesticides. It requires that those who apply or directly supervise others who apply restricted use pesticides be certified. Certification requires some understanding of the environmental concerns of using pesticides. This requirement is implemented under the CES/DOA Pesticide Applicator Program. Certification is not required for those using pesticides that are not classified as "restricted use."

Wastewater Disposal

Chapter 11-62, HAR, administered by DOH, outlines the requirements for locating, building and operating wastewater treatment systems and individual wastewater systems. Section 11-62-03, HAR, defines an "individual wastewater system" as "a facility which is used and designed to receive and dispose of no more than 1,000 gallons per day of domestic wastewater" and "treatment works" as "any treatment unit and its associated collection system and disposal system, excluding individual wastewater systems." The chapter provides specific requirements for both types of wastewater systems. An engineer must evaluate the site for suitability for an OSDS, including depth of permeable soil over seasonal high groundwater, bedrock, or other limiting layer, soil factors, land slope, flooding hazard, and amount of suitable area available. No OSDS can be located within 50 feet of a stream, the ocean at the vegetation line, pond, lake, or other surface water body; or within 1,000 feet of a potable water source serving public water systems.

Chapter 11-62, HAR, also provides for the establishment of Critical Wastewater Disposal Areas (CWDAs), where the disposal of wastewater has or may cause adverse effects on human health or the environment due to existing hydrogeological conditions. CWDAs are established based on one or more of the following concerns: high water table; impermeable soil or rock formation; steep terrain; flood zone; protection of coastal waters and inland surface waters; high rate of cesspool failures; and protection of groundwater resources. CWDAs were designated for each county in 1990 and updated in 1997 (see Figure 22). Within CWDAs, DOH may impose more stringent requirements for wastewater systems, and cesspools are severely restricted or prohibited.

Chapter 11-23, HAR, also administered by DOH, establishes a state underground injection control (UIC) program in order to protect the quality of the State's underground sources of drinking water from pollution by subsurface disposal of fluids. It classifies exempted aquifers and underground sources of drinking water. Unless expressly exempted, all aquifers are considered underground sources of drinking water. UIC maps indicate the boundary line of exempted aquifers. While individual wastewater systems serving single family residential households are excluded from the chapter, no large municipal or community serving systems can use injection wells above the UIC line. Certain activities are also prohibited interior of the line.

EPA regulations required that all existing large capacity cesspools (LCC) be closed and replaced with an alternative wastewater system by April 2005. EPA also banned the construction of new LCC. A large capacity cesspools serves multiple dwellings or commercial property that serves 20 or more people per day. EPA Region 9 has been responsible for implementing the regulations in Hawaii, working with DOH.

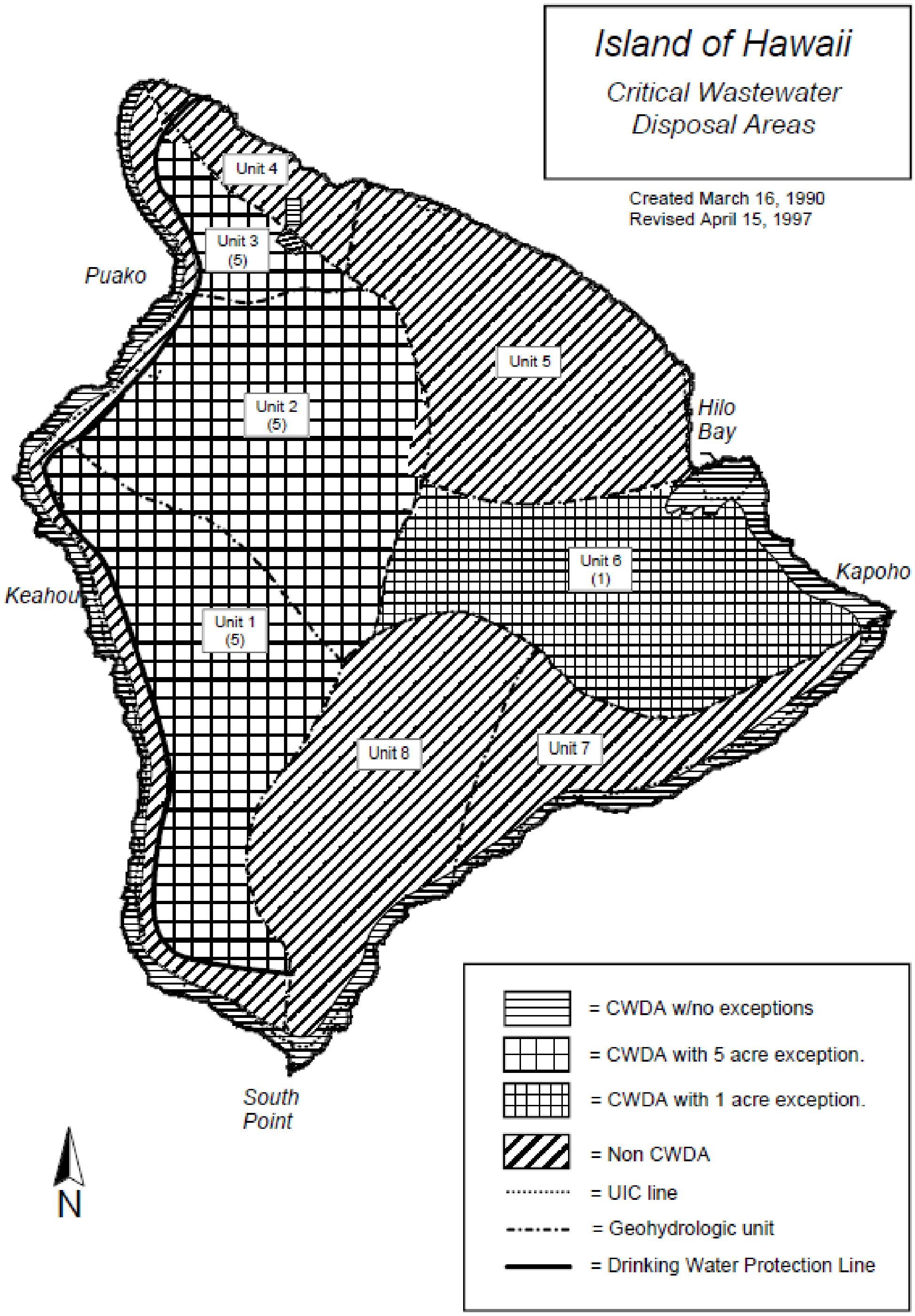


Figure 22: Critical Wastewater Disposal Areas for Hawaii Island

Chapter 17-47, HCC, administered by the County of Hawaii DPW, modifies the Uniform Plumbing Code to require the use of low flow plumbing fixtures. Chapter 27, HCC, states that on-site cesspools and septic systems shall be located to avoid impairment to them or contamination from them during flooding.

Use of Recycled Wastewater
Chapter 11-62, HAR, administered by DOH, allows for the use of recycled water for irrigation with written approval by the director, provided the owner of the recycled water system submits an engineering report for approval which clearly identifies all BMPs to be implemented, an irrigation use plan, overflow control plan, management plan, public information and access plan, labeling plan, employee training plan, vector control plan, and groundwater monitoring plan. For golf courses, the director is guided by DOH's *Guidelines for the Treatment and Use of Recycled Water* (May 2002). R-2 and R-1 waters may be used for golf course irrigation.

Rubbish and Pet Waste
Chapter 342H, HRS, "Solid Waste Management," administered by DOH, prohibits disposal of solid waste anywhere other than a permitted solid waste management system. It encourages the recycling of solid wastes, including animal wastes and selected non-hazardous industrial wastes, and the composting of animal manures and by-products for agricultural and horticultural purposes. It also encourages the use of treated sludge effluent for fertilizer and other agricultural purposes.

Chapter 20, HCC, administered by the Hawaii County DPW, prohibits littering on any highway, street, road, alley, sidewalk, sea beach, public park, or other public place in the county. Litter is broadly defined to include, among other things, dirt, paper, wrappings, cigarettes, yard clippings, leaves, wood, scrap metal, and any other waste materials.

The county also administers the ordinance addressing pet waste. Chapter 4, HCC, prohibits pet owners from allowing their pets to defecate on public streets, including sidewalks, passageways, or bypasses, or on any play areas, parks, or places where people congregate or walk, or on any public property, or on any private property without the permission of the owner of the property, unless the pet owner immediately picks up and properly disposes of the feces.

Hazardous Materials Disposal and Storage
Chapter 342I, HRS, "Special Waste Recycling," administered by DOH, prohibits disposal of used lead acid battery, except by delivery to a lead acid battery retailer or wholesaler, a collection or recycling facility, or a secondary lead smelter, and specifically prohibits disposal of electrolyte from any used lead acid battery onto the ground or into sewers, drainage systems, surface or ground waters, or ocean waters.

Chapter 342J, HRS, "Hazardous Waste," also administered by DOH, prohibits discharge of new, used or recycled oil into sewers, drainage systems, surface or ground waters, watercourse, marine waters, or onto the ground. The prohibition does not apply to inadvertent, normal discharges from vehicles and equipment, or maintenance and repair activities, provided that appropriate measures are taken to minimize releases.

Chapter 11-281, HAR, administered by DOH, regulates underground storage tanks (UST). Each UST must be properly designed, constructed, and installed, and any portion underground that routinely contains product must be protected from corrosion. UST are used to store petroleum products at gas stations in the watershed, two of which are located adjacent to Waikoloa Stream.

Urban Development

In urban areas, the county has the lead in the control of erosion during site development and ensuring proper site planning and stormwater management to protect sensitive natural features, through its ordinances and rules related to zoning, subdivisions, drainage, and erosion and sediment control.

Chapter 10, HCC, "Soil Erosion and Sediment Control," administered by the Hawaii County DPW, requires a permit for grading and grubbing of land, and stockpiling of material in excess of 500 cubic yards. All grading, grubbing, and stockpiling permits and operations must conform to erosion and sedimentation control standards and guidelines. Hawaii County is currently in the process of revising this ordinance.

In Hawaii County, all urban developments (with very few exceptions) have been mandated to maintain pre-development runoff conditions (Chapter 27, HCC, "Floodplain Management"). Pre- and post-development runoffs are calculated using the County "Storm Drainage Standard." The minimum criteria used for runoff calculations are a 1-hour, 10-year storm event. This requirement inhibits conveyance of development runoff into natural drainage systems. It specifies that stormwater shall be disposed into drywells, infiltration basins or other approved infiltration methods. Chapter 23, HCC, "Subdivision," and Chapter 25, HCC, "Zoning," contain these same requirements.

If development activity will disturb one acre or more of total land area, then a National Pollutant Discharge Elimination System (NPDES) permit is required from the Hawaii Department of Health (DOH). This permit process is described in Chapter 11-55, HAR, "Water Pollution Control" (http://gen.doh.hawaii.gov/sites/har/AdmRules1/11-55.pdf). A County grading permit is required for any grading and grubbing work <u>before</u> a NPDES permit can be issued. The grading permit allows the grading, while the NPDES permit regulates stormwater runoff from the construction site.

Typically, large development proposals must undergo numerous permit processes, with their associated environmental assessments and extensive public review. Development in the Conservation District triggers a Conservation District Use Permit (CDUP) from DLNR; development within the counties' Special Management Area (SMA) must seek an SMA permit from the County planning department. Chapter 343, HRS, and Chapter 11-200, HAR, both about the Environmental Impact Statement law, require the preparation of an environmental assessment (EA) and/or environmental impact statement (EIS) for proposed activities that trigger the environmental review process. Some of the trigger conditions are as follows: (1) use of State or county lands or funds; (2) use within the conservation district; (3) use within a shoreline setback area; (4) use within an historic site; (5) reclassification of conservation lands; and (6) certain amendments to a county general plan.

The county administers the Special Management Area (SMA) permit process. SMAs are a subset of the State's coastal zone and include all lands and waters beginning at the shoreline and extending inland or *mauka* at least 100 yards. The SMA permit process, administered by the Hawaii County Planning Department, ensures that developments in these more-sensitive coastal areas are consistent with Hawaii's coastal zone management (CZM) program objectives and policies. Although each county has its own procedures for administering SMA permits, the requirements and review processes for SMA applications are based on Chapter 205A-26, HRS ("Special management area guidelines"). The county requires a permit applicant to describe the proposed development in terms of the CZM objectives and policies.

Roads, Highways and Bridges
In Hawaii, roads, highways and bridges are usually developed by the State or county government, with State, county and/or Federal funds, or by private entities as part of a subdivision or other large development. Privately-constructed roads and highways usually must meet standards set by the State and/or county because they are transferred over to the State or county as public roadways upon completion of construction. Privately-constructed roads that remain private must still comply with county requirements for erosion and sediment control, stormwater management, drainage, zoning and subdivisions. A 1999 State Attorney General's opinion clarified that all public highways are County highways unless declared by Chapter 264, HRS, to be under State jurisdiction.

Hawaii Department of Transportation (DOT) has jurisdiction over State roadways. According to Section 264-8, HRS, specifications, standards and procedures prescribed by DOT are to be followed in the installation and construction of connections for streets, roads and driveways, concrete curbs and sidewalks, structures, drainage systems, landscaping or grading within the highway rights-of-way, excavation and backfilling of trenches or other openings in state highways, and in the restoration, replacement, or repair of the base course, pavement surfaces, highway structures, and other highway improvements.

DOT Standard Specifications are used for highway design and construction for Hawaii's transportation infrastructure. The current specifications in use are dated 1994, though many sections (technical provisions) have been revised since then. The updated 2005 *Standard Specifications for Road and Bridge Construction* requires written, site-specific BMPs describing activities to minimize water pollution and soil erosion into State waters, drainage or sewer systems, and a plan indicating location of the BMPs, areas of soil disturbance, areas where vegetative practices are to be implemented, and drainage patterns. DOT's *Storm Water Permanent Best Management Practices (BMP) Manual* (February 2007) applies to projects statewide within the DOT right-of-way.

Chapter 23, HCC, provides requirements for street design in subdivisions in Hawaii County. It requires the location, width, and grade of a street to conform to the County general plan and to be considered in its relation to existing and planned streets, to topographical conditions, to public convenience and safety, and to the proposed use of land to be served by the street. When an existing street adjacent to or within a tract is not of the width required by this chapter, additional rights-of-way shall be provided at the time of subdivision. Preliminary and final plats must show the location of lots, streets, water mains, and storm drainage systems, and are subject to technical review by the county director of public works, State DOH, and district engineer for DOT when the subdivision involves State highways. The ordinance also provides requirements for dedicable streets and standards for non-dedicable streets. Subdivisions, including roads, must maintain pre-development runoff conditions. Pre- and post-development runoffs are calculated using the County "Storm Drainage Standard." The minimum criteria used for runoff calculations are a 1-hour, 10-year storm event. This requirement inhibits conveyance of development runoff into natural drainage systems. Chapter 22, HCC, "County Streets," defines and regulates construction within a county street. It states that no driveway approach shall interfere with the proper runoff of waters into or passage of waters through existing drainage culverts, swales, ditches, watercourses, defiles, or depressions.

Chapter 19-127.1, HAR, administered by DOT, addresses the design, construction and maintenance of public streets and highways. It applies to all persons and agencies who design, construct, and maintain facilities which are, or are intended to become, public streets and highways in the State. The chapter establishes design, construction and maintenance guidelines that should be followed in the construction, reconstruction, and maintenance of all highways, streets, or roads undertaken either by State or county authorities or by individuals intending to dedicate the facilities to governmental authorities.

Hydromodifications

The State Water Code (Chapter 174C, HRS), adopted by the Hawaii Legislature in 1987 and amended in 2004, provides the regulatory framework to protect streams, wetlands and other areas critical to water quality. The State, in its stewardship capacity, has management responsibility for all water resources of the State through the Commission on Water Resource Management (CWRM) – also known as the Water Commission. The Water Commission sets policies and approves water allocations for all water users.

CWRM issues permits to regulate the use of surface and ground water in the State. Existing uses established prior to 1987 are grandfathered in, provided the existing use is reasonable and beneficial. A stream channel alteration permit (SCAP) is required prior to undertaking a stream channel alteration in order to protect fishery, wildlife, recreational, aesthetic, scenic, and other beneficial instream uses. Routine streambed and drainageway maintenance activities are exempted from obtaining a permit. The Water Code also requires CWRM to establish and administer a statewide in-stream use protection program, including flow standards on a stream-by-stream basis whenever necessary to protect the public interest.

Under Chapter 46-11.5, HRS, the counties are responsible for the maintenance of channels, streambeds, streambanks, and drainageways, whether natural or artificial, including their exits into the ocean, in suitable condition to carry off stormwaters. For lands comprising the channels, streams, streambanks, and drainageways that are privately owned or owned by the State, the respective owner is responsible for maintenance.

The U.S. Army Corps of Engineers (USACOE) has the authority to protect the waters of the United States, including wetlands and some streams, by regulating certain activities within those waters. Section 404 of the Clean Water Act requires that anyone interested in placing dredged or fill material into waters of the United States must first obtain a permit from the Corps. 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. The law applies to any dredging or disposal of dredged materials, excavation, filling, rechannelization, or any other modification of a navigable water of the United States, and applies to all structures large or small. The initiation of a Section 404 permit process triggers a Section 401 water quality certification from DOH.

Chapter 13-190, HAR, "Dams and Reservoirs", is administered by DLNR. These rules govern the design, construction, operation, maintenance, enlargement, alteration, repair and removal of dams in the State. Written approval from DLNR of the construction plans is required for any construction, enlargement, repair or alteration project. Owners are required to provide for adequate and timely maintenance, operation, and inspection of their dams and reservoirs to insure public safety. DLNR is required to inspect all dams and reservoirs at least every five years.

Water Quality Protection

Chapter 342D, HRS, "Water Pollution," prohibits discharge of any pollutant into State waters. It allows DOH to institute a civil action for injunctive relief to prevent violation of State water quality standards. Under the statute, DOH may also request the court to order nonpoint source polluters to implement required management measures.

DOH establishes and enforces the State water quality standards contained in Chapter 11-54, HAR. All inland fresh waters are classified based on their ecological characteristics and other natural criteria as flowing waters (*e.g.*, streams), standing waters (*e.g.*, lakes and reservoirs), and wetlands. These waters are further classified for the purposes of applying water quality standards and selecting appropriate quality parameters and uses to be protected in these waters. Class 1 inland waters are to remain in their natural state as nearly as possible with an absolute minimum of pollution from any human-caused source. Waste discharge into these waters is prohibited. Any conduct that results in a demonstrable increase in levels of point or nonpoint source contamination in class 1 waters is prohibited.

The uses to be protected in class 1(a) waters are scientific and educational purposes, protection of native breeding stock, baseline references from which human-caused changes can be measured, compatible recreation, aesthetic enjoyment, and other non-degrading uses. The additional uses to be protected in class 1(b) waters are domestic water supplies and food processing. Class 2 inland waters are to be protected for recreational purposes, the support and propagation of aquatic life, agricultural and industrial water supplies, shipping and navigation. Class 1(a) waters include all standing and/or flowing waters, and elevated and/or low wetlands: (i) within the natural reserves, preserves, sanctuaries, and refuges established by DLNR under Chapter 195, HRS, or similar reserves for the protection of aquatic life; (ii) in national and state parks; (iii) in state or federal fish and wildlife refuges; (iv) which have been identified as a unique or critical habitat for threatened or endangered species by the U.S. Fish and Wildlife Service; and (v) in protective Conservation District subzones designated under Chapter 13-5, HAR. Class 2 waters shall not act as receiving waters for any discharge that has not received the best degree of treatment or control.

Hawaii also has water quality standards for marine waters. The receiving marine waters at the mouth of the Waiulaula watershed are classified class AA. The objective of "class AA, marine waters" is that these waters remain in their natural pristine state as nearly as possible with an absolute minimum of pollution or alteration of water quality from any human-caused source or actions.

Conservation Lands and Nearshore Waters
DLNR manages and regulates all lands set apart as forest reserves. It is also responsible for the management of the State's Natural Area Reserve System (NARS) to ensure preservation of specific land and water areas which support communities of natural flora and fauna, including wetland areas. Chapter 195, HRS, establishes a Natural Area Partnership program to provide state funds to help match private funds for the management of private lands that are dedicated to conservation. Chapter 173A, HRS, enables the State to acquire lands of exceptional value due to the presence of habitats for threatened or endangered species of flora, fauna, or aquatic resources. Chapter 195D, HRS, authorizes DLNR to acquire habitat for endangered species restoration. Chapter 198, HRS, authorizes DLNR to acquire conservation easements to preserve natural lands and waters.

Chapter 205A, HRS, defines the shoreline as "the upper reaches of the wash of the waves, other than storm and seismic waves, at high tide during the season of the year in which the highest wash of the waves occurs, usually evidenced by the edge of the vegetation growth, or the upper limit of debris left by the wash of the waves." The area seaward or *makai* of the shoreline is part of the Conservation District and is under State jurisdiction. The coastal area landward or *mauka* of the shoreline is managed by the counties as part of the Shoreline Management Area (SMA) established under Chapter 205A, HRS and described above.

DLNR manages the area seaward of the shoreline. Pursuant to Chapter 183, HRS, DLNR is responsible for establishing the procedures and certifying where the shoreline is located, and for promulgating and administering the Conservation District use regulations. All activities proposed within the Conservation District, whether *mauka* or *makai*, require a CDUP, for which there is an application and review process. The Board of Land and Natural Resources can approve, deny, or approve with conditions proposed uses of the Conservation District.

Boat Operation
Rules regulating the operation of vessels in ocean waters and navigable streams, administered by DLNR's Division of Boating and Ocean Recreation (DOBOR) restrict vessel speeds in Ocean Recreation Management Areas, along shorelines, and near other vessels, docks, and swimmers/divers. Chapter 13-244, HAR, specifically states that "no person shall operate a vessel at a rate of speed greater than is reasonable having regard to conditions and circumstances."

Chapter 13-232, HAR, "Sanitation and Fire Safety," administered by DOBOR, prohibits dumping, discharging, or pumping of oil, spirits, gasoline, distillate, any petroleum product, or any other flammable material into the waters of a small boat harbor or designated offshore mooring area.

Chapter 13-235, HAR, "Offshore Mooring Rules and Areas," states that no person shall anchor, moor or stay aboard a vessel except those equipped with an approved marine sanitation device (MSD) in proper working condition, or those vessels exempt from MSD requirements in accordance with USCG regulations.

2.2.10 Future Land Use Considerations

The Hawaii County's General Plan Land Use Pattern Allocation Guide (LUPAG) maps include significant urban expansion areas on both the coast and in Waimea town (see Figure 16). Proposed urban expansion areas allow for a mix of high density, medium density, low density, industrial, industrial-commercial and/or open designation in areas where new settlements may be desirable, but where the specific settlement pattern and mix of uses have not yet been determined. In the South Kohala District, this includes 12,264 acres or 42% of the designated urban expansion area for the entire island. Of this, there are several hundred acres of urban expansion land on the south side of Kawaihae Road just west of Waimea Town along Waikoloa Stream. There are also several hundred acres of rural land shown along the south side of Kawaihae Road, which would encourage low density residential development there.

Parker Ranch also has considerable development slated as part of its Parker Ranch 2020 Plan (see Figure 18). The plan calls for 750 new homes. It proposes to rezone 37.66 acres to multiple-family residential. In addition, commercial lands within Waimea Town were increased by about 104 acres in 1992 as part of the implementation of the Parker 2020 Master Plan. Luala`i at Parker Ranch, for which Phase 1 was completed in 2002, will eventually have 322 residential units, parks and open space on 75 acres.

DHHL's Lalamilo Residential project proposes 442 houses on 160 acres adjacent to both Waikoloa and Keanuiomano streams (Figure 23). The development will also include a community center, parks, general agriculture, preservation area (19.1 acres), and open space areas (44.5 acres). Phase 1, currently under development, includes 34 in-fill house lots. The remaining planned house lots will be built in subsequent phases.

Mauna Kea Resort is tentatively planning to develop a golf course and 135 large acreage residential lots with associated infrastructure and commercial use on its Ouli 2 property near the bottom of the watershed. Waimea Parkside is a 40-lot subdivision on 9.18 acres in Waimea town across Lindsey Road from the park. This development is currently under construction.

Finally, the South Kohala Community Development Plan recommends expanding the Lalamilo Farm lots by over 100 acres and constructing several connector roads around Waimea.

All these projects could have implications for polluted runoff in the watershed. The proliferation of impervious surfaces and the greater number of people living in close proximity to the watershed's streams will likely increase the generation of urban pollutants. With much of this additional growth occurring adjacent to the streams, there is a greater likelihood of the urban pollutants reaching the surface waters.

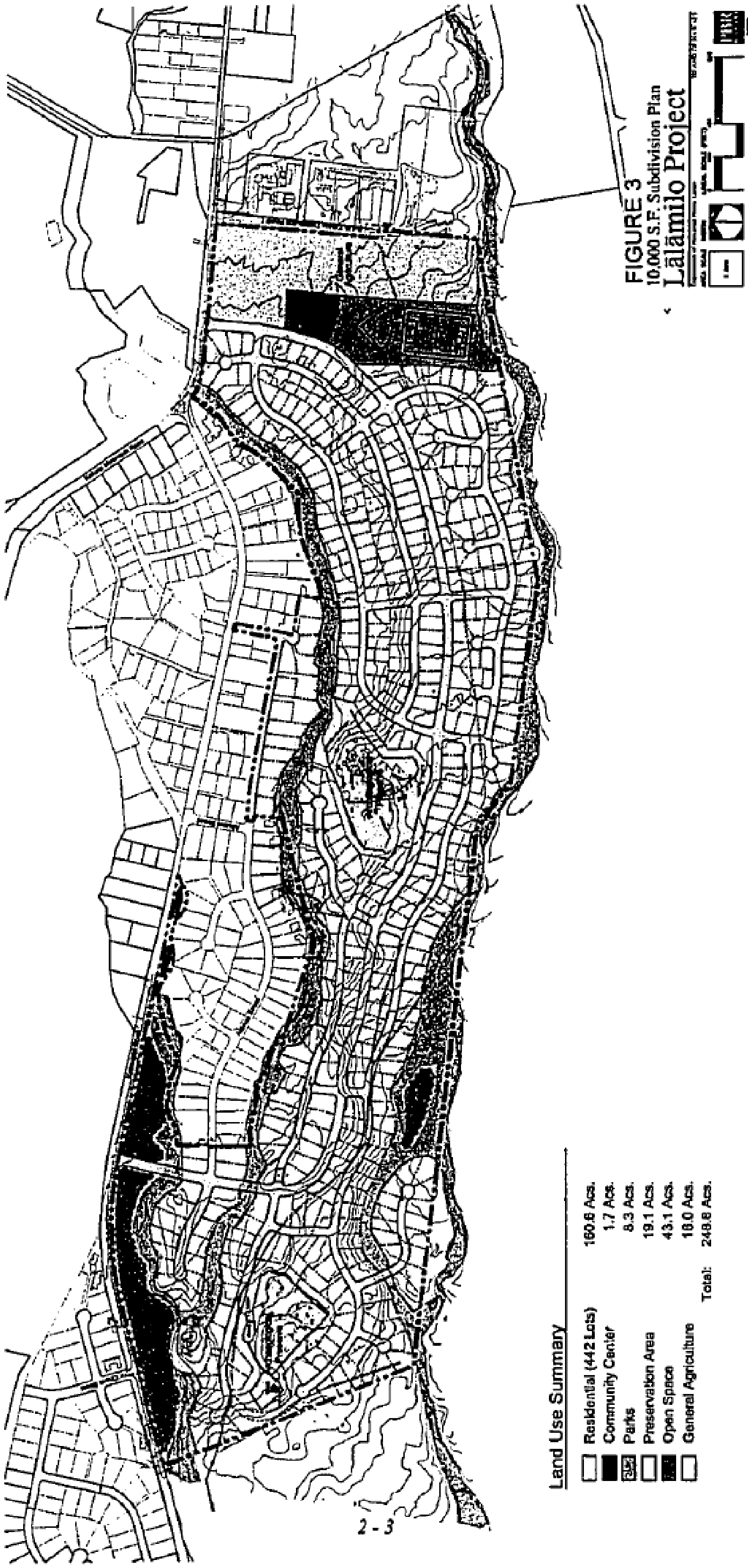


Figure 23: DHHL Lalamilo Residential Project

Chapter 3: Watershed Conditions

3.1 Water Quality Standards

Chapter 11-54, HAR, contains a general policy of water quality anti-degradation: "existing uses and the level of water quality necessary to protect the existing uses shall be maintained and protected" (§11-54-1.1(a)). Chapter 11-54, HAR, classifies inland and marine waters of the State, and establishes use categories for the purposes of applying standards set forth in the chapter.

3.1.1 Designated Uses of Water

Class 1 inland waters are to remain in their natural state as nearly as possible with an absolute minimum of pollution from any human-caused source. Any conduct that results in a demonstrable increase in levels of point or nonpoint source pollution is prohibited. The uses to be protected in Class 1.a. waters are scientific and educational purposes, protection of native breeding stock, baseline references from which changes can be measured, compatible recreation, and aesthetic enjoyment. The uses to be protected in Class 1.b. waters are domestic water supplies, food processing, protection of native breeding stock, the support and propagation of aquatic life, baseline references, scientific and educational purposes, compatible recreation, and aesthetic enjoyment. The objective of Class 2 waters is to protect their use for recreational purposes, the support and propagation of aquatic life, agricultural and industrial water supplies, shipping, and navigation.

Class AA marine waters are to remain in their natural pristine state as nearly as possible with an absolute minimum of pollution or alteration of water quality from any human-caused source or actions.

In the Waiulaula watershed, the streams and wetlands within the State Conservation District are all classified as Class 1.b. because they are within the protective subzone designated under Chapter 13-5, HAR. The streams outside the Conservation District are categorized as Class 2. The nearshore marine waters at the mouth of Waiulaula are Class AA.

3.1.2 Numeric and Narrative Criteria

Numeric water quality standards have been established for waterbody types within the State and are contained in Chapter 11-54, HAR. The standards relevant to the Waiulaula watershed are provided below.

Table 2: Specific Criteria for Streams

Parameter	Geometric mean not to exceed the given value	Not to exceed the given value more than ten percent of the time	Not to exceed the given value more than two percent of the time
Total Nitrogen (mg /L)	0.250* 0.180**	0.520* 0.380**	0.800* 0.600**
Nitrate + Nitrite (mg/L)	0.070* 0.030**	0.180* 0.090**	0.300* 0.170**
Total Phosphorous (mg/L)	0.050* 0.030**	0.100* 0.060**	0.150* 0.080**
Total Suspended Solids (mg/L)	20.0* 10.0**	50.0* 30.0**	80.0* 55.0**
Turbidity (N.T.U.)	5.0* 2.0**	15.0* 5.5**	25.0* 10.0**

*Wet season – November 1 through April 30, **Dry season – May 1 through October 31.

Table 3: Open Coastal Waters Criteria

Parameter	Geometric mean not to exceed the given value	Not to exceed the given value more than ten percent of the time	Not to exceed the given value more than two percent of the time
Total Nitrogen (ug /L)	150.00* 110.00**	250.00* 180.00**	350.00* 250.00**
Ammonia Nitrogen (ug/L)	3.50* 2.00**	8.50* 5.00*	15.00* 9.00**
Nitrate + Nitrite (ug/L)	5.00* 3.50**	14.00* 10.00**	25.00* 20.00**
Total Phosphorous (ug/L)	20.00* 16.00**	40.00* 30.00**	60.00* 45.00**
Light Extinction Coefficient (k units)	0.20* 0.10**	0.50* 0.30**	0.85* 0.55**
Chlorophyll a (ug/L)	0.30* 0.15**	0.90* 0.50**	1.75* 1.00**
Turbidity (N.T.U.)	0.50* 0.20**	1.25* 0.50**	2.00* 1.00**

*“Wet” criteria apply when the open coastal waters receive more than three million gallons per day of fresh water discharge per shoreline mile.
**”Dry” criteria apply when the open coastal waters receive less than three million gallons per day of fresh water discharge per shoreline mile.

3.2 Available Monitoring/Resource Data

3.2.1 Water Quality Data

Existing water quality data: Water quality data were collected at the Marine Dam gage station (16758000) between 1971 and 1989 by the USGS Water Resources Branch. Along with physical parameters like temperature and discharge, nutrients and trace element concentrations were determined (N=14). Nutrient concentrations were all very low (near detection limits) except for orthophosphate which showed two elevated readings. Trace element concentrations resemble dilute sea water due to their source in sea spray aerosols.

New data: Water quality samples for nutrient and suspended sediment analysis were collected from Waikoloa stream at the Marine Dam, Waikoloa stream downstream of Waimea town, Waiulaula stream at the ocean entry, and Makeahua stream at Pelekane Bay. Samples of urban storm water runoff were also collected from a few sites in Waimea town. Twelve storm events were sampled between November 2007 and February 2009. Five storm events were sampled simultaneously at different sites in the watershed. (Currently we have not received laboratory analysis data for three storms sampled by the coastal Waiulaula sampler or the urban runoff.)

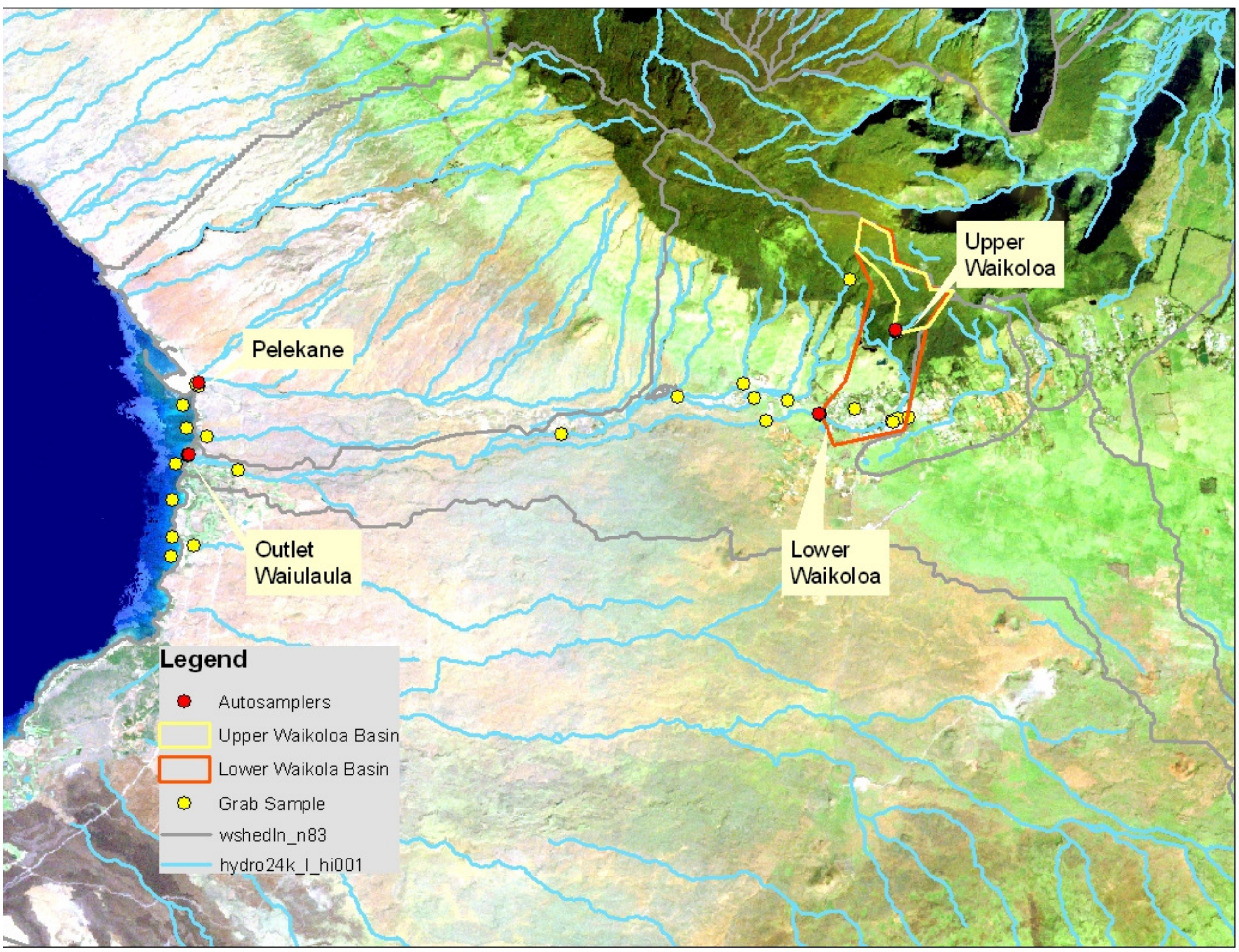


Figure 24: Sample Locations

Drainage basins contributing flow to the four sampling sites are very different. USGS 30-m Digital Elevation Models were used to delineate the drainage basin for each of the four stormwater sample sites. The forested Marine Dam basin (865 ac.) is made up of almost exclusively protected headwater bog. The Sandalwood basin (2,037 ac.) drains much of Waimea Town and includes the Marine Dam basin. Approximately 2 million gallons per day of surface water is withdrawn from Waikoloa stream at the Marine Dam intake to supply water to Waimea and surrounding areas. This is a significant alteration of normal watershed hydrology and has profound impacts on much of the water quality in the watershed. Waiulaula and Pelekane basins cover the entire watersheds and contain a variety of land covers and land uses, both dominated by ranching. Figure 25 shows percent land covers of each of the four drainage basins. Land cover was derived from 2001 NOAA Coastal Change Analysis Program (C-CAP) data.

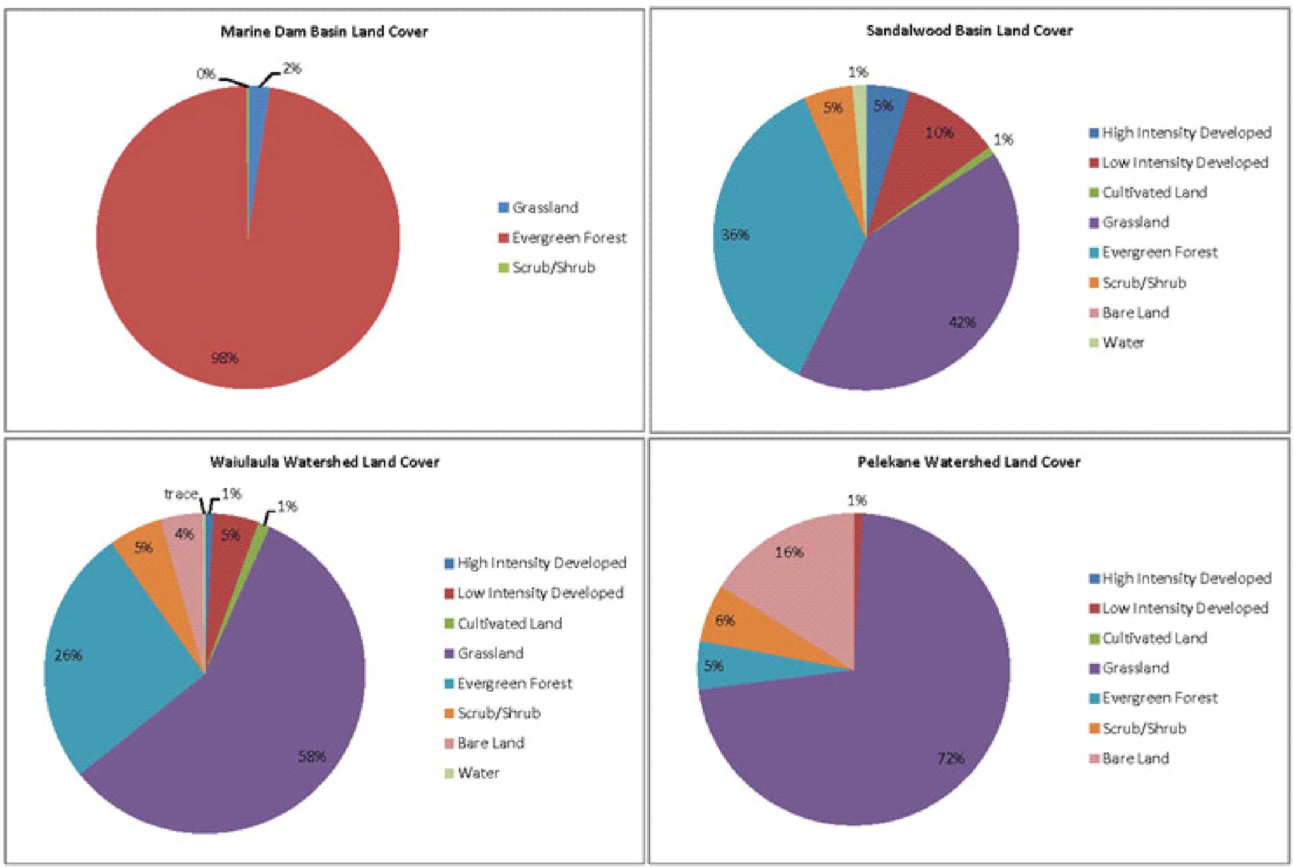


Figure 25: Land Cover in Four Drainage Basins

Automated point samplers were used to repeatedly sample streamwater over the course of storm flow. Sampling routines were developed to begin sampling at a specified rate of increase in stream stage and regularly sample over the expected duration of the storm, typically 12 to 20 hours. Eight to ten one-liter samples were selected from the 24 collected by the autosampler, spanning the duration of the storm event.

Stream Storm Water Samples: Flow data was collected along with concentration values in order to calculate event fluxes of substances in storm flow. Flux can be viewed as the amount of substance passing a point on the stream network, measured in mass / unit time. Multiplying our laboratory-determined concentrations (in mass / volume) and the observed flow rate (in volume / time) yields flux (mass / time). Since the samples combine different concentrations and flow rates through the course of storm flow, we can approximate the storm total efflux by summing the efflux between sample points.

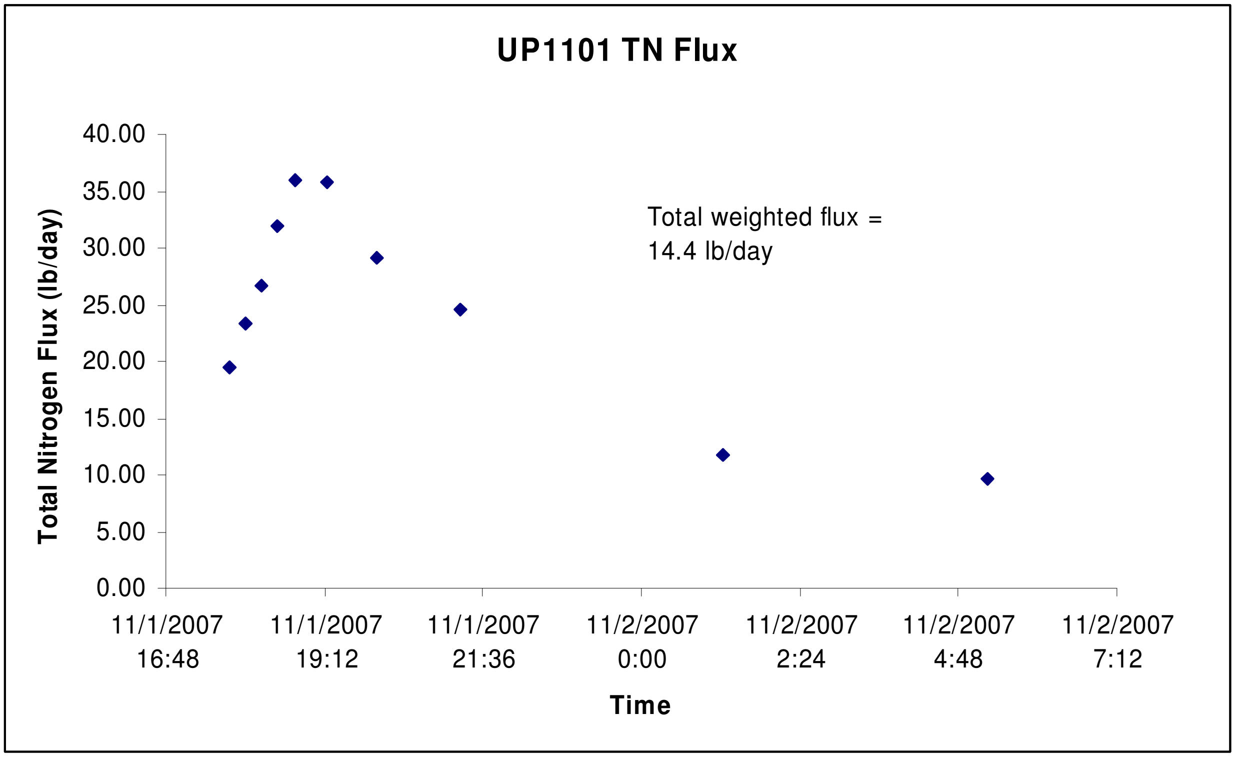
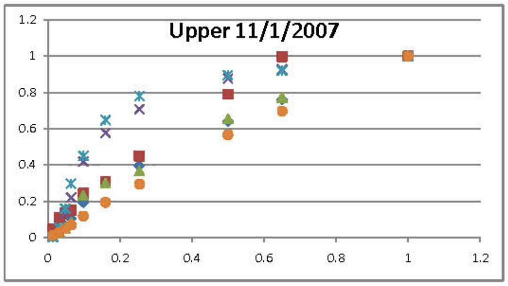
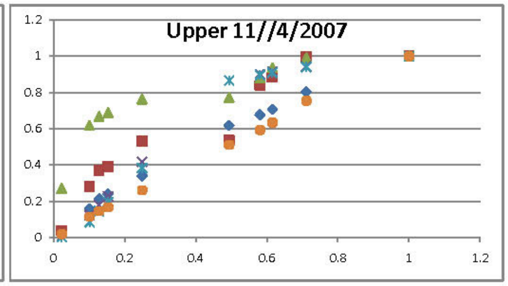


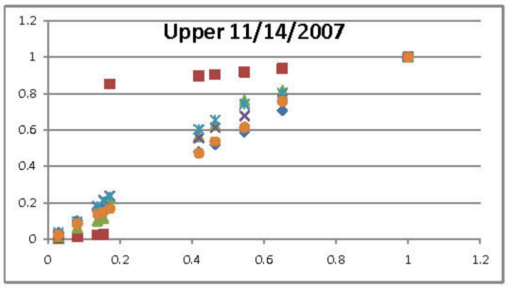
Figure 26: Storm Flux

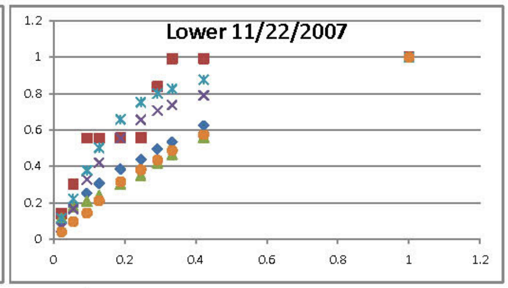
First Flush: One objective of the sampling program was to characterize the change in water quality through the course of a storm event. First flush phenomena are characterized by 80% of storm efflux of a pollutant delivered during the first 30% of storm flow. All storm events were evaluated for their potential for first flush behavior. All efflux-discharge measurement pairs were rescaled to a percent of total storm efflux and discharge. The storm total was extended with the lowest measured flux discharge pair extended to cover 24 hours of flow. For storms that were not sampled for a significant portion of the total storm duration, this introduced significant error. Storms not sampled throughout the ascending and descending periods of the hydrograph were excluded from further consideration. These storms in January 2008 are shown crossed out in the first flush summary table.

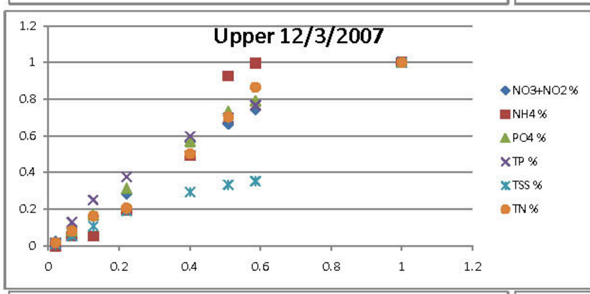
The dimensionless mass-volume (MV) curves below represent the response of pollutants to rainfall and runoff in the Marine Dam (upper) and Sandalwood (lower) drainage basins. Pollutants steadily supplied by a catchment will follow a 1:1 line. For example, at 20% of storm discharge 20% of pollutant mass will have passed. Steeper rising paths show greater export during the early storm flow. Somewhat surprisingly, first flush behavior was not seen in the majority of storms. Only total suspended solids (TSS) and ammonium ($NH_{4)}$ during the 11/22 storm and NH_4 during the 11/14 storm met the first flush threshold. Typically, 25% to 50% of the pollutants were seen in the first 20% of



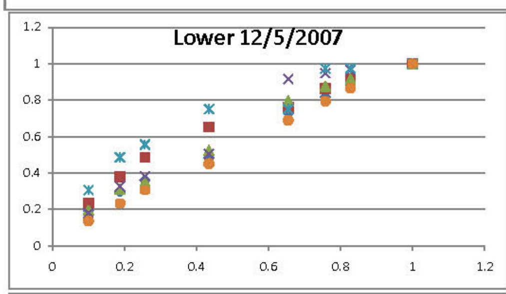


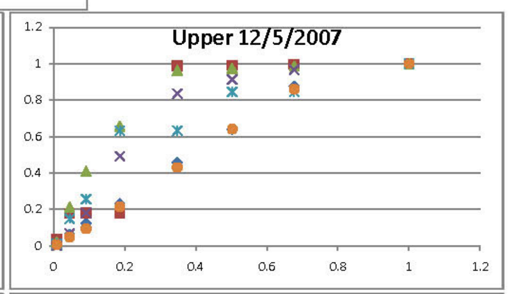


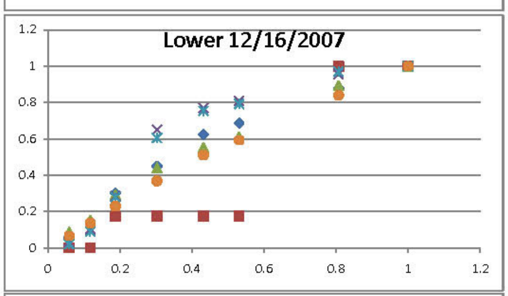


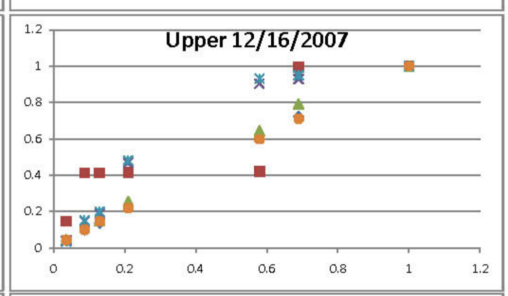


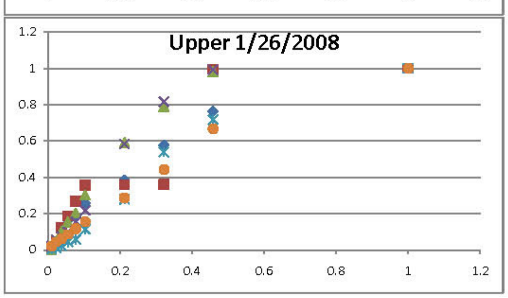
Date	Site	TN	NO3+NO2	NH4	PO4	TP	TSS
11/1/07	Upper	0.294556	0.396932	0.450339	0.367416	0.708047	0.778909
11/4/07	Upper	0.261672	0.341415	0.533299	0.763357	0.416597	0.384252
11/14/07	Upper	0.168021	0.203718	0.852591	0.226178	0.238278	0.233608
11/22/07	lower	0.435006	0.496019	0.838205	0.419434	0.707023	0.800434
12/3/07	Upper	0.206439	0.282296	0.19339	0.31359	0.375842	0.191221
12/5/07	lower	0.306309	0.359572	0.485828	0.353032	0.382408	0.556971
12/5/07	Upper	0.214284	0.232191	0.182177	0.656359	0.492851	0.63229
12/16/07	lower	0.228842	0.30019	0.173019	0.292354	0.284711	0.279941
12/16/07	Upper	0.220428	0.221708	0.414315	0.255156	0.468363	0.48204
1/26/08	lower	0.150473	[illegible]	[illegible]	[illegible]	[illegible]	1
1/26/08	Upper	0.286274	0.386128	0.359252	0.590599	0.583632	0.279303
1/28/08	lower	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0
1/28/08	Upper	0.219524	0.306877	0.301928	0.461502	0.432491	0
Average		*0.258985*	*0.37504*	*0.514833*	*0.457604*	*0.493814*	*0.432228*

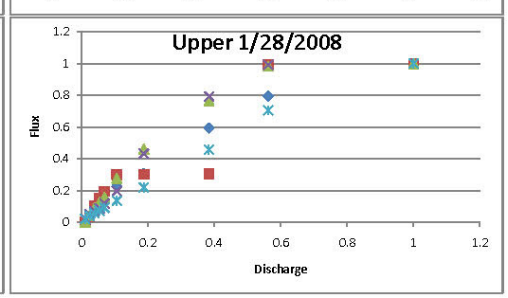












stream flow. Comparing MV curves for paired storm events can also be revealing. Greater export is shown in the earlier storm flow lower in the watershed for most pollutants with the exception of total phosphorus (TP) and TSS during 12/05 and 12/16 storms.

The only water quality parameter that showed significant correlation (0.81) with discharge was TSS. Total Phosphorous also showed moderately strong correlation to discharge (0.78), though it was much more closely correlated with TSS (0.96) because phosphorus binds to sediment in weathered volcanic soils. Lack of strong correlation with discharge precluded the development of transfer functions for predicting water quality based on discharge records.

Event Mean Concentrations: Event mean concentrations (EMC) were calculated in order to make comparisons between storm event pollutant loads. The event mean concentration of a storm is simply the total pollutant load divided by the total volume of discharge and represents a discharge-weighted mean concentration of pollutants. Figure 27 shows EMC values for 9 sampled storms. Precipitation from two Hydronet rain gages in Waimea and flow data from the Marine Dam stream gage are included for comparison. The highest EMC values for all measured pollutants with the exception of Ammonia Nitrogen occurred during the winter storms of 2007. As for first flush calculations, storm efflux was extended to 24 hours using the minimum concentration-discharge pair. In order to prevent overestimation of storm flow volume during the descending extension to 24 hr, half the volume expected by the last discharge measurement was used.

Consistently higher storm Event Mean Concentrations were seen at the Lower Waikoloa site. EMC values for TSS and TP were elevated for a number of storms both at the Upper and Lower Waikoloa sites. TN and NO_3+NO_2 were seen to increase most drastically lower in the watershed with enrichment ratio (ER) values of 1.5 and 2.4 respectively. PO_4 also shows consistent enrichment lower in the watershed with an ER of 2.6.

All of these data should be viewed in light of the significant diversion at the Marine Dam intake. Normally, the stream is completely impounded by the dam and flows into the DWS intake. During a storm event, the water level rises and presumably much of the (less than technically first flush) runoff is consumed by the intake. Only after some period of storm flow does the stream get high enough to overtop the dam. In essence, the DWS system is acting as a large first flush diverter for the background nutrients and sediment from the headwater bog.

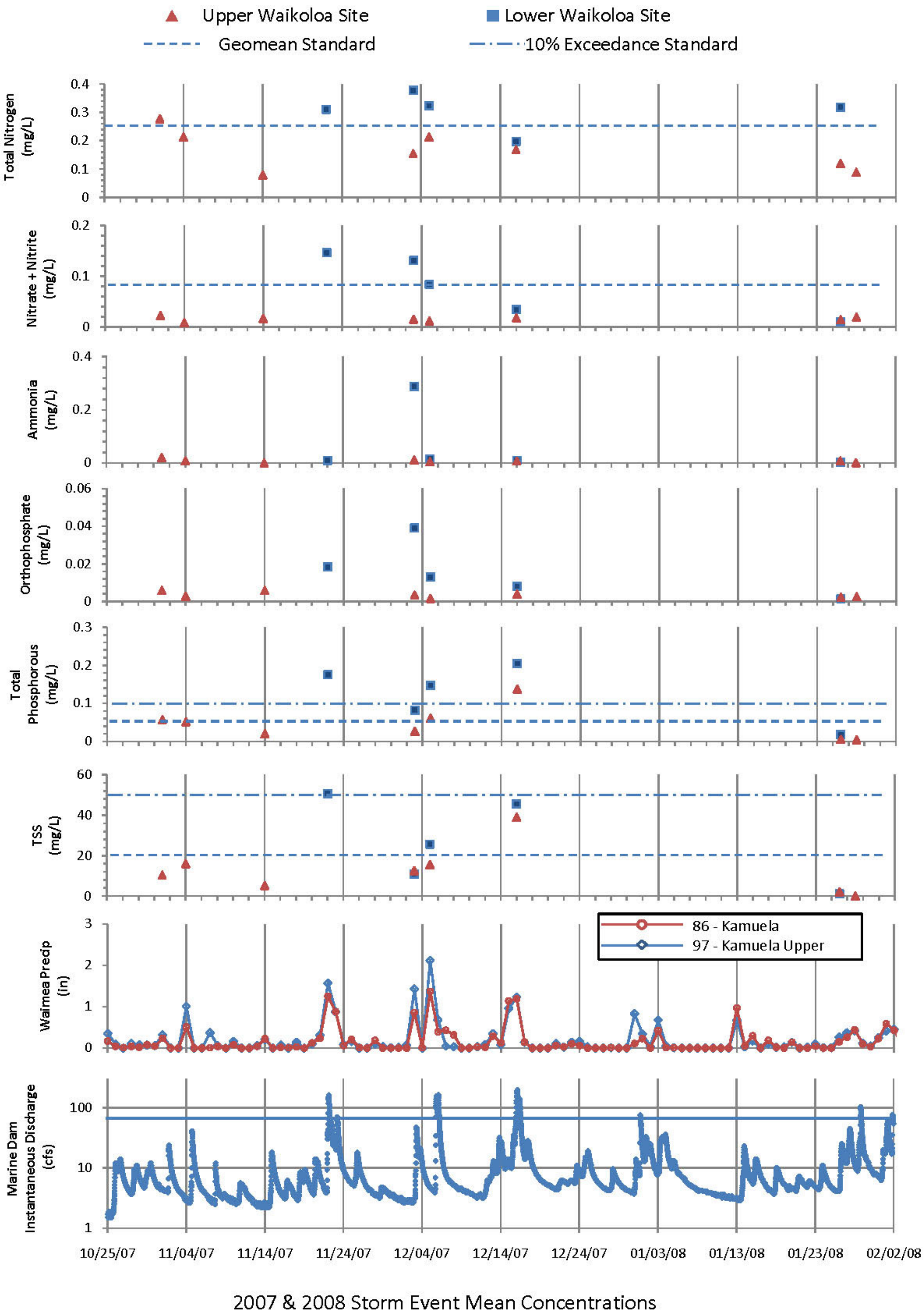
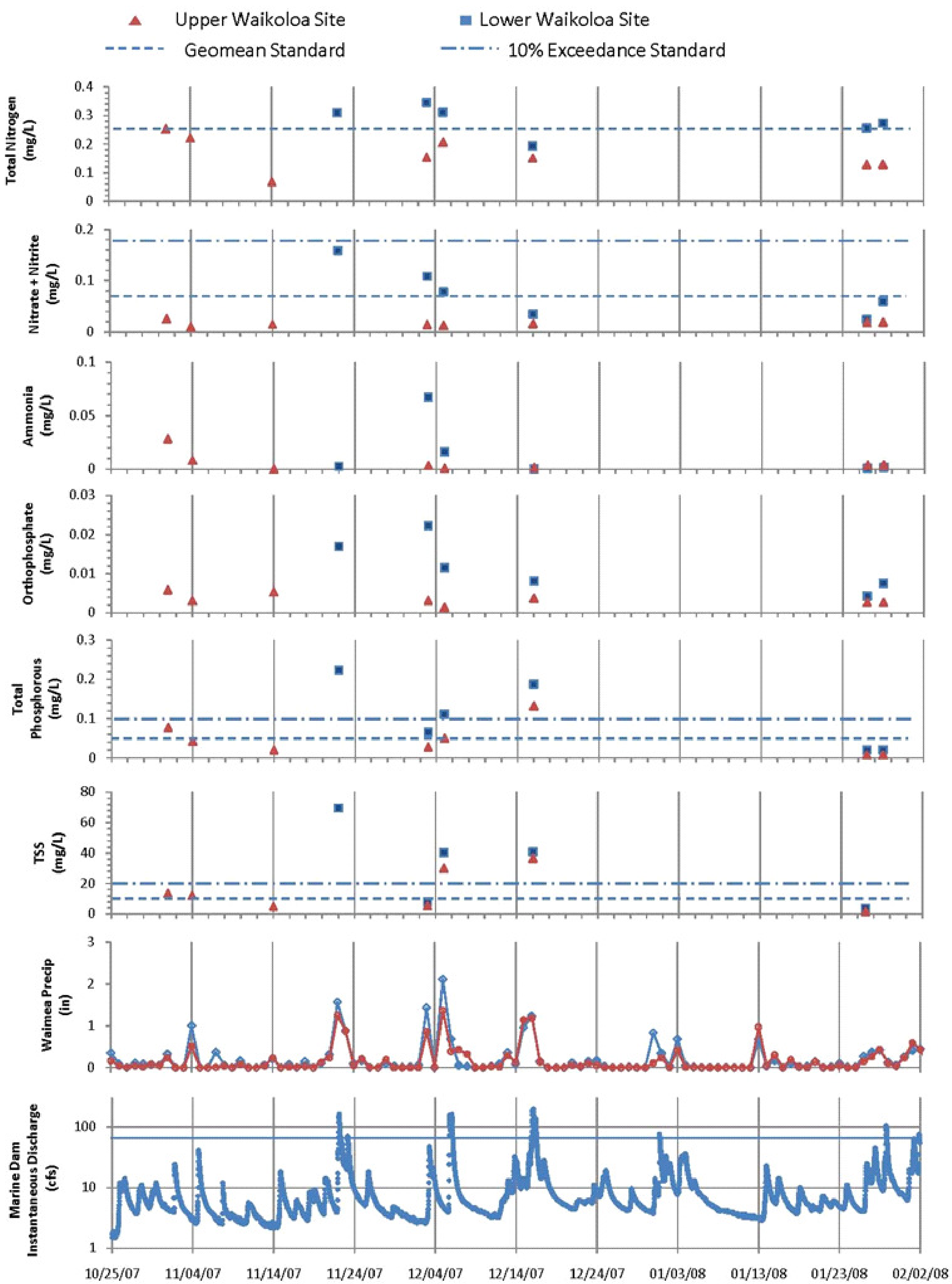


Figure 27: Event Mean Concentration for 2007 and 2008 Storms

Figure 28: Storm Pollutant Concentration Geometric Means



Storm Pollutant Concentration Geometric Means

Whereas EMC values represent a discharge weighted concentration of pollutants, concentration data represent an observed quantity of pollutant in a known volume of water at a particular time. Pollutants may be masked by dilution in increased discharge but the direct comparison to standards is useful.

Significantly higher concentrations of almost all pollutants are seen at the Lower Waikoloa (Sandalwood) site. Enrichment Ratios (ER) were calculated for storms sampled at both the upper and lower Waikoloa sites and are simply calculated as Lower Waikoloa value / Upper Waikoloa value. Higher ER values show greater enrichment of a pollutant as storm flow progresses through the stream network. An ER value of 1 indicates no enrichment.

ER	**TN %**	**NO_3+NO_2 %**	**NH_4 %**	**PO_4 %**	**TP %**	**TSS %**
12/5/2007	1.510	6.372	17.262	8.161	2.180	1.345
12/16/2007	1.293	2.203	0.281	2.188	1.423	1.117
1/26/2007	1.989	1.319	0.221	1.597	2.596	2.394
1/28/2007	2.119	3.195	0.425	2.817	2.575	
average	*1.728*	*3.272*	*4.547*	*3.691*	*2.193*	*1.832*

Average ER values ranged from 1.7 for Total Nitrogen (TN) to 3.7 for Phosphate (PO_4) and 3.3 for Nitrate-Nitrite (NO_3+NO_2). ER values for NH_4 averaged to 4.5, but this is due to high readings from one storm. A statistical test was used to establish the significance of the difference in concentrations seen at the Upper and Lower Waikoloa sites during paired sample events. The table below summarizes the results of the 2 tailed, paired, t-test. Differences between sites were significant for all pollutants except NH_4. Clearly, pollutants are being added to the stream system below the upper autosampler, as Waikoloa Stream flows through Waimea town. In some cases, the water quality of the stream exceeds State standards, particularly for nutrients.

paired t test	p value	different?
TSS	0.069227	yes (at 90% level but not 95%)
TDN	0.014473	definitely
NO_3+NO_2	0.022511	definitely
NH_4	0.981019	no
PO_4	0.020499	yes (at 90% level but not 95%)
TP	0.062058	definitely

Pollutant Export Coefficients represent an average load delivered by a certain class of land cover. Unfortunately, at the time of publication there were insufficient data to develop Pollutant Export Coefficients for different land cover classes found in the watershed.

<u>DOH Open Coastal Water Quality Data</u>: Coastal water quality data were analyzed for the period between September 2006 and December 2008. Figure 29 shows water quality data along with recorded daily mean discharge from the Marine Dam gage station and open ocean wave height from

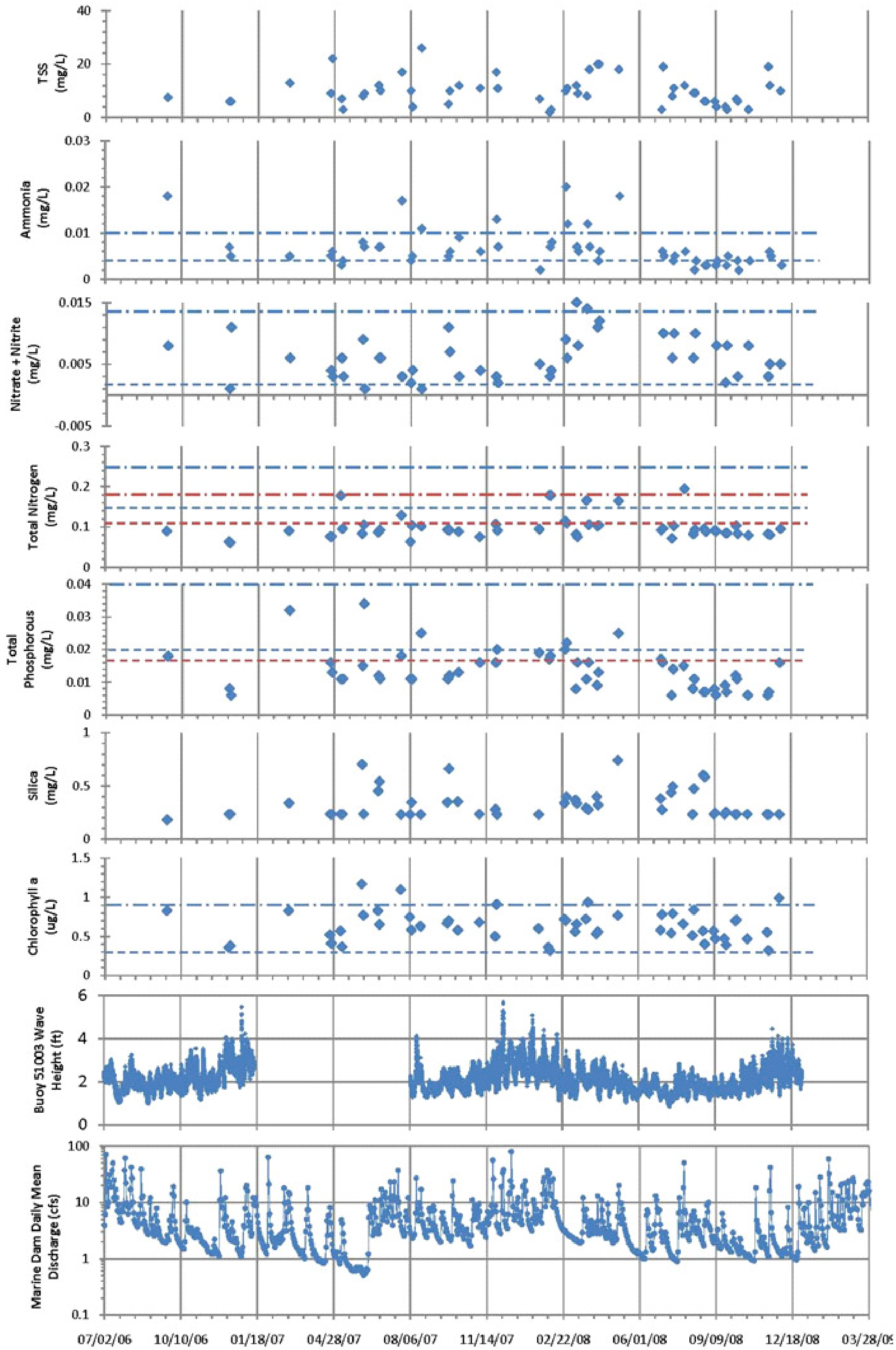


Figure 29: Open Coastal Water Quality Data

NOAA buoy 51003 (19.087N, 160.66W). At the mouth of Waiulaula, TSS shows considerable variability from 1mg/L to nearly 30 mg/L with a geomean of 8.5 mg/L. By comparison, TSS values in Pelekane Bay show a geomean of 43 mg/L.

Ammonia shows consistently elevated values with a geomean of 0.0057, well over the wet geomean standard of 0.0035. Pelekane, again, is much worse off, with a geomean of 0.030, fully double the 2% standard. NH_4 does not correlate with watershed surface water discharge, though it does correlate with TP and, to a limited extent, TN and NH_4 in Pelekane Bay.

Nitrate + Nitrite shows consistent enrichment with a geomean of 0.0063 mg/L, while the wet geomean standard is 0.005 mg/L. Nitrate + Nitrite does not correlate with watershed discharge, implying an adjacent coastal area / watershed source. Nearby coastal water quality monitoring sites (Pelekane and Hapuna) have 8 to 10 times greater concentration of Nitrate + Nitrite on average. Total Nitrogen is generally low and variable, well below any standard levels. TN shows mild correlation with silica (0.58) and Waiulaula discharge (0.59), implying a local watershed source.

Pelekane	TSS	NH4	NO3 + NO2	TN	TP	Silica	Chlorophyll A	Wave ht	Wave ht -1	DMD	DMD-1	DMD-2	DMD-3
TSS	1												
NH4	0.0335617	1											
NO3 + NO2	0.164004	0.2861047	1										
TN	0.7884189	0.30078455	0.39447559	1									
TP	0.5894628	0.32421426	0.36943857	0.77267314	1								
Silica	0.2205217	0.32147667	0.75678036	0.49364197	0.45313269	1							
Chlorophyll A	0.6991932	0.10327648	-0.0234935	0.63988433	0.33463709	0.1639957	1						
Wave ht	0.1049484	0.32946434	0.22128214	-0.0882079	0.05815327	0.0932453	-0.197049566	1					
Wave ht -1	-0.083247	0.09204004	0.18459898	-0.1027409	0.00774134	0.3582191	-0.135600145	0.159089	1				
DMD	-0.120602	0.06977471	0.04950902	-0.1274888	-0.0727416	0.1926051	-0.084313433	0.308414	0.522029	1			
DMD-1	-0.112908	0.09987559	-0.0502807	-0.0894537	-0.0589398	-0.0532227	-0.059353888	0.235794	0.19735	0.395188	1		
DMD-2	-0.122613	0.29681198	0.1042389	-0.0977958	-0.0042172	0.2112922	0.011686077	0.165436	0.617618	0.416928	0.649678	1	
DMD-3	-0.134619	0.33199472	0.40629885	-0.0968005	-0.0783311	0.3458888	-0.184181156	0.159786	0.677301	0.349076	0.180601	0.552484	1

Waiulaula	TSS	NH4	NO3 + NO2	TN	TP	Silica	Chlorophyll A	Wave ht	Wave ht -1	DMD	DMD-1	DMD-2	DMD-3
TSS	1												
NH4	0.2871824	1											
NO3 + NO2	0.1742409	0.00618186	1										
TN	0.0314927	0.3646207	0.16629734	1									
TP	0.3477861	0.60882617	0.02430664	0.43307256	1								
Silica	-0.22556	0.07135824	0.00763573	0.76390653	0.21463776	1							
Chlorophyll A	0.3206399	0.22343415	0.31784486	0.01424526	0.47064831	-0.2966768	1						
Wave ht	0.0293701	0.10705964	-0.1848353	0.09189861	0.12984468	0.0874262	-0.17849187	1					
Wave ht -1	-0.219727	0.01774429	-0.1019572	0.40749305	0.1173788	0.5892582	-0.257848727	0.158859	1				
DMD	0.133825	0.13768627	-0.1136207	0.3567398	0.17004229	0.4332512	-0.371151064	0.308228	0.521746	1			
DMD-1	-0.015272	0.08224275	0.09229454	0.72530653	0.1733814	0.676461	-0.176857396	0.235475	0.196528	0.393428	1		
DMD-2	-0.184852	0.02306841	-0.0573644	0.71472577	0.19753269	0.9051127	-0.349567436	0.16503	0.617416	0.415285	0.648826	1	
DMD-3	-0.130258	0.15409005	-0.1565292	0.46149083	0.18965192	0.6223503	-0.346325978	0.188557	0.782485	0.429392	0.232714	0.655333	1

Correlation analysis was performed on all coastal data to evaluate potential connections between watershed discharge and coastal water quality. The correlation matrix above graphically represents the results of correlation analysis. Values that vary together (when one is high so is the other) have a correlation coefficient closer to 1. Correlation coefficients greater than 0.6 generally indicate some connection between the parameters of interest. Each cell in the correlation matrix holds a correlation coefficient for the row and column intersecting that cell. For instance, the first column on the left in the correlation matrix, each cell evaluates the correlation of total suspended solids to other data on the same date, for all data in the set.

Pelekane: Weak to moderate correlation is shown between TSS, TN, TP and Chlorophyll A. One would expect wave action to re-suspend sediment in Pelekane Bay, but surprisingly there is no correlation between TSS and wave height measured by buoy 51003, either on the same day or the previous day. The test shows moderate to strong correlation (0.78) between Nitrate + Nitrite and Silica, suggesting groundwater influence. Moderate to strong correlation is also shown between TN and TP.

Waiulaula: The striking positive correlations seen in Pelekane bay between TSS, TN, TP and Chl A are totally absent at Waiulaula. Weak correlation exists between TSS and TP. Sediment is obviously not as great a source of impairment at the mouth of Waiulaula. Moderately strong correlations exist between TN, Silica, and DMD-2, suggesting enrichment of TN in coastal waters due to watershed discharge. However, levels are still quite low, with total geomean less than 0.1 mg/L while the wet geomean standard is 0.15 and dry 0.11. Silica shows strong correlation with DMD-2 , showing a 2 day lag between high discharge at the Marine Dam gage and detection of the storm plume at the coastal monitoring site. As in Pelekane Bay, increased discharge or wave action correlates negatively with Chlorophyll A concentrations.

Pollutant Source Assessment: University of Hawaii graduate student, James Tait, prepared a thesis on *Variation of sediment trace elements and stream nitrate isotope ratios with land use in the Waiulaula and Hilo Bay Watersheds* (Tait 2008). The goal of Tait's study was to determine the extent to which nonpoint source pollutants chemically reflect the land uses from which they originated. Four main classes of land use were evaluated as potential sources of pollution: Urban, Cultivated, Pasture / Rangeland, and Forest. The study evaluated the utility of trace elements (Pb, Zn, Cu, As, V) as indicators of the source of sediment. The isotopic composition of N and O in Nitrate were also used to determine possible sources of nutrient enrichment. Tait concluded:

> *Both anthropogenic and natural factors were found to influence the composition of soils, streambed sediments and stream nitrate. The composition of non-point pollutants often showed significant variability but some consistent trends were identified.*
>
> - *Pb and Zn were enriched in surface soils that are near roadways.*
> - *Pb and Zn in streambed sediment increased with the amount of upstream urban land cover. This was also true to a lesser extent for Cu.*
> - *As and possibly Cu were enriched in surface soils of former sugarcane land.*
> - *As is enriched in streambed sediment deposits proportional to the amount of upstream former sugarcane land.*
> - $\delta^{15}N$ *values of stream* NO_3 *increased with the amount of upstream pasture land and at some locations displayed elevated values below urban areas.*

3.2.2 Estimations of Pollutant Loads

Existing Conditions and Pollutant Load Estimates

Gaut (2009) applied the Nonpoint Source Pollution and Erosion Comparison Tool (N-SPECT) to the Waiulaula watershed. N-SPECT is a GIS-based model for watershed management. It has the ability to estimate pollutant loads, identify sub-areas susceptible to erosion, and assess the impacts of potential land use changes on water quality. It is designed to work with local data; however, there are default pollutant coefficients, created from a national dataset, available within N-SPECT.

Waiulaula watershed encompasses the required characteristics for an N-SPECT application: small size, less than 5% urban land use, and less than 30% slopes. Gaut (2009) divided the Waiulaula into 4 sub-basins, based on elevation and precipitation gradients, to allow for distribution of the raining days factor in the model (Figure 30). The Mauna Kea "leg" was excluded, for reasons described in Section 2.1.1.

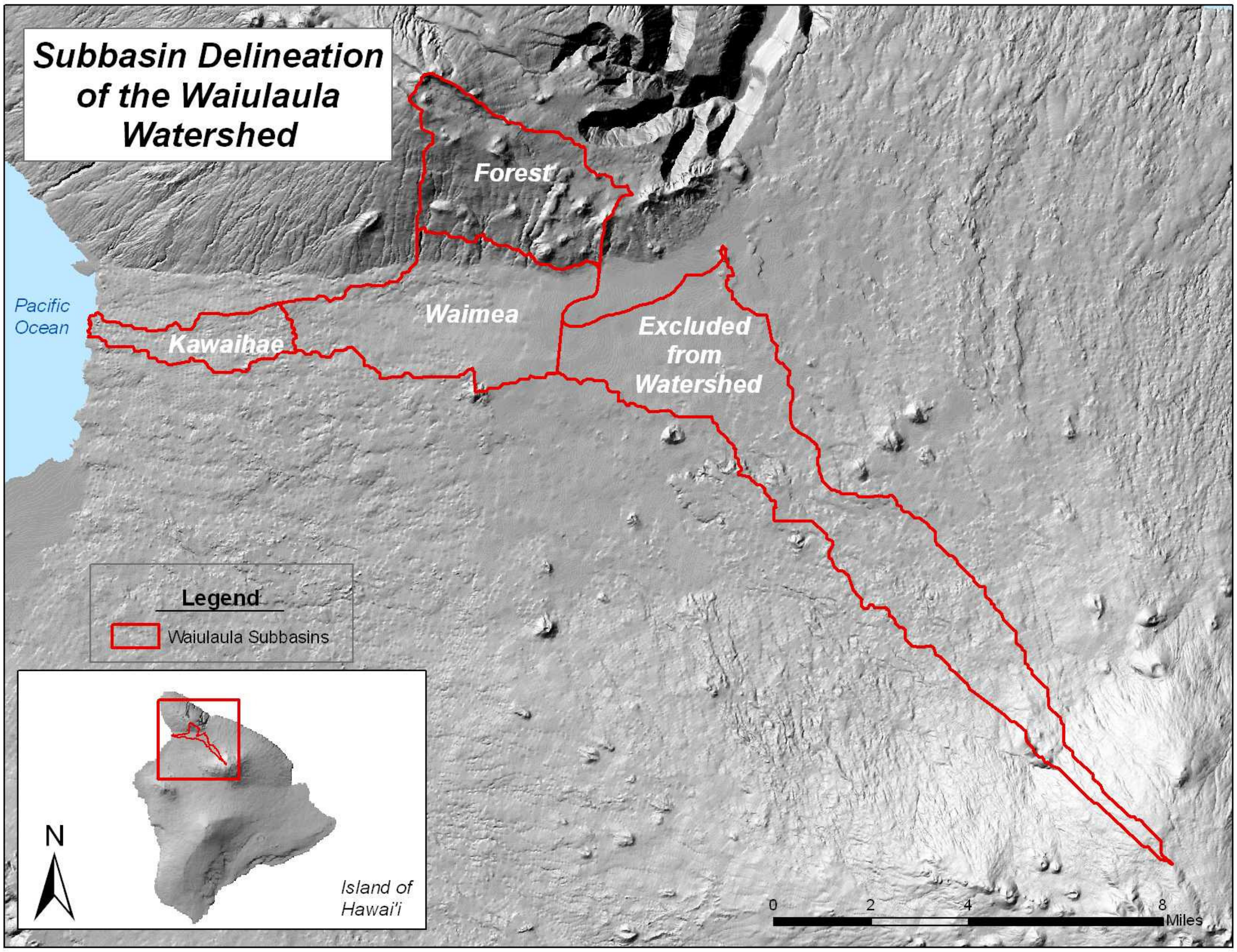


Figure 30: Sub-basin Delineation of the Waiulaula Watershed for N-SPECT (from Gaut 2009)

Gaut (2009) notes that the limited hydrologic and water quality data for the watershed "means that it is not possible to validate the model by statistically rigorous comparison with historic observations." She goes on to add " Nevertheless, model simulations that are based on reasonable assumptions, expert advice of local resource managers, and default parameter values may give results that are of sufficient quality for the purposes of section 319-related watershed management" (p.14).

Precipitation is the primary driver of runoff accumulation. According to Gaut (2009), "the model's average annual accumulated runoff was most accurate when the model was run using the .50 inch precipitation threshold for raining days" (p. 49). Using this threshold, modeled runoff was similar to stream gage measurements in the watershed, as well as other watersheds within Hawaii. In the model, the forest sub-basin accounts for the majority of runoff.

Gaut (2009) calculated the relative contributions of major tributaries for total suspended solids, nitrogen, and phosphorus (See Figure 31 and Table 4). This information can help direct future monitoring efforts in the watershed so that ground-truthing can help confirm these results. She found:

> The largest contributors of runoff were Kohakohau and Waikoloa streams. As these are the only two perennial streams in the watershed, the results are reasonable and expected. These two tributaries also are the primary contributors of nitrogen and total suspended solids to the watershed, with a combined input of 57% and 47%, respectively. Kohakohau and Lanikepu Gulch were the primary and secondary tributary contributors of phosphorus, respectively. Lanikepu Gulch was found to deliver the majority of sediment. Mamaewe Gulch and Kohakohau were the secondary tributaries for sediment delivery. (.67)

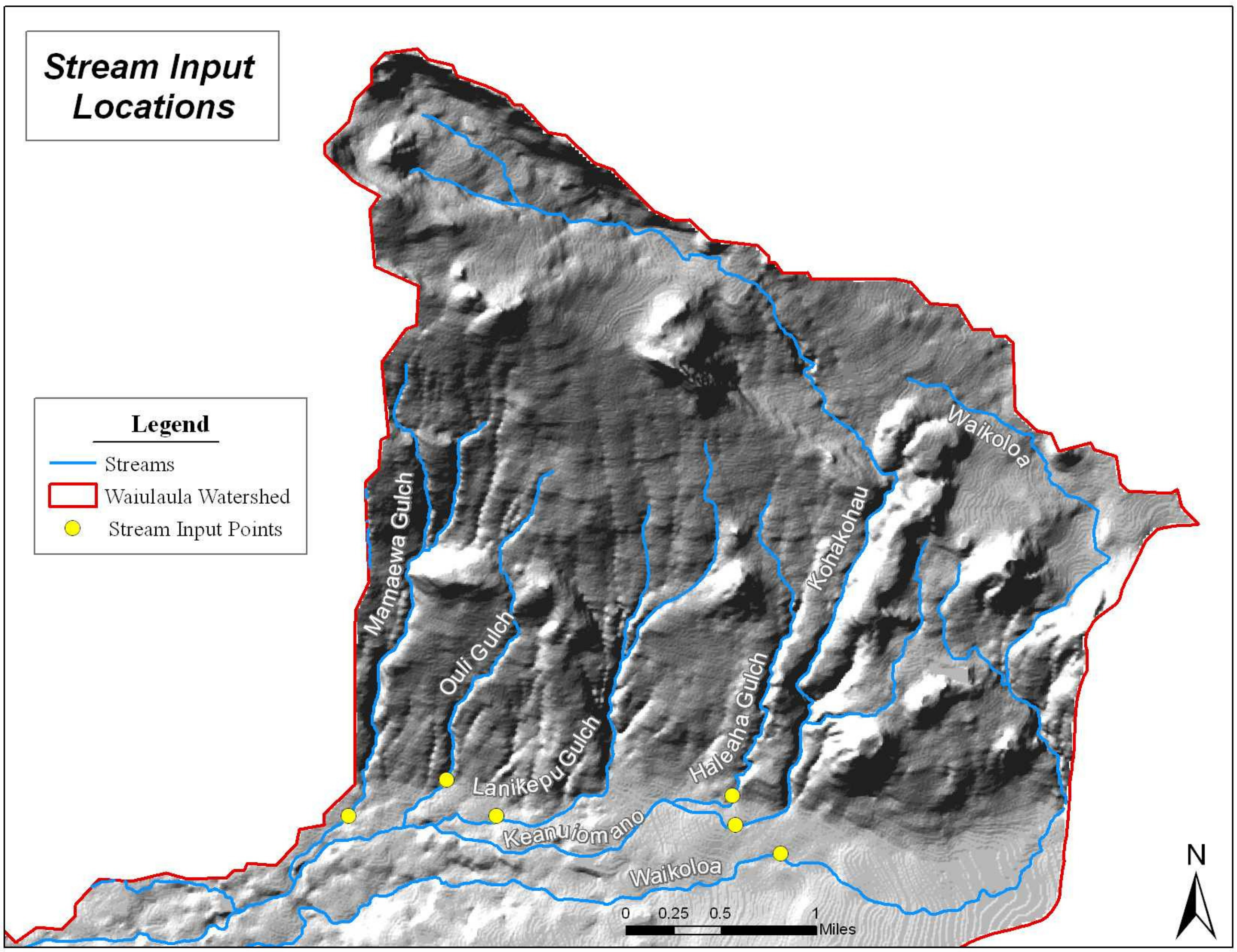


Figure 31: Tributaries in the Waiulaula Watershed assessed for runoff, nutrient, and sediment contributions in Table 4 (Figure 19 in Gaut 2009)

	1	2	3	4	5	6
	Mamaewa Gulch	**Ouli Gulch**	**Lanikepu Gulch**	**Haleaha Gulch**	**Kohakohau**	**Waikoloa**
Accumulated Sediment	**25%**	8%	26%	10%	24%	7%
Accumulated Runoff	11%	4%	15%	7%	39%	**24%**
Accumulated Nitrogen	13%	5%	17%	7%	36%	**21%**
Accumulated Phosphorus	19%	8%	**21%**	10%	28%	14%
Accumulated TSS	13%	5%	17%	7%	36%	**21%**

Table 4: Relative contributions of major tributaries for pollutants displayed. Underlined and bold values represent the first and second largest contributor tributaries for that particular pollutant, respectively. (From Gaut 2009: Table 28)

The model produced unrealistically high sediment loads in comparison to other watersheds in Hawaii. Gaut (2009) surmises that this may be attributed to the model not accounting for sediment redeposition or problems in the application of NRCS's RUSLE equation to Hawaii's environment. "Further research to calibrate erosion rates and processes based on USLE coefficients may increase the N-SPECT sediment modeling estimations" (Gaut 2009: p.89-90).

On an average annual basis, the model predicts that the accumulated nitrogen load from the watershed is approximately 23,000 kg or 1.4 kg/acre/year, while the predicted accumulated phosphorus is 2,176 kg or 0.129 kg/acre/year (Gaut 2009). When compared to other watersheds in Hawaii, N-SPECT produced reasonable estimates of nitrogen and phosphorus loads; however, the limited water quality data collected by autosamplers within the Waiulaula watershed suggest these estimates may be high (Gaut 2009).

Gaut (2009) also modeled critical areas in terms of sediment and nutrient sources (Figures 32a, 32b, and 32c). The model predicts high sediment sources in the mid-west region of the forest sub-basin, as well as the lower reaches of the Waimea sub-basin. Gaut (2009) notes that "through visual examination of the sediment source data, it appears that top 1% source areas are primarily associated with steep slopes on grassland land cover. In the middle region of the watershed, however, the high sediment source areas appear to be associated with bare lands...." (p. 70). The strong correlation between nutrients and precipitation probably accounts for the low nutrient source in the lower watershed.

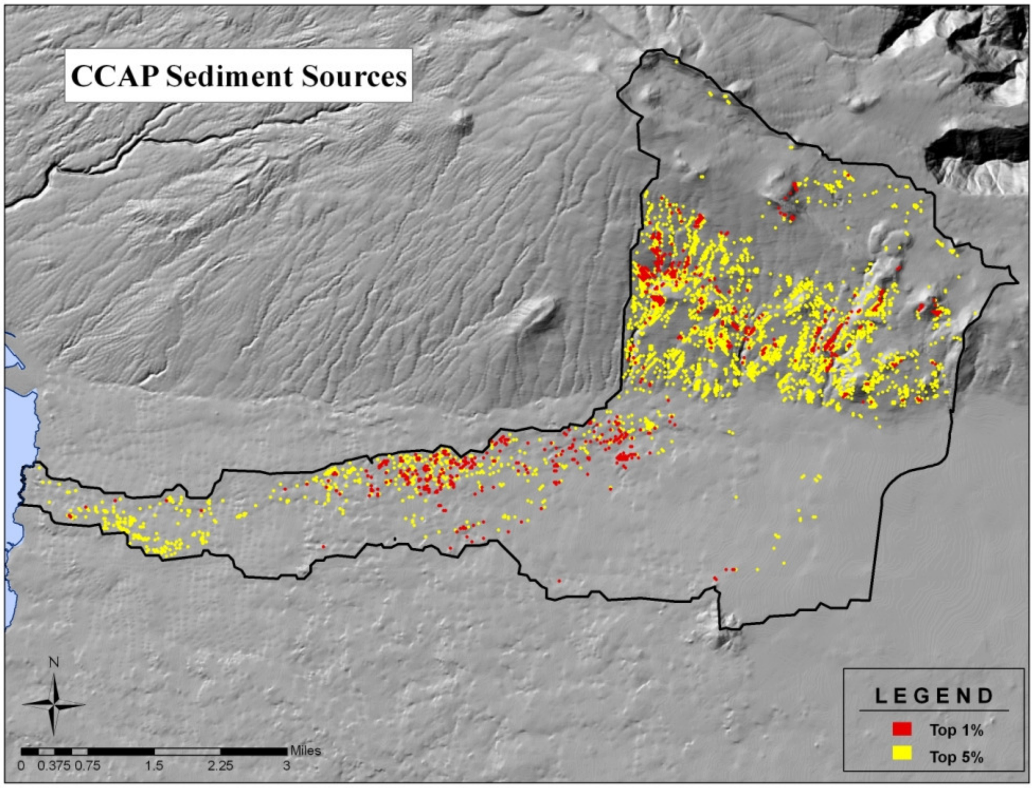


Figure 32a: Modeled Sediment Sources

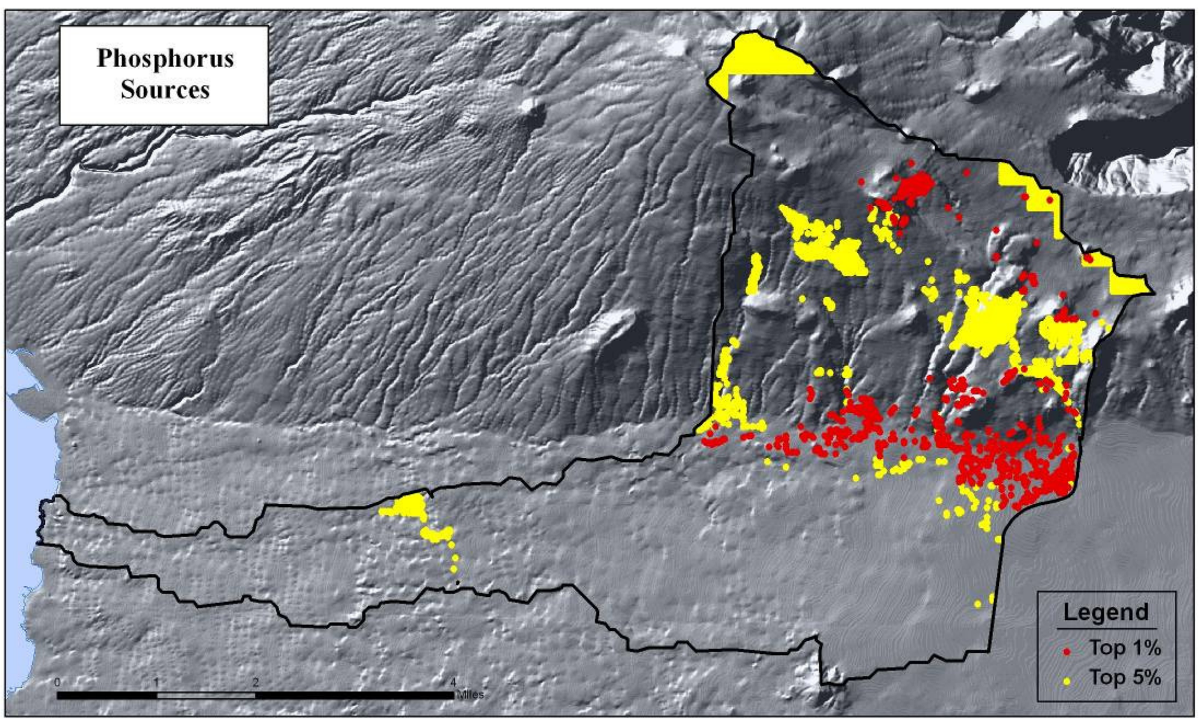


Figure 32b: Modeled Phosphorus Sources

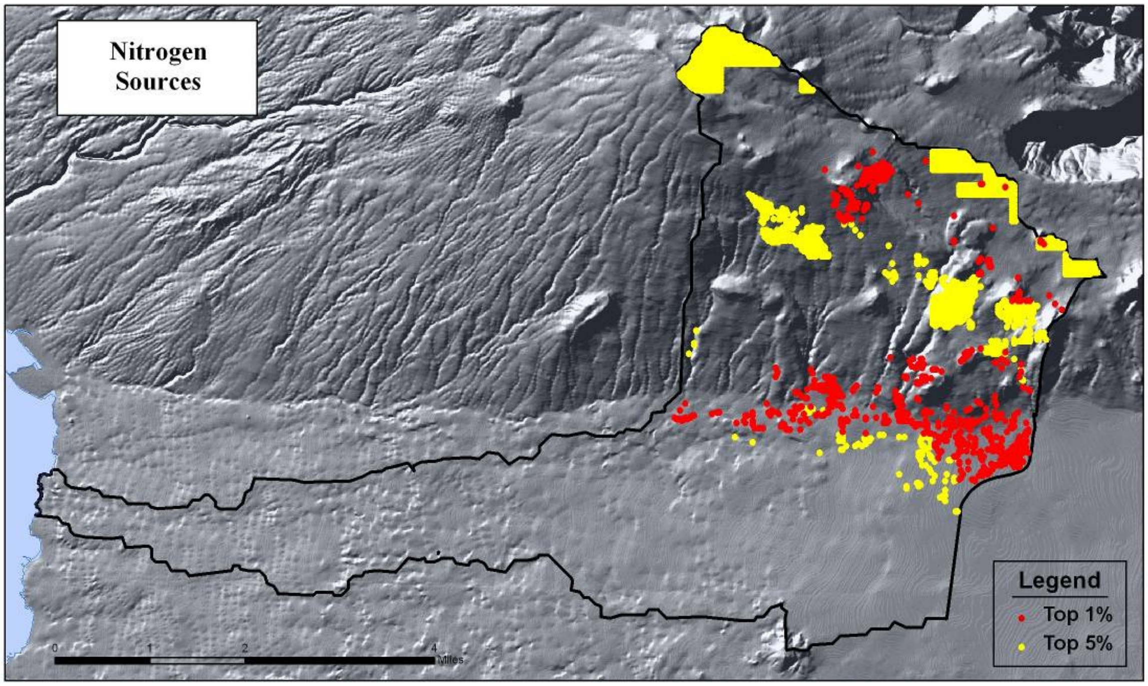


Figure 32c: Modeled Nitrogen Sources

If critical areas are identified, then selected BMPs can be evaluated with N-SPECT to assist in estimating potential load reductions from the implementation of these BMPs. Gaut (2009) examined several BMPs. She found that restoration of riparian areas did result in significant reductions in accumulated sediment and phosphorus (11% and 8%). Replanting of 50% of the bare land resulted in a 15% reduction of accumulated sediment. The modeling effort found little to no change in polluted runoff with the implementation of BMPs on agricultural (cultivated) lands. However, it may be that, given the small proportion of cultivated agricultural land in the watershed, the N-SPECT model operates at too large a scale (30x30 meter pixels) to accurately model these BMPs (Gaut 2009).

Future Conditions and Pollutant Load Estimates

Gaut (2009) also ran a simulation of future conditions, using land use changes projected in Hawaii County's General Plan LUPAG (Table 5). She found:

> Percent changes for the future scenario predict further increases in runoff, nitrogen and phosphorus. The phosphorus amounts are predicted to increase by over 20%. In addition, a large proportion of the increase in the amount of phosphorus is expected to occur at a close proximity to the coast. Much of the watershed that is currently classified as bare land is planned to be converted to urban expansion zones, which will cause the predicted overall accumulated sediment to decrease. (p. 79)

While the absolute quantitative output values may not be accurate, “they are indicative of the overall magnitude and patterns of sediment and nutrient delivery in the watershed” (Gaut 2009: 79).

Table 5: Modeling Future Conditions and Pollutant Load Estimates (based on Gaut 2009: Table 33)

	Current Scenario	Future Scenario	% Change from Current
Accumulated Runoff (m^3/yr)	15,290,900	16,692,500	9%
Accumulated Sediment (tons)	233,637	212,551	-9%
Accumulated Nitrogen (kg)	23,860	26,824	12%
Accumulated Phosphorus (kg)	2,473	3,003	21%

3.2.3 Biological Data

DLNR's *Atlas of Hawaiian Watersheds and Their Aquatic Resources* (2008) compiles information from many years of surveys and publications on Hawaiian stream animals. The following data, taken from DLNR (2008), comes from biotic samples collected in 1968, 1990, 1992, 1994, 1999, 2000, 2001. It includes data most recently collected by Bishop Museum's Hawaii Biological Survey for DHHL's Lalamilo Residential Project EIS.

Distribution of Biotic Sampling: The number of survey locations that were sampled in the various reach types.

Survey type	Estuary	Lower	Middle	Upper	Headwaters
Damselfly Surveys	0	0	1	0	1
DAR Point Quadrat	0	26	41	129	0
HDFG	0	0	0	0	1
Microhabitat Survey	0	0	0	24	0
Published Reports	0	0	0	1	0

BIOTA INFORMATION

Species List

Native Species

Crustaceans	*Macrobrachium grandimanus*
Fish	*Awaous guamensis*
	Lentipes concolor
	Sicyopterus stimpsoni
Worms	*Myzobdella lugubris*

Native Species

Insects	*Anax junius*
	Anax strenuus
	Chironomus hawaiiensis
	Megalagrion sp.
	Orthocladius grimshawi
	Scatella clavipes
	Scatella sp.

Introduced Species

Amphibians	*Bufo marinus*
	Rana catesbiana
	Ranidae sp.
Bryozoans	*Plumatella repens*
Crustaceans	*Macrobrachium lar*
Fish	*Gambusia affinis*
	Misgurnus anguillicaudatus
	Poecilia reticulata
	Poeciliidae sp.
Worms	*Camallanus cotti*

Introduced Species

Insects	*Cricotopus bicinctus*
	Crocothemis servilia
	Enallagma civile
	Ischnura posita
	Ischnura ramburi
	Orthemis ferruginea
	Pantala flavescens
	Rhantus gutticollis

Species Distribution: Presence (P) of species in different stream reaches.

Scientific Name	Status	Estuary	Lower	Middle	Upper	Headwaters
Macrobrachium	Endemic		P			
Lentipes concolor	Endemic				P	
Sicyopterus stimpsoni	Endemic		P	P	P	
Anax strenuus	Endemic				P	
Chironomus hawaiiensis	Endemic				P	
Megalagrion sp.	Endemic			P	P	
Orthocladius grimshawi	Endemic				P	
Scatella clavipes	Endemic				P	
Awaous guamensis	Indigenous		P	P	P	
Anax junius	Indigenous				P	
Scatella sp.	Indigenous				P	
Bufo marinus	Introduced		P	P	P	
Rana catesbiana	Introduced				P	
Ranidae sp.	Introduced		P			
Plumatella repens	Introduced			P		
Macrobrachium lar	Introduced		P	P	P	

Scientific Name	Status	Estuary	Lower	Middle	Upper	Headwaters
Gambusia affinis	Introduced		P	P	P	
Misgurnus anguillicaudatus	Introduced			P	P	
Poecilia reticulata	Introduced		P		P	
Poeciliidae sp.	Introduced		P	P	P	
Cricotopus bicinctus	Introduced				P	
Crocothemis servilia	Introduced				P	
Enallagma civile	Introduced			P	P	
Ischnura posita	Introduced					P
Ischnura ramburi	Introduced			P		
Orthemis ferruginea	Introduced				P	
Pantala flavescens	Introduced				P	
Rhantus gutticollis	Introduced				P	

Chapter 4: Threats to the Water Quality of the Watershed

This section describes the threats to the water quality of Waiulaula watershed. It responds to element (a) of EPA's 9 key elements for watershed-based plans that are critical for achieving improvements in water quality (see Appendix B).

The focus of this management plan is on preventing degradation of water quality. Possible pollutant sources and threats to the watershed are described below. Based on these threats, the management plan establishes goals and objectives for maintaining and restoring water quality.

4.1 Nonpoint Sources of Pollution

Nonpoint source pollution (or polluted runoff) is pollution that cannot be traced to a single source but, rather, comes from many diffuse sources. It generally results from precipitation, land runoff, infiltration, drainage, seepage, hydrologic modification or atmospheric deposition. As runoff from rainfall moves across the landscape, it picks up pollutants from human activities, ultimately depositing them in surface waters. Pollutants can also seep into the ground and affect groundwater, as well as surface water with connections to groundwater.

4.1.1 Agriculture

Agricultural activities, if not properly managed, can contribute polluted runoff in the forms of sediment, nutrients, pesticides and animal waste. Agricultural activities can also directly impact the habitat of aquatic species through physical disturbances caused by livestock or equipment. Agriculture is a land use within the Waiulaula watershed. There are approximately 315 acres in the Lalamilo Farm Lots farmed for a variety of crops, including strawberries, melons, spinach, lettuce, tomatoes, herbs, and flowers, and thousands of acres throughout the watershed used for cattle grazing.

Good soil is essential to conventional farming. Farmers are generally motivated to prevent soil runoff and keep the soil on the land where it benefits food production. However, without proper management, there is always the potential for soil erosion into streams during storm events or from excessive irrigation after fields have been tilled and before there is sufficient vegetative cover to prevent runoff.

Sediment is a result of soil erosion. Soil erosion can be characterized as the transport of particles that are detached by rainfall, flowing water or wind. Eroded soil is either redeposited on the same field or transported from the field in runoff. The types of erosion associated with agriculture are typically sheet and rill erosion, and gully erosion. Sediments transported from the field into waterbodies often have other pollutants attached to the soil particles, such as nutrients and chemicals (herbicides, pesticides, etc.). Suspended sediments in stream and coastal waters reduce the amount of sunlight available to aquatic plants, cover fish spawning areas and food supplies, smother coral reefs, adversely affect the filtering capacity of filter feeders, and clog and harm the gills of fish. Turbidity, a cloudiness caused by suspended solids in the water, reduces visibility, making swimming less safe.

Nitrogen (N) and phosphorus (P) are the two major nutrients from agricultural activities that degrade water quality. Nutrients are applied to agricultural lands in several different forms and come from a variety of sources, including commercial fertilizers, manure, and irrigation water. The Waimea wastewater treatment plant also applies treated effluent to 40 acres of land within the Agricultural District; however, these lands are not used directly for agricultural production. While all plants require nutrients for growth, excessive application can runoff into streams and the ocean, disrupting ecosystems by causing blooms of aquatic and marine plants such as algae. In addition, over-application of nutrients costs the farmer unnecessary expense.

When excessive nutrients are introduced into a stream or ocean, aquatic plant growth may increase dramatically, a process called eutrophication. This adds more organic material to the system, which eventually dies and decays. The decaying organic matter can produce odors and deplete the oxygen supply required by aquatic organisms. Eutrophication also increases turbidity and is harmful to coral reefs.

The term pesticide includes any substance or mixture of substances used to prevent, destroy, repel, or mitigate any pest or intended for use as a plant regulator, defoliant, or desiccant. Pesticides are generally applied to crops to kill insects, molds, mildew, fungus, and weedy plants that are detrimental to the successful growth of the food crop. Pesticides can harm the environment by eliminating or reducing populations of desirable organisms and riparian or aquatic plants. Some chemicals resist degradation and can persist in soils and aquatic environments. Pesticides are normally transported into surface water either through direct application or attached to sediment in runoff.

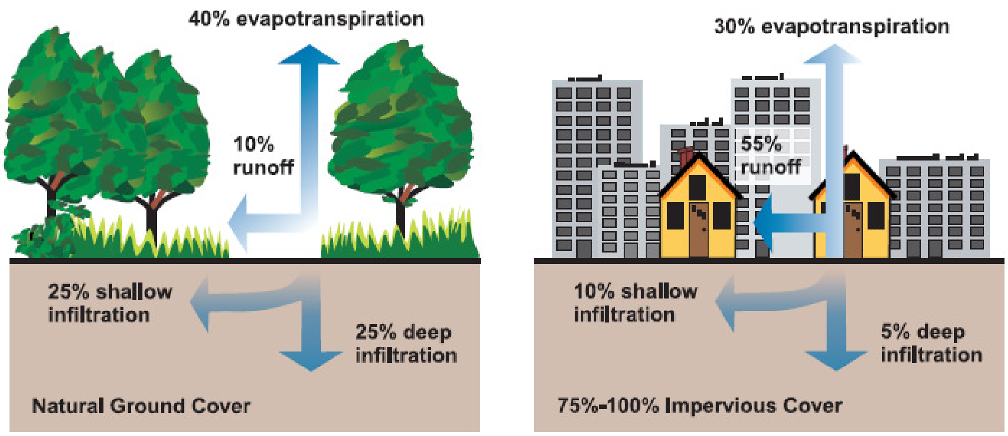
Animal waste from agricultural activities in the Waiulaula watershed is comprised mostly of the fecal and urinary wastes of cattle. Not only is manure high in nutrients that can lead to eutrophication, but it can also contain bacteria, viruses, and pathogens. Cattle are currently allowed to graze adjacent to streams and access the streams for water. This facilitates the introduction of pollutants into the waterbodies of the watershed.

Agricultural activities can also impact riparian habitat. EPA (1993) lists the benefits of properly-functioning riparian buffers as the following: "(1) dissipate stream energy associated with high water flows, thereby reducing erosion and improving water quality; (2) filter sediment and aid floodplain development; (3) support denitrification of nitrate-contaminated ground water as it is discharged into streams; (4) improve floodwater retention and ground-water recharge; (5) develop root masses that stabilize banks against cutting action; (6) develop diverse ponding and channel characteristics to provide the habitat and the water depth, duration, and temperature necessary for fish production, waterfowl breeding, and other uses; and (7) support greater biodiversity" (p. 2-10). Livestock grazing near and in the streams can destabilize streambanks, reduce streambank vegetation, and increase fecal contamination. Land grading and grubbing, construction work adjacent to streambanks, and excessive surface runoff can also affect riparian aras.

4.1.2 Urban/Suburban Runoff

Urban development can have a negative impact on the hydrology and water quality of a watershed. Impervious surface area is often associated with polluted runoff. The "hardening" of the landscape that comes with urbanization increases runoff volumes and pollutant loadings. Impervious surfaces, such as rooftops, roads, parking lots, and sidewalks, decrease the infiltration capacity of the ground and result in greater runoff volumes that can exacerbate flooding problems. Urban development also causes an increase in pollutants, such as sediments, nutrients, pathogens, hydrocarbons, heavy metals, and toxins.

Scientists use percent imperviousness to describe how much of a given area is covered by hard surfaces. As the amount of impervious cover increases, the amount of runoff generated also increases, making it difficult for the water to seep into the soil because it is flowing so quickly. This visual, developed by EPA, shows the relationship between impervious cover and surface runoff. As little as 10% impervious cover in a watershed can result in stream degradation (EPA 2003).



Stormwater picks up nutrients, sediment and chemical contaminants as it flows across yards, construction sites, and parks. Roofs and driveways generate additional stormwater runoff that must be managed. Development activities like clearing vegetation, grading, removing or compacting soil, and adding impervious surfaces also increase stormwater and polluted runoff.

Fifty-five to seventy percent of impervious surfaces in an urban area are transportation associated (Chesapeake Bay Program 2008). Runoff from roadways and parking lots can have a particularly adverse effect on water quality if no measures are taken to remove contaminants before the runoff reaches the receiving water. Oil and grease are leaked onto road surfaces from car and truck engines, spilled at fueling stations, and discarded directly into storm drains instead of being taken to recycling stations. Heavy metals come from car and truck exhaust, worn tires and engine parts, brake linings, weathered paint, and rust. Rain water picks up these pollutants and carries them to roadsides or into storm drains.

While urban areas occupy relatively small areas of the Waiulaula watershed, their contributions can be significant. Furthermore, urban growth within the watershed increased significantly over the past 30 years and is projected to continue to increase.

Hawaii County has historically relied on deep (+20 feet) 5-feet diameter drainage injection wells (or “dry wells”) as the primary means of capturing and disposing of urban stormwater runoff, because Hawaii Island's geology allows for good lateral and downward percolation. The county allows a maximum disposal rate of 6 cubic-feet per second (cfs) of water per dry well (Kuba 2005). Many new and existing developments within the Waimea area employ dry wells, notably the Parker Ranch shopping center, Sandalwood residential area, Parker Ranch's Lualai development, and DHHL's new Lalamilo housing development.

According to Kuba (2005), all dry wells operate functionally “as both a sediment trap and a storm water disposal system.” The County Department of Public Works has a dry well cleaning program to removed accumulated sediment in its more than 1,000 permitted dry wells island-wide, in order to maintain the capacity of these dry wells. It is less clear how frequently private dry wells are maintained. While dry wells are effective in keeping urban runoff out of surface water, it is unclear the effects to groundwater of diverting this polluted runoff into dry wells.

There is one large pipe discharging urban stormwater runoff directly into Waikoloa Stream. This concrete pipe is located behind the Waimea Community Education building on Mamalahoa Highway and discharges untreated runoff from storm drains along Mamalahoa Highway.

4.1.3 Wastewater Disposal Systems

Sewer systems within the Waiulaula watershed are limited to sections of Waimea town and the Mauna Kea Beach Resort properties. Everyone else is using an onsite disposal system (OSDS), either a cesspool or septic system, which are effective over the long-term only if properly operated and maintained. When system failure occurs, untreated wastewater and sewage can be introduced into groundwater or nearby streams and waterbodies, introducing pathogens and causing eutrophication.

Parker Ranch owns and operates the Waimea Treatment Company, the only wastewater treatment plant in the Waimea area. The current treatment capacity is 0.1 MGD (100,000 gallons per day). Currently inflow is 65% of its capacity. Wastewater is treated to R-3 quality, which, according to DOH, is undisinfected secondary recycled water. Treated effluent is disbursed through a 40-acre sprinkler system that is located approximately 300 yards from the treatment plant on Parker Ranch land. The treatment plant currently handles sewage from areas of downtown Waimea, including the KTA shopping center, Parker Ranch shopping center, Ace hardware store, North Hawaii Community Hospital, Kamuela senior housing project, Kahilu Theatre, HoloHolo Ku residential development, and Lualai subdivision.

Mauna Kea Beach Resort also operates a wastewater treatment plant which serves all the resort-associated developments in the coastal part of the watershed, including Kumulani, Moani, Apa Apa`a, Waiulaula, Kaunaoa, High Bluffs, Bluffs, and Hapuna and Mauna Kea Beach resorts. The plant's maximum capacity is 600,000 gallons per day (gpd), though current inflow ranges between 130,000 and 300,000 gpd. The wastewater is treated to R-1 standards, which is the highest level of treatment in Hawaii. This means the wastewater goes through secondary treatment (activated sludge), tertiary treatment (filtration), and ultraviolet disinfection. The treated wastewater is then blended with brackish well water and used to irrigate the golf course.

Chapter 11-62, HAR, administered by DOH, outlines the requirements for locating, building and operating wastewater treatment systems and individual wastewater systems. Section 11-62-03, HAR, defines an “individual wastewater system” as “a facility which is used and designed to receive and dispose of no more than 1,000 gallons per day of domestic wastewater” and “treatment works” as “any treatment unit and its associated collection system and disposal system, excluding individual wastewater systems.” The chapter provides specific requirements for both types of wastewater systems. An engineer must evaluate the site for suitability for an OSDS, including depth of permeable soil over seasonal high groundwater, bedrock, or other limiting layer, soil factors, land slope, flooding hazard, and amount of suitable area available. No OSDS can be located within 50 feet of a stream, the ocean at the vegetation line, pond, lake, or other surface water body; or within 1,000 feet of a potable water source serving public water systems. Chapter 11-62, HAR, also requires that no wastewater system (including OSDSs) be operated in such a way that it creates or contributes to: wastewater spill, overflow, or discharge onto the ground or surface waters; or contamination, pollution or endangerment of drinking water.

The U.S. Environmental Protection Agency (EPA) promulgated Underground Injection Control (UIC) regulations on December 7, 1999, which prohibit the construction of new large capacity cesspools nationwide, effective April 5, 2000. A large capacity cesspool (LCC) is a cesspool serving multiple (two or more) dwellings, a community or regional development, or any non-single family residential building/business that generates sanitary wastes, containing human excreta from 20 or more persons per day. Existing LCCs were required to be replaced by an alternative wastewater system and closed by April 5, 2005.

Houses in the Waimea area built before 1991 will likely have cesspools, unless they were required to convert to a septic system because of problems with the existing cesspool or if significant changes were made to the structure. Houses built more recently, especially if part of a subdivision, will likely have septic systems. The type of wastewater system by TMK has not yet been mapped for the watershed.

Efforts to ban the use of new cesspools statewide have been made through revision to Chapter 11-62, HAR. The rule either bans or severely restricts the use of cesspools throughout the state. New cesspools are completely banned on the islands of Oahu and Kauai. On the islands of Maui, Molokai, and Hawaii, new cesspools for individual homes only are allowed in certain areas. These areas are designated in Critical Wastewater Disposal Area (CWDA) maps. The CWDA maps also delineate areas where cesspools are completely banned. In the Waiulaula watershed, the coastal area and specific areas of Waimea are designated CWDA with no exceptions, meaning that cesspools are not allowed. While there is one small band in the lower watershed delineated as non-CWDA, the majority of the watershed is designated CWDA with 5-acre exception, in which cesspools are allowed for individual houses on parcels greater than 5 acres. The maps are based upon development density, groundwater development, potential contamination of coastal waters, and the use of OSDS.

Although the current rule still allows some new cesspools in limited areas, there are a number of items that either prohibit new cesspools or require that existing cesspools be upgraded. They include:

- Not allowing a new dwelling to be connected to an existing cesspool serving an existing dwelling;
- Requiring an existing cesspool system to meet current wastewater rules if there is a change in building usage or characteristics of the wastewater. For example, an existing cesspool must be upgraded if a non-dwelling using a cesspool is converted to a dwelling or a commercial building (*e.g.*, office space) is converted to a food establishment;
- Current rules do not allow two new dwellings (including `ohana units) to be served by a cesspool; and
- Current rules do not allow non-dwellings generating non-domestic-like wastewater to discharge wastewater into a new cesspool.

The South Kohala Community Development Plan (Hawaii County 2008) includes as a District-wide sub-policy "ensure the quality of South Kohala's groundwater resources and marine resources." It goes on to recommend: “County should consider adding the following requirement to HCC 23-85(b) for residential projects: No cesspools or seepage pits shall be installed in South Kohala after the effective date of this plan. The effluent from any septic tank installed in South Kohala after the effective date of this plan shall be discharged into an absorption system that meets the design standards of the State Department of Health.” (p. 51)

4.1.4 Streambank Erosion

Hawaii's streams are subject to wide fluctuations in both flow depth and velocity because of their flashy nature. As flow depths and velocities increase, the force of water flowing against the streambank removes particles from the banks. Over time, the erosion can cause the streambank to slump and fall into the stream channel. Runoff from adjacent land that enters a stream by flowing over the streambanks can also erode soil from streambanks, particularly if the banks are already unstable because of an absence of vegetation or roots holding soil in place. Streambanks can also be destabilized by hoof action, when cattle access the streams for water. Fallen trees or other debris in the stream channel can contribute to streambank erosion, as the flowing water finds other ways around the impediments in the stream channel.

Riparian buffers can help stabilize eroding streambanks. They can also help improve the quality of water resources by removing or ameliorating the effects of pollutants in runoff. A riparian buffer is defined as:

> an area of trees and other vegetation located in areas adjoining and upgradient from surface water bodies and designed to intercept surface runoff, wastewater, subsurface flow, and deeper groundwater flows from upland sources for the purpose of removing or buffering the effects of associated nutrients, sediment, organic matter, pesticides, or other pollutants prior to entry into surface waters and groundwater recharge areas. (Welsch 2007)

There are a number of streambanks within the Waiulaula that are experiencing erosion. The most significant are along Waikoloa stream within Waimea town and along Keanuiomano stream from Waiaka bridge to Kamuela Plantations.

In 2004, NRCS prepared an *Engineering Report for the Waimea Nature (Ulu La`au) Park* (NRCS 2004), in which they conducted hydrologic and hydraulic analyses and developed alternatives for enhancing stream channel and bank stability and reducing flood-related damage to the park. The document outlines potential streambank treatments for several specific problem areas with the park.

Just upstream and downstream from the Waimea Nature Park, several areas have been identified where streambank stabilization is needed in association with the proposed Waimea Trails and Greenways path. In addition, the county has identified two stream crossings that will require streambank stabilization at the ends of the headwalls and culverts.

The streambanks behind and downstream of KTA shopping center are also experiencing erosion. This is the area where the stream jumped its banks during the 2004 flood event. A riparian buffer along this stream segment would help stabilize the streambank in a highly visible location in the middle of Waimea town.

4.1.5 Feral Ungulates

Wild pigs and goats can contribute to polluted runoff in the Waiulaula watershed. Feral pigs (*Sus scrofa*) create soil disturbances, accelerating degradation, erosion, landslides, and sedimentation. They destroy native habitat, spread seeds of weedy plants and eat native plants. They also serve as carriers and vectors of parasites and diseases, such as Leptospirosis, found in stream waters on Kohala Mountain. Feral pigs reduce and change the understory vegetation, affecting the watershed hydrology.

The population of wild goats (*Ovis aries*) in West Hawaii has increased dramatically over the past decade. Goats are extremely destructive herbivores that will eat nearly any type of available vegetation. These browsing ungulates are having a significant impact on the groundcover in the lower watershed. There is currently no management of these animals, and they roam freely in the watershed, moving in response to available vegetation and water sources. Goat-proof fencing will be critical to the success of any revegetation project proposed in the watershed.

4.1.6 Invasive Plants

There are numerous invasive plants that are well established in the Waiulaula watershed. These plants in the forested upper watershed can out-compete native plants for nutrients or water and quickly alter a native ecosystem by changing the vegetation. The diversity of plants and physical structure of the forest is lost when invasive plants form homogenized plant communities. According to KWP (2007), "Many invasive plant root structures do not hold the soil well when the plants form monotypic stands, which can accelerate geologic processes like erosion.... This in turn accelerates geologic erosion and decreases water quality, resulting in reef sedimentation" (p. 54).

In the lower, more arid parts of the watershed, fountain grass (*Pennisetum setaceum*) has become a problematic plant. It poses a major fire threat and has been designated one of Hawaii's most invasive horticultural plants by DLNR. Fountain grass is considered fire-promoting, because dry fountain grass is an excellent fuel for brush fires. It is also considered fire-adapted because it can survive wildfires, where native plants often cannot.

4.2 Wildfire

Fire is a major threat to restoring and maintaining a healthy ecosystem in the watershed, and the changing composition of vegetation in the watershed has contributed to an increased fire hazard. Fire contributes to the erosion problem by stripping the land of vegetation. Fountain grass (*Pennisetum setaceum*) now dominates much of the lower watershed. Alien grasses, such as fountain grass, are often more fire-adapted than native species and will not only carry fire well but quickly exploit suitable habitat after a fire. The area's strong, gusty winds and naturally hot and dry weather produce a climate conducive to wildfire occurrence and contributes to the rapid spread of fire.

There have been numerous fires within the watershed over the past five years, many of a suspicious nature. In September 2004, a 1,500-acre fire started south of Kawaihae Road near the egg farm and burned down to Queen Kaahumanu Highway, causing the evacuation of 40 homes within the Ouli Ekahi subdivision and 16 homes in the Mauna Kea Uplands subdivision. In May and June of 2005, fires blackened 400 acres at Puupaa on Parker Ranch lands near the Waimea Airport and 100 acres *makai* of Queen Kaahumanu Highway just south of Kawaihae Road. In August 2005, a fire that began near the Lalamilo Farm lots burned 15,000 acres and led to the evacuation of 4,000 residents of Waikoloa Village. The fire also burned north towards Waikoloa Stream. However, the reduced fuel loads from cattle grazing in the area slowed the fire considerably and kept the neighborhoods along Kawaihae Road safe. The August 2005 fire lasted days and required the collective efforts of the Hawaii County Fire Department, volunteer units, U.S. Army, and Hawaii DLNR. In late August 2005, another fire started near the Lalamilo Farm lots, but because of favorable weather conditions and cattle grazing, it was slower moving and more easily contained.

In July 2007, brushfires burned about 10 acres makai of Kawaihae Road near the Puukohola Heiau National Historic Site, forcing the evacuation of residents of the Kawaihae transitional housing, and 600 acres makai of Mamalahoa Highway near the Waimea Airport. In August 2007, a wind-driven brush fire burned down the slopes above Kamuela View Estates, burning approximately 170 acres. The fire, likely caused by a downed power line, came within a quarter of a mile of homes, and a fire break was cut between the flames and homes. In October 2007, a wildfire burned 550 acres near Spencer Beach Park and Mauumae. In July 2008, a fire burned 2-1/2 acres on the south side of Kawaihae Road near mile-marker 66. Another fire burned about 35 acres near the subdivisions of Anekona and Ouli Ekahi in September 2008, causing the evacuation of some homes. While no houses were damaged, the fire came extremely close to 10 homes.

The Hawaii Wildfire Management Organization (HWMO) is a 501(c)(3) non-profit organization established in 2002 to protect, conserve and enhance resource values in West Hawaii by reducing wildfire frequency and size. The organization's goals are to develop and implement fuels management activities, to provide educational opportunities about wildfire, to conduct fuels management research, to promote the protection of native ecosystems from the effects of wildfire, and to promote and facilitate a multi-faceted approach to wildfire prevention and management. Participating agencies and organizations include DLNR, Hawaii County Fire Department, NRCS, U.S. Fish and Wildlife Service (USFWS), U.S. Army, U.S. Forest Service, University of Hawaii Cooperative Extension Service (CES), MKSWCD, and affected landowners and communities. HWMO has developed a fire history map for West Hawaii. Figure 33 excerpts fire history data for the Waiulaula watershed.

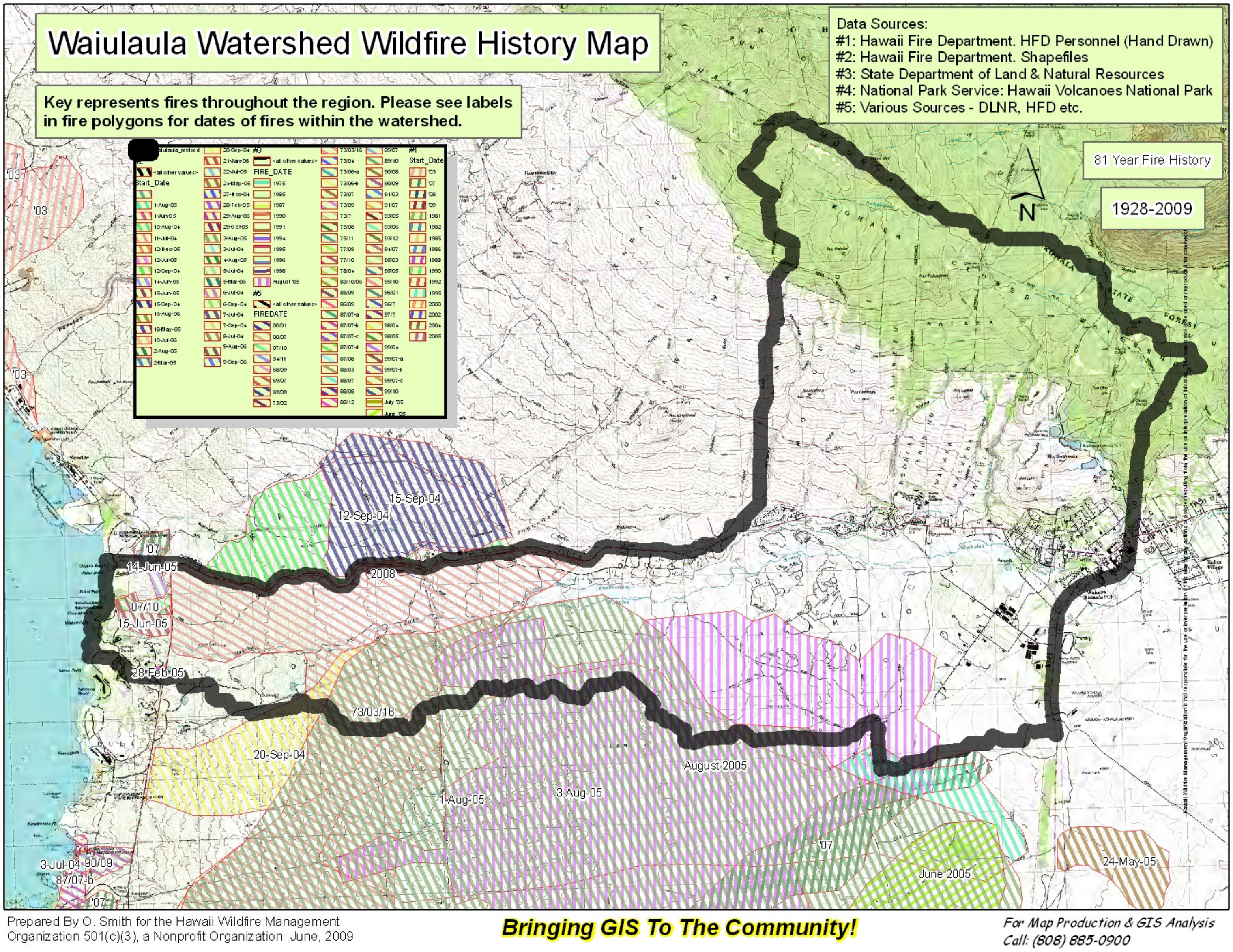


Figure 33: Waiulaula Watershed Wildfire History Map

4.3 Unexploded Ordnance

Between 1943 and 1953, the U.S. military used 130,000 acres of land in West Hawaii for training purposes (Figure 34). At least 40% of the areas was used for training with live military munitions (Hawaii County 2008), including significant portions of the Waiulaula watershed. Following the deactivation of Camp Tarawa and the Waikoloa Maneuver Area, the Department of Defense performed cleanup activities, consistent with the standards and technologies of that time. However, within the last decade, unexploded ordnance (UXO) have been found at several sites within Waimea and in and around Waikoloa Village. At least six people have been killed or injured by old artillery rounds since the 1940s (USACOE 2005).

The Formerly Used Defense Sites (FUDS) program, administered by the U.S. Army Corps of Engineers, addresses potential risks on lands formerly owned or controlled by the Department of Defense prior to

1986 (Hawaii County 2008). The Waikoloa FUDS area covers 137,000 acres, of which 50,000 are considered "high risk." Most of these high risk lands are in or adjacent to the Waiulaula watershed. "To date the Army Corps has cleared about 8,000 acres of land and removed approximately 1,800 pieces of live munitions" (Hawaii County 2008: p. 36). Live ordnance found in the area includes grenades, bazooka rounds, artillery and mortar rounds, land mines, and hedgehog missiles.

As more and more of the region is undergoing development, "the Corps' FUDS team has taken an aggressive approach to reaching current and future homeowners and developers" (Hawaii County 2008: p. 36). Private land owners who have property in high or moderate risk areas that have not yet been cleared are encouraged to contact the USACOE for help in surveying the land for UXO prior to construction.

Because of the risk of unexploded ordnance, the policy of the Hawaii County Fire Department is to not allow firefighters to access those high risk areas on-the-ground to fight wildfires. Rather, they use helicopter water drop operations, fuel breaks, and perimeter defense as a way to control wildfires in these areas.

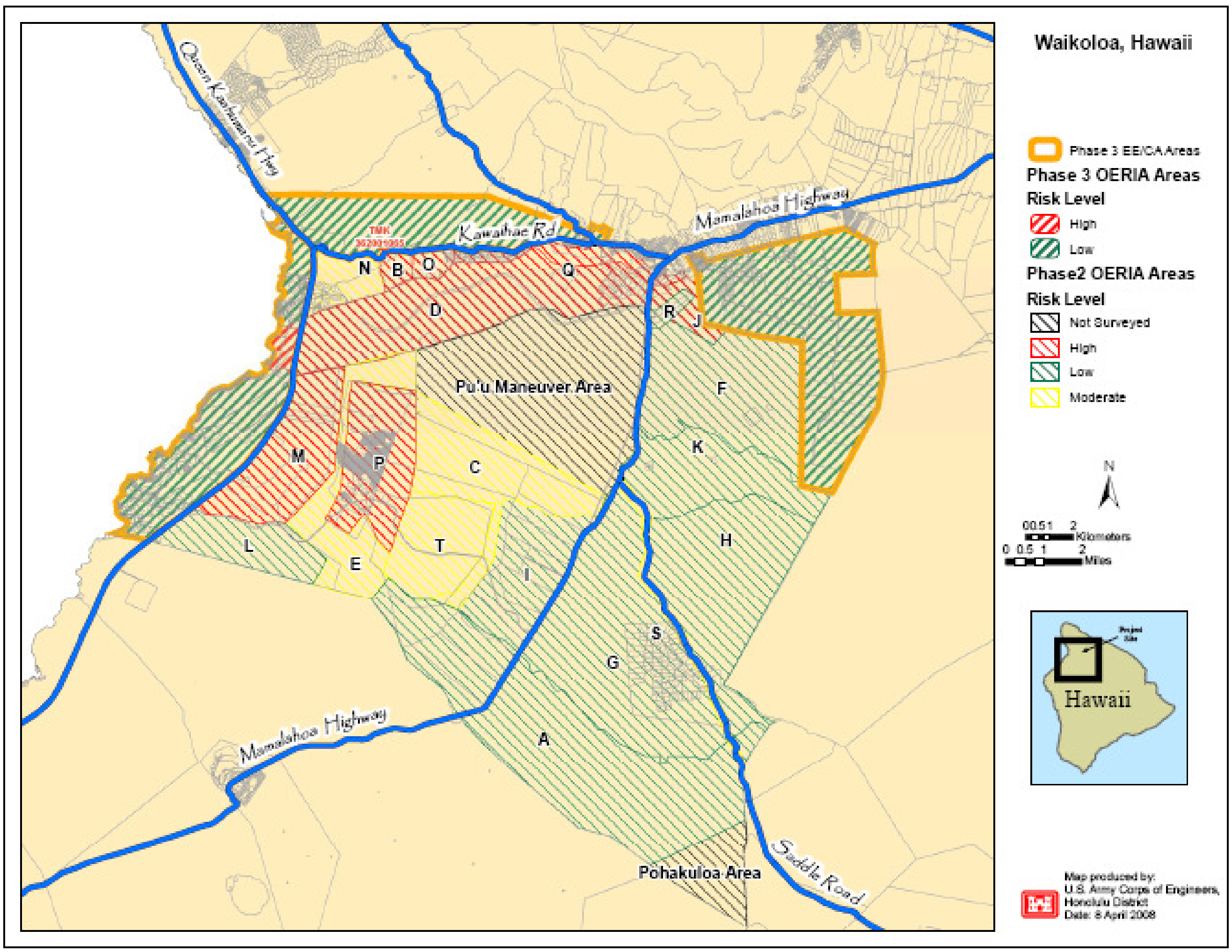


Figure 34: Formerly Used Defense Sites (FUDS) in South Kohala (from Hawaii County 2008)

5.4 Solid and Hazardous Waste

The old Waimea landfill is located immediately adjacent to Waikoloa Stream, downstream of Sandalwood and adjacent to the transfer station. This unlined, 30-40-ft. deep landfill was closed in 1987 and replaced with the solid waste transfer station. It was covered with approximately two feet of soil and planted with grass. Inspections of the old landfill by DOH in 2001 and 2002 confirmed the presence of an active underground fire (DHHL 2002). As material buried in the landfill decomposes, cracks and sinkholes have also developed in the landfill surface. The landfill is under the jurisdiction of the Hawaii County Department of Environmental Management. According to DHHL (2002), the County applies layers of dirt on a regular basis to suppress the smoke and particulate emissions, and fill cracks and fissures. No information is currently available on the effects of the landfill on stream water quality, though it is likely there is seepage of pollutants from the landfill into the adjacent stream.

The County Solid Waste Division Waimea Baseyard and County Solid Waste Transfer Station are also located adjacent to Waikoloa Stream. Trash is deposited at the transfer station into enclosed containers. The containers are removed from the site when they are full, and the waste is transferred to the Puuanahulu landfill. Because the transfer station is exposed to the strong trade winds, trash – usually plastic waste – often blows out of the containers downwind, where it gets caught in fences or trees and shrubs along Waikoloa Stream. This trash often ends up in Waikoloa Stream, where it is carried downstream during storm events.

There are several areas within the watershed that are used as dumping grounds. There are unfenced areas in the lower watershed that are accessed by people to abandon vehicles, which are often smashed up and left to rust, spilling fluids on the ground. There are also sections of Waikoloa stream, particularly in Waimea town, where people litter regularly. Because the stream bed is usually dry, people seem to treat it as more of a “back alley” than a natural asset to be protected. A District-sponsored stream cleanup in April 2008 netted 25 bags of trash, a foam mattress, and several large pieces of rusty metal within a ¼ mile section of stream in town. Parker School classes regularly pick up trash within the stream along the school grounds.

Chapter 5: Watershed Restoration and Protection Goals, Objectives and Recommended Actions

This chapter lays out watershed restoration and protection goals and objectives, as well as recommended actions to address the goals and objectives. Recommended actions that will be elaborated upon in the implementation program outlined in Chapter 6 are marked with a check in the far right-hand column.

Polluted runoff comes from a large number of sources that vary in size and impact on water quality. Degradation of a waterbody results from the cumulative effect of pollutants from these sources. This watershed management plan describes a coordinated program of effective actions to be implemented to prevent and abate polluted runoff within the watershed. Management strategies were developed using EPA's *Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters* (EPA 1993). See Appendix A for a list of relevant management measures.

The watershed management plan also addresses EPA's 9 key elements for watershed-based plans that EPA believes are critical for achieving improvements in water quality. All projects that apply for Section 319(h) funding under the Clean Water Act and administered by the Hawaii Department of Health must include nine key elements in their watershed-based plans. Appendix B lists these 9 required elements and indicates where each is addressed in the WWMP.

<u>Overall Watershed Goal</u>: Prevent water quality degradation in the Waiulaula watershed, in spite of urban growth and development, continued agricultural activities, increasing population, and vegetative changes.

Goal 1: Promote agricultural production that sustains the natural environment.
Agriculture, if not properly managed, can contribute polluted runoff in the forms of sediment, nutrients, pesticides and animal waste. Agricultural activities can also directly impact the habitat of aquatic species through physical disturbances caused by livestock or equipment. Agriculture is a land use within the Waiulaula watershed.

The Mauna Kea Soil and Water Conservation District (MKSWCD) normally works with an agricultural landowner to develop a conservation plan for approval by the district. An approved conservation plan enables the landowner to be exempted from the county grading ordinances for any earthmoving activities. NRCS usually assists in developing conservation plans to treat existing and potential resource problems and has funding available for eligible participants to assist with the installation of best management practices, under the Federal Farm Bill.

The Conservation Reserve Enhancement Program (CREP) is a joint federal-state program that was recently started in Hawaii to help restore degraded agricultural lands and reduce polluted runoff from these lands. It provides incentives to farmers and ranchers to remove degraded cropland and marginal pastureland from agricultural production and convert the land to native grasses, trees, and other vegetation.

<u>Objective 1a</u>: Reduce potential pollutant loads attributed to runoff from cultivated agriculture.

Of the 315 acres currently used for farming, only 94 acres (or 30%) are farmed under conservation plans developed by NRCS and approved by the MKSWCD. While those farms with conservation plans are probably implementing appropriate best management practices to control erosion, properly manage nutrient and pesticide applications, and apply irrigation water, there are many others who may not be. This objective addresses the CNPCP management measures for agricultural erosion and sediment control, nutrient management, pesticide management, and irrigation water management.

Recommended Actions	**Responsible Entity**	**2009-2013 Implementation**
Assist farmers in Lalamilo Farm Lots in completing conservation plans for their cultivated lands through the MKSWCD to address erosion and sediment control, nutrient and pesticide management, and irrigation water management.	MKSWCD/NRCS	√
Encourage farmers to participate in Federal cost-share programs under USDA.	MKSWCD/NRCS	√
Work with farmers adjacent to Waikoloa Stream to install edge-of-field management practices, such as filter strips or field borders along streams, to effectively remove sediment from runoff before it leaves agricultural lands.	MKSWCD/NRCS	√

<u>Objective 1b</u>: Reduce potential pollutant loads attributed to runoff from grazing lands.

A considerable amount of land in the watershed is used for grazing. Some lands are prime kikuyu lands on the slopes of Kohala Mountain that, when well managed, experience little soil erosion and low wildfire risk. Others in the drier elevations are more marginal lands that have burned regularly and continue to be a high risk for wildfire and the subsequent risk of soil loss that comes when the lands are stripped of vegetation during a fire. Careful management of these areas can use grazing as a tool to reduce the fine fuel load and thus the fire hazard, without overgrazing to the point of exacerbating the erosion potential (see Objective 3a).

This objective addresses the CNPCP management measures for grazing management. While the focus of the grazing management measure is on riparian areas, it also encourages the control of erosion from range, pasture, and other grazing lands. Riparian areas are defined as the vegetated ecosystem along a waterbody; they are subject to periodic flooding and influence from the adjacent waterbody. Application of this management measure reduces the physical disturbance to sensitive areas, as well as the discharge of sediment, animal waste, nutrients, and chemicals to surface waters.

At this time, there are two primary grazers of the watershed's rangelands: Parker Ranch in the *mauka* area and FR Cattle Co. in the marginal lands. Much of the grazing land is owned by the State of Hawaii and leased to the ranchers. While these lands are being grazed under existing conservation plans, improvements can still be made. Infrastructure is limited, with more fencing to reduce paddock size and watering facilities needed. In some areas, cattle are accessing streams for water because there are no other sources of water available, causing streambank erosion, and adding nutrients and pathogens to the stream system.

The lower watershed between 1,200-ft elevation and sea level is currently unfenced. This wildland area, classified as Agricultural District, is the most fire-prone part of the watershed. Queen Kaahumanu Highway bisects these marginal lands and Kawaihae Road follows the northern boundary, providing access for intentional and accidental fire starts. The landowners are interested in fencing this area so that the grazer currently running cattle *mauka* can cycle the cattle through this lower area in the winter to graze down the fine fuel load (see Objective 3a).

Recommended Actions	Responsible Entity	2009-2013 Implementation
Work with land user to find alternative water sources (troughs) for cattle away from streams.	MKSWCD/land user	√
Once alternative water sources are found, limit livestock access to streams by fencing.	MKSWCD/land user	√
Install additional fencing to reduce paddock size in order to improve grazing management system to ensure proper grazing use through grazing frequency, livestock stocking rates, livestock distribution and timing, and duration of each rest and grazing period.	MKSWCD/land user	√
Work with landowners to fence lower portion of watershed *mauka* of Queen Kaahumanu Highway so that this fire-prone area can be grazed in the winter to reduce fine fuel loads before the dry summer season.	MKSWCD/land owners/rancher/ HWMO	√
Explore the feasibility of landowner participation in the Hawaii Conservation Resource Enhancement Program (CREP) to remove marginal pastureland from agricultural production and convert those lands to trees and other vegetation, especially in riparian areas.	MKSWCD/NRCS	

Goal 2: Minimize fires within and adjacent to the watershed.
Fire is a major threat to maintaining healthy groundcover in the water. It contributes to the erosion problem by stripping the land of vegetation. Access roads and fire breaks can further contribute to erosion if not carefully planned and properly restored following a fire. The drier, marginal lands *makai* of Waimea are particularly susceptible to wildfire.

Fire-fighting within the Waiulaula watershed is challenging. Access is difficult and, because of the concern about unexploded ordnance from WWII-era firing exercises in the area, it is normally not considered safe for firefighters to fight the fire on the ground. Rather, they are stationed around the perimeter of the fire, and the Fire Department uses helicopters to drop water on the hot spots.

Bulldozers are brought in to cut fire breaks to help contain the fire and protect neighborhoods from its encroachment.

There have been numerous fires within the watershed over the past five years, many of a suspicious nature. (See Section 4.2.)

Objective 2a: Promote grazing as a way to reduce fine fuel loads in fire-prone areas.

Fuel management has a major effect on fire behavior and includes modification of the size, arrangement, and kind of vegetative fuels. Fuel modification can take several forms: changing the vegetation type (to fire resistant plants); reducing fuel volume (by prescribed burning or grazing); and changing the distribution and loading of fuels (mowing or grazing) within a vegetation type (U.S. Army 2000). Grazing, as one form of fuel modification, is most appropriate for use in the Waiulaula watershed.

While a significant portion of the watershed is used for cattle grazing, parts of the watershed have historically remained ungrazed because they have not been fenced and there has been no water available for cattle. These areas have burned several times in the past five years, leaving bare land susceptible to significant erosion.

Recommended Actions	Responsible Entity	2009-2013 Implementation
Support grazing of fire-prone areas to reduce the fine fuel loads. (See Objective 1b.)	MKSWCD/ HWMO	√
Install fencing to divide the lower watershed above Queen Kaahumanu Highway into the appropriate number of paddocks for impact control and plant health. (See Objective 1b.)	MKSWCD/land owners/rancher/ HWMO	√
Install a water tank, pipelines, and troughs to provide water for cattle in these paddocks. (Related to Objective 2b.)	MKSWCD/land owners/rancher/ HWMO	√

Objective 2b: Install on-the-ground measures intended to reduce the number and/or severity of fires.

There are several measures that can be effective in reducing the number and/or severity of fires: fuel breaks; controlling access; pre-suppression planning; and water resources.

Fuel breaks are defined as “a strategically located block or strip on which a cover of vegetation has been manipulated to reduce fuel volume or flammability as an aid to fire control” (US Army 2000, p. 4-7). The appropriate width of a fuel break is site-specific and dependent on fuel type, terrain features, and expected fire weather conditions, especially wind direction and speed.

Most fires within the Waiulaula watershed are started by people, whether accidentally or intentionally. Fencing as described under Objectives 2b and 3a will help limit access into these fire-prone watershed areas.

Effective pre-suppression planning enables fire-fighters and land managers to more easily and effectively control a fire. "Pre-suppression planning focuses on identifying and acquiring the resources needed to suppress anticipated fires once they start... [and is] done before fire occurrence to ensure timely and effective suppression" (US Army 2000, p. 4-4). Knowing the location in the watershed of water resources, access points, and roads/trails and the types of equipment available from land users for fire suppression will enable a quick and effective initial attack against fire outbreaks. As part of pre-suppression planning, it is important for land owners/users and resource and fire suppression agencies to consider how aggressively fire-fighters should respond to a fire. This is especially important in areas with significant natural and cultural resources or high economic value.

Availability of water is critical to the suppression of fire. Therefore, water sources, such as water tanks, must be placed strategically within the watershed to allow access by fire trucks and/or located within a range that allows a two-minute turn-around time for helicopter water drop operations.

Recommended Actions	Responsible Entity	2009-2013 Implementation
Construct and maintain fuel breaks around the residential areas within the fire-prone areas of the watershed to slow the advance of fire and to facilitate fire fighting in the event of a fire (DHHL-Lalamilo, Kamuela Plantations, Kanehoa, Anekona, Ouli Ekahi).	HWMO	
Strategically install water sources, such as tanks, within the watershed for fire suppression. (Related to Objective 2a.)	Land owners/ HWMO	
Develop MOUs with land owners within and adjacent to the watershed for use of water for fire fighting purposes.	MKSWCD/ HWMO	
Draft fire response protocol describing actions to be taken to protect resource values and importance of multi-agency response. Draft and execute an agreement among land owners/users, resource management agencies, and fire response agencies.	HWMO	
Identify and map significant natural, cultural and economic resources in the watershed to be a focus of protection in the event of a fire. This activity should involve all primary land users and land owners in the watershed, resource management agencies, and fire response agencies.	HWMO	

Objective 2c: Establish awareness among residents, visitors, and land users of the watershed of its fire potential.

Education is important to help establish awareness among residents and users of the watershed of its fire potential, especially in the lower areas. Some public education has occurred in the past and is most pronounced immediately following a fire. Regular education is needed to remind people about the ongoing fire hazard and the detrimental impacts of fire on watershed resources.

The non-profit Hawaii Wildfire Management Organization (HWMO), established in 2002 to protect, conserve and enhance resource values in West Hawaii by reducing wildfire frequency and size, has initiated public education and outreach activities. The organization's goals are to develop and implement fuels management activities, to provide educational opportunities about wildfire, to conduct fuels management research, to promote the protection of native ecosystems from the effects of wildfire, and to promote and facilitate a multi-faceted approach to wildfire prevention and management.

Recommended Actions	Responsible Entity	2009-2013 Implementation
Install signage, as appropriate and permissible, along the highways adjacent to the watershed warning of the fire hazard.	Landowners/ HWMO	
Work with HWMO to develop educational materials and public service announcements about reducing the risk of fire in the wildland-urban interface areas.	MKSWCD	√

Objective 2d: Promote post-fire assessment and restoration of burned areas.

Sometimes, areas that have been overgrazed, experienced fires, or suffered severe erosion remain bare for long periods of time, exacerbating their erosion potential. This can occur for a number of reasons: absence of seeds in the soil, poor or depleted soil quality, capping of the soil making seed penetration difficult, and lack of rainfall or other forms of irrigation. Opportunistic species of grasses and plants introduced into an area are sometimes less effective for erosion control and create a greater fire hazard (*e.g.*, fountain grass). In these situations, there may be a need for human assistance in revegetating erosion-prone areas.

Not only does fire itself damage the natural environment, but the process of fighting the fire also affects the resources of the watershed. Fire removes vegetation and increases the potential for soil loss. Construction of fire breaks during a fire can create channels for future erosion. Therefore, it is critical that post-fire assessments be performed and restoration activities undertaken, preferably before available heavy equipment is released from the site following a fire.

A post-fire assessment of the burned area helps to determine effects of the fire on vegetation and other resource values, and effectiveness of pre-suppression and suppression measures. It also helps assess the damage to fuel breaks and access roads so that repairs can occur quickly. Large fires may require post-fire restoration, rehabilitation or revegetation of areas severely impacted by wildfires. There is currently little data available on successful revegetation of burned areas in Hawaii.

Recommended Actions	Responsible Entity	2009-2013 Implementation
Develop a post-fire assessment process to determine effects of a fire on vegetation and other resource values, and effectiveness of pre-suppression and suppression measures, and to assess damage to fuel breaks, and necessary restoration of fire breaks and access roads.	HWMO/ DLNR/ County Fire Dept.	

Recommended Actions	Responsible Entity	2009-2013 Implementation
Implement post-fire assessment after all major fires.	HWMO/ DLNR/ County Fire Dept.	
Repair fuel breaks and access roads, as necessary, following a fire, and restore fire breaks.	Landowners/ HWMO	
Conduct post-fire restoration, rehabilitation, or revegetation, as needed, following all major fires.	MKSWCD/ landowners	
Revegetate the lands *mauka* of Mauumae beach, which burned in 2007 and have the potential to erode directly into the ocean, working with the land owner, local schools and organizations to undertake the plantings and maintenance.	MKSWCD/ Queen Emma Land Co./ local schools & organizations	√

Goal 3: Reduce pollutant loads and volume of urban stormwater runoff conveyed into surface waters.

Urban development can have a negative impact on the hydrology and water quality of a watershed, as described in Section 4.1.2. The Coastal Nonpoint Source Pollution Control Program (CNPCP) has management measures related to both new and existing development; roads, highways, and bridges; and onsite wastewater disposal systems.

While urban areas occupy relatively small areas of the Waiulaula watershed, their contributions can be significant. The South Kohala District which encompasses this watershed has experienced tremendous growth over the past 30 years. Between 1980 and 1990, the population increased by 98.4%, and between 1990 and 2000 it increased by a further 43.7% (County of Hawaii Databook 2001). Much of this growth has occurred within the watershed.

<u>Objective 3a</u>: Reduce delivery and minimize the impacts of pollutants originating from roads, highways and bridges and their associated maintenance activities by use of appropriate management practices.

Many roads within the Waiulaula watershed are fitted with curb and gutter catch basins to convey stormwater away from roads. This stormwater is then discharged into dry wells or directly into streams, affecting either groundwater or surface water. On other roads, stormwater is conveyed to grassy shoulders on either side of the road, where it ponds until it is either absorbed or runs off. All the bridges in the watershed have scuppers that discharge stormwater directly into the streams below.

There are several new highway projects, road realignments, bypasses, and new bridges proposed for the watershed. These provide opportunities for the District to work with the responsible State and county agencies to ensure these projects protect sensitive aquatic ecosystems, consider type and location of permanent erosion and sediment controls, and manage stormwater through a combination of structural and non-structural practices.

Recommended Actions	Responsible Entity	2009-2013 Implementation
Ensure that the siting and development of new and/or reconstructed roads, highways and bridges will limit disturbances of land, natural drainage features and vegetation, and protect sensitive aquatic ecosystems and areas providing important water quality benefits.	DOT/ County DPW	
Incorporate pollution prevention procedures into the operation and maintenance of roads, highways and bridges in the watershed.	DOT/ County DPW	
Identify the location of all storm drain outfalls in the watershed by reviewing county and DOT plans. Determine the number of catch basins and the amount of impervious area associated with each outfall.	MKSWCD	√
Identify priority opportunities to retrofit existing roads, highways and bridges to collect nonpoint source pollutant loadings that threaten the quality of surface waters.	MKSWCD/ County DPW/ DOT Highways	√
Implement a basin insert program, starting with the catch basin near the Waimea Community Education building. Use an absorbent insert liner for removal of oil and grease. Monitor water quality from discharge pipe into Waikoloa stream before and after retrofit.	MKSWCD/ County DPW/ DOT Highways	√

Objective 3b: Encourage future developments to utilize Low Impact Development techniques to minimize impervious cover added to the watershed.

Low Impact Development (LID) is a relatively new concept in stormwater management. “It incorporates a suite of landscaping and design techniques known as “Better Site Design” that attempt to maintain the natural, pre-development hydrology of a site and the surrounding watershed” (Horsley Witten Group 2006, p. 1-2). The goal of LID is to minimize the environmental footprint of a development, while retaining the owner's purpose for the site. According to Horsley Witten (2006), more concentrated (cluster) design creates less impervious area, generates less surface runoff, and requires smaller infrastructure for drainage and other utilities. EPA has found that implementing LID practices saves money for developers, property owners and communities while protecting and restoring water quality (EPA 2007).

All counties in Hawaii have ordinances that provide for cluster development and flexible design standards, though these are not well-publicized. While it appears that economics may be the driving factor in the development of these provisions, since clustering results in a cost savings with respect to infrastructure, these ordinances may also allow for innovative stormwater management techniques, reduced street and sidewalk widths, and other management measures to attenuate runoff from developments. While these ordinances do not explicitly promote the minimizing of impervious surfaces, they may permit the use of pervious pavements and other management measures that are not currently allowed under regular zoning and subdivision provisions.

In Hawaii County, Chapter 25, HCC, “Zoning,” provides for Cluster Plan Development, in which exceptions are made to the density requirements of the single-family residential (RS) district on lands greater than two acres so that permitted density of dwelling units contemplated by the minimum building site requirements is maintained on an overall basis, and desirable open space, tree cover, recreational areas, and scenic vistas are preserved. It also provides for Project Districts, which are intended to provide for a flexible and creative planning approach rather than specific land use designations for quality developments on lands greater than 50 acres, establishing a continuity in land uses and designs while providing for a comprehensive network of infrastructural facilities and systems.

Recommended Actions	Responsible Entity	2009-2013 Implementation
Encourage owner of the KTA shopping center to use innovative techniques to minimize impervious pavement and manage stormwater on its new parking area adjacent to Waikoloa stream.	MKSWCD/ landowner	√
Educate developers, landowners, and residents about Low Impact Development techniques and county regulations that allow for such development.	MKSWCD/ OP/ County	√
Work with DHHL to integrate LID techniques into the next phase of the Lalamilo housing development.	MKSWCD/ DHHL	
Work with the county to improve enforcement of construction site erosion and sediment control and stormwater management measures.	MKSWCD/ County DPW	

<u>Objective 3c</u>: Develop projects to reduce runoff pollutant concentrations and volumes from existing and new development.

The effects of urbanization on water quality are well-documented. Factors of urbanization that have an effect on water quality include diverse pollutant loadings, large runoff volumes, limited area suitable for surface water runoff treatment systems, and destruction or absence of stream buffer zones that can filter pollutants and prevent the destabilization of streambanks.

The South Kohala Community Development Plan (Hawaii County 2008) includes as a District-wide sub-policy: “Encourage the County to review and revise as appropriate rules and guidelines that will reduce flooding and erosion that may occur from developing on steep slopes” (p. 52).

Studies have shown that what is called the “first flush” of urban runoff contains the majority of pollutants. This first flush is the initial stormwater that is generated by rainfall. As it runs off hardened surfaces, it picks up the pollutants that have accumulated during the dry weather. The existence of this first flush of pollutants provides an opportunity for controlling stormwater pollution. First flush collection systems can be used to capture and isolate this most polluted runoff, with subsequent runoff being diverted directly to the stormwater system.

In response to flood hazards caused by development in the early 1980s, all new urban developments (with very few exceptions) have been mandated by Hawaii County to maintain pre-development runoff conditions (Kuba 2005). Developers island-wide are now routinely required to dispose of all development-generated runoff. These requirements have been codified in Chapter 23, HCC, "Subdivisions," Chapter 25, HCC, "Zoning," and Chapter 27, HCC, "Flood Control." Hawaii County relies on deep (+20 feet) 5-feet diameter drainage injection wells (or "dry wells") as the primary means of capturing and disposing of stormwater runoff.

Recommended Actions	Responsible Entity	2009-2013 Implementation
Identify priority opportunities to improve existing urban runoff control structures. Identify areas that could be retrofitted to reduce impervious surfaces.	MKSWCD	
Implement a dry well insert program, starting with the dry wells receiving parking lot runoff. Install oil-water separators or absorbent liners on these dry wells to treat pollutant loads. Monitor water quality of effluent compared to effluent in drywells without treatment.	MKSWCD/ landowners	
Work with private property owners to implement routine maintenance procedures for dry wells in Waimea town.	MKSWCD/ landowners	
Establish a riparian buffer along Waikoloa Stream between the KTA shopping center and Lindsey Road bridge to restore the natural filtering function of streamside vegetation.	MKSWCD/ Parker School/ landowner	√
Encourage the use of rain barrels and rain gardens to reduce runoff pollutant concentrations and volumes from residential areas by hosting community workshops on these practices. (Related to Objective 7d.)	MKSWCD	√

Objective 3d: Reduce bacterial loads from cesspools and septic systems.

Sewer systems within the Waiulaula watershed are limited to sections of Waimea town and the Mauna Kea Beach Resort properties. Everyone else is using an onsite disposal system (OSDS), either a cesspool or septic system, which are effective over the long-term only if they were properly sited, designed, operated and maintained.

Recommended Actions	Responsible Entity	2009-2013 Implementation
Identify and map type of wastewater treatment systems by TMK within the watershed.	MKSWCD/ DOH	√
Work with State and county agencies and local realtors to develop voluntary point-of-sale inspections of OSDS.	MKSWCD	

Recommended Actions	Responsible Entity	2009-2013 Implementation
Develop educational pamphlet to inform residents with OSDS about proper and timely maintenance. The pamphlet could also cover the advantages of converting cesspools to septic systems or alternative wastewater treatment system. Work with DWS to distribute pamphlet with water bills.	MKSWCD/ DOH/ DWS	√

Objective 3e: Minimize the impact of inactive (closed) landfill, transfer station, roadside dumping and littering on the water quality of the watershed.

The old Waimea landfill is located immediately adjacent to Waikoloa Stream, downstream of Sandalwood and adjacent to the transfer station. The County Solid Waste Division Waimea Baseyard and County Solid Waste Transfer Station are also located adjacent to Waikoloa Stream. Finally, there are several areas within the watershed that are used as dumping grounds. These threats are described in Section 4.4.

Recommended Actions	Responsible Entity	2009-2013 Implementation
Work with the State and County to identify methods and potential funding sources to remediate the old dump, which is unlined, burning underground and adjacent to Waikoloa stream.	MKSWCD/ County/ DOH	
Create an inventory of roadside dumping hotspots. Work with landowners to remove dumped material and secure access points to prevent future dumping.	MKSWCD/ County/ DOH/ land owners	
Work with the County to install management practices to reduce flyaway plastic trash from the transfer station. Currently, plastic trash blows out of the containers and is carried downwind into Waikoloa Stream and adjacent lands.	MKSWCD/ County DEM	
Develop an “Adopt-a-Stream” program to foster local stewardship of the watershed's stream resources. The program will provide a hands-on way for residents and businesses to make a positive commitment to caring for the watershed.	MKSWCD	√

Goal 4: Protect and enhance riparian buffers.

Establishing riparian buffer zones and protecting existing riparian zones help in trapping sediment and particulates, in slowing flows, and in increasing percolation. It also helps stabilize streambanks that would otherwise be prone to erosion.

There are mechanisms that could be used to strengthen protection of riparian areas. Mechanisms such as overlay districts or zones have been used in recent years around the U.S. to provide a framework for conservation of special geographical areas. An overlay district is an additional zoning requirement that is placed on a geographical area but does not change the underlying zoning. An overlay zone focused on conserving natural features, such as wetlands, riparian areas, aquifers, or other sensitive resource areas, would typically impose greater restrictions on the development of the land, but only on those parcels whose development, as permitted under the zoning, may threaten the viability of these features. In the context of protecting wetlands and riparian areas, an overlay district could be adopted that contains setback provisions, requires a portion of the existing vegetation to be maintained as a buffer, limits the amount of tree and shrub clearing, limits impervious surfaces in the stream buffer unless approved by special permit, or requires the use of additional BMPs.

Objective 4a: Protect existing riparian buffers.

Recommended Actions	Responsible Entity	2009-2013 Implementation
Fence healthy riparian buffers to exclude cattle and other ungulates. (Related to 1b.)	MKSWCD/ landowners	
Work with the County Council to establish an overlap district via ordinance to explicitly protect wetlands and riparian areas.	MKSWCD/ County Council	
Control invasive plant species, such as Christmas berry, that clog up stream channels and reduce stream channel capacity, and encourage replanting riparian buffer with native vegetation.	MKSWCD/ landowners	

Objective 4b: Reestablish adequate riparian buffer zones with appropriate species.

A riparian buffer is land next to a stream that is vegetated, usually with trees and shrubs, which serves as a protective filter for streams. It protects water quality against pollutants and helps stabilize eroding streambanks. Riparian buffers can vary in width, depending on the stream, soil type, vegetation, slope, surrounding land use, and desired level of protection.

Bishop Museum has developed an interactive plant key designed to assist in selecting native plants appropriate for their outplanting sites. This plant key *Riparian Plant Restoration: A Management Tool for Habitat Restoration in Hawaii* can be found at http://hbs.bishopmuseum.org/botany/riparian/.

Recommended Actions	Responsible Entity	2009-2013 Implementation
Identify areas suitable for re-establishing buffer zones, replanted primarily with native and/or non-invasive plants.	MKSWCD	
Establish a riparian buffer along Waikoloa Stream between the KTA shopping center and Lindsey Road bridge to restore the natural filtering function of streamside vegetation. (Related to Objectives 3c and 4a)	MKSWCD/ Parker School/ landowner	√
Support ongoing efforts of the Waimea Outdoor Circle to re-establish riparian vegetation in the Waimea Nature Park.	MKSWCD/ WOC	

Objective 4c: Enhance the biological integrity of the watershed's stream systems.

Recommended Actions	Responsible Entity	2009-2013 Implementation
Conduct outreach into the neighborhoods along the streams to educate residents about Hawaii's streams and aquatic resources, and the regulatory requirements for withdrawing water from or placing structures within the streams. (Related to Objective 7c)	MKSWCD/ CWRM	
Cooperate with the State Commission on Water Resource Management to take action against landowners illegally withdrawing water from or placing structures within the streams. (Related to Objective 7c)	MKSWCD/ CWRM	
Educate residents about aquatic invasive species and the importance of not releasing these species into the streams accidentally or intentionally.	MKSWCD/ DLNR	√
Study the effects of Kohakohau and Marine dams on the ability of the native aquatic fishes to migrate upstream.	DLNR	
Identify specific stream reaches in which aquatic habitat can be improved.	MKSWCD/DLNR-DAR	

Objective 4d: Reduce Stabilize eroding streambanks where erosion is a serious nonpoint source pollution problem, using vegetative methods if possible.

The problem of streambank erosion is described in Section 4.1.4. Traditional methods for dealing with eroding streambanks were expensive to install and maintain and usually involved hardening of the stream channel. Today, there are numerous techniques, using natural channel design principles, that can be used to move a stream toward a healthy, naturally-stable system.

Recommended Actions	Responsible Entity	2009-2013 Implementation
Implement existing NRCS recommendations to stabilize streambanks in the Waimea Nature Park.	WOC	√
Stabilize streambanks in association with development of the Waimea Trails and Greenways path.	T&G Committee/ County	√
Identify other sites throughout the watershed that require streambank stabilization measures.	MKSWCD	

Goal 5: Increase public education, understanding, and participation regarding watershed issues.

Objective 5a: Develop and implement education and outreach programs for community members, landowners, and other stakeholders.

Recommended Actions	Responsible Entity	2009-2013 Implementation
Nurture and expand existing partnerships with schools and other organizations.	MKSWCD	√
Participate in community events as a way to educate residents about watershed management and the Waiulaula watershed management project.	MKSWCD	√
Promote media coverage of watershed enhancement activities.	MKSWCD	√
Work with local *kupuna* and cultural practitioners to develop an educational program that links Hawaiian legends, history, and cultural activities to current watershed protection activities.	MKSWCD/ Kanu o ka Aina	√

Objective 5b: Provide on-the-ground service learning opportunities for school children and community members.

Hands-on opportunities both increase awareness of watershed conditions and enable community members to participate in improving those conditions.

Recommended Actions	Responsible Entity	2009-2013 Implementation
Organize and implement community planting/reforestation opportunities within the watershed.	MKSWCD	√
Organize periodic community stream cleanups to remove litter and invasive plant species that clog up stream channels and reduce stream channel capacity.	MKSWCD/ WOC	√
Establish a volunteer water quality monitoring program, in which students and community members are trained to help collect and analyze water samples throughout the watershed.	MKSWCD/ Malama Kai Foundation	√

Goal 6: Restore appropriate groundcover in the watershed.

Objective 6a: Revegetate bare land contributing to sediment erosion.

Recommended Actions	Responsible Entity	2009-2013 Implementation
Revegetate the lands *mauka* of Mauumae beach, which burned in 2007 and have the potential to erode directly into the ocean, working with the land owner, local schools and organizations to undertake the plantings and maintenance. (Related to Objective 2d.)	MKSWCD/ Queen Emma Land Co./ local schools & organizations	√
Identify other areas of bare land that are contributing to sediment erosion and are good candidates for revegetation.	MKSWCD	

Management Goal 7: Protect water resources.

Objective 7a: Maintain a structurally-complex vegetative cover in the forested watershed that promotes infiltration and groundwater recharge and minimizes erosion.

According to KWP (2007), "resource experts over the past century have recognized the importance of the forested watershed in promoting infiltration and groundwater recharge, with the overstory and understory both performing important watershed functions" (p. 62). A healthy native ecosystem in the upper elevations of the Waiulaula watershed helps ensure that the source waters for the streams within the watershed are of good quality and minimizes erosion generated from the upper watershed. The *Kohala Mountain Watershed Management Plan* (KWP 2007) outlines goals, objectives and specific actions related to the protection of water resources and watershed functions and the management of threats to these resources.

Recommended Actions	Responsible Entity	2009-2013 Implementation
Manage threats, including invasive plant species, feral ungulates, water quality, and wildfire as specified in the Kohala Mountain Watershed Management Plan, to minimize disturbances to robust forested watershed.	KMWP	√
Monitor and document changes in forest composition and health.	DLNR	

Objective 7b: Protect, enhance, and manage high yield watershed areas to maintain water quality and quantity.

There are State statutes and regulations to protect surface water quality and quantity. DOH administers regulatory mechanisms to protect water quality. Chapter 342D, HRS, "Water Pollution", prohibits discharge of any pollutant into State waters, while Chapter 11-54, HAR, "Water Quality Standards", classifies water uses and establishes water quality standards to maintain and protect those uses. DOH's Safe Drinking Water Branch administers regulations to protect Hawaii's drinking water sources, both surface and ground, from contamination, under Chapter 340E, HRS.

A portion of the watershed has been designated as the Kohala Restricted Watershed under Chapter 13-105, HAR, in order to protect surface water sources that supply domestic drinking water from contamination by public access. However, interviews conducted as part of the Kohala Mountain Watershed Plan development process found that most people interviewed “agreed that access restrictions are rarely enforced and do little to afford real protection to surface water quality” (KWP 2007: p. 63)

The Water Commission is responsible for managing water quantity under Chapter 174C, HRS, “Hawaii Water Code”.

Recommended Actions	Responsible Entity	2009-2013 Implementation
Support efforts of the Kohala Mountain Watershed Partnership.	DLNR/ land owners	√
Continue monitoring water quality in the forested watershed above the Marine Dam.	MKSWCD	√

Objective 7c: Manage water withdrawals from the streams to ensure sufficient baseflow to protect aquatic habitats.

Balancing water use and protection are critical to the health of the Waiulaula watershed. The surface waters of Kohala Mountain are the source of domestic and agricultural water for the majority of residents within the Waiulaula watershed. The Hawaii County Department of Water Supply (DWS) diverts water from Waikoloa and Kohakohau streams to supply drinking water to users within the Waiulaula watershed. Water diverted from watersheds on windward Kohala is transported for use by farmers in Lalamilo. In addition, Parker Ranch diverts water for livestock. At the same time, the native aquatic species rely on episodic flows in all reaches of the streams for their lifecycles.

The State Water Code (Chapter 174C, HRS), adopted by the Hawaii Legislature in 1987 and amended in 2004, provides the regulatory framework to protect streams and other areas critical to water quality. The State, in its stewardship capacity, has management responsibility for all water resources of the State through the Water Commission. The Water Commission sets policies and approves water allocations for all water users. Existing uses established prior to 1987 are grandfathered in, provided the existing use is reasonable and beneficial. The diversions described in Section 2.2.5 have all been grandfathered in.

In addition to these permitted diversions of water, there is one additional diversion on Kohakohau stream and seven on Keanuiomano stream that were declared in 1989 (and grandfathered) or permitted since then. One of the diversions on Keanuiomano stream diverts water via the Ouli *auwai* for use by members of the Kanehoa Auwai Compact for irrigation of landscapes and windbreaks on eleven properties totaling 59.4 acres.

Site visits to Keanuiomano stream reveal that there are numerous unpermitted withdrawals of water from the stream. Chapter 13-168, HAR, "Water Use, Wells, and Stream Diversion Works" requires a permit from the Water Commission for any construction of a stream diversion works. "Stream diversion works" means any artificial structure, excavation, pipeline, or other conduit constructed singly or in combination for the purpose of diverting or otherwise removing water from a stream into a channel, ditch, tunnel, pipeline, etc. Before issuing a permit, the Water Commission must ensure that the quantity and quality of the stream water or the stream ecology will not be adversely affected, and that the proposed diversion works shall not interfere substantially or materially with existing instream or non-instream uses.

Recommended Actions	Responsible Entity	2009-2013 Implementation
Identify and map all legal and illegal water withdrawals from the streams in the Waiulaula watershed.	CWRM/ MKSWCD	√
Conduct outreach into the Kanehoa and Anekona neighborhoods to educate residents about Hawaii's streams and aquatic resources, and the regulatory requirements for withdrawing water from the streams. (Related to Objective 4c.)	MKSWCD/ CWRM	
Cooperate with CWRM to take action against landowners illegally withdrawing water from the streams. (Related to Objective 4c.)	MKSWCD/ CWRM	

<u>Objective 7d</u>: Promote water recycling and conservation practices.

Water conservation is a key link between balancing current and future water needs. There are numerous ways to conserve water: using less water more efficiently, harvesting rainwater, and recycling graywater and treated effluent. The Waiulaula watershed is unique in that most of the domestic and agricultural water used in the watershed comes from surface water sources that are susceptible to the changes in weather patterns and annual rainfall amounts, making water conservation that much more important.

Using less water more efficiently is the most cost-effective and environmentally-sound way to reduce our demand for water in order to ensure adequate water for everyone and to minimize water restrictions during times of drought. There are many ways to conserve water. Farmers can conserve water through their irrigation practices and residents can implement water conservation practices at home, in their gardens, by xeriscaping, and when washing cars.

Rain barrels have been popular around the world for centuries as a way to harvest and save rainwater. Estimates show that during a 1-inch rainfall, a half-gallon of water per square foot of roof area can be collected. This is water that would normally pour off the roofs directly or flow through roof gutter downspouts and become stormwater runoff. Rainwater captured from roofs can be used to water gardens and landscapes (by soaker hose or watering can), keep compost bins moist, and rinse off gardening tools. Rain barrels are inexpensive and easy to build and install.

The *South Kohala Community Development Plan* (Hawaii County 2008) includes as a District-wide sub-policy: "The County shall require water conservation measures and plans for new large scale development projects (*i.e.*, residential and agricultural subdivisions, resorts, commercial and industrial centers, etc.) in South Kohala" (p. 51).

Promoting the use of recycled water is one of DOH's high priority goals. It has adopted *Guidelines for the Treatment and Use of Recycled Water* (DOH 2002) in order to protect public health, prevent environmental degradation, delineate specific recycled water application with recycled water quality treatment, facilitate use of recycled water in greater amounts, and facilitate acceleration of planning, design, permitting and implementation of water reclamation projects.

Chapter 11-62, HAR, administered by DOH, establishes a permit process for the use of recycled water. There are three categories of recycled water, with allowable uses defined for each, depending on level of treatment (DOH 2002). Treated effluent from wastewater treatment facilities within the Waiulaula watershed is used for irrigation. Currently, effluent from the Mauna Kea Beach Resort wastewater treatment plant is used to irrigate the golf course. Treated effluent from the Waimea treatment plant is dispersed through a 40-acre sprinkler system on Parker Ranch land. (For more information on these treatment plants, see the description under Objective 4d.)

More recently, Chapter 11-62, HAR, provides criteria for the design of residential graywater systems. Graywater is all the non-toilet wastewater produced in the average household, including the water from bathtubs, showers, sinks, washing machines, and dishwashers. By diverting graywater from individual wastewater systems, it extends the capacity of these septic systems. It can also be used for irrigation, thereby reducing water demand.

Recommended Actions	Responsible Entity	2009-2013 Implementation
Educate agricultural producers about the importance of proper timing and delivery of irrigation water to promote efficient water use and minimize wastage and runoff. (Related to Objective 1a.)	MKSWCD/ NRCS	√
Work with DWS to promote water conservation in residential homes and gardens, and car washing.	MKSWCD/DWS	√
Encourage the use of rain barrels to capture roof runoff for residential irrigation by hosting community workshops on devising low-cost rain barrels from easy-to-find materials. Rain barrels help residents both reduce consumption of public water and save money. (Related to Objective 3c.)	MKSWCD/DWS/ Recycle Hawaii	√
Educate homeowners about graywater recycling as a form of water conservation – current regulations, methods, retrofits, etc. – through public workshops.	MKSWCD/DOH	√

Chapter 6: Recommended Implementation Program for 2009-2013

This chapter details the strategies or recommended actions that will implement the watershed goals and objectives. It establishes an implementation schedule, interim milestones, indicators to measures progress, and an estimation of costs and technical assistance needed. A monitoring program to track and evaluate the effectiveness of the implementation efforts is described in Chapter 7.

6.1 Education and Outreach Component

Public education and outreach is critical to the success of the watershed management strategies. As noted earlier, water quality in the watershed is generally good, and the goal of this plan is to prevent degradation in spite of increasing land use pressures. Public involvement and participation will encourage proactive changes in behavior and foster support for preventative measures that will help ensure that the water quality standards continue to be met. This section addresses EPA's key element (e).

Recommended Action	Watershed Objective(s) Addressed	Project Tasks	Indicator for Measuring Progress
Educate agricultural producers about the importance of proper timing and delivery of irrigation water to promote efficient water use, and minimize wastage and runoff.	7d 1a	- meet with agricultural producers and determine their patterns of irrigation - prepare presentation and handouts based on this information with recommended irrigation practices - present information to agricultural producers individually or in a group	-number of agricultural producers at meetings -number of new conservation plans implementing irrigation water management - post-presentation survey of agricultural producers to determine if changes were made that promote efficient water use and minimize wastage and runoff
Work with DWS to promote water conservation in residential homes and gardens, and car washing.	7d	-develop educational insert -distribute insert with local water bills	-number of educational inserts mailed -survey gauging effectiveness of educational insert
Encourage the use of rain barrels to capture roof runoff for residential irrigation and to reduce runoff pollutant concentrations and volumes by hosting community workshops on devising low cost rain barrels from easy-to-find materials.	7d 3c	-advertise workshop(s) -collect registration fees -purchase materials -conduct workshop(s)	-number of workshops held -number of people trained
Educate homeowners about graywater recycling as a form of water conservation – current regulations, methods, retrofits, etc. – through public workshops and public information brochures.	7d	-prepare PowerPoint presentation and handouts -advertise workshop(s) -provide copies of handouts to Planning Dept. to distribute to prospective home builders.	-number of people trained -follow-up interviews with County Planning to assess usefulness and effectiveness of handouts

Recommended Action	Watershed Objective(s) Addressed	Project Tasks	Indicator for Measuring Progress
Work with HWMO to distribute educational materials and develop public service announcements about reducing the risk of fire in the wildland-urban interface areas.	2c	-distribute handouts on wildfire risk reduction for homeowners and agricultural producers -develop PSA for radio on wildfire risk reduction. -present information at the neighborhood association meetings at Kanehoa and Anekona	-number of brochures presented to homeowners and agricultural producers -number of PSAs on radio -six months after first meeting with neighborhood associations, meet again and survey group about implementation of wildfire risk reduction measures
Educate developers, landowners, and residents about Low Impact Development (LID) techniques and county regulations that allow for such development.	3b	-provide LID handout to landowners in the area at neighborhood association meetings -provide LID handouts to County Planning and DPW offices to give to applicants for grading and grubbing permits and building permits -provide handouts to local realtors who market lots in this area	- number of handouts presented to potential land developers, home builders, and realtors - follow up interviews with County Planning and DPW staff to assess usefulness of handout for target audience -number of sites with LID practices installed
Develop educational pamphlet to inform residents with OSDS about proper and timely maintenance.	3d	-develop educational insert -distribute insert with local water bills and through OSDS pumpers	-increase in maintenance of OSDS
Develop an “Adopt-a-Stream” program to foster local stewardship of the watershed's stream resources. The program will provide a hands-on way for residents and businesses to make a positive commitment to caring for the watershed.	3e	-develop program brochure that describes the roles and responsibilities of someone who adopts a stream segment -meet with homeowners and landowners at neighborhood association meetings and present program	-number and length of stream segments adopted
Educate residents about aquatic invasive species and the importance of not releasing these species into the streams accidentally or intentionally.	4c	-develop handout to educate residents about aquatic invasive species -distribute to area pet stores -develop PSA about the dangers of releasing aquatic invasive species -present information at neighborhood association meetings and on the radio	-number of handouts distributed -number of meetings -number of PSAs -reduction in invasive species

Recommended Action	Watershed Objective(s) Addressed	Project Tasks	Indicator for Measuring Progress
Nurture and expand existing partnerships with schools and other organizations.	5a	-meet with the leadership of local area schools and other organizations, and develop appropriate activities for school participation in watershed management activities	-number of school classes and organizations participating in watershed management activities
Participate in community events as a way to educate residents about watershed management and the Waiulaula watershed management project.	5a	-research and prepare schedule of community events, contact event organizers, arrange to participate and recruit volunteers	-number of new volunteers recruited -survey to document changes in behavior by volunteers
Promote media coverage of watershed enhancement activities.	5a	-develop briefing paper on project and schedule of activities -meet with editorial staff of West Hawaii Today, North Hawaii News, Big Island Weekly, KWYI radio and other radio news programs to provide information on watershed project and upcoming activities -prepare and send out press releases about events and human interest stories	-number of newspaper stories printed -number of radio news stories broadcast
Work with local *kupuna* and cultural practitioners to develop an educational program that links Hawaiian legends, history, and cultural activities to current watershed protection activities.	5a	-research and prepare a collection of local legends and history that are relevant and supportive of watershed protection -in consultation with cultural practitioners, identify appropriate cultural activities related to watershed protection -integrate this information into an educational program for local residents and schools	-completion of educational materials for program -number of *kupuna* and cultural practitioners involved in developing educational program -number of individuals participating in the educational programs
Organize community planting/reforestation opportunities within the watershed.	5b	-collaborate with Kohala Watershed Partnership to expand planting program	-number of plants planted -area planted or reforested -number of participating community members in planting/reforestation events

Recommended Action	Watershed Objective(s) Addressed	Project Tasks	Indicator for Measuring Progress
Organize periodic community stream cleanups to remove litter and invasive plant species that clog up stream channels and reduce stream channel capacity.	3e 5b	-identify the priority segments of the stream that need to be cleaned of litter and invasive plants -organize a series of cleanup days with a lead sponsoring organization for each day	-pounds of trash collected on stream clean-up days -volume of green waste collected on stream clean-up days
Establish a volunteer water quality monitoring program, in which students and community members are trained to help collect and analyze water samples throughout the watershed.	5b	-adapt existing volunteer water quality monitoring training manuals to select the most appropriate volunteer water quality monitoring protocol and training program -identify partnering organizations from which volunteers will be recruited	-number of trained volunteer monitors

It is not practicable to estimate pollutant load reductions for education and outreach activities. However, because this plan focuses on preventing future loads, education and outreach activities aimed at changing people's behaviors and improving individual stewardship of the watershed resources will be one of the most cost-effective components of the project.

6.2 Management Strategies

The tables below identify management strategies to prevent an increase in pollutant loads as land use changes occur in the watershed. They describe the activities that will be undertaken during the next four years. These activities have been determined to be implementation-ready and of high priority. Pollutant loads prevented have been calculated using the NSPECT model or identified from the published literature. Cost estimates are based on NRCS's cost data for Hawaii and the Pacific Islands, where applicable (NRCS 2007). Monitoring, described in Chapter 7, will track implementation of measures and any changes in water quality. This section addresses EPA's key elements (b), (c), (f), (g), and (h). (See Appendix B for a description of EPA's 9 key elements and a summary of where each element is addressed in the WWMP.)

Goal 1: Promote agricultural production that sustains the natural environment. Objective 1a: Reduce potential pollutant loads attributed to runoff from cultivated agriculture.						
Recommended Actions	**Responsible Party**	**Cost ($)**	**Funding Mechanism**	**Indicators**	**Time Frame**	**Milestones**
Assist farmers in Lalamilo Farm Lots in completing conservation plans for their cultivated lands through MKSWCD to address erosion and sediment control, nutrient and pesticide mgt, and irrigation water mgt.	MKSWCD NRCS	$20,000	DOH funds for conservation specialist USDA funds	-# of new conservation plans for Lalamilo Farm lots	Years 1 and 2	-identify farms without conservation plans -meet with farmers to discuss benefits of conservation planning -develop conservation plans for those farmers who choose to participate
Encourage farmers to participate in Federal cost-share programs under USDA.	MKSWCD NRCS	$10,000	DOH funds for conservation specialist USDA funds	- # of new participants from Lalamilo Farm lots in Farm Bill programs	Years 1 and 2	-meet with farmers to discuss Federal cost-share programs -encourage interested farmers to sign up during USDA enrollment period -develop conservation plans for those farmers who choose to participate
Estimated Load Reduction: TBD when specific conservation plans are developed.						

Goal 1: Promote agricultural production that sustains the natural environment. Objective 1a: Reduce potential pollutant loads attributed to runoff from cultivated agriculture.						
Recommended Actions	**Responsible Party**	**Cost ($)**	**Funding Mechanism**	**Indicators**	**Time Frame**	**Milestones**
Work with farmers adjacent to Waikoloa Stream to install edge-of-field management practices to effectively remove sediment from runoff before it leaves agricultural lands.	MKSWCD NRCS	$20,000 plng $938/ac filter strip or $4.03/ft. veg border	DOH funds for conservation specialist USDA funds	- % of streamside farmers implementing edge-of-field practices -feet of stream protected	Year 3	-identify farm operations adjacent to Waikoloa stream -meet with farmers to discuss benefits of edge-of-field management practices as part of conservation planning -revise or develop new conservation plans to incorporate these practices
Estimated Load Reduction: TN 8%; TP 15%; sediment 25% (See Appendix C.)						

Goal 1: Promote agricultural production that sustains the natural environment. Objective 1b: Reduce potential pollutant loads attributed to runoff from grazing lands.						
Recommended Actions	**Responsible Party**	**Cost ($)**	**Funding Mechanism**	**Indicators**	**Time Frame**	**Milestones**
Work with land users to find alternative water supplies (troughs) for cattle away from streams.	MKSWCD land user	$5,000	DOH funds for conservation specialist	- number of additional alternative water supplies provided in areas where cattle use streams	Years 1 and 2	-identify sites where cattle are accessing stream for water -work with DWS to identify possible water sources -work with CWRM to identify possible stream diversion
Once alternative water supplies are found, limit livestock access to streams by fencing.	MKSWCD land user	$4.59/ft. fence $0.76/gal trough $8.13/ft. diversion	Section 319 funds	-linear feet of stream that is fenced to keep livestock away from stream	Years 3 and 4	-develop water supply -purchase fence materials -install fence
Estimated Load Reduction: TN 60%; TP 60%; sediment 75% (See Appendix C.)						

Goal 1: Promote agricultural production that sustains the natural environment. Objective 1b: Reduce potential pollutant loads attributed to runoff from grazing lands.						
Recommended Actions	**Responsible Party**	**Cost ($)**	**Funding Mechanism**	**Indicators**	**Time Frame**	**Milestones**
Work with landowners to fence lower portion (1,536 ac) of watershed mauka of Queen Kaahumanu Highway so that this fire-prone area can be grazed to reduce fine fuel loads.	MKSWCD Queen Emma Land Co. Mauna Kea Resort FR Cattle Co. HWMO	$4.59/ft. fence $0.76/gal water $1.93/ft. pipe	Section 319 funds HWMO funds private monies	-total number of cattle being grazed in this area before and after fence improvements -stubble height of grass following grazing	Year 1 and 2	-bulldoze fence line where needed -install 35,000-ft of fencing to enclose the land -install pipeline from Mauna Kea Resort property and trough to provide water for cattle -graze seasonally to reduce fine fuel loads.
Estimated Load Reduction: sediment 15-40%						

Goal 2: Minimize fires within and adjacent to the watershed. Objective 2d: Promote post-fire assessment and restoration of burned areas.						
Recommended Actions	**Responsible Party**	**Cost ($)**	**Funding Mechanism**	**Indicators**	**Time Frame**	**Milestones**
Revegetate the lands *mauka* of Mauumae beach, which burned in 2007 and have the potential to erode directly into the ocean, working with the land owner, local schools and organizations to undertake the plantings and maintenance.	MKSWCD Queen Emma Land Co. local schools and organization	$10.20/ft. game-proof fence $400/ac site prep $1,391/ac planting $1.93/ft pipeline $5.26/ft irrigation	Section 319 funds	-Number of vegetation planted -Number of volunteers involved -Total area revegetated -condition of plants after 1st, 2nd, and 3rd years	Years 2 and 3	-decide on acreage for initial planting -secure source of irrigation water for plantings until they are established -fence area to be planted for protection from goats -purchase plants, preferably natives -prep ground for planting -use volunteers to help with planting -undertake regular maintenance
Estimated Load Reduction: sediment 15-40%						

Mauumae Beach

Goal 3: Reduce pollutant loads and volumes of urban stormwater runoff conveyed into surface waters. Objective 3a: Reduce delivery and minimize the impacts of pollutants originating from roads, highways and bridges and their associated maintenance activities by use of appropriate management practices.						
Recommended Actions	**Responsible Party**	**Cost ($)**	**Funding Mechanism**	**Indicators**	**Time Frame**	**Milestones**
Identify the location of all storm drain outfalls in the watershed by reviewing county and DOT plans. Determine the number of catch basins and the amount of impervious area associated with each outfall.	MKSWCD	$5,000	Section 319 funds		Year 2	-meet with county and DOT personnel to review plans -inventory and map all storm drains in watershed -using GIS, calculate impervious area associated with each outfall.
Identify priority opportunities to retrofit existing roads, highways and bridges to collect nonpoint source pollutant loadings that threaten the quality of surface waters.	MKSWCD County DPW DOT Highways	Cost dependent on feasible retrofit projects	Section 319 funds County funds		Year 3	-meet with county and DOT personnel to identify priority roads, highways and bridges that can be retrofitted to collect nonpoint source pollutant load -identify type of retrofit necessary and calculate cost
Estimated Load Reduction: TBD when specific retrofit options are decided.						

Goal 3: Reduce pollutant loads and volumes of urban stormwater runoff conveyed into surface waters. Objective 3a: Reduce delivery and minimize the impacts of pollutants originating from roads, highways and bridges and their associated maintenance activities by use of appropriate management practices.						
Recommended Actions	**Responsible Party**	**Cost ($)**	**Funding Mechanism**	**Indicators**	**Time Frame**	**Milestones**
Implement a basin insert program, starting with curb gutters that drain into pipe that discharges near the Waimea Community Education building. Monitor water quality from discharge pipe into Waikoloa stream before and after retrofit.	MKSWCD County DPW	cost dependent on specific basin insert agreed upon	Section 319 funds County funds	-# of basin inserts installed -water quality sampling results before and after installation	Years 2 and 3	-identify curb gutters and drains discharging into drainage pipe behind Waimea Community Education building; -work with county DPW to identify best treatment insert option -install basin insert -monitor water quality from discharge pipe before and regularly after retrofit -regularly maintain basin insert
Estimated Load Reduction: TN 10%; TP 10%; sediment 10-42%; metals 5-80%						


site of proposed 1 ac. riparian restoration

Goal 3: Reduce pollutant loads and volumes of urban stormwater runoff conveyed into surface waters. Objective 3c: Develop projects to reduce runoff pollutant concentrations and volumes from existing and new development.						
Recommended Actions	**Responsible Party**	**Cost ($)**	**Funding Mechanism**	**Indicators**	**Time Frame**	**Milestones**
Establish a riparian buffer along Waikoloa Stream behind and downstream of the KTA shopping center to restore the natural filtering function of streamside vegetation (1 acre total).	MKSWCD KTA Shopping Center Parker School	$4,475/ac $1.93/ft. pipe $5.26/ft. irrigation	Section 319 funds Parker School KTA shopping center	-# of plants established -# of volunteers involved in planting and maintenance -reduction in rate of streambank erosion -ability of plants to withstand high flows	Years 2 and 3	-meet with KTA shopping center manager and Parker School personnel to agree upon planting area (~1 ac. - 15-ft buffer each side) -develop site design -prepare sites for planting -establish irrigation, using water supply from KTA shopping center -purchase plants, preferably natives -use volunteers for planting conduct regular maintenance
Estimated Load Reduction: TN 25%; TP 50%; sediment 50%						

Goal 3: Reduce pollutant loads and volumes of urban stormwater runoff conveyed into surface waters.
Objective 3d: Reduce bacterial loads from cesspools and septic systems.

Recommended Actions	Responsible Party	Cost ($)	Funding Mechanism	Indicators	Time Frame	Milestones
Identify and map type of wastewater treatment systems by TMK within the watershed.	MKSWCD DOH	$10,000	Section 319 funds		Year 3	-Complete inventory of wastewater systems.
Develop educational pamphlet to inform residents with OSDS about proper and timely maintenance.	MKSWCD DOH DWS	$1,000	Section 319 funds	-% change in OSDS pumping requests	Year 3	-Prepare and send letter to OSDS owners in watershed reminding them to pump out their cesspools and septic tanks every 3-5 years.

Estimated Load Reduction: TN 5%

Goal 4: Protect and enhance riparian buffers.
Objective 4d: Stabilize eroding streambanks where erosion is a serious nonpoint source pollution problem, using vegetative methods if possible.

Recommended Actions	Responsible Party	Cost ($)	Funding Mechanism	Indicators	Time Frame	Milestones
Implement NRCS recommendations to stabilize streambanks in the Waimea Nature Park.	MKSWCD WOC	TBD	Section 319 funds other sources of funding	-Linear feet of stabilized streambank	Year 3 and 4	-decide on priority of measures to be implemented -prepare applications for relevant permits -start work
Stabilize streambanks in association with development of the Waimea Trails and Greenways.	Waimea Trails and Greenways		County funds Federal funds	-Linear feet of stabilized streambank	Years 2 and 3	-completion of project design -start work

Estimated Load Reduction: TBD when specific streambank stabilization options are decided.

Goal 7: Protect water resources. Objective 7c: Manage water withdrawals from the streams to ensure sufficient baseflow to protect aquatic habitats.						
Recommended Actions	**Responsible Party**	**Cost ($)**	**Funding Mechanism**	**Indicators**	**Time Frame**	**Milestones**
Identify and map all legal and illegal water withdrawals from the streams in the Waiulaula watershed.	MKSWCD	$2,000	DOH funds for conservation specialist	-# of permitted and unpermitted withdrawals mapped	Year 1	-GPS all water withdrawals on Waikoloa, Kohakohau, and Keanuiomano streams -Identify by TMK and map all water withdrawals -Determine whether withdrawals are permitted or unpermitted
Conduct outreach into the Kanehoa and Anekona neighborhoods to educate residents about Hawaii's streams and aquatic resources, and the regulatory requirements for withdrawing water from the streams.	MKSWCD CWRM	$2,000	Section 319 funds state funds	--# of people attending meetings -# of owners of illegal withdrawals who apply for CWRM permit	Year 2	-prepare PowerPoint presentation and handouts -attend neighborhood association meetings in Kanehoa and Anekona
Take action against landowners illegally withdrawing water from the streams.	CWRM	$5,000	State funds		Year 4	

6.3 Estimation of Costs and Technical Assistance Needed

The first phase of implementation is expected to take 4 years.

A watershed coordinator and part-time education specialist will be hired, totally 1.5 FTE. The annual cost of personnel will be $100,000, including fringe benefits.

The scope, specifications, and costs of the specific land treatments to be installed under this implementation plan will be further developed in a work plan. This work plan will be written following further discussions with our project partners about the details of each project component. At that time, we will be able to estimate project costs and ascertain technical assistance needed, as required by EPA's key element (d).

Chapter 7: Monitoring

The Waiulaula watershed management plan is a working document. It is expected that the implementation process will reveal new information, emerging technologies, and practical operational realities that can be used to improve or revise the plan. An adaptive management approach is recommended for plan implementation, so that as we learn from actions taken, future management strategies can be altered as necessary in response. An effective adaptive management program requires input from continuous monitoring to assess the effectiveness of implementation activities. This chapter addresses EPA's key element (i).

7.1 Implementation Monitoring

Implementation monitoring determines whether the management strategies outlined in the work plan are being implemented as written. Data gathered from this monitoring will help the District determine how well it is doing in implementing the work plan, as well as help the District modify the management strategies as needed to better protect water quality.

Implementation monitoring involves:

- documenting types, amounts and locations of management activities on a quarterly basis;
- comparing results with interim milestones included in implementation plan;
- providing feedback to stakeholders; and
- determining need for modifications.

Agendas, minutes, activity and project status reports, and other records should be maintained so that important issues and decisions are well-documented.

7.2 Land-Treatment Tracking

Tracking the installation of management practices enables the District to measure the effectiveness of these measures in protecting water quality. This tracking involves maintaining an inventory and map of practices/measures implemented. The status of each practice/measure in terms of its installation on-the-ground, as well as its operation and maintenance, can be tracked. From this, using water quality monitoring data, an index of the effects of implementation of measures on protecting water quality can be developed. N-SPECT can be used to model pollutant load reduction and/or prevention.

7.3 Water Quality Monitoring

The goal of the water quality monitoring program is to gain data which can be used to monitor effectiveness of management strategies in preventing or reducing pollutant loads. The emphasis will be on nutrients and sediments. Data will also be used to develop event mean concentration (EMC) coefficients specific to the Waiulaula watershed. This, in turn, will enable the District to refine the N-SPECT model for use in determining pollutant loads prevented or reduced by the implementation of management practices.

A detailed sampling and analysis plan that outlines parameters to be monitored, sampling location and frequency, roles and responsibilities, documentation and records, quality control requirements, and chain of custody will be developed prior to implementation of management projects.

Parameters to be sampled include: Nutrients (TN, TP, nitrate+nitrite), Total Suspended Sediments (TSS).

7.3.1 Sampling Methods

Autosamplers

Storm event samples will be collected with ISCO 6712 autosamplers (6712C for the Pelekane site) and triggered with pressure transducer probes. Autosamplers will trigger at specified intervals during the rising and falling limbs of the hydrograph, and each of the samples will be analyzed separately.

Existing Autosamplers:
Waikoloa Stream at Marine Dam – in the forested watershed (Conservation District)
Waikoloa Stream at Sandalwood – below Waimea's urban area
Waiulaula Stream at mouth – at bottom of watershed

New Autosamplers:
There are currently no autosamplers located on Keanuiomano or its tributaries. N-SPECT modeling suggests that this stream contributes significantly to runoff and pollutant loads in the watershed. Two or three autosamplers will be sited within this stream system so that data can be collected to verify N-SPECT estimates and assess effects of this stream system on watershed health.

Grab Samples

Grab samples will be taken above and below sites of land treatment activities before and after implementation to monitor effects of land treatment on water quality.

Trained community volunteers will take grab samples at specified locations in the watershed during storm events (preferably catching the "first flush") using 0.5 liter HDPE bottles. These samples will complement those taken by the autosamplers and enable MKSWCD to assess polluted runoff derived from specific sub-basins within the watershed.

Urban storm runoff samples will also be collected at four to six locations (storms drains and streets that are subject to storm runoff), including the pipe discharging into Waikoloa Stream behind the Waimea Community Education building in the Waimea urban core. In particular, samples will be collected before and after the installation of catch basin inserts to determine effectiveness in removing pollutants.

Volunteer Water Quality Monitoring

MKSWCD personnel will train volunteers and local teachers and students on how to collect and analyze samples using the MKSWCD Hach water quality monitoring kits. This monitoring will serve primarily as an educational tool and as a way to involve community members in caring for the watershed. Data collected will be posted to a website managed by a local school, so that students will be able to use the data for school projects and to monitor trends over time.

Sediment Sampling for Trace Elements

Sediment samples will be taken to determine levels of anthropogenic input of trace elements and heavy metals to aquatic ecosystems from agricultural and urban sources through processes of sedimentation. The elements being measured include Copper (Cu), Zinc (Zn), Arsenic (As), Strontium (Sr), Yttrium (Y), Barium (Ba), Lead (Pb), Thorium (Th), Vanadium (V), Cobalt (Co) and Nickel (Ni). The protocol for sediment sampling will follow many of the recommendations of the USGS Guidelines for Collecting and Processing Samples of Stream Bed Sediment for Analysis of Trace Elements and Organic Contaminants for the National Water-Quality Assessment Program (Open file report 94-458).

7.3.2 Analytical Methods

Samples will be analyzed by either University of Hawaii at Hilo or a private laboratory, following established protocols. These protocols will be identified in the sampling and analysis plan.

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Appendix A: Relevant CNPCP Management Measures

<u>Agriculture</u>

A. Erosion and Sediment Control Management Measure

Apply any combination of conservation structural and management practices based on U.S. Department of Agriculture – Natural Resources Conservation Service standards and specifications to minimize the delivery of sediment from agricultural lands to surface waters, or

Design and install a combination of management and structural practices to settle the settleable solids and associated pollutants in runoff delivered from the contributing area for storms of up to and including a 10-year, 24-hour frequency.

C. Nutrient Management Measure

Develop, implement, and periodically update a nutrient management plan to: (1) apply nutrients at rates necessary to achieve realistic crop yields, (2) improve the timing of nutrient application, and (3) use agronomic crop production technology to increase nutrient use efficiency. When the source of the nutrients is other than commercial fertilizer, determine the nutrient value. Determine and credit the nitrogen contribution of any legume crop. Soil and/or plant tissue testing should be used at a suitable interval. Nutrient management plans contain the following core components:

1. Farm and field maps showing acreage, crops, soils, and waterbodies.
2. Realistic yield expectations for the crop(s) to be grown, based on achievable yields for the crop. Individual producer constraints and other producer's yields would be considered in determining achievable yields.
3. A summary of the soil condition and nutrient resources available to the producer, which at a minimum would include:
- An appropriate mix of soil (pH, P, K) and/or plant tissue testing or historic yield response data for the particular crop;
- Nutrient analysis of manure, sludge, mortality compost (birds, pigs, etc.), or effluent (if applicable);
- Nitrogen contribution to the soil from legumes grown in the rotation (if applicable); and
- Other significant nutrient sources (e.g., irrigation water).
4. An evaluation of field limitations based on environmental hazards or concerns, such as:
- Lava tubes, shallow soils over fractured bedrock, and soils with high leaching or runoff potential,
- Distance to surface water,
- Highly erodible soils, and
- Shallow aquifers.
5. Best available information is used in developing recommendations for the appropriate mix of nutrient sources and requirements for the crops.
6. Identification of timing and application methods for nutrients to: provide nutrients at rates necessary to achieve realistic crop yields; reduce losses to the environment; and avoid applications as much as possible during periods of leaching or runoff.
7. Methods and practices used to prevent soil erosion or sediment loss.
8. Provisions for the proper calibration and operation of nutrient application equipment.

D. Pesticide Management Measure

To eliminate the unnecessary release of pesticides into the environment and to reduce contamination of surface water and ground water from pesticides:

1. Use integrated pest management strategies where available that minimize chemical uses for pest control.

2. Manage pesticides efficiently by:
    1. calibrating equipment;
    2. using appropriate pesticides for given situation and environment;
    3. using alternative methods of pest control; and
    4. minimizing the movement of pest control agents from target area.
3. Use anti-backflow devices on hoses used for filling tank mixtures.
4. Enhance degradation or retention by increasing organic matter content in the soil or manipulating soil pH.

E. Grazing Management Measure

Protect range, pasture and other grazing lands:

1. By implementing one or more of the following to protect sensitive areas (such as streambanks, wetlands, estuaries, ponds, lake shores, near coastal waters/ shorelines, and riparian zones):
    1. Exclude livestock,
    2. Provide stream crossings or hardened watering access for drinking,
    3. Provide alternative drinking water locations,
    4. Locate salt and additional shade, if needed, away from sensitive areas, or
    5. Use improved grazing management (e.g., herding) to reduce the physical disturbance and reduce direct loading of animal waste and sediment caused by livestock; *and*
2. By achieving either of the following on all range, pasture, and other grazing lands not addressed under (1):
    1. Implement range and pasture conservation and management practices that apply the progressive planning approach of USDA-NRCS following the standards and specifications contained in the FOTG that achieve an acceptable level of treatment to reduce erosion, and/or
    2. Maintain range, pasture, and other grazing lands in accordance with activity plans established by the Division of Land Management of DLNR, federal agencies managing grazing land, or other designated land management agencies.

F. Irrigation Water Management Measure

To reduce nonpoint source pollution of surface waters caused by irrigation:

1. Operate the irrigation system so that the timing and amount of irrigation water applied match crop water needs. This will require, as a minimum: (a) the measurement of soil-water depletion volume and the volume of irrigation water applied; (b) uniform application of water; and (c) application rate which does not exceed infiltration rate in the field.
2. When chemigation is used, include backflow preventers for wells, minimize the harmful amounts of chemigated waters that discharge from the edge of the field, and control deep percolation. In cases where chemigation is performed with furrow irrigation systems, a tailwater management system may be needed.

The following limitations and special conditions apply:

1. In some locations, irrigation return flows are subject to other water rights or are required to maintain stream flow. In these special cases, on-site reuse could be precluded and would not be considered part of the management measure for such locations.
2. By increasing the water use efficiency, the discharge volume from the system will usually be reduced. While the total pollutant load may be reduced somewhat, there is the potential for an increase in the concentration of pollutants in the discharge. In these special cases, where living resources or human health may be adversely affected and where other management measures (nutrients and pesticides) do

not reduce concentrations in the discharge, increasing water use efficiency would not be considered part of the management measure.

3. The time interval between the order for and the delivery of irrigation water to the farm may limit the irrigator's ability to achieve the maximum on-farm application efficiencies that are otherwise possible.
4. In some locations, leaching is necessary to control salt in the soil profile. Leaching for salt control should be limited to the leaching requirement for the root zone.
5. Where leakage from delivery systems or return flows supports wetlands or wildlife refuges, it may be preferable to modify the system to achieve a high level of efficiency and then divert the "saved water" to the wetland or wildlife refuge. This will improve the quality of water delivered to wetlands or wildlife refuges by preventing the introduction of pollutants from irrigated lands to such diverted water.
6. In some locations, sprinkler irrigation is used for crop cooling or other benefits (*e.g.*, watercress). In these special cases, applications should be limited to the amount necessary for crop protection, and applied water should not contribute to erosion or pollution.

Urban Areas

Urban Runoff

A. New Development Management Measure

1. By design or performance:
    1. After construction has been completed and the site is permanently stabilized, reduce the average annual total suspended solid (TSS) loadings by 80%. For the purposes of this measure, an 80% TSS reduction is to be determined on an average annual basis,* or
    2. Reduce the postdevelopment loadings of TSS so that the average annual TSS loadings are no greater than predevelopment loadings, and
2. To the extent practicable, maintain postdevelopment peak runoff rate and average volume at levels that are similar to predevelopment levels.

Sound watershed management requires that both structural and nonstructural measures be employed to mitigate the adverse impacts of storm water. Nonstructural Management Measures II.B and II.C can be effectively used in conjunction with Management Measure II.A to reduce both the short- and long-term costs of meeting the treatment goals of this management measure.

C. Site Development Management Measure

Plan, design, and develop sites to:

1. Protect areas that provide important water quality benefits and/or are particularly susceptible to erosion and sediment loss;
2. Limit increases of impervious areas, except where necessary;
3. Limit land disturbance activities such as clearing and grading, and cut and fill to reduce erosion and sediment loss; and
4. Limit disturbance of natural drainage features and vegetation.

Existing Development

A. Existing Development Management Measure

Develop and implement watershed management programs to reduce runoff pollutant concentrations and volumes from existing development:

1. Identify priority local and/or regional watershed pollutant reduction opportunities, e.g., improvements to existing urban runoff control structures;
2. Contain a schedule for implementing appropriate controls;
3. Limit destruction of natural conveyance systems; and

4. Where appropriate, preserve, enhance, or establish buffers along surface waterbodies and their tributaries.

Onsite Disposal Systems

A. New Onsite Disposal Systems (OSDS) Management Measure

1. Ensure that new Onsite Disposal Systems (OSDS) are located, designed, installed, operated, inspected, and maintained to prevent the discharge of pollutants to the surface of the ground and to the extent practicable reduce the discharge of pollutants into ground waters that are closely hydrologically connected to surface waters. Where necessary to meet these objectives: (a) discourage the installation of garbage disposals to reduce hydraulic and nutrient loadings; and (b) where low-volume plumbing fixtures have not been installed in new developments or redevelopments, reduce total hydraulic loadings to the OSDS by 25%. Implement OSDS inspection schedules for preconstruction, construction, and postconstruction;
2. Direct placement of OSDS away from unsuitable areas. Where OSDS placement away from unsuitable areas is not practicable, ensure that the OSDS is designed or sited at a density so as not to adversely affect surface waters or ground water that is closely hydrologically connected to surface water. Unsuitable areas include, but are not limited to, areas with poorly or excessively drained soils; areas with shallow water tables or areas with high seasonal water tables; areas overlaying fractured bedrock that drain directly to ground water; areas within floodplains; or areas where nutrient and/or pathogen concentrations in the effluent cannot be sufficiently treated or reduced before the effluent reaches sensitive waterbodies;
3. Establish protective setbacks from surface waters, wetlands, and floodplains for conventional as well as alternative OSDS. The lateral setbacks should be based on soil type, slope, hydrologic factors, and type of OSDS. Where uniform protective setbacks cannot be achieved, site development with OSDS so as not to adversely affect waterbodies and/or contribute to a public health nuisance;
4. Establish protective separation distances between OSDS system components and groundwater which is closely hydrologically connected to surface waters. The separation distances should be based on soil type, distance to ground water, hydrologic factors, and type of OSDS;
5. Where conditions indicate that nitrogen-limited surface waters may be adversely affected by excess nitrogen loadings from ground water, require the installation of OSDS that reduce total nitrogen loadings by 50% to groundwater that is closely hydrologically connected to surface water.

B. Operating OSDS Management Measure

1. Establish and implement policies and systems to ensure that existing OSDS are operated and maintained to prevent the discharge of pollutants to the surface of the ground and to the extent practicable reduce the discharge of pollutants into ground waters that are closely hydrologically connected to surface waters. Where necessary to meet these objectives, encourage the reduced use of garbage disposals, encourage the use of low-volume plumbing fixtures, and reduce total phosphorus loadings to the OSDS by 15% (if the use of low-level phosphate detergents has not been required or widely adopted by OSDS users). Establish and implement policies that require an OSDS to be repaired, replaced, or modified where the OSDS fails, or threatens or impairs surface waters;
2. Inspect OSDS at a frequency adequate to ascertain whether OSDS are failing;
3. Consider replacing or upgrading OSDS to treat influent so that total nitrogen loadings in the effluent are reduced by 50%. This provision applies only:
    1. where conditions indicate that nitrogen-limited surface waters may be adversely affected by significant groundwater nitrogen loadings from OSDS, and
    2. where nitrogen loadings from OSDS are delivered to groundwater that is closely hydrologically connected to surface water.

Pollution Prevention

A. Pollution Prevention Management Measure

Implement pollution prevention and education programs to reduce nonpoint source pollutants generated from the following activities, where applicable:

1. The improper storage, use, and disposal of household hazardous chemicals, including automobile fluids, pesticides, paints, solvents, etc.;
2. Lawn and garden activities, including the application and disposal of lawn and garden care products, and the improper disposal of leaves and yard trimmings;
3. Turf management on golf courses, parks, and recreational areas;
4. Improper operation and maintenance of onsite disposal systems;
5. Discharge of pollutants into storm drains including floatables, waste oil, and litter;
6. Commercial activities including parking lots, gas stations, and other entities not under NPDES purview; and
7. Improper disposal of pet excrement.

B. Golf Course Management Measure

1. Develop and implement grading and site preparation plans to:
    1. Design and install a combination of management and physical practices to settle solids and associated pollutants in runoff from heavy rains and/or from wind;
    2. Prevent erosion and retain sediment, to the extent practicable, onsite during and after construction;
    3. Protect areas that provide important water quality benefits and/or are environmentally-sensitive ecosystems;
    4. Avoid construction, to the extent practicable, in areas that are susceptible to erosion and sediment loss;
    5. Protect the natural integrity of waterbodies and natural drainage systems by establishing streamside buffers; and
    6. Follow, to the extent practicable, the amended U.S. Golfing Association (USGA) guidelines for the construction of greens.
2. Develop nutrient management guidelines appropriate to Hawaii for qualified superintendents to implement so that nutrients are applied at rates necessary to establish and maintain vegetation without causing leaching into ground and surface waters.
3. Develop and implement an integrated pest management plan. Follow EPA guidelines for the proper storage and disposal of pesticides.
4. Develop and implement irrigation management practices to match the water needs of the turf.

Roads, Highways, and Bridges

A. Management Measure for Planning, Siting, and Developing Roads and Highways

Plan, site, and develop roads and highways to:

1. Protect areas that provide important water quality benefits or are particularly susceptible to erosion or sediment loss;
2. Limit land disturbance such as clearing, grading and cut and fill to reduce erosion and sediment loss; and
3. Limit disturbance of natural drainage features and vegetation.

B. Management Measure for Bridges

Site, design, and maintain bridge structures so that sensitive and valuable aquatic ecosystems and areas providing important water quality benefits are protected from adverse effects.

E. Management Measure for Operation and Maintenance
Incorporate pollution prevention procedures into the operation and maintenance of roads, highways, and bridges to reduce pollutant loadings to surface waters.

F. Management Measure for Road, Highway, and Bridge Runoff Systems
Develop and implement runoff management systems for existing roads, highways, and bridges to reduce runoff pollutant concentrations and volumes entering surface waters.

1. Identify priority and watershed pollutant reduction opportunities (e.g., improvements to existing urban runoff control structures); and
2. Establish schedules for implementing appropriate controls.

Hydromodifications

Channelization and Channel Modification

A. Management Measure for Physical and Chemical Characteristics of Surface Waters

1. Evaluate the potential effects of proposed channelization and channel modification on the physical and chemical characteristics of surface waters in coastal areas;
2. Plan and design channelization and channel modification to reduce undesirable impacts; and
3. Develop an operation and maintenance program for existing modified channels that includes identification and implementation of opportunities to improve physical and chemical characteristics of surface waters in those channels.

B. Instream and Riparian Habitat Restoration Management Measure

1. Evaluate the potential effects of proposed channelization and channel modification on instream and riparian habitat in coastal areas;
2. Plan and design channelization and channel modification to reduce undesirable impacts; and
3. Develop an operation and maintenance program with specific timetables for existing modified channels that includes identification of opportunities to restore instream and riparian habitat in those channels.

Dams

C. Management Measure for Protection of Surface Water Quality and Instream and Riparian Habitat
Develop and implement a program to manage the operation of dams in coastal areas that includes an assessment of:

1. Surface water quality and instream and riparian habitat and potential for improvement and
2. Significant nonpoint source pollution problems that result from excessive surface water withdrawals.

Streambank and Shoreline Erosion

A. Management Measure for Eroding Streambanks and Shorelines

1. Where streambank or shoreline erosion is a serious nonpoint source pollution problem, streambanks and shorelines may need to be stabilized. Vegetative methods are strongly preferred. Structural methods may be necessary where vegetative methods cannot work and where they do not interfere with natural beach processes or harm other sensitive ecological areas.
2. Protect streambank and shoreline features with the potential to reduce nonpoint source pollution.
3. Protect streambanks and shorelines from erosion due to uses of either the shorelands or adjacent surface waters.
4. Where artificial fill is eroding into adjacent streams or coastal waters, it should be removed.

Wetlands, Riparian Areas, and Vegetated Treatment Systems

A. Management Measure for Protection of Wetlands and Riparian Areas

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.

B. Management Measure for Restoration of Wetlands and Riparian Areas

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.

C. Management Measure for Vegetated Treatment Systems

Promote the use of engineered vegetated treatment systems such as constructed wetlands or vegetated filter strips where these systems will serve a significant nonpoint source pollution abatement function.

Appendix B: EPA's Nine Key Elements

To ensure that Section 319 projects funded with incremental dollars make progress towards restoring waters impaired by nonpoint source pollution, watershed-based plans that are developed or implemented with Section 319 funds to address 303(d)-listed waters must include at least the elements listed below.

a. An identification of the causes and sources or groups of similar sources that will need to be controlled to achieve the load reductions estimated in this watershed-based plan, as discussed in item (b) immediately below. Sources that need to be controlled should be identified at the significant subcategory level with estimates of the extent to which they are present in the watershed.

This element is addressed in Chapter 4 "Threats to the Water Quality of the Watershed" and, to a lesser extent, Chapters 2 and 3.

b. An estimate of the load reductions expected for the management measures described under paragraph (c) below (recognizing the natural variability and the difficulty in precisely predicting the performance of management measures over time).

This element is addressed in Section 6.2 "Management Strategies" of the WWMP.

c. A description of the NPS management measures that will need to be implemented to achieve the load reductions estimated under paragraph (b) above, and an identification of the critical areas in which those measures will be needed to implement this plan.

This element is addressed in Section 6.2 "Management Strategies" of the WWMP.

d. An estimate of the amounts of technical and financial assistance needed, associated costs, and/or the sources and authorities that will be relied upon, to implement this plan. As sources of funding, States should consider the use of their Section 319 programs, State Revolving Funds, USDA's Environmental Quality Incentives Program and Conservation Reserve Program, and other relevant Federal, State, local and private funds that may be available to assist in implementing this plan.

This element is addressed in Section 6.3 "Estimation of Costs and Technical Assistance Needed" of the WWMP.

e. An information/education component that will be used to enhance public understanding of the project and encourage their early and continued participation in selecting, designing, and implementing the NPS management measures that will be implemented.

This element is addressed in Section 6.1 "Education and Outreach Component" of the WWMP.

f. A schedule for implementing the NPS management measures identified in this plan that is reasonably expeditious.

This element is addressed in Section 6.2 "Management Strategies" of the WWMP.

g. A description of interim, measurable milestones for determining whether NPS management measures or other control actions are being implemented.

This element is addressed in Section 6.2 "Management Strategies" of the WWMP.

h. A set of criteria that can be used to determine whether loading reductions are being achieved over time and substantial progress is being made towards attaining water quality standards and, if not, the criteria for determining whether this watershed-based plan needs to be revised.

This element is addressed in Section 6.2 "Management Strategies" of the WWMP.

i. A monitoring component to evaluate the effectiveness of the implementation efforts over time, measured against the criteria established under item (h) immediately above.

This element is addressed in Chapter 7 "Monitoring Plan" of the WWMP.

EPA believes, as this guidance reflects, that there must be a balanced approach. On one hand, it is absolutely critical that States make, at the subcategory level, a reasonable effort to identify the significant sources; identify the management measures that will most effectively address those sources; and broadly estimate the expected load reductions that will result. Without such information to provide focus and direction to the project's implementation, it is much less likely that the project can efficiently and effectively address the nonpoint sources of water quality impairments. On the other hand, EPA recognizes that even with reasonable steps to obtain and analyze relevant data, the available information at the planning stage (within reasonable time and cost constraints) may be limited; preliminary information and estimates may need to be modified over time, accompanied by mid-course corrections in the watershed plan; and it often will require a number of years of effective implementation for a project to achieve its goals. EPA fully intends that the watershed planning process described above should be implemented in a dynamic and iterative manner to assure that projects whose plans address each of the nine elements above may proceed even though some of the information in the watershed plan is imperfect and may need to be modified over time as information improves.

Appendix C: Load Reduction Estimates from the Chesapeake Bay Program Watershed Model

Table 1: Nonpoint Source Best Management Practices that have been Peer-Reviewed and CBP-Approved for Phase 5.0 of the Chesapeake Bay Program Watershed Model Revised 1/18/06				
Agricultural BMPs	***How Credited***	***TN Reduction Efficiency***	***TP Reduction Efficiency***	***SED Reduction Efficiency***
Riparian Forest Buffers and Wetland Restoration - Agriculture[1]:	Landuse conversion + efficiency	Efficiency applied to 4 upland acres	Efficiency applied to 2 upland acres	Efficiency applied to 2 upland acres
Coastal Plain Lowlands	Efficiency	25%	75%	75%
Coastal Plain Dissected Uplands	Efficiency	40%	75%	75%
Coastal Plain Uplands	Efficiency	83%	69%	69%
Piedmont Crystalline	Efficiency	60%	60%	60%
Blue Ridge	Efficiency	45%	50%	50%
Mesozoic Lowlands	Efficiency	70%	70%	70%
Piedmont Carbonate	Efficiency	45%	50%	50%
Valley and Ridge Carbonate	Efficiency	45%	50%	50%
Valley and Ridge Siliciclastic	Efficiency	55%	65%	65%
Appalachian Plateau Siliciclastic	Efficiency	60%	60%	60%
Riparian Grass Buffers - Agriculture:	Landuse conversion + efficiency	Efficiency applied to 4 upland acres	Efficiency applied to 2 upland acres	Efficiency applied to 2 upland acres
Coastal Plain Lowlands	Efficiency	17%	75%	75%
Coastal Plain Dissected Uplands	Efficiency	27%	75%	75%
Coastal Plain Uplands	Efficiency	57%	69%	69%
Piedmont Crystalline	Efficiency	41%	60%	60%
Blue Ridge	Efficiency	31%	50%	50%
Mesozoic Lowlands	Efficiency	48%	70%	70%
Piedmont Carbonate	Efficiency	31%	50%	50%
Valley and Ridge Carbonate	Efficiency	31%	50%	50%
Valley and Ridge Siliciclastic	Efficiency	37%	65%	65%
Appalachian Plateau Siliciclastic	Efficiency	41%	60%	60%

[1] These peer-reviewed BMP efficiencies and/or landuse conversions will be refined with more recent data for use in Phase 5.0 of the Chesapeake Bay Program Watershed Model based on results of the EPA CBPO FY2006 BMP Literature Synthesis project. Estimated Completion Date: TBD.

Agricultural BMPs (continued)	***How Credited***	***TN Reduction Efficiency***	***TP Reduction Efficiency***	***SED Reduction Efficiency***
Conservation Plans - Agriculture[1] (Solely structural practices such as installation of grass waterways in areas with concentrated flow, terraces, diversions, drop structures, etc.):	Efficiency			
Conservation Plans on Conventional-Till	Efficiency	8%	15%	25%
Conservation Plans on Conservation-Till and Hay	Efficiency	3%	5%	8%
Conservation Plans on Pasture	Efficiency	5%	10%	14%
Cover Crops[1]:	Efficiency			
Cereal Cover Crops on Conventional-Till:	Efficiency			
Early-Planting - Up to 7 days prior to published first frost date	Efficiency	45%	15%	20%
Late-Planting - Up to 7 after published first frost date	Efficiency	30%	7%	10%
Cereal Cover Crops on Conservation-Till:	Efficiency			
Early-Planting - Up to 7 days prior to published first frost date	Efficiency	45%	0%	0%
Late-Planting - Up to 7 after published first frost date	Efficiency	30%	0%	0%
Commodity Cereal Cover Crops / Small Grain Enhancement on Conventional-Till:	Efficiency			
Early-Planting - Up to 7 days prior to published first frost date	Efficiency	25%	0%	0%
Late-Planting - Up to 7 after published first frost date	Efficiency	17%	0%	0%
Commodity Cereal Cover Crops / Small Grain Enhancement on Conservation-Till:	Efficiency			
Early-Planting - Up to 7 days prior to published first frost date	Efficiency	25%	0%	0%
Late-Planting - Up to 7 after prior to published first frost date	Efficiency	17%	0%	0%
Off-stream Watering with Stream Fencing (Pasture)[2]	Efficiency	60%	60%	75%
Off-stream Watering with Stream Fencing and Rotational Grazing (Pasture)[3]	Efficiency	20%	20%	40%

[1] These peer-reviewed BMP efficiencies and/or landuse conversions will be refined with more recent data for use in Phase 5.0 of the Chesapeake Bay Program Watershed Model based on results of the EPA CBPO FY2006 BMP Literature Synthesis project. Estimated Completion Date: TBD.
[2] Will be credited as a landuse conversion in the final Phase 5.0 of the Watershed Model.
[3] Will be credited as a landuse conversion and efficiency in the final Phase 5.0 of the Watershed Model.

Agricultural BMPs (continued)	How Credited	TN Reduction Efficiency	TP Reduction Efficiency	SED Reduction Efficiency
Off-stream Watering without Fencing (Pasture)	Efficiency	30%	30%	38%
Animal Waste Management Systems - Applied to model manure acre where 1 manure acre = runoff from 145 animal units:[2]	Reduction in manure acres			
Livestock Systems[2]	Reduction in manure acres	100%	100%	N/A
Poultry Systems[2]	Reduction in manure acres	100%	100%	N/A
Barnyard Runoff Control / Loafing Lot Management[2]	Reduction in manure acres	100%	100%	N/A
Conservation-Tillage[1]	Landuse conversion	N/A	N/A	N/A
Land Retirement - Agriculture	Landuse conversion	N/A	N/A	N/A
Tree Planting - Agriculture	Landuse conversion	N/A	N/A	N/A
Carbon Sequestration / Alternative Crops	Landuse conversion	N/A	N/A	N/A
Nutrient Management Plan Implementation - Agriculture	Landuse conversion	135% of modeled crop uptake	135% of modeled crop uptake	N/A
Enhanced Nutrient Management Plan Implementation – Agriculture[1]	Landuse conversion + Built into simulation	115% of modeled crop uptake	115% of modeled crop uptake	N/A
Alternative Uses of Manure / Manure Transport	Built into preprocessing	Reduction in nutrient mass applied to cropland	Reduction in nutrient mass applied to cropland	N/A
Poultry Phytase	Built into preprocessing	N/A	Reduction in nutrient mass applied to cropland	N/A

[1] These peer-reviewed BMP efficiencies and/or landuse conversions will be refined with more recent data for use in Phase 5.0 of the Chesapeake Bay Program Watershed Model based on results of the EPA CBPO FY2006 BMP Literature Synthesis project. Estimated Completion Date: TBD.

[2] Will be credited as a landuse conversion in the final Phase 5.0 of the Watershed Model.

Agricultural BMPs (continued)	*How Credited*	*TN Reduction Efficiency*	*TP Reduction Efficiency*	*SED Reduction Efficiency*
Dairy Precision Feeding / and Forage Management[1]	Built into preprocessing	Reduction in nutrient mass applied to cropland	Reduction in nutrient mass applied to cropland	N/A
Swine Phytase	Built into preprocessing	N/A	Reduction in nutrient mass applied to cropland	N/A
Continuous No-Till:				
Below Fall Line	Efficiency	10%	20%	70%
Above Fall Line	Efficiency	15%	40%	70%
Water Control Structures	Efficiency	33%	N/A	N/A
Urban and Mixed Open BMPs				
Stormwater Management::	Efficiency			
Wet Ponds and Wetlands[1]	Efficiency	30%	50%	80%
Dry Detention Ponds and Hydrodynamic Structures[1]	Efficiency	5%	10%	10%
Dry Extended Detention Ponds[1]	Efficiency	30%	20%	60%
Infiltration Practices	Efficiency	50%	70%	90%
Filtering Practices	Efficiency	40%	60%	85%
Erosion and Sediment Control[1]	Efficiency	33%	50%	50%

[1] These peer-reviewed BMP efficiencies and/or landuse conversions will be refined with more recent data for use in Phase 5.0 of the Chesapeake Bay Program Watershed Model based on results of the EPA CBPO FY2006 BMP Literature Synthesis project. Estimated Completion Date: TBD.

Urban and Mixed Open BMPs (continued)	How Credited	TN Reduction Efficiency	TP Reduction Efficiency	SED Reduction Efficiency
Nutrient Management (Urban)	Efficiency	17%	22%	N/A
Nutrient Management (Mixed Open)	Efficiency	17%	22%	N/A
Abandoned Mine Reclamation[2]	Landuse change converted to efficiency	Varies by model segment	Varies by model segment	Varies by model segment
Riparian Forest Buffers – Urban and Mixed Open	Landuse conversion + efficiency	25%	50%	50%
Wetland Restoration – Urban and Mixed Open	Landuse conversion	N/A	N/A	N/A
Stream Restoration – Urban and Mixed Open[1]	Load reduction converted to efficiency	0.02 lbs/ft	0.0035 lbs/ft	2.55 lbs/ft
Impervious Surface and Urban Growth Reduction / Forest Conservation	Landuse conversion	N/A	N/A	N/A
Tree Planting – Urban and Mixed Open	Landuse conversion	N/A	N/A	N/A
Resource and Septic BMPs				
Forest Harvesting Practices[1]	Efficiency	50%	50%	50%
Septic Denitrification	Efficiency	50%	N/A	N/A
Septic Pumping	Efficiency	5%	N/A	N/A
Septic Connections / Hook-ups	Built into pre-Processing	N/A	N/A	N/A

[1] These peer-reviewed BMP efficiencies and/or landuse conversions will be refined with more recent data for use in Phase 5.0 of the Chesapeake Bay Program Watershed Model based on results of the EPA CBPO FY2006 BMP Literature Synthesis project. Estimated Completion Date: TBD.

[2] Will be credited as a landuse conversion in the final Phase 5.0 of the Watershed Model.