WEST MAUI WATERSHED PLAN:
Kahana, Honokahua and Honolua Watersheds Characterization Report

September 2016

WEST MAUI Ridge 2 Reef INITIATIVE

Prepared For:

U.S. Army Corps of Engineer

State of Hawai'i Department of Land and Natural Resources

Cover Photos:

Left - Honokahua Valley and southern ridge (Cami Kloster)

Middle - West Maui aerial (Tova Callender)

Right - Kaʻōpala coastline after rain (John Seebart)

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By:

GROUP 70 INTERNATIONAL

With

SUSTAINABLE RESOURCES GROUP INTN'L INC.

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ABBREVIATIONS & ACRONYMS

DBCP	1,2-Dibromo-3-Chloropropane
BMP	Best Management Practice
BOD	Biological Oxygen Demand
CIP	Capital Improvement Projects
CORAL	Coral Reef Alliance
CoRIS	Coral Reef Information System
CRWG	Coral Reef Working Group
Cu	Copper
CWA	Clean Water Act
CWB	Clean Water Branch
CWRM	Commission on Water Resources Management
CZARA	Coastal Zone Act Reauthorization Amendments
CZM	Coastal Zone Management
CZMP	Coastal Zone Management Plan
DAR	Division of Aquatic Resources
DBEDT	Department of Business Economic Development and Tourism
DLNR	Department of Land and Natural Resources
DO	Dissolved Oxygen
DOA	Department of Agriculture
DOFAW	Division of Forestry and Wildlife
DOH	Department of Health
DOH-CWB	Department of Health Clean Water Branch
DOT	Department of Transportation
EC	Engineer Circular
ECI	Environmental Consultants Inc.
EDB	Ethylene Dibromide
EPA	Environmental Protection Agency
FAST	Funding and Agency Support Team
FIRM	Flood Insurance Rate Map
GIS	Geographic Information System
GPS	Global Positioning System
HAR	Hawaiʻi Administrative Rules
IR	Integrated Report
KHHWMP	Kahana, Honokahua and Honolua Watershed Management Plan
l	Liter
LAS	Local Action Strategies
MG	Miligrams
mgd	Million Gallons per Day
MHI	Main Hawaiian Islands
MLCD	Marine Life Conservation Districts
ML&P	Maui Land & Pineapple Company
MRC	Marine Research Consultants
MSL	Mean Sea Level
mg	Milligram
NCCA	National Coastal Condition Assessment
NHPA	National Historic Preservation Act
NRCS	Natural Resources Conservation Service
NOAA	National Oceanic Atmospheric Administration
NPDES	National Pollution Discharge Elimination System
NPS	Nonpoint Sources
OSDS	Onsite Sewage Disposal Systems
PAHs	Polyaromatichydrocarbons
Pb	Lead
PCBs	Polychlorobiphenyls
PSA	Pacific Subtropical Anticyclone
R2R	Ridge to Reef
SDWA	Safe Drinking Water Act
SWCD	Soil and Water Conservation Districts
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TP	Total Phosphorus
TSS	Total Suspended Solids
UH	University of Hawaiʻi
UIC	Underground Injection Control
US	United States
USACE	US Army Corps of Engineers
USCRTF	US Coral Reef Task Force
USDA	US Department of Agriculture
USGS	US Geological Survey

WMMWP	West Maui Mountains Watershed Partnership
WMP	Watershed Management Plan
WMSWCD	West Maui Soil and Water Conservation District
WRDA	Water Resources Development Act
WTF	Water Treatment Facility
Zn	Zinc
μg	Microgram

EXECUTIVE SUMMARY

Nearly 30% of the West Maui coral reef cover has been lost over the last 30 years. Impacts to the coral reef and declines in watershed health are due in part to the history of land use changes including loss of forestland, plantation era agricultural practices, legacy sediments in streams and gulches, stream channelization and urban development. These have resulted in land-based pollutants which impair water quality and adversely impact the marine ecosystem.

The *West Maui Watershed Plan* is being developed under Section 729 of the Water Resources Development Act (WRDA) of 1986. Section 729 of WRDA 1986 authorizes the development of watershed plans that are multi-purpose and multi-objective in scope and developed in cooperation with Federal, State and local government entities. The US Army Corps of Engineers (USACE) and the State of Hawaiʻi Department of Land and Natural Resources (DLNR) are cosponsors of this plan. The West Maui Watershed Plan collaborative planning process draws upon the efforts and resources of many Federal and State agencies and on the ground representation via the West Maui Ridge 2 Reef Working Group. Collectively this entire interactive and collaborative process is called the West Maui Ridge to Reef (West Maui R2R) Initiative.

The *West Maui Watershed Plan* will serve as a guide to restore and enhance the health and resiliency of West Maui coral reefs and nearshore waters through the reduction of land-based pollution threats from the summit of Puʻu Kukui to the outer reef. These efforts will be guided by the values and traditions of West Maui. The objectives are to:

- Reduce land-based sources of pollution impacts to Maui's coral reefs through the year 2065 to reduce further decline of the coral ecosystem.
- Empower the West Maui community to steward the terrestrial and coral resources and drive good decision-making that benefits the resources and community over the next 50 years.
- Protect and restore native ecosystems of West Maui to benefit nearshore resources through 2065.

The *West Maui Watershed Plan* process is being developed in multiple phases. The first phase was the development of the *Wahikuli and Honokōwai Watershed Management Plan* funded by National Oceanic and Atmospheric Administration (NOAA). The next phase is development of a watershed management plan for the northern three watersheds of Kahana, Honokahua and Honolua. The *Wahikuli-Honokōwai Watershed Management Plan Watershed Characterization* and this *Kahana, Honokahua and Honolua Watershed Characterization Report* will provide baseline conditions for the more comprehensive five-watershed *West Maui Watershed Plan.*

This Kahana, Honokahua and Honolua Watershed Characterization Report evaluates watershed processes, and determines land uses and activities that generate pollutants which potentially cause adverse impacts to the watersheds' ecosystem and subsequently the decline of nearshore and coral reef ecosystems. This report addresses Steps 1 through 3 (Define Study Area, Identify Problems and Opportunities and Inventory and Forecast Resources) of the West Maui Watershed Plan. This report also addresses Element 1 of the Environmental Protection Agency (EPA) Nine Elements of a Watershed Plan (Identification of Causes and Sources of Water Quality) that will need to be controlled to achieve targeted load reductions). The second volume, West Maui Watershed Plan: Kahana, Honokahua and

Honolua Watersheds Strategies and Implementation Report, will provide management practices to reduce pollutants and improve water quality for the purpose of restoring nearshore and coral reef ecosystems. The second volume will inform Step 4 (Evaluate & Compare Alternative Approaches) and 5 (Strategy Selection) of the USACE watershed planning process as well as Elements 2 through 4 of the EPA Nine Elements for Watershed Plans. The two reports will be in accordance with USACE watershed planning regulations and policies and EPA's Nine Elements of a Watershed Plan and the management practices will be potentially eligible for Federal funding under Clean Water Act Section 319, subject to determination by State of Hawai'i Department of Health.

Overall the focus of the *Kahana, Honokahua, and Honolua Watersheds Characterization Report* and the *Strategies and Implementation Report* is on management actions that will protect and for nearshore and coral reef ecosystems**,** and meet water quality goals as required by the State Department of Health and inform the USACE watershed planning process. The State and EPA water quality goal is to restore and protect water quality and aquatic life through the meeting of all appropriate water quality standards.

ES.1 Land Use History and Impacts

Historically, lands of the three watersheds supported Hawaiians hundreds of years prior to Western contact with evidence of this history in the archaeology and landscape features such as lo'i kalo. From the mid 1800s, watershed lands were used for farming and grazing, with pineapple as the primary crop from the 1920s until 2008. Hotel and condominium development began in the 1960s with the first Kapalua hotel constructed in 1978. Urban development along the coastline has continued, including current expansion to lands ma uka of Honoapi'ilani Highway, with more planned. The upper watershed was established as the Pu'u Kukui Watershed Preserve in 1978, and is managed by Maui Land and Pineapple to protect watershed forests, and associated native plants and animals.

Land uses vary by State Land Use Districts and have impacted the watersheds in different ways. In the Conservation Land Use District, feral ungulate activity and trespassing by humans for activities such as dirt bike riding have contributed to vegetation destruction, soil disturbance, and compaction of soils. Introduction of Axis deer to Maui pose another threat to vegetation and soils, and are anticipated to move into the watersheds from areas where they are currently established to the south. Such disturbance leads to soil erosion and reduced water infiltration rates.

Impacts from the Agricultural Land Use District include transport of stream water across watersheds through extensive irrigation and ditch systems, terracing for fields and road construction with water diversions which carry sediments off fields and into streams and gulches. Later in the 1970s and 1980s, desilting basins were constructed to reduce the amount of sediments and nutrients transported into streams and nearshore waters. Fallow agricultural fields following the end of pineapple cultivation have allowed non-native plants to grow, and have increased infiltration and decreased run-off rates.

The Urban Land Use District was once covered with coastal vegetation, wetlands, and sand dunes that served as flood plain filters and attenuated storm flows. Urbanization of coastal areas has created impervious surfaces which generate runoff. More than 21% of the Urban District is covered by impervious surfaces (e.g., paved roads, parking lots and roofs). Impervious surfaces and the separate storm sewer system serving the urban area increase the magnitude and frequency of storm water runoff with associated pollutants.

ES.2 Summary of Watershed Characteristics

Table ES.1 summarizes primary characteristics by watersheds, and Figure ES.1 depicts the three watersheds with subwatershed delineations and the urban sub-areas.

Kahana is largest of the three watersheds with the largest urban area. The Kahana agricultural area is the largest of the watersheds and was the last area cultivated for pineapple. The northern part of Kahana watershed and Honokahua watershed includes the Kapalua resort and golf course. Honolua watershed is largely Conservation Land Use District, due to the natural resource designations of Honolua Stream and Honolua Bay's designation as part of the Marine Life Conservation District. Land ownership of the agricultural and conservation lands in all three watersheds is highly consolidated with Maui Land and Pineapple owning 80% of the lands.

Table ES.1 Summary of Watershed Characteristics

WATERSHED	KAHANA		HONOKAHUA		HONOLUA	
Land Use (Acres/%)	**Acres**	**Percent**	**Acres**	**Percent**	**Acres**	**Percent**
Conservation	1,015	17%	578	19%	2,262	75%
Agricultural & Rural	3,625	62%	2,172	69%	766	25%
Urban	1,224	21%	367	12%	-	-
Area (acres)	5,864		3,117		3,028	
Impervious Surface: Ag District (acres)	156		72		45	
Impervious Surface: Urban District (acres)	308		33		-	
Streams	Kahana		Honokahua		Honolua	
Stream Length (miles)	17		9.7		12	
Estimated Stream Flow[1]	No flow 50% of time		No flow 50% of time		Ma uka to ma kai less than 80% of time	
Subwatersheds	Kahana *(incl. Kahana A)* Kaʻōpala *(incl. Kaʻōpala A & B)* Honokeana Nāpili 4-5 Nāpili 2-3		Honokahua A Honokahua Mokupeʻa Kahauiki		Honolua Līpoa Point	
Desilting Basins	Kahana, Kaʻōpala Honokeana, Nāpili 4-5, Nāpili 2-3		None		None	

[1] Estimated Stream Flow from Cheng (USGS) 2014 study which estimated stream flows; there are no gaged streams

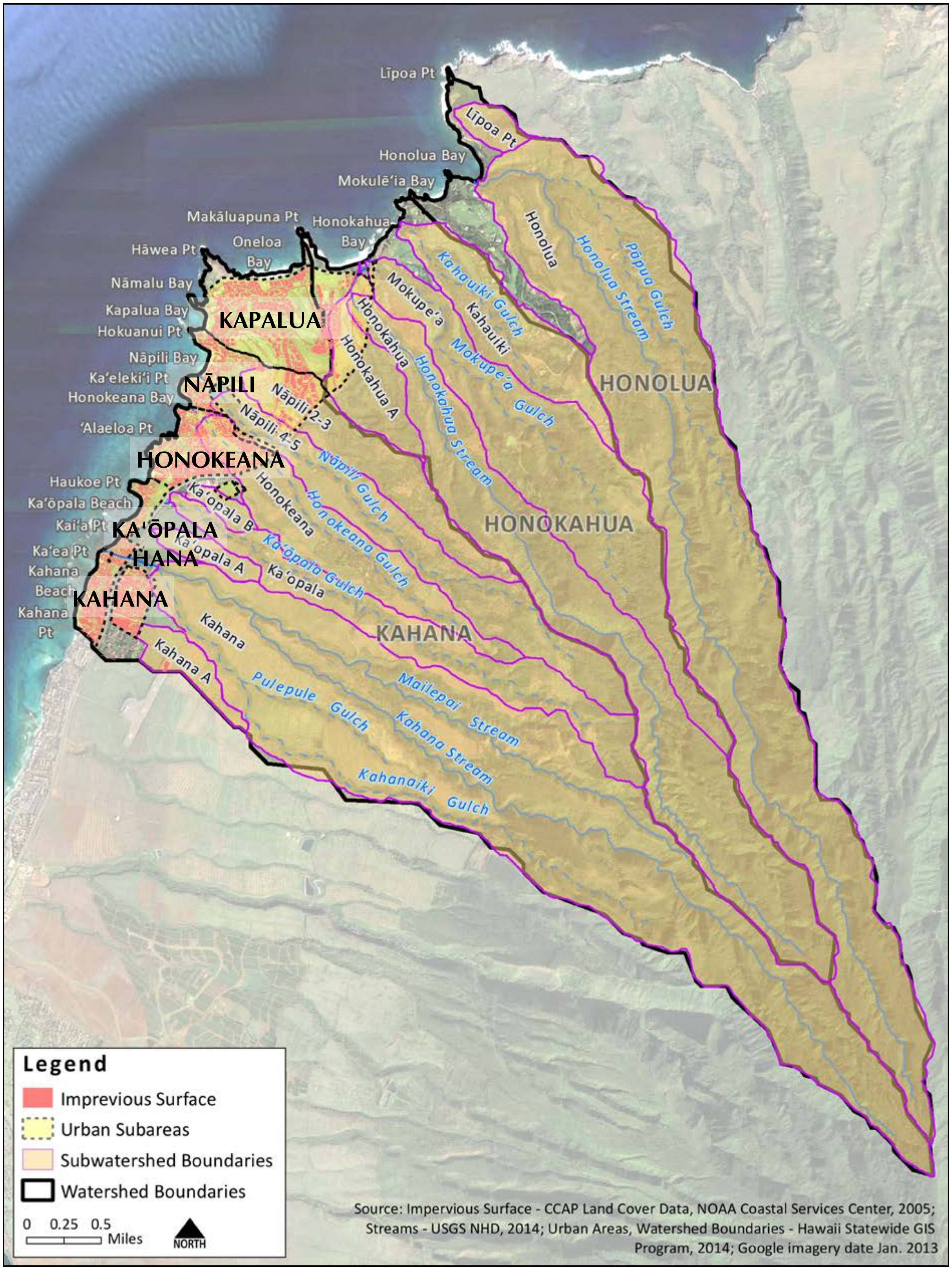


Figure ES.1 Kahana, Honokahua and Honolua Watersheds, Subwatersheds and Urban Sub-areas

ES.3 Water Quality Data Summary

Table ES.2 provides a summary of water quality data from Chapter 5. High levels of turbidity occur in coastal waters. Nearshore waters of Kahana and Kaʻōpala subwatersheds and Honokahua and Honolua watersheds have the highest levels of turbidity. Nutrient (nitrogen and phosphorous) data is limited. Hawaiʻi State Department of Health has begun more recent testing for nutrients, and data analysis for nutrient sources will be critical in pollutant source identification. The types and amounts of current use contaminants are unknown. DOH bacteriological data is limited and does not indicate sewer issues. A 2013 study (Woodley, et al) found a Kapalua exceedance and monitoring is warranted.

Table ES.2 Water Quality Data Summary

Watersheds / Urban Sub-Areas		Turbidity (State standard = 0.2 NTU)	Chemical (Nutrients)	Bacteriological (*Enterococci*) Exceedances
		Geometric Mean of 6 samples from 2014-2015 (NTU)	Available data post plantation era (after 2008)	2008-2013
KAHANA	Kahana	3.04 (S Turns as proxy)	No Data	None
	Kaʻōpala	5.46	No Data	1
	Honokeana	No Data	No Data	None
	Nāpili	1.72	Significant Exceedances - Nitrate + Nitrite and Ammonia Nitrogen	None
	Kapalua	1.81 Kapalua	No Data	None
		0.90 Oneloa	No Data	None
HONOKAHUA	Mokupeʻa	2.83 DT Fleming Beach	No Data	None
	Kahauiki	No Data	No Data	None
HONOLUA	Honolua	1.79 Mokulēʻia	No Data	None
		3.50 Honolua	No Data	5

ES.4 Summary of Pollutant Sources

Pollutants are generated and transported through the Kahana, Honokahua, and Honolua watersheds. Identifying activities and land uses that generate pollutants and transport mechanisms will help locate projects to mitigate generation and/or transport of pollutants.

Table ES.3 summarizes various pollutant sources in the three watersheds that were identified via field observations and high resolution satellite images. Field inspections were comprehensive but not exhaustive, and there may be additional pollutant sources in the watersheds.

Chapter 6 describes available information on the pollutant sources and land uses. Where available, pollutant loading data is provided and in some case pollutant loads are estimated using modeling programs. Pollutant data and estimates are used to prioritize sources and subwatersheds.

Table ES.3 Primary Pollutant Summary

Watersheds & Subwatersheds / Urban Sub-Areas	Primary Pollutants	KAHANA					HONOKAHUA	HONOLUA
		Kahana	Ka'ōpala	Honokeana	Nāpili	Kapalua		
Existing Agriculture & Conservation Sources								
Feral Ungulates	*Sediments*	X	X	X	X	X	X	X
Invasive Flora	*Sediments*	X	X	X	X	X	X	X
Unauthorized Human Access	*Sediments*	X	X	X	X	X	X	X
Access Roads	*Sediments*	X	X	X	X	X	X	X
Fallow Fields	*Sediments*	X	X	X	X	X	X	X
Stream / Gulch Sediments	*Sediments*	X	X	X	X	X	X	X
Existing Urban Sources								
Highway Storm Water System	*Sediments, Hydrocarbons*	X	X				X	X
Roadways, Parking Lots & Buildings	*Nutrients, Sediments, Metals, Hydrocarbons*	X	X	X	X	X	X	X
Illicit Discharges	*Misc contaminants*	X	X	X	X	X		
Outfall Sediments	*Sediments*			X	X			
Coastal Erosion	*Sediments*		X					
Golf Courses	*Nutrients, Pesticides*				X	X	X	X
Landscaping Maintenance	*Nutrients, Pesticides*	X	X	X	X	X	X	X
On-site Sewage Disposal Systems	*Nutrients & Misc contaminants*	X	X	X	X	X	X	X
Wastewater Pumping Stations & Lines	*Nutrients*	X	X	X	X	X		
Honolua Bay and Līpoa Point	*Nutrients, Sunscreen*							X
Future Urban Nutrient Loading and Sources								
Wildfire	*Sediments*	X	X	X	X	X	X	X
Grazing	*Sediments, Nutrients*	X						
Construction	*Sediments*	X	X	X	X	X	X	X
Roadways, Parking Lots & Buildings	*Nutrients, Sediments, Metals, Hydrocarbons*	X	X	X	X	X	X	

ES.5 Priority Sources and Subwatersheds

Sediments pollutant sources are primarily due to past agricultural practices that deposited sediments in stream valleys. Dirt access roads are also contributing sediments. Kahana and Kaʻōpala subwatersheds and Honolua and Honokahua watersheds appear to have higher levels of sediment contributions to nearshore waters. These are relative priorities and the other watersheds also contribute sediments to nearshore waters. Sediments from Kapalua Mauka development construction in the Honokahua and Nāpili subwatershed are a concern and should be prevented.

Nutrient source priorities are based on land uses that are likely contributors of fertilizers and animal wastes. These include golf courses and landscaping in the Kapalua, Honokahua and Honolua urban sub-areas / watersheds and planned grazing in Kahana subwatershed. With forthcoming DOH water quality monitoring, nutrient source priorities can be verified or updated.

Priorities for other pollutants or contaminants are also prioritized based on land uses. Baseline testing of current use contaminants is needed.

ES.6 Next Steps

The second volume for the three watersheds, the *West Maui Watershed Plan: Kahana, Honokahua and Honolua Watersheds Strategies and Implementation Report,* builds on this *Characterization Report* and provide policy and management measures and outreach initiatives to mitigate pollutant sources for the purpose of restoring nearshore and coral reef habitats.

Together the *Kahana, Honokahua and Honolua Watersheds Characterization Report* and the *Strategies and Implementation Report* will guide improvements to the watersheds and subsequently the nearshore and coral reef ecosystems and contribute to the comprehensive, five-watershed *West Maui Watershed Plan.*

1.0 INTRODUCTION

1.1 West Maui Watershed Plan Overview

The *West Maui Watershed Plan* is being developed under Section 729 of the Water Resources Development Act (WRDA) of 1986. Section 729 of WRDA 1986 authorizes the development of watershed plans that are multi-purpose and multi-objective in scope and developed in cooperation with Federal, State and local government entities. Section 729 of WRDA 1986 states "WATERSHED AND RIVER BASIN ASSESSMENTS… may assess the water resources needs of river basins and watersheds of the United States (US), including needs relating to-

(1) ecosystem protection and restoration;
(2) flood damage reduction;
(3) navigation and ports;
(4) watershed protection;
(5) water supply; and
(6) drought preparedness."

In addition, under US Army Corps of Engineers (USACE) Engineer Circular (EC) 1105-2-411 "Watershed planning is an approach for managing water resources within specified drainage areas or watersheds and addresses problems in a holistic manner that reflects the interdependency of water uses, competing demands, and the desires of a wide range of stakeholders in addressing watershed problems and opportunities. Watershed planning facilitates the collaborative evaluation of a more complete range of potential solutions and is more likely to identify the most technically sound, environmentally sustainable, and economically efficient means to achieve multiple goals in the entire watershed over the long term, i.e., integrated water resources management." The West Maui watershed planning process meets both the stated water resource assessment guidelines stated in §729 of WRDA 1986 and EC 1105-2-411.

1.1.1 Plan Area

The West Maui watershed includes 24,000 acres from Kāʻanapali to Honolua (Figure 1.1). The plan area supports habitat for 62 terrestrial and marine species listed under the Endangered Species Act, with 6,000 acres of native forests and wetlands, several State Marine Managed Areas, and the Hawaiian Islands Humpback Whale National Marine Sanctuary.

1.1.2 Problems

Over the last 13 years, nearly 30% of the West Maui coral reef cover has been lost. Increased sedimentation associated with loss of forestland, historical plantation agriculture practices, legacy sediments in riparian corridors, stream channelization and rapid development has impacted coral reef health. Because of Hawaiʻi's geographic isolation, over 25% of its coral reef species are found nowhere else in the world. Invasive marine species have increased in nearshore waters as a result of excessive nutrients from surface and ground water discharge. The Hawaii Coral Reef Initiative Research Program estimated that coral reefs contribute up to $800M per year in gross annual revenue for the State of Hawaiʻi.

Degradation is not just about a loss of coral cover. Habitat quality and topographical complexity are also in decline. The biodiversity that supports ecosystem services, biological resources, and social benefits are diminished. The recreational and commercial value of reefs declines. Fish stocks migrate away or die, and related ocean resources decline. With the decline of coral reef resources also come social impacts on local communities such as changes to lifestyle, inability to rely on sustenance from ocean resources, and impacts to Native Hawaiian culture which highly values the coral reef ecosystem.

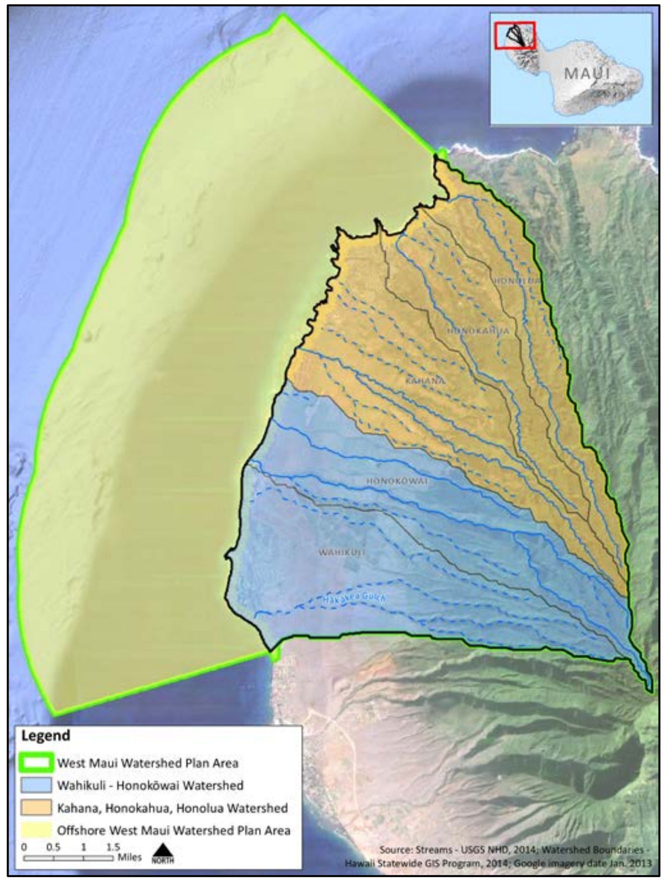


Figure 1.1 West Maui Watershed Plan Area

Land use in this area over the past century has altered natural flood plain processes and riparian habitat functions. These alterations and intensive land uses have resulted in land-based pollutants which have impaired the water quality of nearshore ocean waters and resulted in adverse impacts to the marine ecosystem. Sediments and nutrients (e.g. nitrogen and phosphorus) are the most studied and best understood in terms of impacts on the coral reef ecosystem. The occurrence and impacts of organics, metals, hydrocarbons and pathogens in the West Maui marine environment are less studied. Previous restoration efforts, while successful, have been limited.

The conceptual ecosystem model in Figure 1.2 shows factors that affect coral ecosystem health. The yellow frame highlights the land-based effects that are the focus of this plan.

Marine predators and climatic conditions are acknowledged contributors to coral reef decline but not a part of the plan focus. Fishing pressures on predator species impact the amount of grazing to control algal species, and are being or can be managed by regulations e.g. the Kahekili Herbivore Fisheries Management Area. Climate change is likely to increase sources of land-based pollution beyond existing conditions throughout the watershed if no action is taken to reduce these threats. Because climatic conditions are not easily affected by local management strategies, the plan will manage for climate change uncertainties by examining climate change scenarios and potential sea level rise outcomes.

The causes of coral reef decline are complex and not yet fully understood. However, land-based sources of pollutants are known to be clear and serious threats to coral reef ecosystems because:

- Agriculture, urban and coastal development have altered ridge to reef hydrologic processes and natural shoreline.

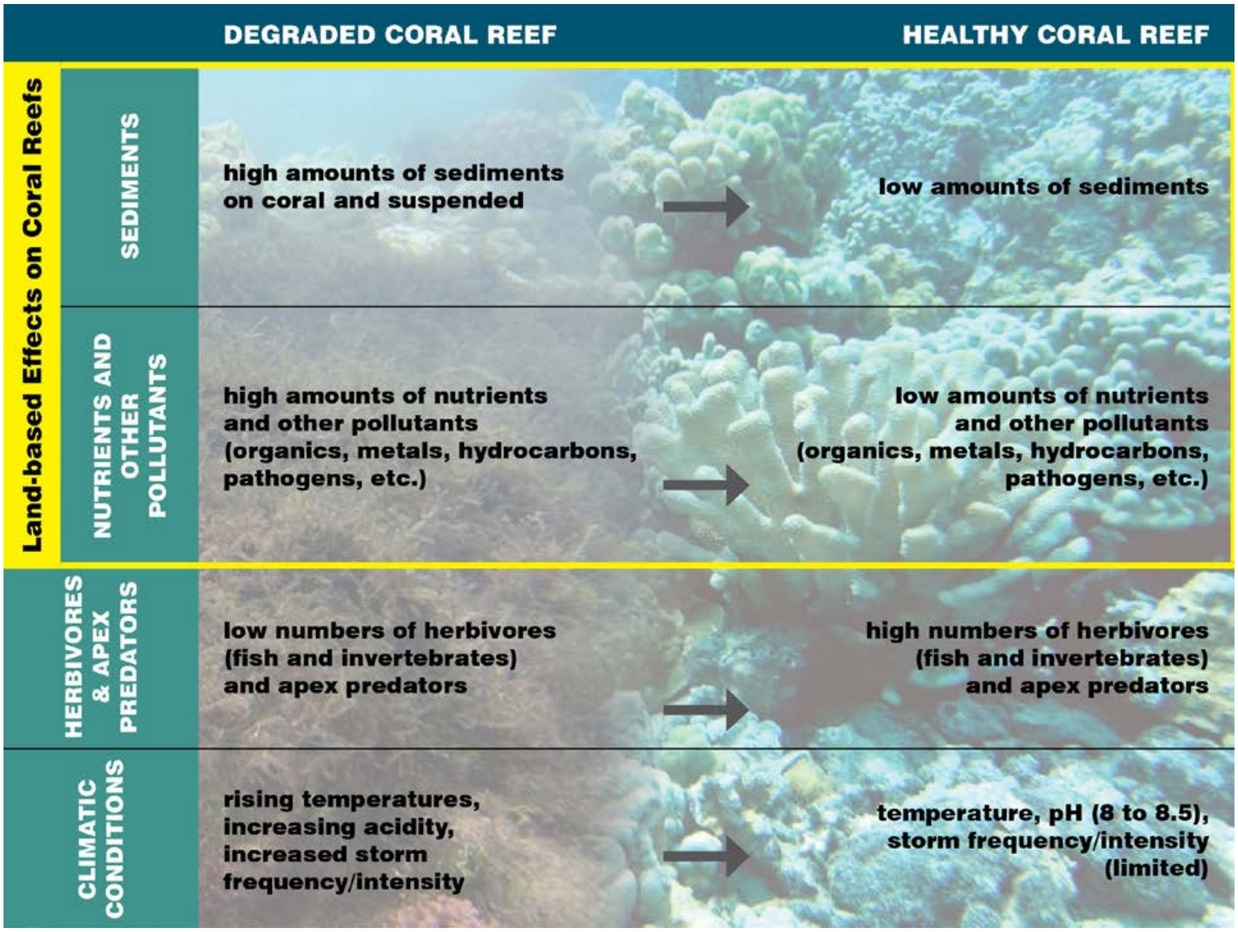


Figure 1.2 Conceptual Ecosystem Model

- Surface water runoff and ground water discharge transfer pollutants (sediments, nutrients, chemicals and pathogens) into nearshore marine environment and affect coral reef health.
- Impacts to stream corridors and riparian habitat have resulted in sediment accumulation in these corridors and sediment plumes on the reefs during heavy rainfall events.
- Urban development has increased storm water and wastewater inputs into the nearshore waters, resulting in the decline of coral reef health.
- Invasive species, both plant and animal, have impacted upper watershed conservation areas, increasing sediment loading downstream.
- Drought and wildfires have increased soil erosion and introductions of alien species.
- The landscape is in transition as large portions of currently designated agricultural fields are slated for urban development, which may further increase sediments, nutrients, chemicals and pathogens in the nearshore waters.

Some of these issues are addressed in the *Kahana, Honokahua and Honolua Watersheds Characterization Report* and *Kahana, Honokahua and Honolua Watersheds Strategies and Implementation Report* and other issues will be addressed in the context of the larger *West Maui Watershed Plan.*

1.1.3 Opportunities

Opportunities are descriptions of what could be and focus on positive and future conditions. They highlight good chances for advancement or progress.

Opportunities exist in West Maui to:

- Restore coastal and ridge to reef hydrologic processes.
- Reduce stormwater and wastewater inputs into the nearshore waters.
- Restore stream flow, riparian habitat and stream corridors.
- Improve the surface and ground water supply.
- Affect policy changes and implementation to guide future development practices.
- Incorporate Native Hawaiian values and practices in watershed planning and outcomes.
- Manage drought and wildfires through innovative planning and implementation strategies.
- Learn by doing with ongoing implementation of land-based pollutant reducing measures.
- Understand the interrelationships among the various coral reef stressors.

1.1.4 Plan Focus and Collaboration

The focus of the *West Maui Watershed Plan* is to identify measures that would restore and enhance the health and resiliency of West Maui coral reefs and nearshore waters through the reduction of land-based pollution threats from the summit of Puʻu Kukui to the outer reef. The study will specifically evaluate five (5) watersheds along the West Maui coastline including Wahikuli, Honokōwai, Kahana, Honokahua and Honolua in Figure 1.1. The local sponsor is the State of Hawaiʻi Department of Land and Natural Resources (DLNR). A cost-sharing agreement was executed between the USACE and the DLNR on 9 August 2012.

The *West Maui Watershed Plan* builds on already established efforts and leverages resources across a number of agencies and community groups to implement actions to reduce key sources of reef decline. Table 1.1 highlights the large number of plan participants and shows the collaborative nature of the planning process. Shaded cells depict which issues in the guidelines (§729 of WRDA 1986 and EC 1105-2-411) are of interest or considered an issue to stakeholders, or are clearly within the statutory authority of a partner agency. A dollar sign ($) indicates that an agency has provided support such as technical expertise, direct funding or participation on one or more of the project working groups.

This plan supports an interagency priority partnership designated by the US Coral Reef Task Force, and identified as a national action item for the National Ocean Council in 2011. Other partners include the State of Hawaiʻi Department of Health (DOH), National Oceanic and Atmospheric Administration (NOAA), Environmental Protection Agency (EPA), Natural Resources Conservation Service (NRCS), US Geological Survey (USGS) and National Fish and Wildlife Foundation (NFWF). The participating State and Federal agencies meet regularly and are referred to as the Funding and Agency Support Team or FAST (Figure 1.3 and Table 1.2).

Table 1.1 West Maui Watershed Plan Agency Interest, Issues and Support

Issues/Agencies	FUNDING AND AGENCY SUPPORT TEAM (FAST)										Other Partners							
	USACE	EPA	FWS	NOAA	NRCS	USGS	DLNR / DAR	DLNR / CWRM	DLNR/ DOFAW	HDOH	DHHL	WMMWP	County of Maui	UH	NFWF	ML&P	NGO Community	WMS&WCD
Land-Based sources of Pollutants (sediments and polluted runoff causing coral decline)	$	$	$	$	$	$	$	$	$	$	$	$	$	$	$	$	$	$
Fallow agricultural fields													$					
Water supply						$		$					$		$	$		
Wildfire management				$			$		$			$	$			$		
Ecosystem restoration of upper watershed/ conservation area			$						$			$	$		$	$		
Ecosystem restoration of riparian habitat/gulches			$		$			$										
Ecosystem restoration of coral reefs		$		$	$	$	$						$	$		$	$	
Drought preparedness					$			$										
Climate change impacts	$	$	$	$		$												
Fishing pressure				$		$	$								$		$	

■ = Issues is of interested to the stakeholder and/or within their statutory authority

$ = Agency has provided support (technical expertise, direct funding, or participation on one or more working groups)

Maui representation is comprised of two groups, the West Maui Ridge 2 Reef Working Group (WMR2RWG), and the Ridge to Reef (R2R) Hui. Members of the WMR2RWG include representatives from the large landowners such as Maui Land & Pineapple, Inc. (ML&P), tourism sector, agricultural sector, Native Hawaiian community, Non-Governmental Organizations (NGO), Maui County, and DLNR Division of Aquatic Resources (DAR) Maui office. The Working Group is chaired by DAR and provides input on community concerns and priorities to the FAST.

The R2R Hui is a loosely affiliated group of community and NGO representatives that have also provided support to the West Maui watershed planning initiative. Organizations in the R2R Hui include Kāʻanapali Makai Watch, Coral Reef Alliance, Project S.E.A.-Link, Maui Nui Marine Resources Council, Surfrider Foundation, The Nature Conservancy, University of Hawaiʻi, and many more. Collectively this entire interactive and collaborative process is called the West Maui Ridge to Reef (West Maui R2R) Initiative. The West Maui Watershed Coordinator has a critical role in facilitating the WMR2RWG, serving on the FAST, coordinating with the R2R Hui, and conducting outreach to the local community.

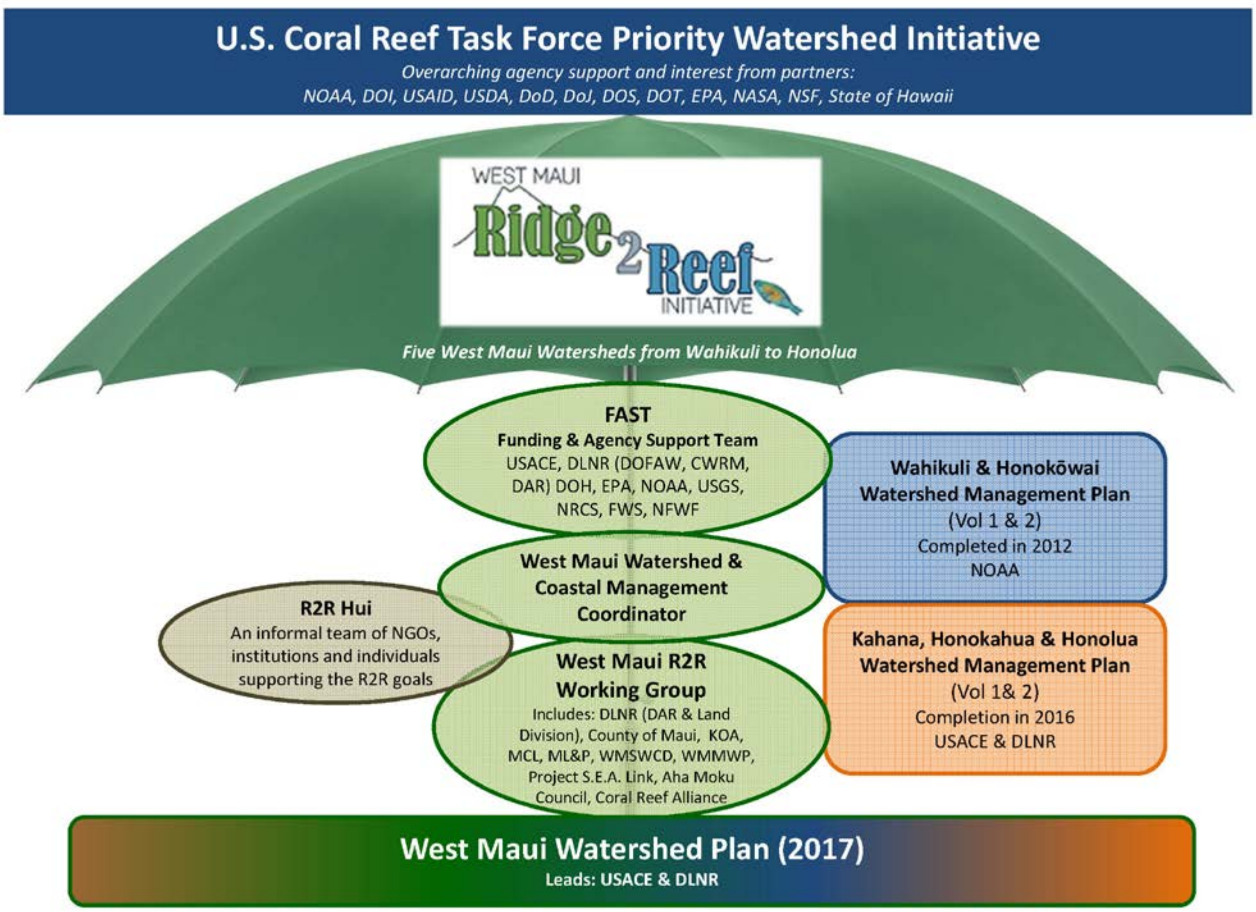


Figure 1.3 West Maui Watershed Plan Framework

Table 1.2 West Maui Watershed Plan Partners and Efforts

Funding and Agency Support Team (FAST)
US Army Corps of Engineers (USACE). Federal lead agency of the comprehensive *West Maui Watershed Plan*. USACE is also facilitating and managing the process and funding development of the interim reports: *Kahana, Honokahua and Honolua Watersheds Characterization Report* and the *Kahana, Honokahua and Honolua Watersheds Strategies and Implementation Report*.
State of Hawai'i Department of Land and Natural Resources (DLNR). DNLR is also funding this effort as the cosponsor.
DLNR Division of Aquatic Resources (DAR). Responsible for coordinating Hawai'i's reef management efforts in the main Hawaiian Islands. Uses the Hawai'i Coral Reef Strategy to guide activities. Supports critical program support, planning efforts, community action, awareness-raising activities and scientific research with direct management applications.
DLNR Division of Forestry and Wildlife (DOFAW). Responsible for managing State lands in Conservation District.
DLNR Commission on Water Resource Management (CWRM). Responsible for setting policies and approving water allocations for all water users and administering a statewide instream use protection program.
National Fish and Wildlife Foundation (NFWF). Funding and administration for implementing management practices.
State of Hawai'i Department of Health (DOH). Oversees State water quality monitoring and beach closures. Issues permits for point source discharges and construction sites > 1 acre. Funding for implementing management practices through Clean Water Act Section 319 funding.
US Environmental Protection Agency (EPA). Funding for implementation projects to improve water quality. Technical expertise. Water quality monitoring and permitting to assess and potentially regulate pollution levels.
US Geological Survey (USGS) Pacific Coastal & Marine Science Center. Conducts scientific research on sources, timing and magnitude of sediment and ground water discharge and residence time in coastal waters and thus impact to coral reefs.
USGS Pacific Islands Water Science Center. Clearing house for water resource information, including surface water and ground water.
USDA National Resources Conservation Service. Funding for cost-share implementation of conservation practices on eligible private lands.
US NOAA Coral Reef Conservation Program (CRCP). NOAA CRCP includes a focus on addressing land-based sources of pollutants in addition to climate change and fishing pressures. NOAA funded the Wahikuli-Honokōwai Watershed Management Plan, implementation of management priorities, monitoring and assessment efforts, and the creation of the Kumuwai Campaign.
West Maui Ridge 2 Reef Working Group
The West Maui R2R Working Group represents key interests in agriculture, land development, resort operation, soil conservation, traditional Native Hawaiian knowledge, non-profit marine conservation, recreational ocean users, Maui County and fishing. It is a local body providing community input to the FAST, and coordinates and communicates information and efforts undertaken by community partners. It is chaired by DLNR DAR and facilitated by the West Maui Watershed Coordinator.
West Maui Ridge 2 Reef Watershed Coordinator
West Maui Watershed Coordinator facilitates the working group and a number of other roles including (but not limited to) the primary agency, community, landowner, and researcher contact, tracking and providing assistance on research projects, facilitating project implementation through grant, working group, and partner initiatives, and monitoring status of progress of watershed efforts.

1.1.5 Plan Vision, Goal and Objectives

The plan vision, goal and objectives were collaboratively developed by the FAST and other stakeholders to guide the *West Maui Watershed Plan* and are listed in Figure 1.4.

Vision

West Maui's coral reef ecosystem is diverse and abundant because of consistent community and agency support for reducing impacts from ma uka to ma kai.

Goal

Restore and enhance the health and resiliency of West Maui coral reefs and nearshore waters through the reduction of land-based pollution threats from the summit of Puʻu Kukui to the outer reef. These efforts will be guided by the values and traditions of West Maui.

Objectives

- Reduce land-based sources of pollution impacts to West Maui's coral reefs through the year 2065 to reduce further decline of the coral ecosystem.
- Empower the West Maui community to steward the terrestrial and coral resources and drive good decision-making that benefits the resources and community over the next 50 years.
- Protect and restore native ecosystems of West Maui to benefit nearshore resources through 2065.

Figure 1.4 Vision, Goal & Objectives for the West Maui Ridge 2 Reef Initiative and West Maui Watershed Plan

1.1.6 Planning Constraints & Considerations

Planning constraints and considerations were identified through the collaborative planning process. Constraints are restrictions that limit the extent of the planning process. For *West Maui Watershed Plan* these include the need to:

- Avoid any additional loss of the flood plain (in accordance with Executive Order 11988 Flood Plain Management).
- Minimize impacts to cultural sites and landscapes.
- Minimize the proliferation of alien species.
- Minimize loss of ongoing livelihood in West Maui.
- Minimize loss of shoreline access or recreational opportunities.
- Minimize community divisiveness during the planning or implementation of the study actions.

Planning considerations were identified that will need to be carefully considered in the development of the watershed plan. These include the following:

- Most of the land is held in private ownership, and therefore any recommended strategies need to take into account the willingness and ability of the landowners to implement the recommended actions.
- There are many different landowners in the lower watershed making coordination a challenge.

- There is limited availability of water storage and retention throughout the five watersheds.
- There is an increasing demand for housing in West Maui, which is one of the drivers behind the proposed urban development and change in land use from agriculture to urban.
- Much of the agricultural land is planned for development therefore any long-term management strategies must address the planned development pressures.

1.1.7 Planning Process Timeline

The West Maui watershed planning process is being developed in multiple phases. Based on input from stakeholders, this phased planning process allows for implementation of short- and mid-term solutions to address identified priorities, while planning for long-term solutions that will be addressed in the comprehensive *West Maui Watershed Plan*. The *West Maui Watershed Plan* will also incorporate information that is still being collected (e.g. more detailed stream and gulch analysis and coral coverage data).

The *Kahana, Honokahua and Honolua Watersheds Characterization Report*, along with the *Wahikuli-Honokōwai Watershed Management Plan Watershed Characterization* will provide the basis for Chapters 1, 2, and 3 of the more comprehensive *West Maui Watershed Plan*. The *Kahana, Honokahua and Honolua Watersheds Strategies and Implementation Report*, along with the *Wahikuli-Honokōwai Strategies and Implementation* volume will provide measures for alternative formulation and evaluation in the *West Maui Watershed Plan*.

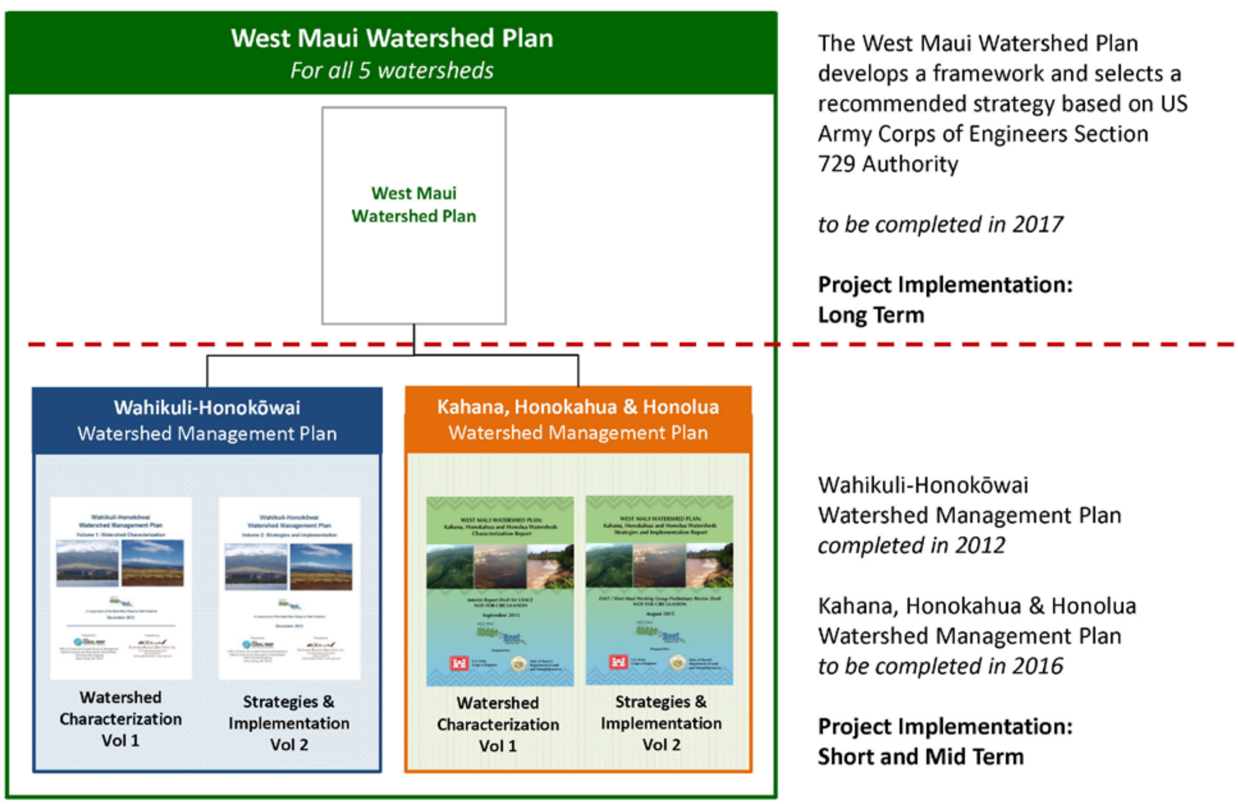


Figure 1.5 West Maui Watershed Plan Efforts: Purposes and Timeframes

1.1.8 Public Involvement

While this document does not have a National Environmental Policy Act (NEPA) requirement for public involvement, public outreach has been prioritized as an essential component to the success of the plan. Public engagement in the watershed management planning process will be a key factor in garnering community support and in successfully developing and implementing the plan.

Five public meetings have been held to gather stakeholder input into the planning process. Two meetings were to obtain public input on the Wahikuli-Honokōwai Watershed Plan. A third meeting was on the comprehensive watershed planning process. A fourth public meeting in November 2014 provided the public with an opportunity to review maps and data gathered for the characterization of Kahana, Honokahua and Honolua watersheds. Community input has been positive, and issues raised during the public process have been incorporated into the planning process. Key concerns raised were for proposed management strategies to consider Hawaiian values and traditions, and for management measures to avoid further hardening of the landscape. A fifth public meeting coincided with release of the draft Kahana, Honokahua and Honolua Watersheds Strategies and Implementation Report. Additional community input will be sought when the comprehensive West Maui Watershed Plan draft is completed.

Input has also been gathered through frequent public outreach events held to raise awareness about watershed issues. These have ranged from an annual "Ridge to Reef Rendezvous" to volunteer conservation and monitoring activities, and the planting of two community rain gardens at shoreline beach parks. The West Maui Watershed Coordinator has played a key role in gathering public input through public outreach events and reaching out to various community groups and members.

1.2 Kahana, Honokahua and Honolua Watersheds Characterization Report

1.2.1 Report Area

The Kahana, Honokahua and Honolua watersheds are located in West Maui (Figure 1.6). The ma kai boundary of the study area extends from Kahana Beach up to Līpoa Point, and encompasses the communities of Kahana, Nāpili, and Kapalua. The study area extends ma uka into Mauna Kahalawai also known as the West Maui Mountains and ma kai to the outer reef. The focus of this report is on the upland and freshwater contributors of land-based pollution impacts to the nearshore.

1.2.2 Kahana, Honokahua and Honolua Watershed Management Goals

The goal of Kahana, Honokahua and Honolua watershed management reports is to guide actions to restore and protect water quality and aquatic life. This may be achieved in part through meeting appropriate water quality standards. However, the strength of the plan to achieve this goal is through assessment of the pollutant sources and identification of solutions to address and reduce the pollutant loads into waterbodies.

This *Kahana, Honokahua and Honolua Watersheds Characterization Report* evaluates watershed processes and determines land uses and activities that may generate pollutants, alter the hydrologic regime and ecological processes, and potentially cause adverse impacts to the watershed's ecosystem and subsequently the decline of nearshore and coral reef ecosystems. This report addresses Steps 1-3 (Define Study Area, Identify Problems and Opportunities, and Inventory and Forecast Resources) of the *West Maui Watershed Plan*. This report also addresses Element 1 of the EPA Nine Elements of a Watershed Plan (Identification of Causes and Sources of Water Quality) that will need to be controlled to achieve targeted load reductions.

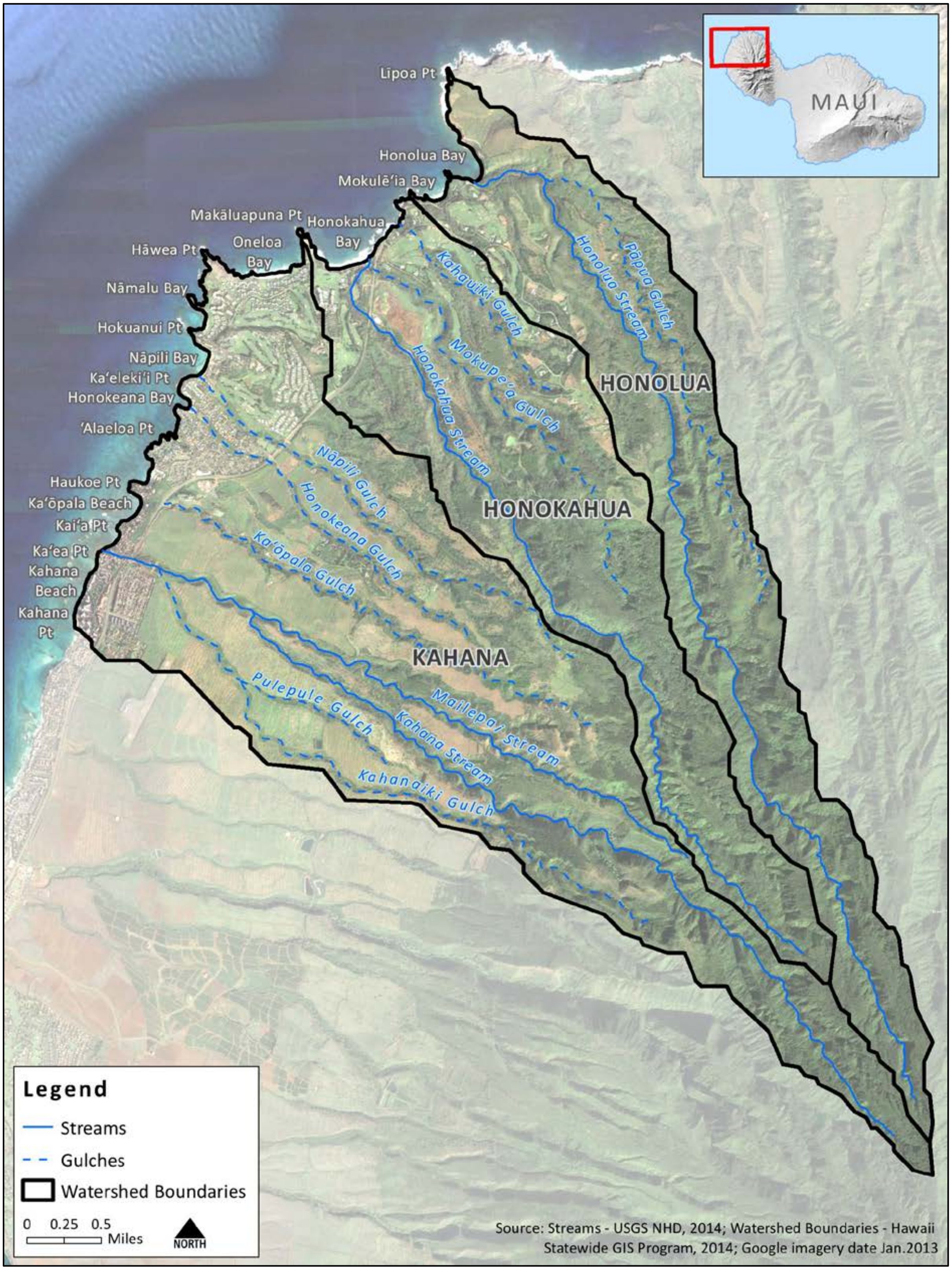


Figure 1.6 Kahana, Honokahua and Honolua Watersheds Characterization Report Area

1.2.3 Relationship to Strategies Implementation Report and West Maui Watershed Plan

The *Kahana, Honokahua and Honolua Watersheds Characterization Report* forms the basis for identifying management practices to remediate pollutants and is the first of two interim reports on the three watersheds. The second report, *West Maui Watershed Plan: Kahana, Honokahua and Honolua Watersheds Strategies and Implementation Report,* provides management practices to improve water quality for the purpose of restoring nearshore and coral reef ecosystems. The second volume will inform Step 4 (Evaluate & Compare Alternative Approaches) and 5 (Strategy Selection) of the USACE watershed planning process as well as Elements 2-4 of the EPA Nine Elements for Watershed Plans. Together the two reports will be in accordance with USACE watershed planning regulations and policies and the EPA's Nine Key Components for Watershed-Based Plans (Appendix A, Figure A.1) and the management practices will be potentially eligible for Federal funding under Clean Water Act Section 319 subject to determination by the State of Hawaiʻi DOH.

The two reports for the Kahana, Honokahua and Honolua watersheds, together with the two volumes *Wahikuli-Honokōwai Watershed Management Plan,* will assist in inventorying and forecasting conditions for the overall five-watershed *West Maui Watershed Plan* as well as providing needs, opportunities, and measures for evaluation and selection of the long-term integrated strategy.

1.2.4 Kahana, Honokahua and Honolua Watersheds Characterization Report Methodology

A watershed characterization utilizes a multi-disciplinary scientific approach to assess the ecosystem processes, resource conditions and historical changes due to cumulative effects of management practices. Categories, as presented in EPA's *Handbook for Developing Watershed Plans to Restore and Protect Our Waters (2008)*, were used to document the Kahana, Honokahua and Honolua watersheds' population, land use, physical and natural features, waterbody conditions and monitoring data, and pollutant sources.[1]

1.2.4.1 Geographic Information System

A large geodatabase of Geographic Information System (GIS) data was compiled for the project area. Data layers were obtained from various available public sites and project partners including NOAA, DOH and Maui County. Watershed boundaries, defined in a data layer from the Hawaiʻi Statewide GIS program, were used and other GIS layers and maps were clipped to the project watershed area for further analysis. The high resolution satellite imagery was used as background for analysis and figures depicting features on the watersheds. GIS was used to further analyze spatial relationships, derive additional data and create maps showing land uses, land cover, soils, landowners, water quality sampling areas and other relevant features of the project watersheds.[2] This data was also used to compute areas and sizes of various features for the watershed characterization.

[1] See http://www.epa.gov/nps/watershed_handbook/.

[2] For all layers used, datum is North American Datum of 1983 and projection is Universal Transmercator Zone 4 North (NAD83 UTM4N). Unless specified, all calculations are based on GIS data available from the Hawaiʻi GIS Data Repository, hosted by the Office of Planning. http://planning.hawaii.gov/gis/

1.2.4.2 Field Work

Field work consisted primarily of general observations to identify location and condition of major drainage networks and land uses within the project area. Initial visual observations helped preliminarily identify pollutant sources within the Agricultural and Urban Districts. The field work also involved ground truthing locations within the watersheds that appear on satellite imagery and GIS layers. Locations observed on the ground were entered into a Global Positioning System (GPS) data logger and/or on hard copies of the satellite imagery, and subsequently brought into GIS. Informal interviews with stakeholders assisted in preparing a characterization of watershed conditions, land uses, and pollutant inputs. Integral the field work was collection of historic and current information on land use, land practices and specific points of interest.

Ten days were spent conducting inventory and assessments, including time in the Agricultural and Urban Land Use Districts of the three watersheds, and the lower Conservation District of Honolua watershed. An inspection of specific pollutant inputs, hotspot areas, drainage courses, assessment of land conditions, and drainage networks and pollutants, coastal erosion and areas where pollutants enter the nearshore waters was conducted using GPS, satellite images, and photos showing areas of interest. A tour of the Agricultural District with Wes Nohara (West Maui Soil and Water Conservation District) was integral in creating an overall picture of the historic and current land use, practices, dams and desilting basins, and areas of pollutant input.

2.0 WATERSHED PLANNING CONTEXT

This chapter focuses on coral reef coverage decline and land use history to provide context for the watershed existing conditions presented in Chapters 3, 4 and 5 and informs the report water quality goal.

2.1 Decline in Coral Reef Cover

The amount of data on coral coverage decline in Kahana, Honokahua and Honolua is limited. Based on the monitoring that has occurred, the largest areas of coral cover in the three watersheds occur in Honolua and Kapalua Bays. A Department of Land and Natural Resources (DLNR) Division of Aquatic Resources (DAR) monitoring site in Honolua Bay has shown a decrease in cover from 42% in 1994 to 10% in 2013. DLNR DAR has periodically monitored coral coverage in Kapalua Bay which has shown a decline from 40% coral cover in 2007 to about 35% in 2013. The causes of coral reef decline include many factors that disrupt the coral life cycle and ability to grow, reproduce, and thrive.

While marine impacts negatively affect corals, land-based pollutant sources are known to be significant factors in coral reef ecosystem decline. Land-based pollutants, carried into the nearshore waters via surface and ground waters, disrupt the biogeochemical processes of the ocean waters resulting in stress to corals and proliferation of invasive algae. The primary land-based pollutants of concern include sediment and nutrients (nitrogen and phosphorus). These pollutants are generated across the watersheds both from natural processes and human activities.

2.2 Land Use and Impacts

Current and historical land uses contribute to the land-based pollution that is impacting the quality of stream and ocean waters and coral reef health. Highlights of the land uses through time and their associated pollutant generation are discussed.

2.2.1 Historic Land Use

Pre-Contact Land Use

The three watersheds were used by Native Hawaiians prior to Western contact as described in *Native Planters* (Handy, Handy, & Pukui 1972):

> *North of Lahaina are five valleys watered by stream draining the western slopes of the West Maui watershed: Honokōwai, Kahana, Honokahua, Honolua, and Honokōhau. The first four all had extensive loʻi lands in their valley bottoms, where terraces rose tier on tier in symmetrical stone-faced loʻi.*

The first human interaction with the watersheds was likely from Polynesian settlers who diverted a portion of stream water and into taro and fish loʻi in the inland valleys. Harvesting of plants and animals occurred from upland forests to low-lying coastal areas and ocean.

Stories and chants of West Maui handed down over the centuries tell of a rich history of chiefs and battles and speak to pre-contact use of the watersheds. With the development of the Ritz-Carlton

Maui resort in the late 1980s, evidence of Hawaiians was literally unearthed. Over 1,100 ancestral remains were found at this site in the Honokahua watershed.

Mid 1800s to mid 1900s

In the mid 1800s, Dr. Dwight Baldwin was awarded a land grant of over 2,500 acres from Māhinahina (just south of Kahana) to Honolua for farming and grazing. Initially used for grazing, by the 1920s pineapple was planted across West Maui from just south of Kahana to beyond Honolua. A cannery was built in Honokahua in 1914. Shortly thereafter a small plantation community developed at Honokahua and Nāpili focused around the Honolua Ranch/Baldwin Packers operations. Pineapple cultivation continued and in the 1960s, and Baldwin Packers merged with Maui Pineapple Company to became Maui Land and Pineapple (ML&P).

Grazing and farming during this period significantly altered vegetation communities in the coastal zones and inland forest. By the early 1900s large tracts of land within the larger West Maui region were actively used for sugarcane and pineapple production. The pineapple lands in Kahana, Honokahua, and Honolua were terraced and had water diversions (and later plastic mulch was added) to facilitate the fields' ability to shed water, thereby preventing water from infiltrating into the soil and rotting the roots of pineapple plants. The water running off the land picked up and carried sediments which were deposited into gulches, streams, and nearshore waters.

The introduction of non-native plants in the Conservation Lands occurred with various plants brought in for wind and fire breaks. An arboretum was established by ML&P with many experimental plants with potential for fuel, fruit, and medicine. Some were brought over from O'ahu from the Hawai'i Sugar Planters Association research station (now Lyon Arboretum), and other plant species were brought in via other mechanisms. Some of these introduced plants became invasive weed species in the watersheds (H. Oppenheimer, Pers. Comm.).

Mid 1900s to late 1900s

In 1902 Forest Reserve was established primarily to protect water flow for plantation usage. In the 1960s pigs were introduced to the Forest Reserve for hunting. The pigs multiplied and expanded in range reaching the Pu'u Kukui summit in the 1980s (H. Oppenheimer, Pers. Comm.).[1] In 1988, the Pu'u Kukui Watershed Preserve was created, and in the early 1990s, the West Maui Mountains Watershed Partnership was established with the Pu'u Kukui Watershed Preserve as the founding entity.

In 1978 the first hotel was constructed at Kapalua Resort, and other hotels and condominiums were developed along the shoreline. The shoreline and adjacent uplands were built up to support the residential development and tourism. Hotels and condos were built starting in the 1960s and into the 1980s with mainly infill development occurring in the 1990s. In addition to residential housing, hotels, and condominiums, Kapalua-West Maui Airport, and associated services (e.g. restaurants, gas stations) were also developed. A golf academy and three Kapalua golf courses were constructed: the Plantation, and Bay Courses and the Village Courses. Construction activity likely added sediments into the nearshore waters, and fertilizer use for golf course and resort landscaping and wastewater were likely sources of nutrients into the nearshore waters.

[1] Loope, Lloyd. Undated. Regional Trends of Biological Resources — Hawaii and the Pacific Island. USGS. http://www.nwrc.usgs.gov/sandt/Hawaii.pdf

Pineapple cultivation continued during this period with sediments and nutrient inputs into nearshore waters. The exception to pineapple was a small portion of lands in the southern Kahana watershed ma kai of Honokōhau/Honolua Ditch which was in sugarcane until the 1980s when it was converted to pineapple (Engott and Vana, 2007). Small scale grazing leases occurred above pineapple fields and below the conservation area in all three watersheds during this time period. In the late 1970s the Soil and Water Conservation Service (today known as National Resource Conservation Service) designed and planned for desilting basins, five of which were later constructed in the Kahana watershed. These basins in gulches and stream channels slowed the waters before flowing into nearshore waters and allowed for sediments to settle out. While they did not eliminate sediments generated in the Kahana watershed from entering nearshore waters, they reduced the occurrences of brown water events especially during small periodic storm events. No desilting basins were constructed in the Honokahua or Honolua watersheds. Smaller sediment basins and other sediment control measures were implemented from 1990 into 2000 using Clean Water Act (CWA) Section 319 funds.

Accelerated nutrient inputs occurred from fertilizers applied to agriculture fields. The large nutrient inputs caused nuisance algal blooms in the nearshore waters in 1989 and again in 1991. These ocean algal blooms contributed to the decline of coral by blocking sunlight and disrupting larval settlement. The *West Maui Owners Manual* (1997) was developed initially in response to algal blooms and provided research findings and recommendations to reduce human effects to the nearshore waters from land-based sources of pollutants and recreational uses.

The movement of sediments in agricultural runoff continued for many decades. Increased fine sediment discharges into the nearshore environment smothered corals and contributed to their decline.

2.2.2 Land Use Today

Accelerated erosion rates on lands altered by feral ungulates and human uses continue to some extent in the agricultural and conservation areas. The extensive pineapple cultivation was phased out by 2008. While some erosion continues today from the fallow fields, the rates of erosion are much less than during active plantation era farming.

According to the 2010 US census there are approximately 6,000 people living in the West Maui area from the Kapalua airport to Līpoa Point. Over the past two decades agriculture and tourism have been the primary economic activities in the region. Agriculture no longer provides the number of jobs and monies to the local economy as it once did. Today, tourism is the primary economic driver with the visitor industry generating more than 80% of Maui County's economic activity and provides 75% of all private sector jobs (County of Maui 2012). The tourism industry employs an estimated 3,000 people in West Maui. Former agricultural lands are planned for future residential and commercial development and solar energy production, and some development has already occurred.

The urban Kahana shoreline is lined with hotels, condominiums and single family homes. Further north along the Honokahua shoreline are rocky points and protected bays with manicured and green landscaped areas of Kapalua resort, golf courses and residential parcels.

There are a host of pollutants associated with the urban areas that are generated and carried in surface and ground waters. These include pathogenic and non-pathogenic strains of bacteria; viruses; metals; and organics and other chemicals used in pesticide, herbicide and petroleum products.

Anthropogenic effects of land use continue to contribute to poor water quality and coral decline. Pollutants adversely impact water quality, induce stress to aquatic organisms including coral, reduce recreational opportunities and transmit disease to both humans and animals. Fine sediments can reduce light and smother coral, excess nutrients can negatively affect coral health and toxic compounds and pathogens can stress coral. Water flowing off impervious surfaces during rainstorms carries pollutants that from ground surfaces and can increase erosion rates and sediment generation.

2.3 Impacts and Water Quality Goal

The impacts of land use over the last two centuries may continue to affect nearshore waters because pollutants can take many years to work through the watershed systems. For example, fertilizers and pesticides applied to agricultural fields were detected in wells in the 1990s and may still be moving through the ground water aquifer before eventually moving out into nearshore waters via submarine seeps and springs.

While ongoing surface erosion has a lag time before reaching coastal waters, legacy sediments in gulches and streams from pineapple fields are actively being transported into nearshore waters during rainfall events. Sediments that reach nearshore waters may be resuspended over and over again. This has been cited as one of the possible reasons for decline in Honolua Bay, as well as impacts the Kahana and Honokahua shoreline (Storlazzi, et al 2003; Storlazzi and Presto, 2005; and Storlazzi and Jaffe 2003).

Just as the health of the West Maui coral reefs and watersheds are linked, so are the Kahana, Honokahua, and Honolua watersheds connected to nearshore water quality in the region. Pollutants move along the coastline and affect more than just local water quality, and the coral larvae that seed the coral reef ecosystem can come from other areas of Maui (see Chapter 5, Figure 5.3) (Storlazzi, et al 2004; Storlazzi and Field, 2008).

Even after pollutant loads have been reduced, there may a corresponding lag time in coral reef recovery. All of these factors complicate the ability to link water quality improvements to increased health and resiliency of coral reef ecosystems.

The overall focus of the *Kahana, Honokahua, and Honolua Watersheds Characterization Report* and the *Strategies and Implementation Report* is on management actions that will protect nearshore and coral reef ecosystems to meet State Department of Health (DOH) water quality goals. The State and Environmental Protection Agency water quality goal is to restore and protect water quality and aquatic life through the meeting of all appropriate water quality standards. Much remains to be known about current water quality, and monitoring is needed to chart the progress towards this goal.

3.0 LAND USE CHARACTERISTICS

This chapter summarizes land use characteristics by State Land Use Districts, land ownership and future development projects to inform identification of pollutant sources (Chapter 6) that lower water quality and contribute to coral decline.

3.1 Land Use Districts

Land use within the watersheds is characterized by four State-designated Land Use Districts as defined by the Hawaiʻi Land Use Law, Chapter 205 Hawaiʻi Revised Statutes: Conservation, Agricultural, Urban and Rural. Land within the Kahana, Honokahua and Honolua watersheds occurs in all four designations (Table 3.1 and Figure 3.1).

Generally, the current land uses within each of the Land Use Districts match the type of District (e.g. urban use in the Urban District). The exceptions are that the Agricultural District has very little agricultural as most is fallow pineapple lands and some former agricultural lands are designated Urban District in anticipation of future development. For purposes of this report the Rural District will be included in the discussions of the Agricultural District.

Kahana is the largest of the three watersheds and has the largest areas of Agricultural and Urban District lands. Honokahua and Honolua are smaller and similarly sized. Honokahua watershed contains all four Land Use Districts, and Honolua watershed is mainly in Conservation with the remaining acreage in the Agricultural District. Each Land Use District is discussed in turn below.

Table 3.1 Land Use Districts

Land Use District	Kahana (acres)	Kahana (%)	Honokahua (acres)	Honokahua (%)	Honolua (acres)	Honolua (%)	Total Area (acres)	Total Area (%)
Conservation	1,015	17	578	19	2,262	75	3,855	32
Agricultural	3,539	60	1,995	64	766	25	6,300	53
Rural	86	2	177	5	-	-	263	2
Urban	1,224	21	367	12	-	-	1,591	13
Watershed Total	**5,864**	**100**	**3,117**	**100**	**3,028**	**100**	**12,009**	**100**

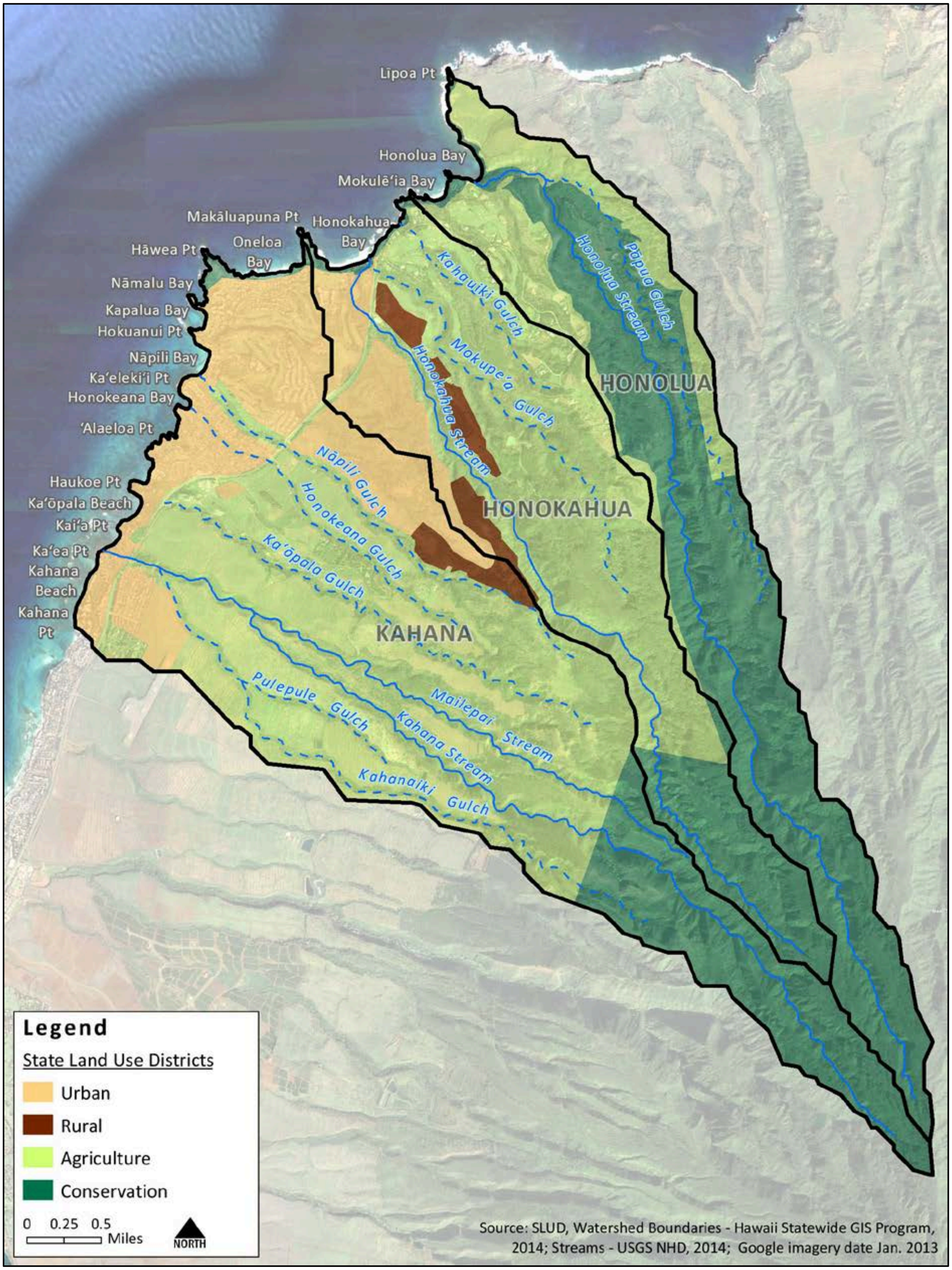


Figure 3.1 State Land Use Districts

3.1.1 Conservation District

There are nearly 4,000 acres of conservation lands in the three watersheds. Lands designated as Conservation District are located in the middle to upper elevations of Kahana and Honokahua watersheds and in all elevations of Honolua watershed. Conservation District lands account for 32% of the total land area within Kahana, Honokahua, and Honolua watersheds (Table 3.1 and Figure 3.1).

The majority of the ma uka (upper) Conservation District is moderately- to steeply-sloped forested lands. The upper rain forests absorb rainwater and protect soils from erosion.

The ma uka Conservation lands of Kahana and Honokahua, and the mid to coastal elevation Conservation lands of Honolua and the Conservation lands along Honolua Bay are classified as Resource, the third most environmentally sensitive subzone of the Conservation District (Figure 3.2). The upper Honolua Conservation lands are classified as Protective, the most environmentally sensitive subzone. (Appendix A.5.7.5). Human uses in the ma uka Conservation District are primarily recreational (e.g. hiking).

The ma kai Conservation District lands are those along Honolua Stream corridor and along the coastline including Hāwea Point and Oneloa, Honokahua and Honolua Bays (Figures 3.2). The Hāwea Point Conservation lands are classified as General, the most basic level of environmental sensitivity of the Conservation lands subzones. Oneloa and Honokahua Bays are classified as Limited, the second most environmentally sensitive subzone.

Līpoa Point agricultural lands and some lands along Honolua Bay were recently sold by Maui Land & Pineapple (ML&P) to the State with the intent of keeping the lands out of future development. However, the State Land Use Designations have not changed with the transaction.

Adjacent to coastal conservation lands in Honolua, is the Marine Life Conservation District (MLCD) of Honolua and Mokulēʻia Bays. This area and the offshore waters of all three watersheds attract many recreational users who snorkel, surf, and engage in beach activities.

Lands in the Conservation District are administered by State Board of Land and Natural Resources and uses are governed by rules promulgated by the State Department of Land and Natural Resources (DLNR).

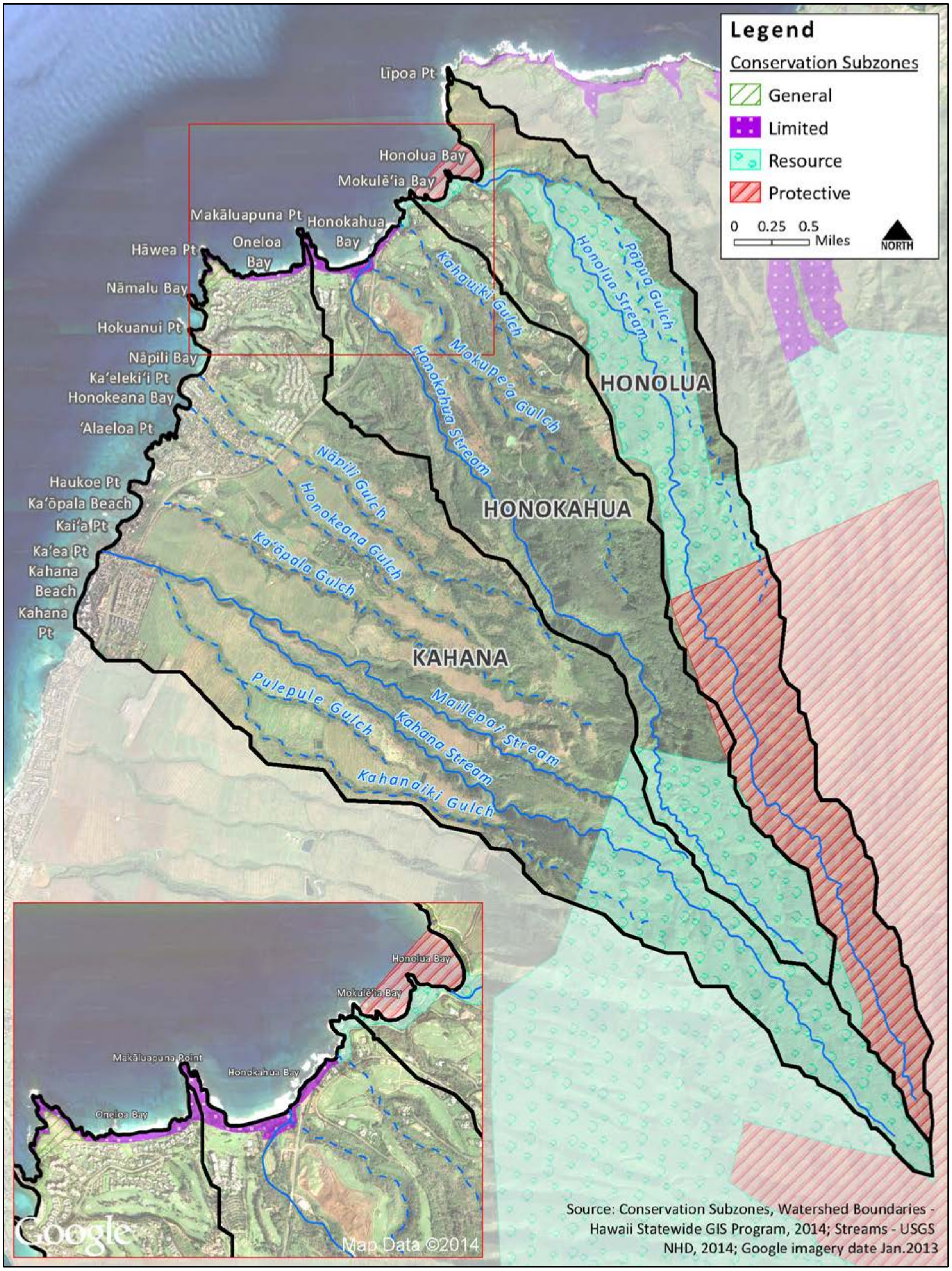


Figure 3.2 Conservation Subzones

3.1.2 Agricultural District

The Agricultural and Rural Districts total over 6,000 acres and are 50% of the total study area within Kahana, Honokahua and Honolua watersheds. Approximately 2% of the study area is in the Rural District which is intended primarily for small farms intermixed with low-density residential lots (Table 3.1 and Figure 3.1).

Large tracts of land in the Agricultural District consist of fallow pineapple fields covered with a mixture of non-native vegetation, including non-native grasses, shrubs, trees, and remnant pineapple plants. The density and vigor of these plants varies, likely as a result of rainfall gradient. In lower elevations, plant density and vigor are less in comparison to plants in the middle and upper fields where rainfall is greater.

Agricultural subdivisions with lots greater than or equal to 10 acres (such as Honolua Ridge) are possible in the Agricultural District.

Jurisdiction over Rural and Agricultural Districts is shared by the State Land Use Commission and County of Maui (Appendix A.5.7.6). The County of Maui is responsible for zoning within the Agricultural District. Within the Agricultural District, the West Maui Soil and Water Conservation District (WMSWCD) advises landowners and land managers seeking soil and water conservation planning for their land. The Natural Resources Conservation Service is currently working with ML&P on a draft agricultural management plan for the former pineapple fields.

3.1.3 Urban District

The Urban District within the three watersheds totals nearly 1,600 acres and 13% of the total land area. The Kahana watershed contains the largest developed area within the three watersheds and currently only Kahana watershed has significant development ma uka of Honoapiʻilani Highway. Honokahua watershed's Urban District is 367 acres and the majority of development in this watershed is Kapalua Resort. Honolua watershed contains no Urban District lands.

The Urban District contains resort complexes, residential housing, commercial properties, golf courses, and the Kapalua-West Maui Airport. Small patches of natural open spaces (e.g. shrubs, wetlands, and parks) are found throughout the Urban District.

The jurisdiction of the Urban District is primarily with the County of Maui (Appendix A.5.7.8).

3.2 Major Landowners, Managers and Uses

ML&P is the largest landowner of the three watersheds with approximately 80% of the landholdings comprised of over 9,600 acres. Nearly all of the ma uka Conservation lands, most of the ma kai Conservation lands, and most of the Agricultural District lands are owned by ML&P.

Table 3.2 lists major landowners within the Conservation, Agricultural and Urban Districts, and ML&P and government ownership are shown in Figure 3.3.

Table 3.2 Major Landowners

Landowners	Kahana (Acres)	Honokahua (Acres)	Honolua (Acres)	TOTAL
Conservation District				
Maui Land & Pineapple Company, Inc.	974	540	2,179	3,693
State of Hawaiʻi	-	-	23	23
Total Conservation District	**974**	**540**	**2,202**	**3,716**
Agricultural District				
Maui Land & Pineapple Company, Inc.	3,278	1,360	316	4,954
808 Oneloa Holdings LLC	-	81	-	81
State of Hawaiʻi	-	-	64	64
Honolua Ridge I RE, LLC	-	31	-	31
TY Management Corporation	-	128	95	223
Total Agricultural District	**3,278**	**1,600**	**475**	**5,353**
Rural				
Maui Land & Pineapple Company, Inc.	64	177	-	241
Urban				
Maui Land & Pineapple Company, Inc.	404	279	-	683
RCK Maui LLC	109	33	-	142
TY Management Corporation	54	-	-	54
Total Urban District	**567**	**312**	**-**	**879**
Total Major Landowner	**4,883**	**2,629**	**2,677**	**10,189**
Total Maui Land & Pineapple Company, Inc.	4,720 (80%)	2,356 (76%)	2,495 (82%)	9,571 (80%)
Total Non-Major Landowner	**981**	**488**	**351**	**1,820**
Watershed Total	**5,864**	**3,117**	**3,028**	**12,009**

Data source: Office of Planning, Statewide GIS Program, 'TMK', 'State Land Use Districts', 'Reserves'; and Maui County Parcel ID website: http://agis10g.co.maui.hi.us:8080/agis/map/viewer.jsp.

Note: Due to variations in average lot size within each of the districts, the following minimum areas were used to define a major landowner: Conservation District - 30 acres (12 ha); Agricultural District - 30 acres (12 ha); Urban District - 10 acres (4 ha).

The Urban District is comprised of smaller parcels with a multitude of individual landowners (Figures 3.4, 3.5 & 3.6). ML&P continues a small portion of land in the Urban District. TY Management Corporation owns the two Kapalua golf courses (Bay and Plantation) and golf academy in the Urban and Agricultural Districts with acreage totally 277 acres.

Maui Land & Pineapple Company, Inc.

As a landholding and operating company, ML&P owns approximately 23,000 acres of land on the Island of Maui, with nearly half of it dedicated to conservation management. The 8,824 acre Pu'u Kukui Watershed Preserve encompasses the upper elevations of all three watersheds as well as conservation lands in the two adjacent watersheds. ML&P manages the Pu'u Kukui Watershed Preserve and coordinates its efforts with the West Maui Mountains Watershed Partnership.

In the mid-elevation ML&P Conservation lands of Honolua watershed is the 30-acre Honolua Wao Kele, a DLNR stewardship and reforestation project that began in 2008. More than 10,000 native plants have been planted since the project's inception.

ML&P owns Agricultural District lands in all three watersheds. Most of the lands were in pineapple cultivation until 2008. The ML&P lands within the Agricultural District are now primarily vegetated fallow pineapple fields. ML&P operates the Kapalua Resort community along the coastline in the Urban District.

State of Hawai'i

A portion of the Kapalua-West Maui Airport is within the Urban District of Honokōwai watershed. It was acquired by the State of Hawai'i in 1993 and is administered by the Airports Division of the State Department of Transportation. It is managed by the Maui Airport District, located at Kahului Airport in Kahului. The airport includes a single runway with terminal and support facilities.[1] It is served by commercial propeller air carriers and commuter/air taxi aircraft, and operations are limited to daylight hours.

The State of Hawai'i recently acquired 244 acres at Līpoa Point and around Honolua Bay. These Agricultural District lands were acquired for conservation purposes and plans for their management are being developed. The management will likely have a strong community management component.

Major Resort and Condominium Ownership

Major landowners and managers of resorts and condominiums occupying over 10 acres of land are included in Table 3.2.

TY Management owns the two Kapalua Resort golf courses: the Plantation Course and the Bay Course, which are managed by Troon Golf. Other smaller hotel and condominiums parcels are called out in Figures 3.4, 3.5, and 3.6.

[1] See http://hawaii.gov/jhm/airport-information

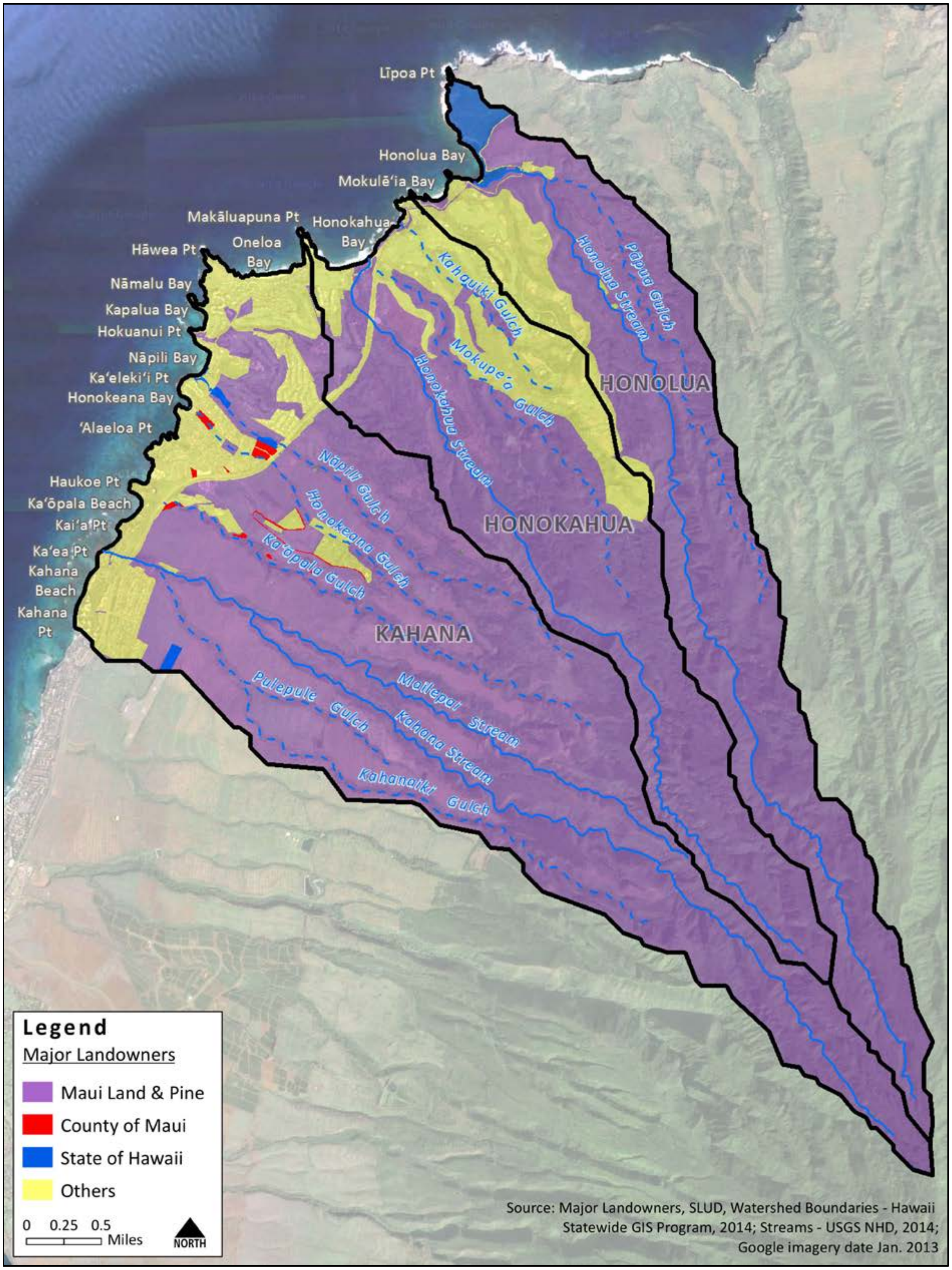


Figure 3.3 Major Landowners

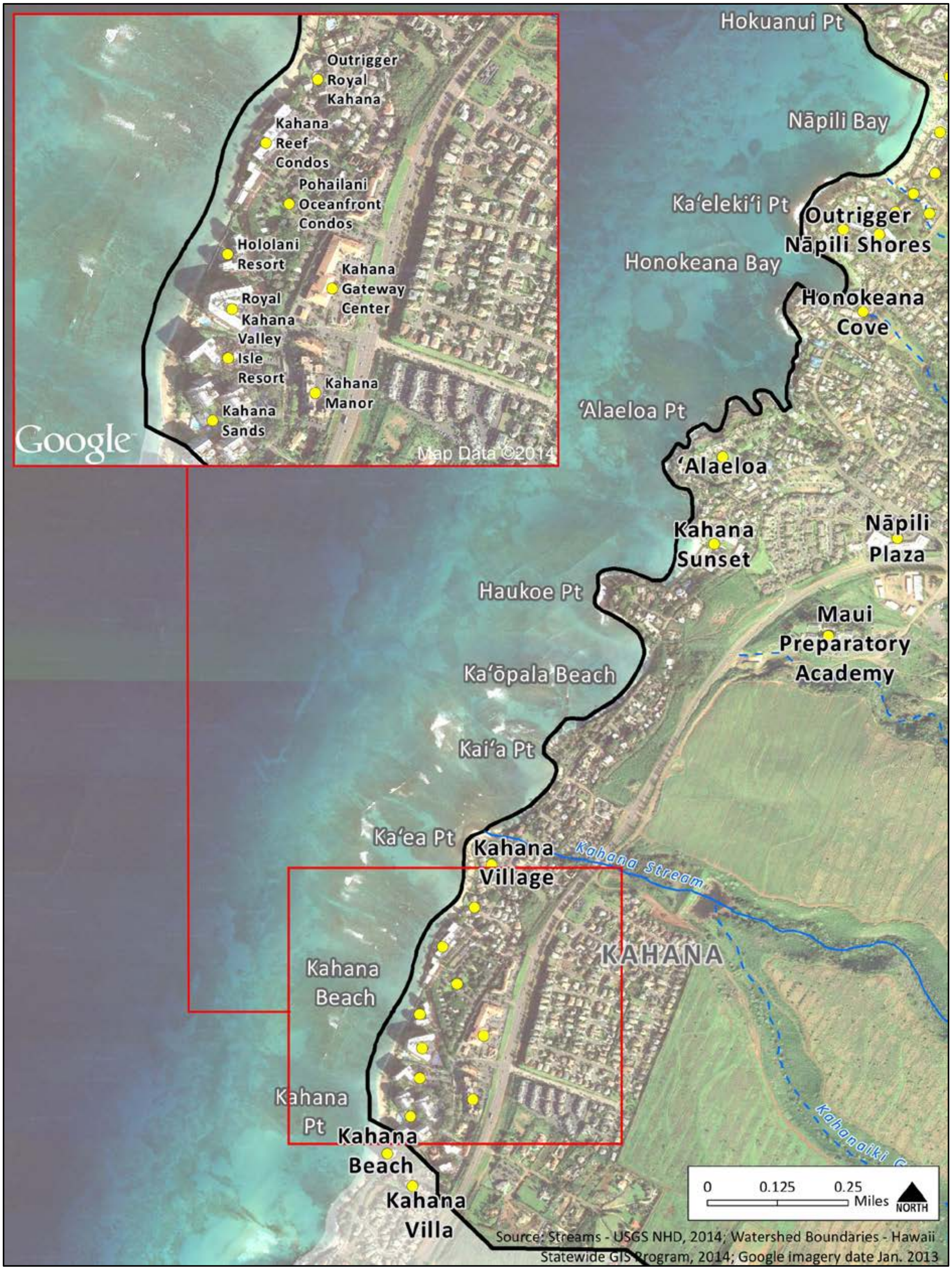


Figure 3.4 South Kahana Watershed: Condominiums & Resorts

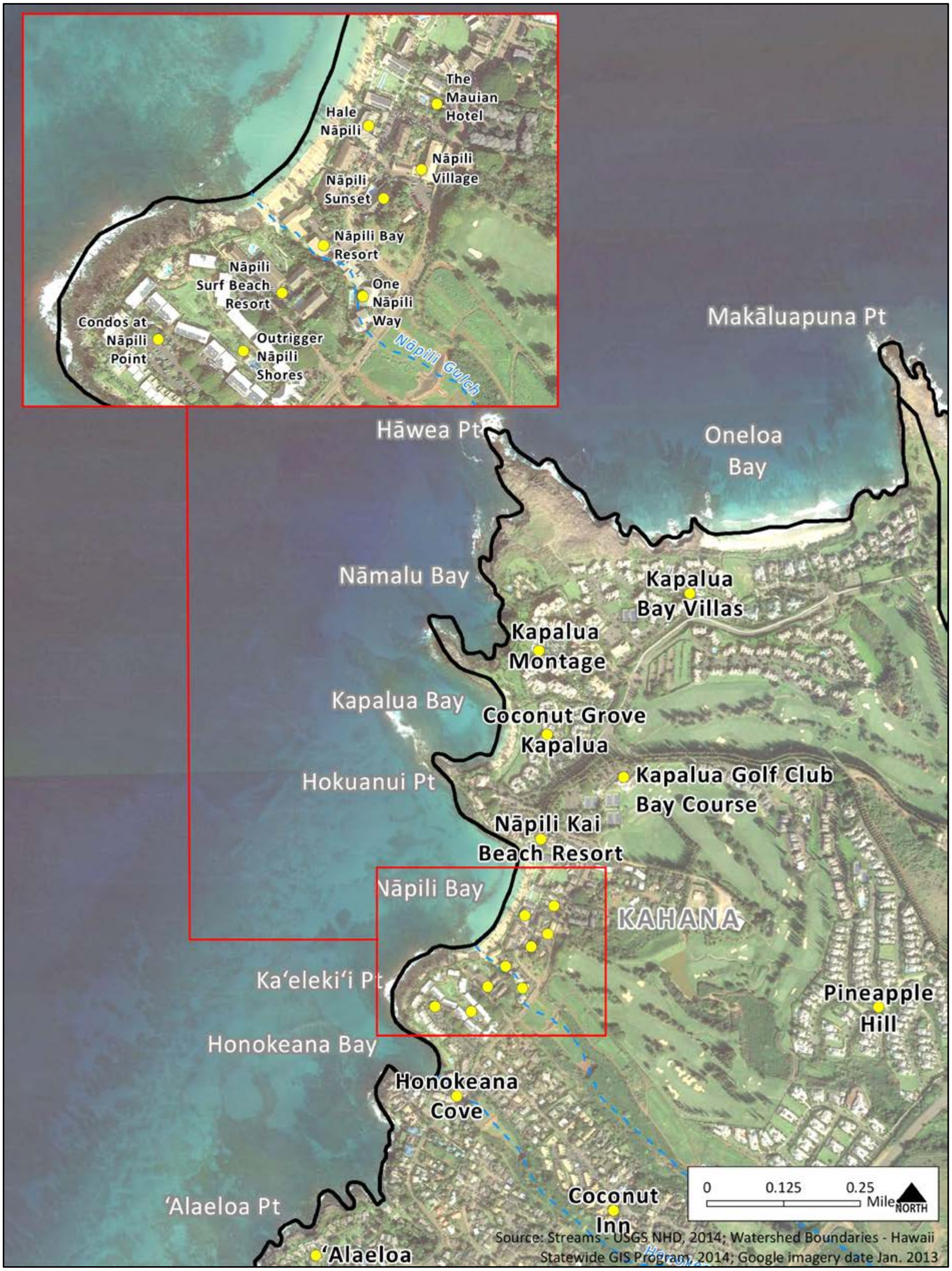


Figure 3.5 North Kahana & Honokahua Watersheds: Condominiums, Resorts & Golf Courses

Figure 3.6 Honokahua Watershed: Resort & Golf Courses

3.3 Future Land Use

The County of Maui Department of Planning's Long Range Division provides information on development projects that have come to their attention. There are several proposed projects in the Kahana, Honokahua and Honolua watersheds (Table 3.3 and Figure 3.7). Future development can affect watershed conditions during construction and have ongoing impacts.

The County of Maui identified projects in the following categories:

> **"Planned/Committed"** – projects have appropriate conforming Community Plan and zoning entitlements, are approved agricultural subdivisions, or are approved 201G/H (affordable housing).
>
> **"Planned/Designated"** – projects have urban or rural Community Plan designations but not the conforming zoning entitlements to proceed (no "Planned/Designated" projects in Report area).
>
> **"Proposed"** - projects are currently lacking required urban or rural Community Plan designations.

The four development projects in the three watersheds being tracked by the County of Maui are "Planned/Committed" projects. These projects have most permits needed except for grading, grubbing and building permits.

The largest project is Kapalua Mauka Residential which encompasses over 900 acres in both the Kahana and Honokahua watersheds. The Kapalua Mauka project includes the Mahana subdivision which is currently under construction. The Pulelehua project is the largest in terms of dwelling units, with 882, and is located on ML&P lands in both Honokōwai and Kahana watersheds. Based on proportion of acreage in Kahana, 101 units are in the Report area. In total, 10% of the land area equaling 1,178 acres, within the three watersheds has been identified as potential future development projects and have the necessary Community Plan and zoning entitlements.

Table 3.3 County of Maui: Development Projects Mapping

Name of Project	Extent (Acres)	% Total (3) Watershed Study Area	Single Family Units	Multi-Family Units	Current State Land Use District
Planned/Committed					
Kapalua Mauka Residential	919	9	690	0	Urban, Rural, & Ag.
Pailolo Place	4	<1	0	42	Urban
West Maui Village Affordable Condominiums	10	<1	0	158	Urban
Pulelehua (partially in Honokōwai)	67	<1	115	76	Urban
Total	**1,000**	**~10**	**805**	**276**	**N/A**

[1] County of Maui Long Range Planning Division Development Projects Mapping listing of proposed projects as of February 2014.

Some future land development will not require a change in Land Use District designation, if the proposed use conforms to the existing District requirements (e.g. an agricultural subdivision located in the Agricultural District). However, with conflicts between District requirements and characteristics of a development, changes in the Land Use require approval by the State Land Use Commission.

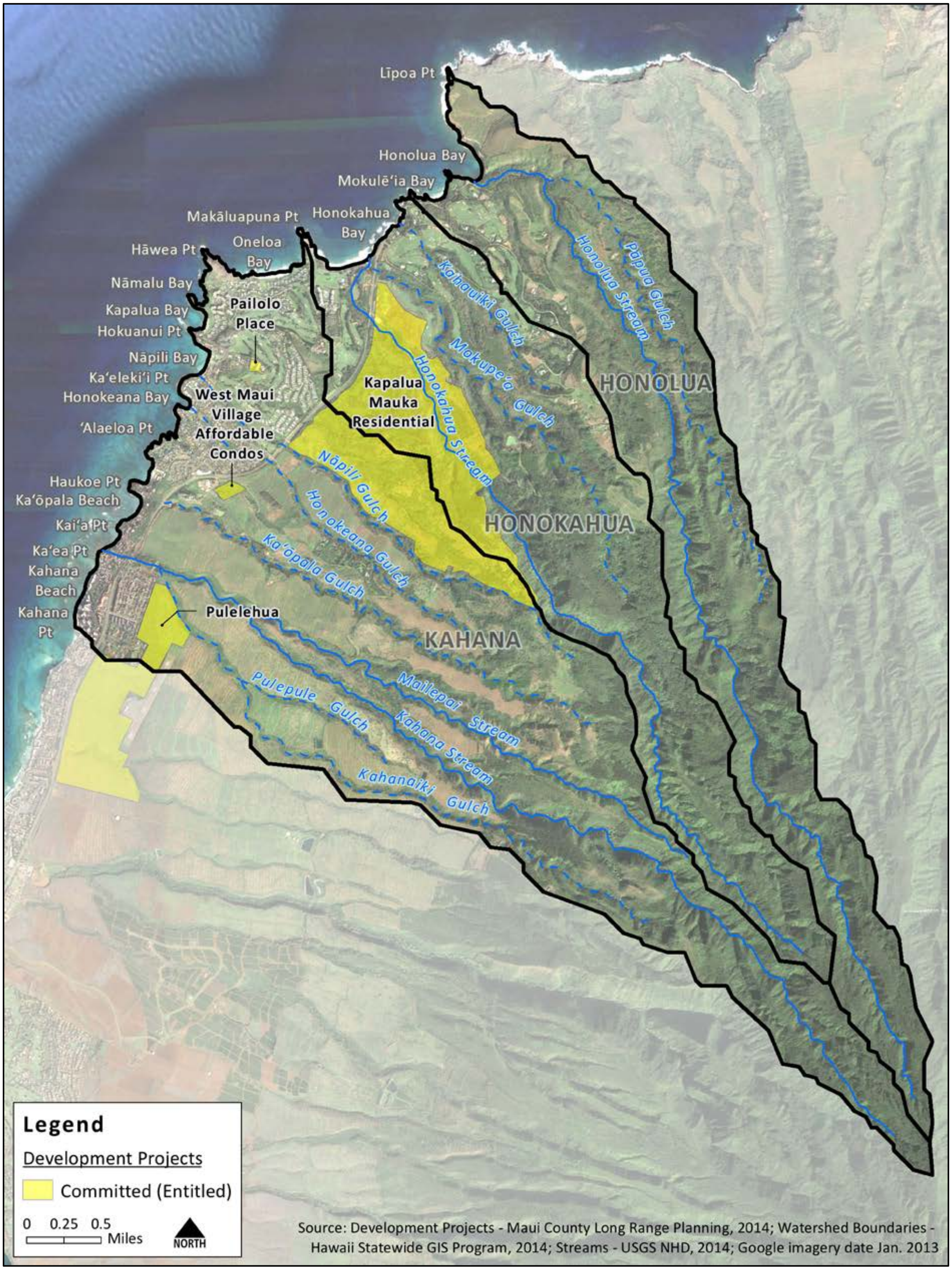


Figure 3.7 County of Maui Development Projects Mapping

3.4 Land Use Summary

Table 3.4 provides a summary of key land use characteristics by watershed.

Kahana is the largest watershed (5,864 acres), and its area is nearly equal to Honokahua and Honolua watersheds combined. Kahana has the most Urban and Agricultural District lands (1,224 acres and 3,625 respectively), highest percentage of urban area and the most proposed development in terms of units (687 units).

While each watershed has conservation lands in the ma uka reaches, Honolua has the most Conservation acreage (2,262 acres or 75%) with the remainder of the lands (25%) in Agricultural/Rural Districts.

The three watersheds are primarily owned by ML&P with percent ownership ranging from 76% in Honokahua to 85% in Honolua.

Table 3.4 Summary of Key Land Use Characteristics

Watershed	Kahana		Honokahua		Honolua	
Land Use	**Acres**	**Percent**	**Acres**	**Percent**	**Acres**	**Percent**
Conservation	1,015	17%	578	19%	2,262	75%
Agricultural & Rural	3,625	62%	2,172	69%	766	25%
Urban	1,224	21%	367	12%	-	-
Total	5,864	100%	3,117	100%	3,028	100%
Ownership	**Acres**	**Percent**	**Acres**	**Percent**	**Acres**	**Percent**
Maui Land and Pineapple	4,720	80%	2,356	76%	2,582	85%
Other	1,144	20%	761	24%	446	15%
Proposed Development[1]	**Acres**	**Units**	**Acres**	**Units**	**Acres**	**Units**
Kapalua Mauka Residential	394	296[2]	525	394[2]	-	-
Pailolo Place	4	42	-	-	-	-
West Maui Village Affordable Condominiums	10	158	-	-	-	-
Pulelehua (Partially in Honokōwai)	67	191[2]	-	-	-	-
Total Proposed Development	**475**	**687**	**525**	**394**	**-**	**-**

[1] County of Maui Long Range Planning Division Development Projects Mapping listing of proposed projects as of February 2014.
[2] Approximate; where a project crosses watershed boundaries, units were assigned in proportion to the project acreage in each watershed.

4.0 PHYSICAL AND NATURAL FEATURES

This chapter details the physical and natural features and associated human impacts that affect the hydrologic cycle with an emphasis on features that contribute pollutants and/or facilitate transport.

Hydrology refers to the movement and fate of water across the watershed, its quality, and the man-made and natural drainage networks. The fate of water running over a watershed plays a significant role in the transport of pollutants to the nearshore and coral reef ecosystems. Alterations to a watershed by people, plants, and animals can affect all of the pathways, and in many cases the alterations results in adverse impacts to the ecosystem.

The physical and natural features and the associated human impacts are described by watershed, and in some cases by subwatersheds. This chapter also presents information on the coral reef ecosystem and offshore circulation patterns.

4.1 Watershed Boundaries

The State Department of Land and Natural Resources (DLNR) Division of Aquatic Resources (DAR) watershed boundaries are used for watershed delineations. Using Geographic Information System (GIS) and locations of constructed debris and sediment basins collect and channel water flow. The watersheds characteristics are listed in Table 4.1 and shown in Figure 4.1.

4.1.1 Kahana Watershed

Kahana Watershed covers 5,863 acres and is approximately 7 miles long by 2 miles wide (Figure 4.1). The highest point of the Kahana Watershed is 4,468 feet elevation. The western boundary is formed by approximately 5 miles of coastline, stretching from Kahana Beach (near the Kapalua Airport) to Makāluapuna Point. The developed area along the coast includes the residential communities and resorts of Kahana, Nāpili and Kapalua.

Kahana Iki Gulch, Pulepule Gulch and Mailepai Stream merge into Kahana Stream in its lower reach. North of Kahana subwatershed are the gulches and subwatersheds of Ka'ōpala, Honokeana, Nāpili 4-5 and Nāpili 2-3 (Figure 4.1).

4.1.2 Honokahua Watershed

Honokahua Watershed encompasses 3,117 acres and is approximately 6 miles long by 1 mile wide at its midpoint (Figure 4.1). The highest point is 3,274 feet elevation, and the coastline is approximately 1 mile long stretching from Makāluapuna Point to 'Alaelae Point. Kapalua Resort and Bay and Plantation Golf Courses occupy this stretch of coast.

Honokahua Watershed includes three main drainages - Honokahua Stream, Mokupe'a Gulch and Kahauiki Gulch. The stream courses for Honokahua and Mokupe'a are mapped by US Geological Survey (USGS) as intersecting at Honokahua Bay. Kahauiki Gulch terminates in the Kapalua Golf Course.

4.1.3 Honolua Watershed

Honolua Watershed covers 3,027 acres and is approximately 7 miles long by 1 mile wide at its midpoint (Figure 4.1). The highest point of the Honolua Watershed is 4,291 feet, and the northern boundary is formed by 2 miles of coast stretching from ʻAlaelae Point to Līpoa Point. This watershed is unique among the three described in this report as its land use has been largely regulated as Conservation Use District Land.

The watershed is named for Honolua Stream, which runs from its headwaters down a 12-mile course to Honolua Bay.

4.1.4 Watershed Summary

Table 4.1 provides an overview of the three watersheds. The subwatersheds with letters A or B are used to name small subwatersheds adjacent to the larger subwatersheds and are included as part of the subwatershed with the same name in this report.

Table 4.1 Watershed Summary

Watershed	Kahana	Honokahua	Honolua
Area (acres)	5,864	3,117	3,028
Shoreline (miles)	5	1	2
Width (miles)	2	1	1
Length (miles)	7	6	7
Maximum Elevation (feet above mean sea level)	4,468	3,274	4,291
Streams	Kahana (with tributary of Mailepai Stream)	Honokahua	Honolua
Subwatersheds	Kahana A Kahana Kaʻōpala A Kaʻōpala Kaʻōpala B Honokeana Nāpili 4-5 Nāpili 2-3	Honokahua A Honokahua Mokupeʻa Kahauiki	Honolua Līpoa Point

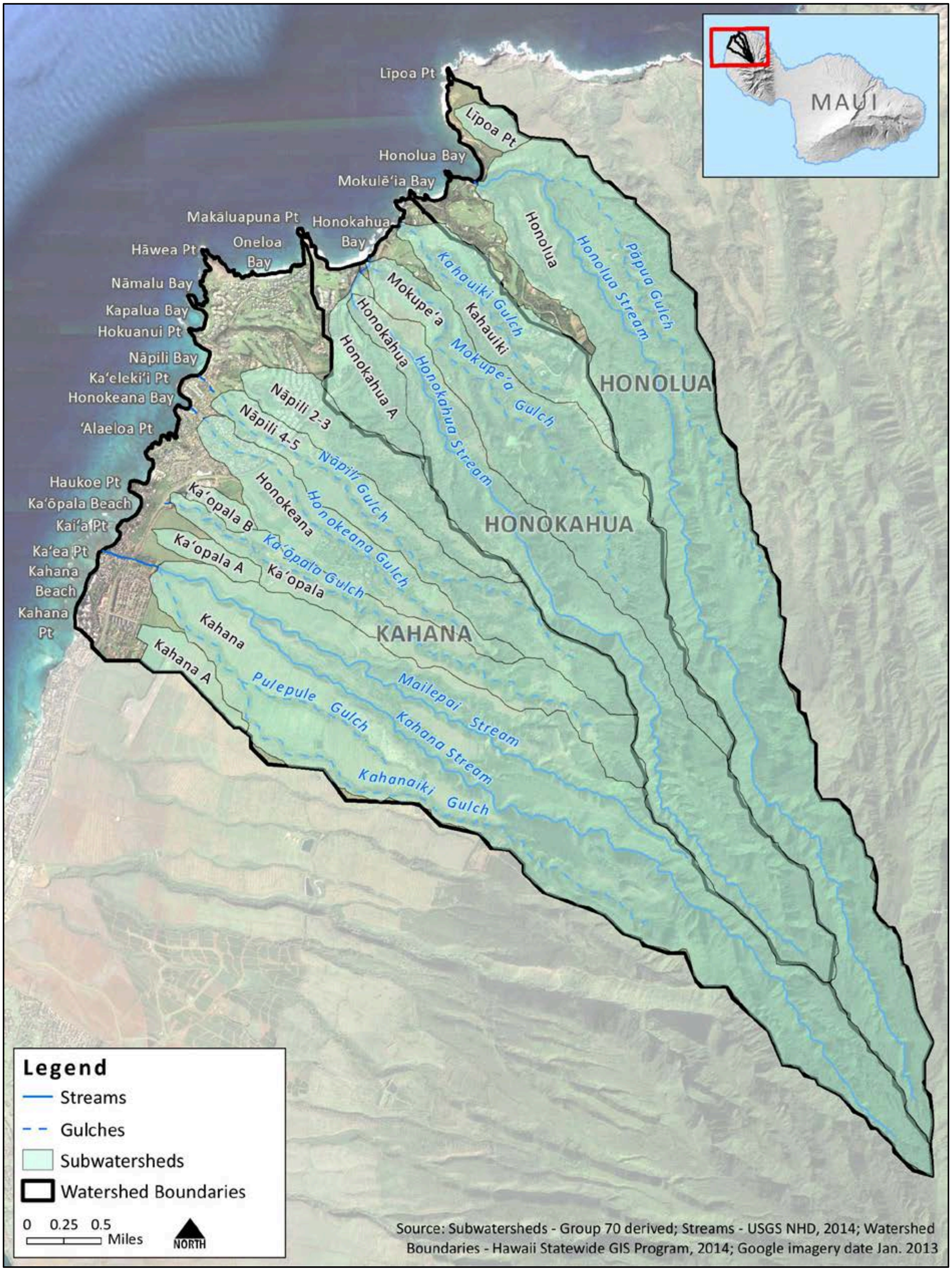


Figure 4.1 Watershed and Subwatershed Boundaries

4.2 Topography

Topography characterizes the surface shape and features of the earth including slope, relief and landforms. The topography of West Maui was shaped by the geologic formation of the West Maui Volcano. The steepest slopes occur along gulch and stream edges, and in the upper elevations (Figure 4.2). Slopes of up to 78% occur along stream corridors in the elevations above 1,500 feet. Slopes within the former plantation fields generally range from 10-40%, with steeper slopes into gulches and streams adjacent to the fields. Slopes generally range from 0-10% throughout the more developed lower elevations of the Urban District. Surface runoff from rain drains at different rates due to the variability in surface slopes, surface cover and soil types. Generally runoff moves quickly down the steep sections and slowly along the flat coastal areas. Topography is used in calculating the potential soil loss in Chapter 6.

4.3 Soils

Silty clay soils are predominant throughout the watersheds. Clay soils contain very small void spaces, which retain moisture for long periods using capillary action and chemical bonds. These small voids are prone to compaction and reduction of pore volume from mechanical actions that exert shear stress on the soil horizons, resulting in reduced infiltration rates and water holding capacities. The susceptibility of these soils to compaction can often lead to erosion problems by reducing infiltration and creating concentrated surface runoff and flow along the compacted surface.

Clay soils are generally resistant to detachment due to the chemical bond between particles (called colloids). However, because of their planar shape and small size, once detached they are readily transported via water (and to a lesser degree via wind). The colloids present a difficult challenge to control once they are detached and become suspended in surface water runoff. They can remain in suspension for long periods of time and/or become resuspended under low turbulent conditions such as when small waves break along the shoreline.

Figure 4.3 illustrates the soil series in Kahana, Honokahua and Honolua Watersheds as classified by the Natural Resources Conservation Service (NRCS).[2] The soil descriptions assist in the understanding soil erosion and transport. These series come from four major soil orders: Inceptisols, Oxisols, Mollisols and Ultisols, which are described below and summarized in Table 4.2.

Inceptisols are poorly developed soils with minimal development of soil horizons. The Kahana series of the Inceptisols order is an agriculturally important soil and occupies the intermediate uplands of West Maui from 100-1,200 feet elevation. Kahana series soils formed from basic igneous rock that has weathered in place. Kahana series silty clays are found largely in the Kahana watershed along the urban coastline and up into the agricultural fields (Figure 4.3).

Oxisols are highly weathered tropical soils with low nutrient holding capacity and high iron and aluminum oxides. The Lahaina series of the Oxisols order is found in southern Kahana watershed in the lower elevation areas (Figure 4.3). Lahaina series soils formed in place from igneous rock with alluvial deposits and may contain fragments of coral, sand and gravel.

[2] Detailed information on the soil series can be found at http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/geo/?cid=nrcs142p2_053587

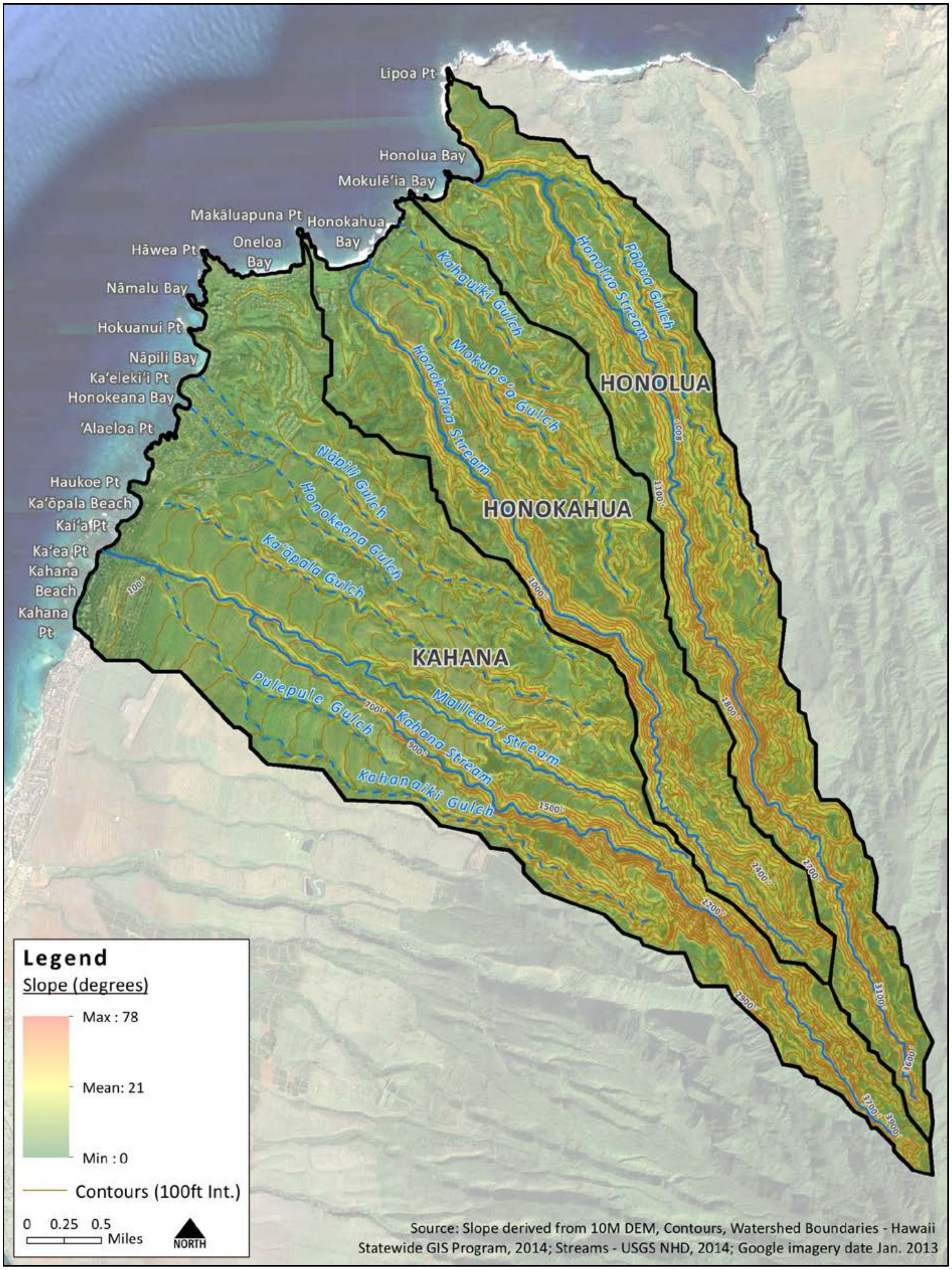


Figure 4.2 Slope

Mollisols are moderately weathered, fertile soils with high organic carbon and high base saturation. Small areas of the Pulehu series of the Mollisols order are found in southern Kahana and along Honokahua Stream mouth (Figure 4.3). The Pulehu series soils of the Mollisols order are well drained soils formed from alluvium washed from basic igneous rock.

Ultisols are strongly acidic soils with good physical properties and depleted in calcium, potassium and magnesium. The ʻAlaeloa series of the Ultisols order are deep, well-drained soils that formed in material weathered from basic igneous rock and occur in West Maui from the coastline in Honolua to upper elevation agriculture fields in Kahana (Figure 4.3). The Honolua series of the Ultisols order are well drained soils formed from basic igneous rocks. These occur in the upper agricultural areas and lower conservation areas of all three watersheds.

The Olelo series of the Ultisols order are deep, well-drained soils that formed from basic igneous rock. Olelo silty clays are woodland soils found in the conservation area of Kahana Watershed (Figure 4.3).

The majority of the conservation areas of both watersheds consist of rough mountainous land, rough broken land and rock land, where the parent soil material, basaltic lava, still remains to be weathered. These upland soils are classified as having severe erosion hazard.

Soil types within each series are included below and provide supplemental information to Figure 4.3 legend:

Legend

Soil Types by Series - Percentages Listed are % Slope

Soil Series with One Soil Type

Beaches
Beaches

Dune
Dune land

Ewa Series
EaA: Ewa silty clay loam, 0-3%

Jaucas Series
JaC: Jaucas sand, 0-15%

Olelo Series
OFC: Olelo silty clay, 3-15%

Pulehu Series
PsA: Pulehu clay loam, 0-3%

Soil Series with Multiple Soil Types

Alaeloa Series
AeB: Alaeloa silty clay, 3-7%
AeC: Alaeloa silty clay, 7-15%
AeE: Alaeloa silty clay, 15-35%

Honolua Series
HwC: Honolua silty clay, 7-15%
HwD: Honolua silty clay, 15-25%

Kahana Series
KbB: Kahana silty clay, 3-7%
KbC: Kahana silty clay, 7-15%
KbD: Kahana silty clay, 15-25%

Lahaina Series
LaB: Lahaina silty clay, 3-7%
LaC: Lahaina silty clay, 7-15%

Rock Series
rHT: Hydrandepts-Tropaquods association
rLW: Lava flows, aa
rRK: Rock land
rRR: Rough broken land
rRS: Rough broken and stony land
rRT: Rough mountainous land
rSM: Stony alluvial land

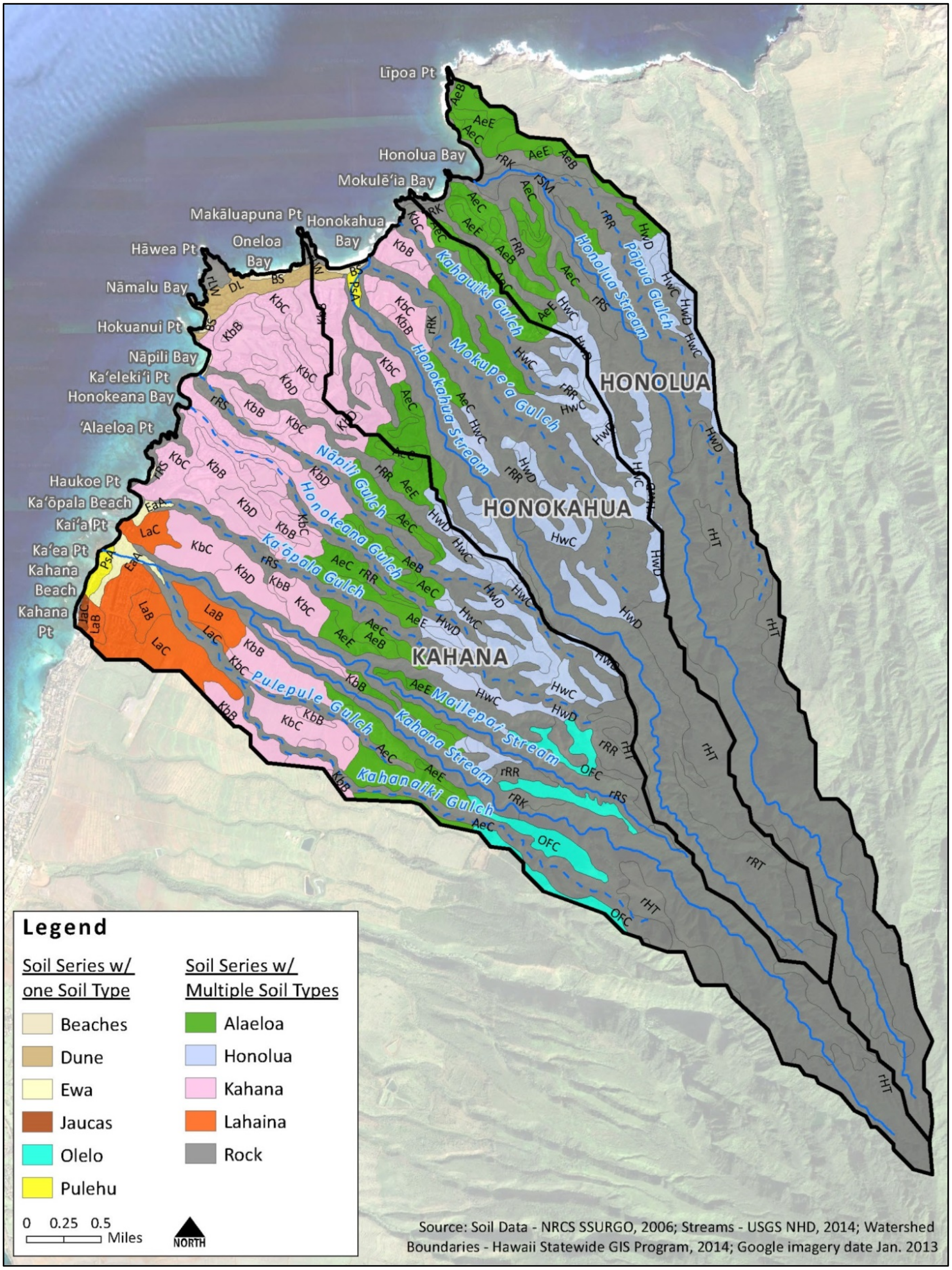


Figure 4.3 Soils

Table 4.2 Major Soil Order & Series

Soil Order	Soil Series	Texture	Color	Runoff Rate	Perme-ability	Drainage	Typical Use	Location
Inceptisols	Kahana	Silty clay	Dark reddish brown	Slow to medium pace	Moderately rapid	Good	Pineapple, irrigated sugarcane, some pastureland	Kahana and Honokahua: urban and agricultural area
Oxisols	Lahaina	Silty clay	Dark reddish brown	Slow to rapid pace	Moderate	Good	Pineapple, irrigated sugarcane	Kahana: urban and agricultural areas
Mollisols	Pulehu	Silty clay	Dark brown	Slow to medium pace depending on slope	Moderate	Good	Irrigated sugarcane, pasture and truck crops	Kahana and Honokahua: coastal area (minimal component)
Ultisols	ʻAlaeloa	Silty clay	Dark reddish brown	Slow to rapid pace depending on slope	Moderately rapid	Good	Pastureland, small areas used for truck crops	Kahana and Honokahua: lower part of the agricultural areas; Honolua Watershed lower elevations
	Olelo	Silty clay	Dark reddish brown	Slow	Moderately rapid	Good	Woodland	Kahana: conservation area
	Honolua	Silty clay	Dark reddish brown	Slow to medium pace depending on slope	Moderately rapid	Good	Pastureland	Kahana, Honokahua and Honolua: upper agricultural area into conservation area

Woodward and Clyde in 1996 described the West Maui soils based on their hydrologic soil group from A, low runoff and high infiltration, to D low infiltration and high runoff potential. Relatively few Type A soils were found in Kahana, Honokahua and Honolua and only along the coastline. These are typically well-drained sand and gravel such as in beach and shoreline areas. The B soils have moderate rates of infiltration and are moderately coarse-grained textures such as silty clay soils found predominately in the three watersheds. The streams and gulches with rocks and boulders overlying the silty clay soils are hydrologically classified as Type C, and are moderately-fine to fine-grain textured. Upper watershed areas of basal rock and rock outcrops with low infiltration rates and high runoff potential are Type D.

4.4 Land Cover

Land cover is the description of the natural and manmade material, on or above the earth surface, e.g. trees or parking lots. Land cover can be broadly delineated as either pervious or impervious surfaces. Pervious surfaces are present throughout the watersheds, with examples including forested zones, fallow and active agricultural lands, and urban landscaped areas. The previous surfaces allow rainwater to pass through and soak into the ground. The rates of infiltration vary with the types of land cover.

Impervious surfaces affect storm water runoff quantity and quality by: (1) not allowing rainfall to infiltrate into the ground, preventing water from recharging soil and the aquifer; and (2) causing ponding almost immediately at the onset of rains, generating rapid runoff with higher volumes than compared to a pervious surface. This rapid transport of runoff reduces detention time of water on the watershed and the amount of rainfall that infiltrates into the ground. This diminishes the capture and remediation of pollutants by microbes in the soils and plant roots and results in direct delivery of contaminants to the ocean. Examples of impervious surfaces include naturally occurring sections of exposed rock, paved and concrete surfaces and buildings.

Figure 4.4 and Table 4.3 provide a detailed breakdown by land cover category. The data are from the 2005 National Oceanic Atmospheric Administration (NOAA) Coastal Change Analysis Program data. This data provides percentage estimates of impervious surfaces, although data may be underestimated as impervious lands generally increase with time. The cultivated crops land cover class is now fallow fields. This data set was used in calculations of potential relative surface soil loss presented in Chapter 6.

Based on field observations in the watersheds, soils have been affected by land use activities which occurred in the past and present (Chapter 2). The level of effect varies according to the extent of land use and activity within the area. In the Conservation District, soil compaction from human and animal presence has been noted, along with disturbed and trampled areas and trails of exposed soils resulting from dirt bike impacts.

In the Agricultural District, soils across large tracts of land have been impacted by tilling, earthen roads, grading, and general compaction of soils. An extensive network of dirt roads provides field access and connects to the lower urban areas. These dirt roads are considered impervious surfaces due to their compaction from years of use. Dirt roadways account for most of the 273 acres of impervious surface in the Agricultural District.

In the Urban District, hardscapes and grading associated with development have significantly compacted soils and reduced infiltration rates, often rendering them virtually impervious to infiltration. There are more than 341 acres of impervious surfaces in the Urban District.

Figure 4.4 illustrates the approximate extent of highly compacted/impervious surfaces within the watersheds in red. Table 4.4 lists impervious area by watershed and land use district. The impervious acreage is used in Chapter 6 to calculate relative urban pollutant loading. Significant impervious areas are identified and described in that chapter.

Kahana watershed has the most impervious surfaces due to its size and amount of urban area, and it has the largest cultivated crop area from past agriculture. Honolua watershed has impervious surfaces due to access roads in the mid-elevation conservation lands.

Table 4.3 Land Cover

Land Cover Class	Kahana		Honokahua		Honolua		TOTAL	
	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent of Total Area
Impervious	465	8%	108	3%	61	2%	634	5%
Evergreen Forest	1,908	33%	1,737	56%	1,584	52%	5,229	44%
Cultivated Crops	1,584	27%	191	6%	200	7%	1,976	16%
Scrub/Shrub	1,035	18%	425	14%	520	17%	1,980	16%
Developed, Open Space	320	5%	240	8%	46	2%	605	5%
Palustrine Forested Wetland	241	4%	248	8%	358	12%	847	7%
Grassland/ Herbaceous	163	3%	93	3%	114	4%	370	3%
Palustrine Scrub/Shrub Wetland	65	1%	45	1%	105	3%	215	2%
Palustrine Emergent Wetland	2	0%	1	0%	6	0%	8	0%
Bare Land	45	1%	22	1%	31	1%	98	1%
Open Water	36	1%	8	0%	3	0%	47	0%

Table 4.4 Impervious Area by Watershed and Land Use Districts

Land Use District	Watershed			Total (acres)
	Kahana (acres)	Honokahua (acres)	Honolua (acres)	
Urban	308	33	0	341
Agricultural and Rural	156	72	45	273
Conservation	1	3	16	20
Total	**465**	**108**	**61**	**634**

4.5 Climate

4.5.1 Precipitation

Rainfall is highly variable with elevation and season (Figure 4.5). Mean annual rainfall ranges from less than 35″ along the coast in Kahana and up to 217 inches in the mountains in Kahana and Honolua watersheds (Giambelluca et al. 2013).

Hawaiians long ago distinguished the annual precipitation cycle into six month seasons: *kau* (May to October) and *hoʻoilo* (November to April) (Lau and Mink 2006). Modern analysis now divides the annual cycle in Hawaiʻi into a summer season of five months (May to September) and a winter season of seven months (October to April) (Blumenstock and Price 1967).

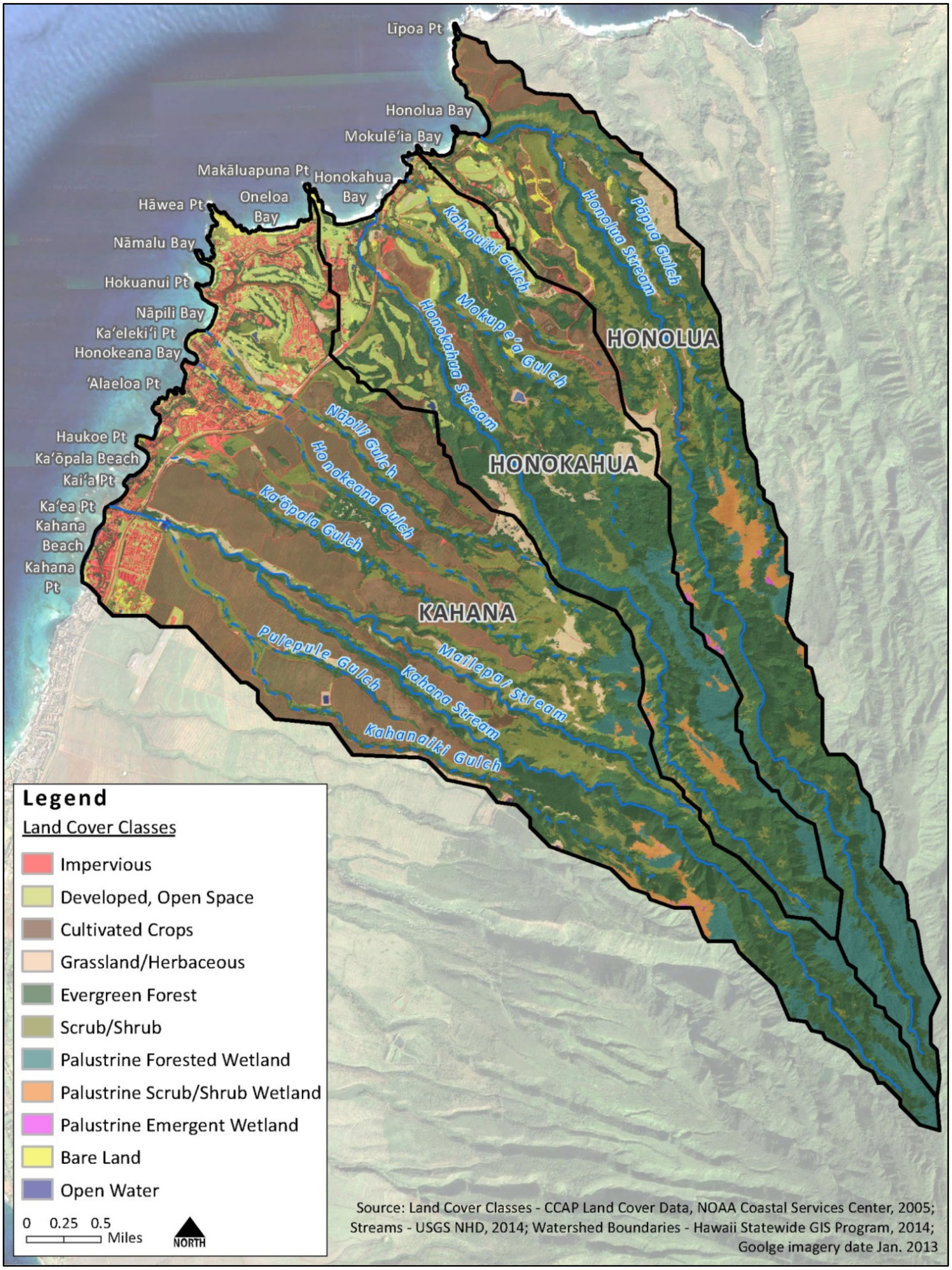


Figure 4.4 Land Cover

During the summer season with trade winds, maximum rainfall is generally on windward slopes (Chu and Chen 2005). During the winter season, the trade winds may die down, and kona storms mechanisms generate widespread rainfall as the main source of winter season rainfall. This weather pattern generally occurs over the Kahana, Honokahua, and Honolua watersheds.

As noted during the summer and/or periods of drought, the non-native plants on the fallow fields become stressed or dry, and a portion dies off. These areas of the watersheds are most vulnerable to erosion with the onset of rains because there is less vegetative cover to protect the soil from rainfall. Further, dry vegetation in fields is likely to burn if an ignition source is present.

4.5.2 Temperature

Temperatures in West Maui are mild and generally range from a daily mean minimum of 65° Fahrenheit (F) to a maximum of 89° F, with the warmest temperatures occurring in August and September (WMO 2009).

4.5.3 Evapotranspiration

Evapotranspiration is an important component in understanding the overall hydrologic cycle. Evapotranspiration includes three processes that take water from surfaces and transform it into water vapor. These are 1) movement of water through plants (transpiration), 2) evaporation of water deposited on plant from leaves (wet canopy evaporation) and 3) evaporation directly from soil (soil evaporation). Evapotranspiration losses vary with elevation, aspect and existing land cover and evapotranspiration from the Evapotranspiration of Hawaiʻi website (from the University of Hawaiʻi at Mānoa Department of Geography) is shown in Figure 4.6 (Giambelluca et al. 2014).

4.5.4 Natural Hazards

Hawaii Coastal Hazards Atlas describes hazard areas from Kahana to Hāwea Point as Nāpili and from Hāwea Point north around the coastline as Honolua Bay (Fletcher et al. 2002). For the Nāpili coast the Overall Hazard Assessment is “moderate to high (5) and is largely influenced by high tsunami, stream flooding, and erosion hazards and moderately high storm, sea-level rise, and seismicity threats on this Maui coastline”. For Honolua Bay, the Overall Hazard Assessment is “variable but relatively high”. The rating variability is due to Hāwea and Līpoa points having ratings of moderate (4), and the bays with moderate ratings of high (5) and high (6).

The coast’s high tsunami hazard rating is supported by a 1946 event during which a 15 feet tsunami made landfall and reached 24 feet inland Honolua Bay (Fletcher et al. 2002). Otherwise, records show few historic tsunami events.

The region’s high stream flooding hazard rating is supported by a 1968 event during which heavy rains and flash floods resulted from 24 inches of rainfall in 48 hours. High wave threats are ranked high from Hāwea Point around to Honolua “where north swell often generates breaking-wave heights of 10 to 20 feet in the winter months.”

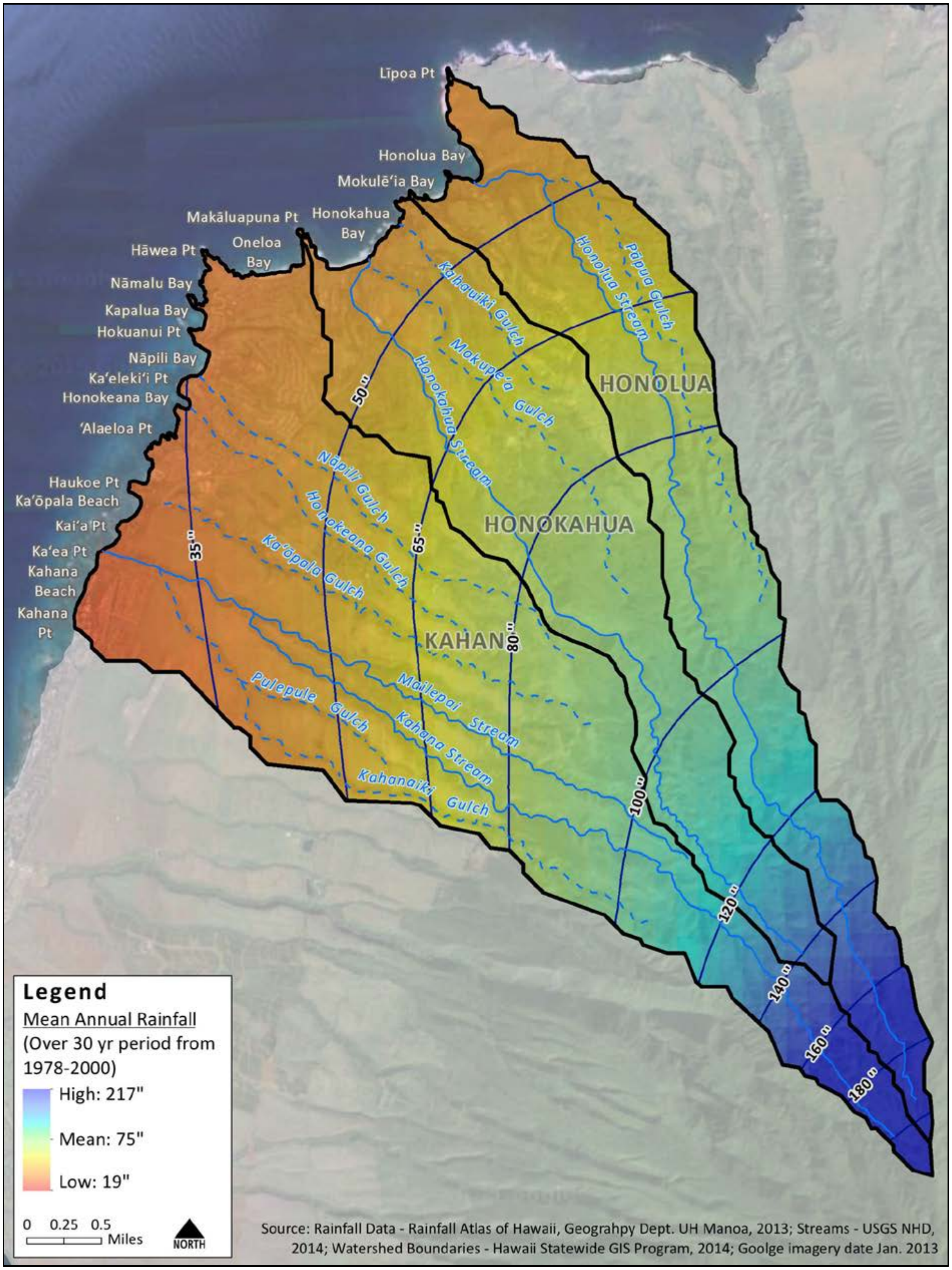


Figure 4.5 Rainfall

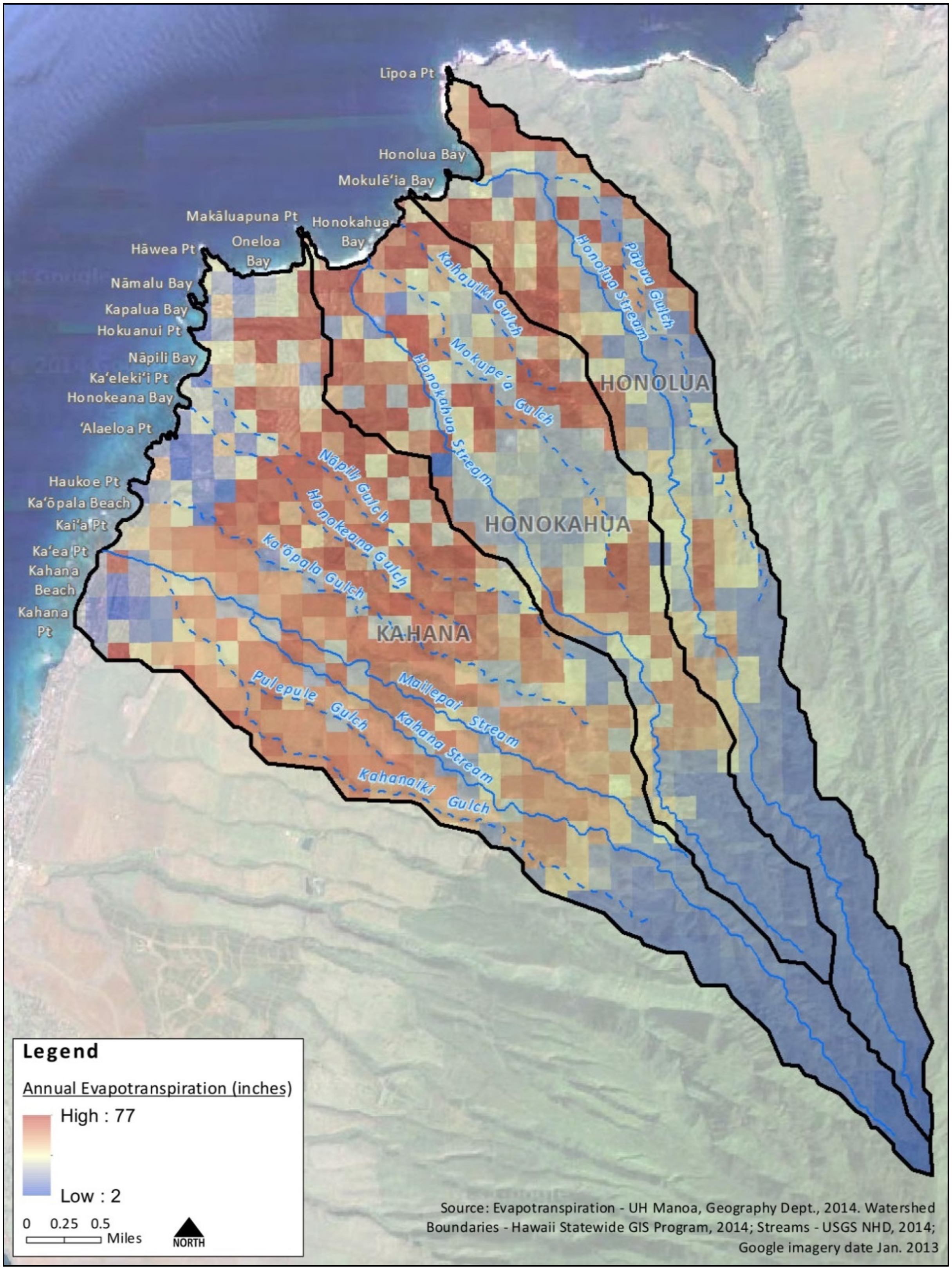


Figure 4.6 Evapotranspiration

4.5.5 Climate Change

The US Army Corps of Engineers (USACE) Honolulu District recently completed a climate change analysis for the West Maui Watershed Plan (USACE 2014). The analysis modeled climate impacts of rainfall amount, frequency, and intensity in addition to sea-level rise by downscaling available state level projections and other relevant sources. A time horizon of 50 years was used with an end year of 2065. The analysis examines and acknowledges many studies with climate change modeling. Based on the results of the various studies, the report concludes rainfall amounts, frequency and intensity would remain at current levels.

For the report, three sea-level rise scenarios were modeled per USACE ER 1100-2-8162 *Incorporating Sea Level Change in Civil Works Programs*. The sea-level rise projections ranged from 6 to 18 inches, with 12 inches (a 1-foot rise) in the middle of the range. Sea-level rise will change the shoreline and impact the aquifer water table. Ground water may increase in salinity, thereby reducing freshwater availability. Drainage channels may back up at outlets due to higher sea-level elevation. This would reduce the ability of channels to convey water and increase amount and time of runoff water in channels.

The impacts of sea-level rise can also be considered by looking at the Flood Zone maps where the VE zone is identified (Figures 4.15 and 4.16). These are low lying areas where ocean effects are the greatest during storm events and may eventually be impacted similarly by sea-level rise.

Pacific Regional Integrated Sciences and Assessments (Pacific RISA) and partners are conducting a multi part climate change study for Maui. Future Maui land use scenarios were developed as spatial data sets with extensive stakeholder participation and made available in May 2015. The land coverages for each scenario will feed into a USGS groundwater recharge model that uses the future climate projections (generated via dynamically downscaled climate models at the UH International Pacific Research Center) to predict groundwater recharge and availability.

4.6 Major Streams

4.6.1 Major Streams Overview

The larger, more developed streams in the region have headwaters originating in the upper West Maui Mountains where high rainfall amounts generate surface flow and recharge aquifers that leak into streams during dry periods[3]. These large streams continue downslope through fallow agricultural fields and into the urban area, before terminating at the coastline. The watersheds are named for major streams: Kahana, Honokahua, and Honolua (Figure 4.1). All three are listed as perennial streams in the 1990 Hawai'i Stream Assessment (by the Hawai'i Cooperative Park Service Unit).

The definition of perennial streams in Hawai'i Administrative Rules Chapter 11-54 (Water Quality Standards):

"'Perennial streams' means fresh waters flowing year-round… portions of which may be modified by humans. Flow in perennial streams may vary seasonally… Perennial streams may be either continuous

[3] 'Stream' is a descriptor usually given to a naturally formed channel that flows year round (perennial) or did historically. 'Gulch' is a descriptor given to channel that flows for short periods of time (ephemeral) following rainfall events. An 'intermittent stream' contains threads of water or pools perennially. A stream may be perennial in some sections such as the upper elevations and intermittent and/or ephemeral in other sections.

or interrupted. Continuous perennial streams discharge continuously to the ocean in their natural state… interrupted perennial streams usually flow perennially in their upper reaches but only seasonally in parts of their middle or lower reaches, due to either downward seepage of surface water flow (naturally interrupted) or to man-made water diversions (artificially interrupted)."

Most of the stream channels are no longer discernible ma kai of Honoapiʻilani Highway due to urbanization, agriculture development and sediment control structures which have altered the natural hydrology. The geology of streambeds affects low flow in streams because natural low flow is primarily from ground water resources. Where ground water contributes to streamflow, these stream reaches are known as "gaining reaches", typically found where the stream bed intersects dike-impounded ground water. Lower elevation stream reaches are often "losing reaches", with streamflow discharging through permeable rocks in dike-free zones and contributing water to the freshwater lens aquifer system (Cheng 2014).

A recent study by the USGS in cooperation with the State of Hawaiʻi Commission on Water Resource Management (CWRM) describes natural low-flow conditions for a number of streams in West Maui. Low-flow characteristics, under natural (unregulated) streamflow conditions were determined by analyzing historical and current streamflow data from continuous-record streamflow-gaging stations and miscellaneous sites, and additional data collected at partial-record sites. The results of the study, *Low-Flow Characteristics of Streams in the Lahaina District, West Maui, Hawaiʻi* (Cheng 2014), were intended to assist in the determination of technically defensible instream-flow standards for West Maui streams. The results are provided in the stream descriptions and Table 4.5.

The overall trends in streamflow from 1913-2003 in Hawaiʻi were studied by USGS (Oki 2004). Downward trends were found in base-flow more than high streamflow and peak flows. The study suggests that long term downward trends in base flows may point to decreases in groundwater discharge to streams caused by decreases in storage and recharge.

For all three streams, there are no net stream flow diversions. Honolua stream has a diversion, and the water is returned to the stream shortly after the diversion. The streams that provide water into the Honolua/Honokōhau Ditch System are the Honokōhau Stream north of Honolua watershed and other streams south of Kahana watershed.

4.6.2 Kahana Stream System

Kahana Stream was classified as perennial and described with a total length of 17 miles and a maximum elevation of 4,475 feet in the *Atlas of Hawaiian Watersheds and their Aquatic Resources* (Parham et. al. 2008). Two drainages join the stream corridor in the lower elevations, one on each side of the main channel. Pulepule Gulch lies south of Kahana Stream, and Mailepai Stream, a tributary of Kahana Stream, lies to the north of Kahana Stream, meeting the Kahana Stream drainage at 360 feet elevation.

Kahana Stream is physically impaired in the lower reaches by urban development and the Kahana Desilting Basin (Section 4.7.2) which alter the natural stream hydrology below the desilting basin. Water is discharged from the Kahana Desilting basin via a pipe into an unlined spillway with energy dissipaters (large concrete blocks positioned to slow the water). Overland flow continues to the shoreline along an unlined sandy channel into the ocean (Figure 4.7). Above the Kahana Desilting Basin in the Agricultural District, years of agriculture have sent runoff, sediments and other pollutants into the stream channel.

The recent USGS report (Cheng 2014) categorized Kahana Stream as "ephemeral", meaning stream flow is in response to rainfall sufficient to cause runoff. Flow monitoring revealed the stream had zero flow 50% of the time based on seven observations between December 2011 and July 2012. The stream has no diversions.

Figure 4.7 Kahana Stream at Shoreline

4.6.3 Honokahua Stream System

Honokahua Stream was classified a perennial stream with a length of 9.7 miles in the 2008 *Atlas of Hawaiian Watersheds and their Aquatic Resources* (Parham et al.). Mokupe'a Gulch drains land in the Honokahua watershed, meeting Honokahua Stream at the ma kai end near Honokahua Bay. There are no diversions on Honokahua Stream.

Honokahua Stream does not have a desilting basin nor has it had intensive urban development along it lower reaches (Figure 4.8). Pineapple cultivation was limited along Honokahua Stream and the former fields are now the site of the Mahana subdivision project. In general, the upper reaches of Honokahua Stream are less impacted because of topography and limited access.

Figure 4.8 Honokahua Stream Valley at Honokōhau Ditch Siphon

The recent USGS report (Cheng 2014) categorized Honokahua Stream and its tributary Mokupe'a Gulch as ephemeral streams. Both had zero flow at least 50% of the time.

Honokahua Stream enters Honokahua Bay at the north end of DT Flemings Beach Park in a transition area from sandy beach to rocky shoreline (Figures 4.9 and 4.10).

Figure 4.9 Honokahua Stream Mouth

Figure 4.10 Honokahua Stream Waters Entering Ocean Waters

4.6.4 Honolua Stream System

Honolua Stream was defined as perennial, continuous (flowing to the sea year-round) by the 1990 *Hawai'i Stream Assessment*. The stream begins around 3,900 feet elevation in the West Maui Mountains and is 12 miles long (Parham et al. 2008). Several steep waterfalls occur in the first mile below the headwaters and the valley is narrow and steep with a wetted stream width varying between 3 – 27 feet (SWCA 2006 in Chaston 2007). A USGS gauge (station number 16623000) recorded discharge from 1913 to 1917. The gauge measured natural stream flow at 840 feet elevation above a diversion intake downstream at 800 feet elevation.

Honolua Stream does not have a desilting basin nor has it been channelized or altered except for the diversion mechanism. Historically, approximately 3 million gallons of water daily were diverted from Honolua into the Honokōhau Ditch from 1903 to 2004 for agricultural use (CWRM 1990 in Chaston 2007). Maui Land & Pineapple (ML&P) voluntarily ceased using diverted water in 2004. While water continues to go through the diversion intake (a metal grate spanning the entire width of the stream), all water is now returned to the stream 100 feet downstream (Figure 4.11 and Figure 4.12) (Schmidt 2007 in Chaston 2007).

Figure 4.11 Honolua Stream Diversion Intake

Figure 4.12 Honolua Stream Diversion Return

Honolua Stream is estimated to support ma uka to ma kai flow less than 80% of the time (Cheng 2014). The estimated natural median (or 50%) flow duration discharge at Honolua Stream upstream from the intake is 3.8 cubic feet per second. Pāpua Gulch is a tributary of Honolua Stream and is categorized as ephemeral by the recent USGS report (Cheng 2014). Pāpua Gulch was observed to be dry with zero flow at least 50% of the time. Honolua Stream is joined by drainage from Pāpua Gulch before flowing to Honolua Bay.

Figure 4.13 Honolua Stream at Shoreline

Along Honolua Stream the State Land Use is Conservation District. Former pineapple fields on the ridges may have transported sediments into the streams (Section 6.2.7.2). Honolua Stream enters Honolua Bay along the southern edge of the rocky bay (Figure 4.13).

4.6.5 Riparian Vegetation

The streams in the three watersheds are lined with riparian vegetation that changes along a ma uka to ma kai transect. In the ma uka reaches, riparian areas have native vegetation, with the mid to lower elevation riparian sections comprised primarily of introduced species.

In the upper reaches in the Conservation District, the strip of riparian vegetation is often narrow due to the width of the valleys. In the lower reaches of the streams, near the mid to low elevations, the riparian zone is dominated by non-native plants, particularly those species adapted to low water conditions. In places where the water table elevation is near the stream bed and/or surface water is frequently in the channels, the plant composition includes more water demanding species.

Generally, the wetter sections of the stream channels have greater riparian vegetation density and diversity. Sections with high plant density may erode at lower rates than sections with lower plant density and diversity, assuming all other variables are equal.

4.6.6 Stream Summary

Table 4.5 summarizes the stream characteristics of the three watersheds.

Table 4.5 Stream Characteristics

Characteristics	Kahana Stream	Honokahua Stream	Honolua Stream
Stream length	17 miles	9.7 miles	12 miles
Ma uka to Ma kai flow[4]	No flow 50% of the time	No flow 50% of the time	Ma uka to Ma kai less than 80% of the time
Estimated natural median flow duration	-	-	3.8 cubic feet per second
Diversions	None	None	One diversion; since 2004 diverted water has been returned 100 feet downstream. Net diversion = 0

4.6.7 Floodway Issues

The banks of Kahanaiki Gulch and Kahana Stream are Zone A designated flood zones, meaning there is a 1% annual chance of flooding (with no base flood elevations), and a 26% chance that flooding will occur over the duration of 30 years (Figure 4.15). Portions of coastal areas ma kai of Honoapiʻilani Highway near Kahana Beach and Nāpili Bay are designated as regulatory floodways, or areas where encroachments are prohibited to prevent substantially greater flood heights in the event of a 1% annual chance flood (Figure 4.16). Flood plains along Kaʻōpala, Honokeana and Nāpili gulches from the coast up to a mile inland, also fall under this designation. Within a quarter mile from the coast, the stretch from Kahana Point to ʻAlaeloa Point, and areas fronting Hokuanui Point, Hāwea Point, and Oneloa Bay are mapped as AE (Figure 4.14), with a 1% annual chance of flooding with base flood elevations. Residential and resort areas fronting Kaʻea and Kaʻelekiʻi Points and Namalu Bay are at a greater risk for flooding, as they lie within the VE designated flood zone (high risk coastal zone area) (Figure 4.14).

[4] Cheng 2014

In Honokahua and Honolua, the tsunami evacuation zone includes ma kai areas bounded by Lower Honoapiʻilani Road and Honoapiʻilani Highway. Zone A-designated flood zones extend from the coast to inland areas in the flood plains of Honokahua and Honolua streams, no more than one mile from the coast (Figure 4.15). Regulatory floodways are located primarily within the first half mile of Honokahua Stream along the flood plains, and AE (1% annual chance of flooding, with base flood elevations) flood zones are those coastal areas near Makāluapuna Point, along the banks of Honokahua Stream, and Honolua Stream within a quarter mile from the ocean. The high risk coastal area (VE) flood zone in Honokahua is located along Honokahua Bay and at the mouth of Honokahua Stream and Mokupeʻa Gulch. In Honolua, the mouth and flood plain of Honolua Stream is designated as VE. Figures 4.15 and 4.16 depict the region's Flood Insurance Rate Map (FIRM) flood zone classifications, and Figure 4.14provides definitions.

Zone A: Areas with a 1% annual chance of flooding and a 26% chance of flooding over the life of a 30-year mortgage. Since detailed analyses are not performed for such areas; no depths or base flood elevations are shown in these zones.

Zone AE: Areas with a 1% annual chance of flooding and a 26% chance of flooding over the life of a 30-year mortgage. In most cases, base flood elevations derived from detailed analyses are shown at selected intervals within these zones.

Zone B, X: Areas outside the 1% annual chance floodplain, areas of 1% annual chance sheet flow flooding where average depths are less than 1 foot, areas of 1% annual chance stream flooding where the contributing drainage area is less than 1 square mile, or areas protected from the 1% annual chance flood by levees. No Base Flood Elevations or depths are shown within this zone. Insurance purchase is not required in these zones.

Zone D: Areas with possible but undetermined flood hazards. No flood hazard analysis has been conducted. Flood insurance rates are commensurate with the uncertainty of the flood risk.

Zone VE: Area in the 100-year coastal floodplains that have additional hazards associated with storm waves.

Floodway: Area that is the channel of a stream plus adjacent areas that must be kept free of encroachment so that the 1% annual chance of flood can be carried without substantial increases in flood heights.

Figure 4.14 FIRM Flood Zone Designations[5]

[5] FEMA website: http://msc.fema.gov/webapp/wcs/stores/servlet/info?storeId=10001&catalogId=10001&langId=-1&content=floodZones&title=FEMA%20Flood%20Zone%20Designations.

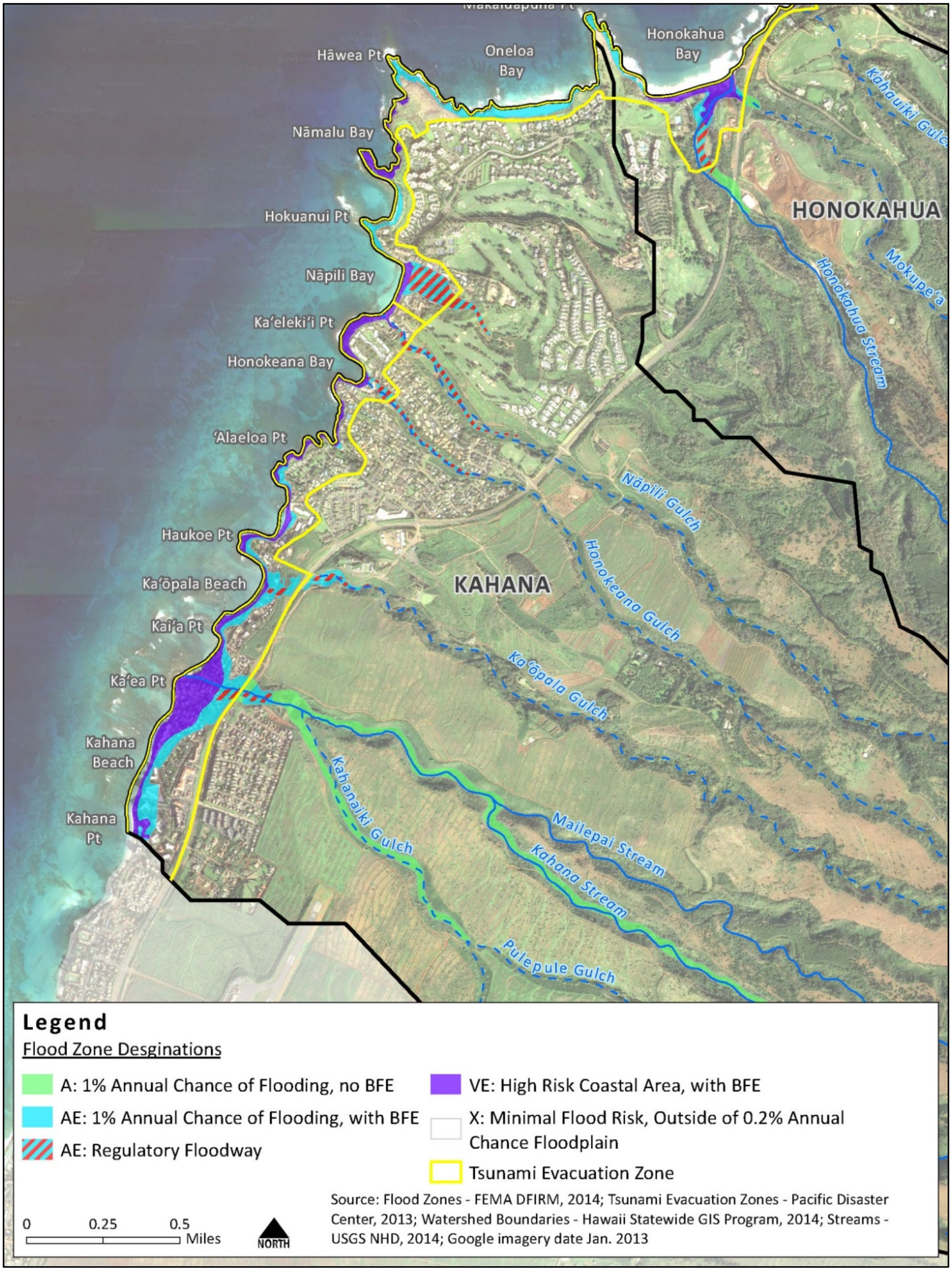


Figure 4.15 Flood Zones – Kahana to Hāwea Point

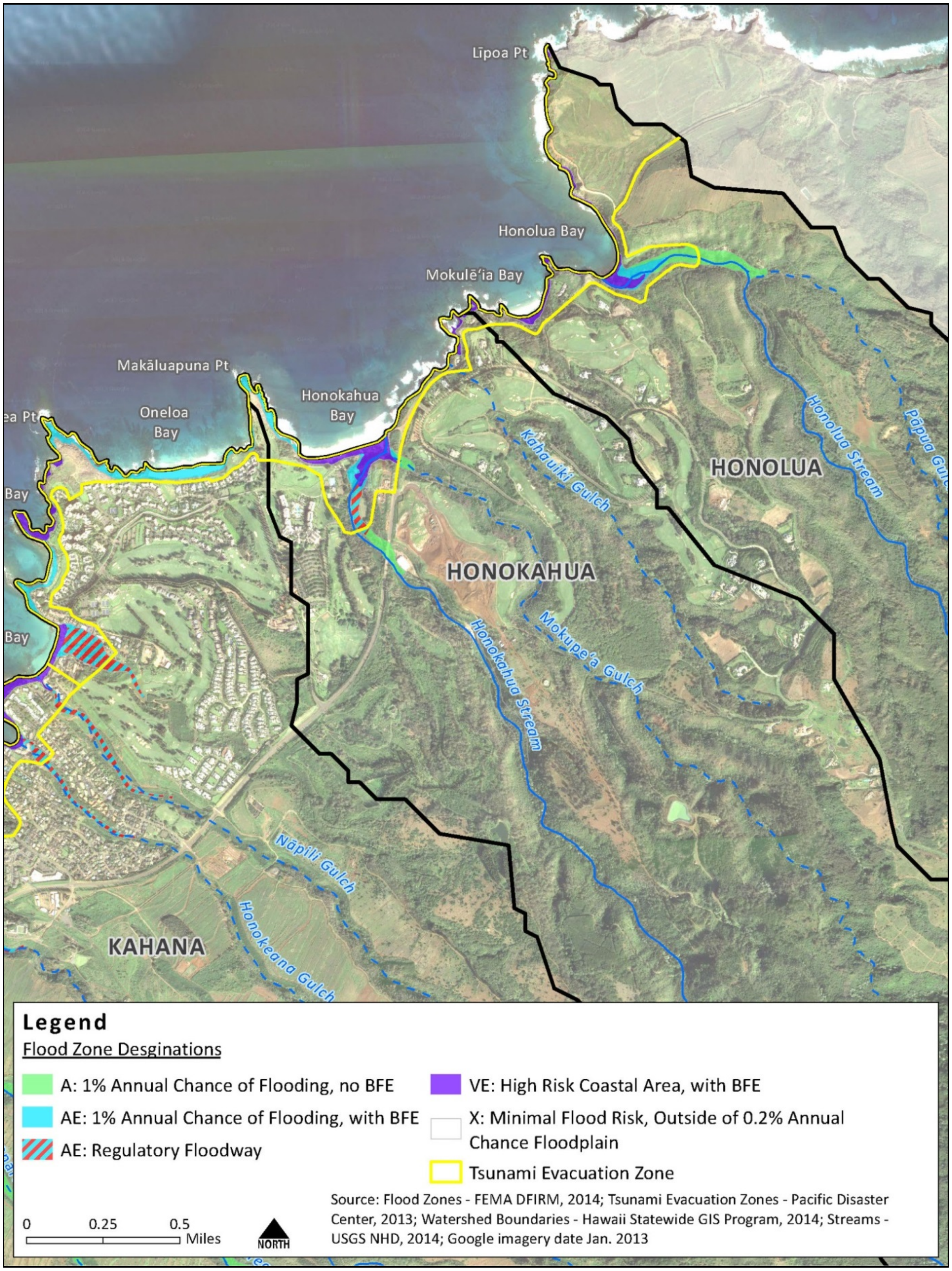


Figure 4.16 Flood Zones – Hāwea Point to Līpoa Point

4.7 Agricultural Lands Hydrology Alterations

Water flow on agricultural lands has changed over time due to built structures. The first structure constructed was Honokōhau/Honolua Ditch, which continues to bring water from Honokōhau Stream north of Honolua to watersheds south of Honokōwai valley. The history and use of this ditch is presented in Section 4.7.1. The second significant alteration to agricultural land hydrology was desilting basin construction within stream and gulch channels to slow water flow and facilitate sediment settling before the water reached nearshore waters. Locations and effectiveness of desilting basins are discussed in Section 4.7.2. Other measures employed to mitigate the impacts of sediments, including sediment basins, are discussed in Section 4.7.3.

4.7.1 Honokōhau/Honolua Irrigation Ditch

Figure 4.17 Honokōhau/Honolua Irrigation Ditch

Honokōhau Ditch was built between 1902 and 1904 to convey water through the West Maui agricultural region and provide irrigation to the crop fields. In 1912, instead of conducting maintenance on deteriorating weirs and flumes, a new ditch, called Honolua Ditch, was constructed parallel to the existing ditch. Honolua Ditch was concrete lined and tunnels replaced wooden flumes (Figures 4.17 and 4.18). Today this ditch is known by both names: Honokōhau/Honolua (Wilcox 1996). Honolua is used for the portion of the ditch on ML&P lands; south of Mahinahina it is referred to as the Honokōhau Ditch (W. Nohara Pers. Comm.) The Honokōhau/Honolua Ditch is aligned perpendicular to the slope of the land and carries water under the force of gravity. Numerous lateral smaller ditches were used to supply water to fields. The ditch brought water to enable cultivation of sugarcane for nearly 80 years.

The primary source of ditch water is the Honokōhau Stream, located in the Honokōhau watershed just north of Honolua watershed. Per the 2004 Agricultural Water Use Plan, a maximum of 34 million gallons per day (mgd) is supplied by Honokōhau. Previously, Honolua stream diversion also supplied water to the ditch; the diversion was halted in 2004.

Today water from the Honokōhau/Honolua Ditch provides water to the Māhinahina Water Treatment Facility (WTF) for potable water by Maui County Department of Water Supply, and supplies nonpotable water used by Kapalua for landscaping and golf course irrigation, Ka'ōpala area agricultural fields and for coffee in the Kā'anapali area (Table 4.6). Excess water is stored in the 140 Reservoir with un-used water being released back into Honokōwai Stream.

Based on observations of the general condition of the ditch, it is not considered a major source of fine sediments to nearshore waters compared to other surfaces in the watersheds.

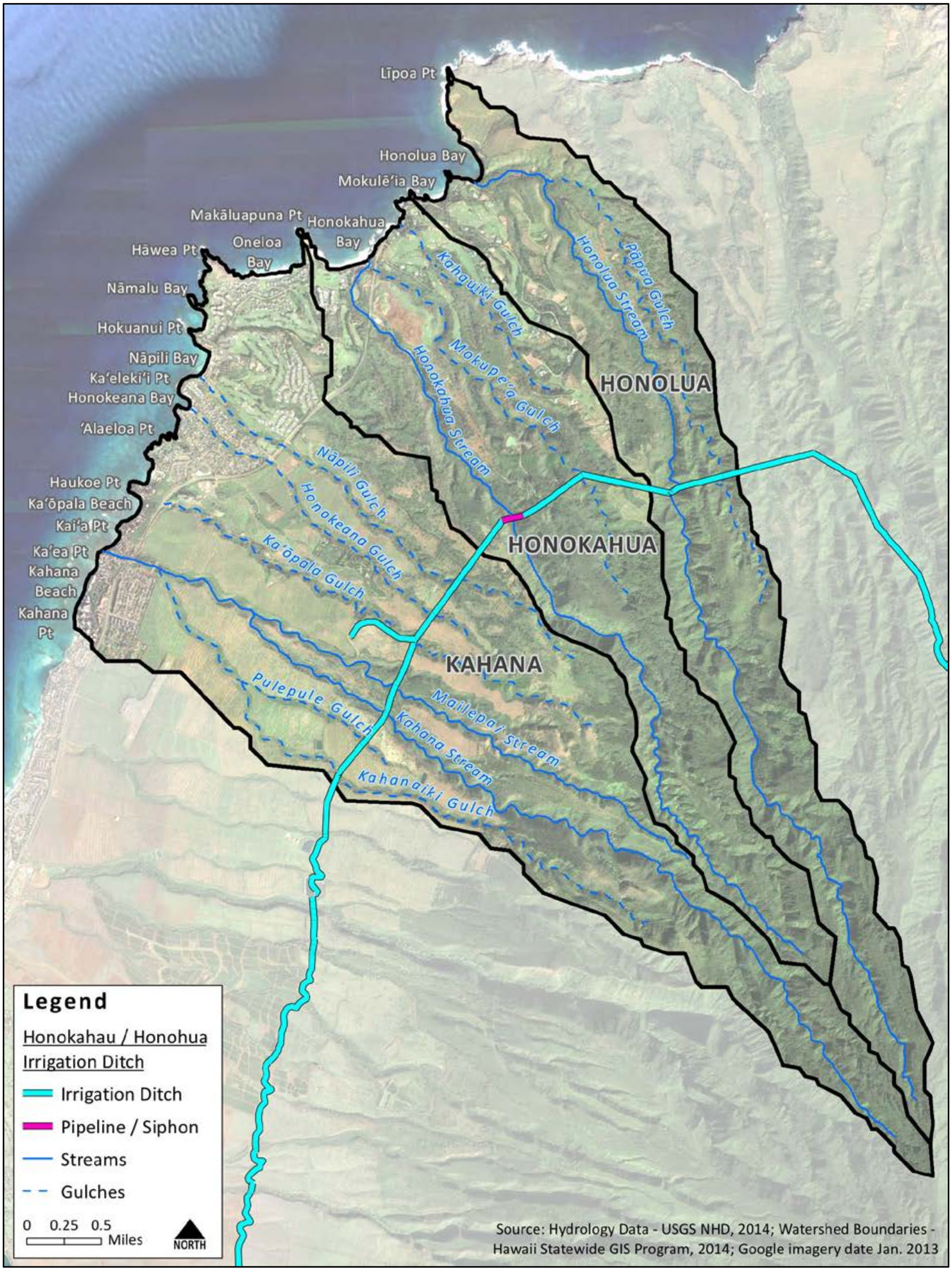


Figure 4.18 Honokōhau/Honolua Irrigation Ditch

The hydrologic alternations of the irrigation ditch system bring additional freshwater into the watersheds which may cause increased fluctuations in salinity than are naturally occur in nearshore waters. Irrigation water can also transport pollutants via surface and ground water flows.

Table 4.6 Honokōhau/Honolua Irrigation Ditch in Honolua, Honokahua and Honolua

Gage #	Use	2009	2010	2011	2012	4-Year Average
39	Kapalua Water Irrigation	1.092	1.139	1.263	1.103	1.147
40	Troon (Golf)	1.093	1.049	0.827	0.846	0.957
41	Agricultural Irrigation	0.115	0.156	0.305	0.443	0.251
	TOTAL	**2.300**	**2.345**	**2.394**	**2.393**	**2.355**

Source: CWRM from Maui Land and Pineapple reporting; all units are million gallons per day (mgd)

4.7.2 Kahana Watershed Dams and Desilting Basins

In the late 1980s and early 1990s, government agencies and landowners (primarily ML&P) constructed five dams and desilting basins in Kahana watershed in response to algal blooms and large pulses of sediment laden stream and gulch flows into ocean waters. The desilting basins were designed by NRCS with Public Law 83-566 funding.[6] All were constructed within the channel of streams and gulches (Figure 4.19).

The desilting basin designs detain water and allow suspended sediments to settle out before water reaches the ocean. Some basin designs included a mechanism for adjusting water height behind the dam before flowing over a spillway to the ocean. Each basin design also had an emergency spillway to prevent a build-up of water behind the dam that might pose a threat to people and property.

A US Soil Conservation Service Honolua Watershed Study (1976) for the Kahana watershed assessed potential environmental impacts of desilting basins and floodwater diversion to "reduce annual floodwater, erosion, and sediment damages; improve the quality of coastal waters; reduce damage to marine habitat; improve social and economic conditions; and reduce risk of loss of life." While NRCS designed dams and associated desilting basins were intended to capture sediments carried in runoff, they were constructed primarily for economic and safety reasons (flood control), and environmental benefits were considered secondary benefits. No desilting basins were designed for Honokahua or Honolua watersheds as financial returns were based on risk of property damages did not meet the criteria at that time. Smaller sediment basins were later constructed in those watersheds (Section 4.7.4).

The five desilting basins continue to be operated and maintained by the County of Maui. The County's role is critical to continued functionality of the dams and basins. Without removal of basin sediments, the basins would contribute to sediment loading in nearshore waters. Maintenance of the basins also includes mowing grass on the dam/embankment and spillway, and assuring functionality of adjustable valves, where used. Improvements to dam and desilting basin functioning may help to reduce sediments being transported out into nearshore waters.

[6] PL-83-566, along with PL 78-534, is the USDA's nationwide Small Watershed Program, which "assists local organization in conducting watershed surveys and investigations, and in planning and installing structural and land treatment measures for watershed protection and flood prevention".

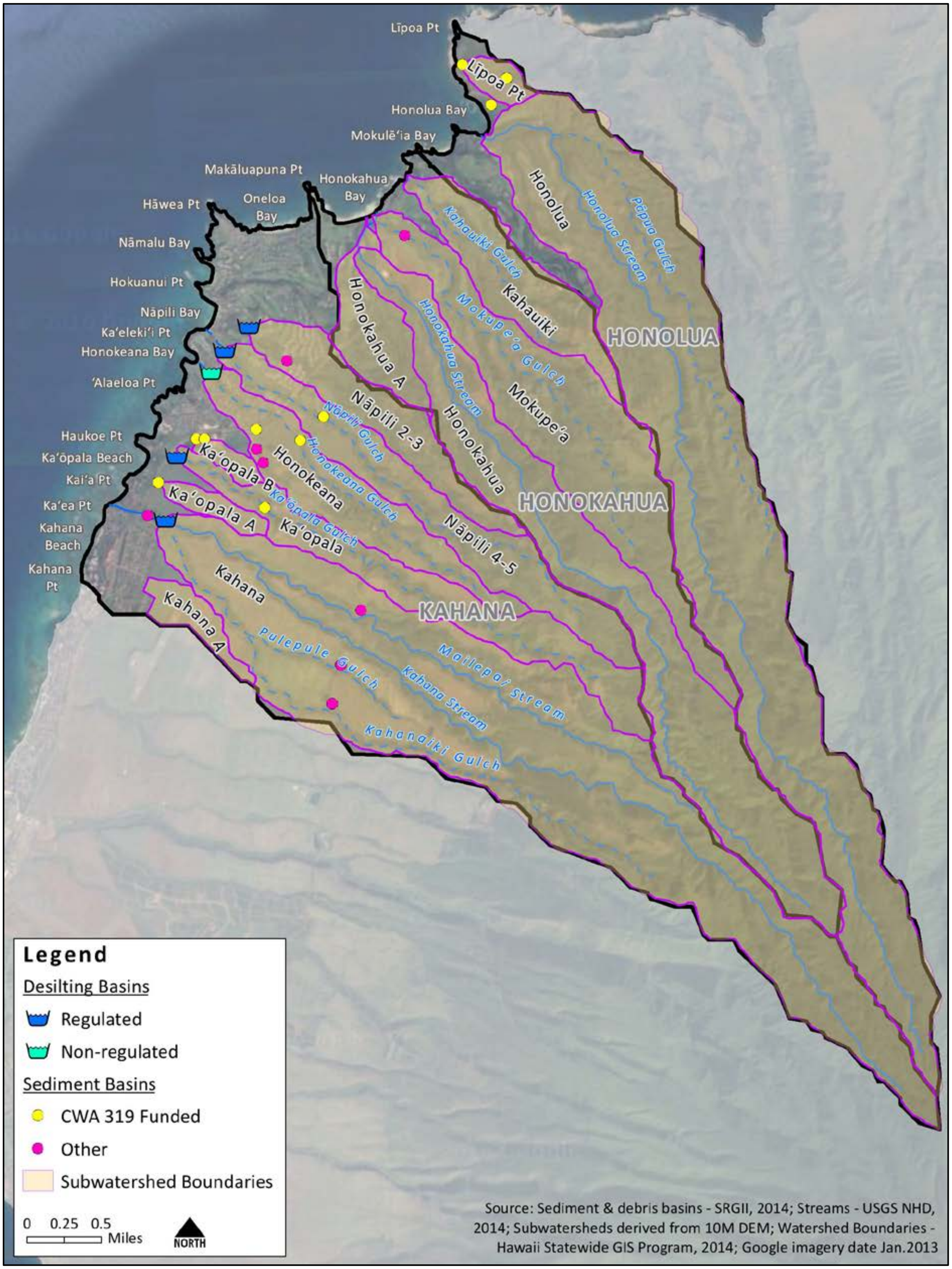


Figure 4.19 Debris and Sediment Basins

4.7.2.1 Kahana Nui Desilting Basin

Kahana Nui desilting basin within the Kahana Stream channel captures a drainage area of nearly five square miles. The basin is considered undersized for the drainage area. Constructed in 1984, it has a 50 feet high earthen dam which is State-regulated and a maximum storage capacity of 73 million gallons. The basin outlet consists of a concrete structure with ports for trapping coarse debris (Figure 4.20). An emergency spillway south of the dam conveys water from high flow storm events to prevent overtopping of the earthen dam structure. It is on the State list of regulated dams through the DLNR Dam Safety Program.

Buried outlet pipes have prevented complete drying of the basin, which in turn prevents equipment from being able to remove sediments and results in significantly decreased retention volume. The County of Maui Department of Public Works Highways Division is planning to attempt to locate the control structure to allow for sediment removal. The capacity of this basin to capture sediments and prevent them from being transported into nearshore waters will diminish over time unless sediment removal maintenance can be conducted.

Figure 4.20 Kahana Dam & Basin Aerial and Kahana Intake

4.7.2.2 Kaʻōpala Desilting Basin

Kaʻōpala Desilting Basin, constructed in 1997, is located within Kaʻōpala Gulch, ma uka of the highway (Figure 4.21 and 4.22). It is on the State list of regulated dams through the DLNR Dam Safety Program. This basin is undersized and is constrained by site topography.

Sediment size sampling of Kaʻōpala Desilting Basin (done for the *Engineering Analysis and Development of Retrofit Designs for Sediment Retention for the Honokowai Structure #8* in 2014 draft) showed a relatively high percentage of gravel (23%), sand (57%) and much smaller amounts of silt and clay (20%). The composition may reflect gravel contributions from ridge activities or perhaps only the large sediments are settling out of the water. John Stock observed in July 2014 a sediment plume where Kaʻōpala Gulch storm water entered nearshore waters (Stock 2014).

Figure 4.21 Kaʻōpala Desilting Basin

Figure 4.22 Kaʻōpala Desilting Basin Spillway Downstream Channel and Culverts

4.7.2.3 Honokeana Desilting Basin

Honokeana Desilting Basin is an impoundment constructed in 1997 and is maintained by Maui County (Figure 4.23). It is not regulated by the DLNR Dam Safety Program. Below the outlet, water is causing erosion adjacent to Lower Honoapiʻilani Road. This basin has acceptable functioning to reduce sediment transport to nearshore waters as it is appropriately sized for the drainage area.

Figure 4.23 Honokeana Desilting Basin

4.7.2.4 Nāpili 4-5 Desilting Basin

Nāpili 4-5 impoundment is regulated under the DLNR Dam Safety Program. Constructed in 1985, the original dam control valve was not able to be located. A new valve was installed with funding from the Nāpili Bay and Beach Foundation, and functionality has been restored (Figure 4.24). During small storm events the valve can be set to allow longer retention time, which allows more sediment to settle out of the water column and prevent sediments from being discharged into nearshore waters. During larger storm events the valve can be adjusted and water can pass through. Nāpili Bay and Beach Foundation funded the 2010 Preliminary Drainage Report. In addition to the valve replacement, the study recommended increasing basin capacity by excavating a portion of the basin. The less costly alternative of replacing the valve has been successful, and there are no plans to proceed with the excavation. In 2013 Maui County removed 188 cubic yards of sediment from the basin as routine maintenance. The Nāpili 4-5 dam is being considered for removal from the State Dam Safety Program because of its size.

Figure 4.24 Nearly Completed Nāpili 4-5 Dam Outlet Valve

4.7.2.5 Nāpili 2-3 Desilting Basin and Channel

Nāpili 2-3 Desilting Basin was constructed in 1988 and is now a water feature of Kapalua Bay Golf Course (Figure 4.25 and 4.26). This dam is regulated as part of DLNR Dam Safety Program. It currently has lower storage than the original design capacity and is undersized for the drainage basin.

Figure 4.25 Nāpili 2-3 Desilting Basin

Figure 4.26 Nāpili 2-3 Crest and Spillway Channel

4.7.3 Kahana Watershed Desilting Basins Efficacy

The ability of the desilting basins to settle out sediments varies based on several factors. One is the size of the contributing subwatershed basin drainage area. Another factor is the amount of water passing through the drainage area which varies with the intensity and duration of rainfall events. The more water the basin can hold, the more effective the basin is at trapping sediments. In most cases, ample area existed for appropriately sized desilting basins. In other cases, such as Kaʻōpala Basin, the topography of the drainage area limits the debris basin size.

Adjustable outlet valves were a part of the Kahana and Nāpili 4-5 designs to allow water from smaller storm events to be retained longer than from a large storm event when it is desirable to open valves and allow water to flow out. As discussed, that functionality has been restored for Nāpili 4-5 Dam and is lacking for the Kahana Dam.

The assessment for this report does not provide a quantitative analysis on the amount and size of sediments retained by the basin. Fine sediments can remain suspended longer than larger sediments, requiring significant time to settle. For rainfall events that generate runoff volumes greater than the holding capacity, desilting basins allow sediments to pass through to nearshore waters without retaining suspended sediments.

The Woodward and Clyde 1996 study noted that the basins (Kahana, Nāpili 4-5, and Nāpili 2-3 in existence at the time of the study) were most effective during low flow conditions and storm events smaller than the 2-year storm.

Three of the basins are regulated under the State of Hawaiʻi's Dam Safety Act (Hawaiʻi Revised Statutes 179) (Table 4.7). Nāpili 4-5 is planned for removal from the State list of regulated dams. While modifications to regulated dams are allowable, changes require extensive amounts of design, review and permitting. Regulated dams are also costly to operate as they require periodic extensive inspections.

Table 4.7 Desilting Basin Characteristics and Assessment Summary

	Kahana Watershed Subwatershed Desilting Basins				
Characteristics /Assessment	**Kahana**	**Kaʻōpala**	**Honokeana**	**Nāpili 4-5**	**Nāpili 2-3**
Subwatershed Area (acres)	2,830	550	480	600	293
Basin design capacity (Normal/Max in MG)	19/73	-/13	-/-	-/8	6/19
Top of Dam (feet msl)	77	69.1	30.5	41.4	74.7
Spillway Crest Elevation (feet msl)	58.2	56	28	41.4	61
Height of Dam (feet)	50	30	5	17	40
Storage Capacity at Spillway (MG)	59	15	10.6	25	17
State Regulated Dam under HRS 179, Dam Safety Act	Yes	Yes	No	Yes	Yes
Assessment	Undersized	Undersized	Acceptable	Acceptable	Undersized

4.7.4 Sediment Basins & Past Erosion Control Measures

Sediment basins (also called silt catchment basins) are smaller, simpler basin designs than desilting basins. Sediment basins rely on a small embankment to impound water and induce settling of suspended sediments before the water flows toward and into the ocean. Figure 4.19 includes locations of known sediment basins in the Agricultural District. Some sediment basins are in series with a large desilting basin, such as those upslope of Kahana dam. Others basins are located on drainages without desilting basins. Some of the sediment basins were funded by individual landowners, and others were constructed using Clean Water Act (CWA) Section 319 funds.

In addition to sediment basins, various measures were implemented to reduce erosion of pineapple fields and sedimentation in waterways. In response to the algal blooms that occurred in in 1989 and 1999, CWA 319 funds between 1994 and 1996, were used for measures that included field layout changes, construction of infield and grass terraces, and road improvements. In Honolua between 1997 and 1999, CWA Section 319 funds for projects included reconstruction of field terraces, road and gulch drainage improvements, field drainage improvements, plastic mulch catchment fence at two fields, revegetation of 17 acres of "badlands", and formation of three silt catchment basins. The purpose of these improvements was to decrease runoff transported in Honolua Stream and discharged into the Bay. Between 2000 and 2003, another 319 project added a culvert crossing at Kahana Basin and an improved drainage pattern in Field 23. The purpose of these measures was to reduce further degradation of nearshore coastal waters. Wes Nohara (Pers. Comm.) noted that cumulatively the various measures did provide a significant sediment reduction during active pineapple cultivation period, and he recalled an NRCS estimate that the various measures had reduced sediment by 68% into coastal waters. The amount of sediment reduced by each measure is not known for these projects.

The current condition and effectiveness of sediment basins varies. There are indicators of sediment movement out of basins to downstream waters. The sediment basins on ML&P lands are periodically assessed for maintenance needs, and removal of sediments is contracted out (P. Kaniaupio-Crozier Pers. Comm.). With vegetation covering most of the field areas, less soil erosion is occurring than during the plantation era and means less sediment basin maintenance. For some basins vegetation reclamation may be appropriate.

4.8 Ground Water

Ground water is water found in underground layers of rock or sediment, referred to as an aquifer. An aquifer is roughly defined as an area in which the spaces (voids) are filled with water. The water table is the upper level of water in an aquifer. Similar to surface water, water in an aquifer flows under the force of gravity. The flow rate of water through an aquifer is a function of the elevation head (or slope) of the water table, the hydraulic conductivity of the substrate it encounters, the cross section of the area it flows through, and the viscosity of the water. In general flow rates through dense material are slower compared to flow through loosely packed materials if all other variables are the same. Water in aquifers can either be fresh, salt or brackish.

From the geologic formation of West Maui, there are numerous dikes near the caldera and within the rift zones at higher altitudes. These low permeability dikes can impound ground water levels to as high as 3,000 feet above sea level (Sterns and Macdonald 1942 in Cheng 2014). Gingerich and Engott (2012) estimated the extent of dike-impounded water body in West Maui from dikes exposed in valley wall, tunnels, water levels in wells, and streamflow.

The watershed aquifers are separated into four types (Figure 4.27).

- High Level, Unconfined, Dike
- Basal, Unconfined, Flank
- Basal Unconfined, Flank/Dike
- Basal, Unconfined, Sedimentary

The State has a ground water Status Code that is assigned to each aquifer type. The five-digit Status Code describes the aquifers with respect to: development stage, utility, salinity, uniqueness and vulnerability to contamination. The code categories are based on Environmental Protection Agency directives and were developed so that ground water resources would receive protection from adverse impacts.

- Flank and Flank/Dike aquifer is classified (11111):
  Currently used, Drinking, Fresh, Irreplaceable, and High.
- Dike aquifer is classified (21111):
  Potential Use, Drinking, Fresh, Irreplaceable, and High.
- Sedimentary aquifer is coded (33421):
  No potential use, No utility, High salinity, Replaceable, and High.

4.8.1 High Level, Unconfined, Dike Aquifer

The High Level (2), Unconfined (1), Dike (2) Aquifer is located beneath land surface from top of watersheds down to the lower boundary of the State Conservation Land District in Kahana and Honokahua watersheds (Figure 4.27). High Level means the water is fresh and does not contact seawater. Unconfined means the top of the water table in the aquifer is the upper surface.

Dike means that the water is held in dike compartments which are similar to boxes filled with water. The compartment sides are dense rock aligned in a mostly vertical pattern. Dikes fill up as water percolates down into the box, and drain out when the box fills, or through leaks in the sides or bottom. The high level aquifers occur in the high rainfall zones (greater than 90 inches mean annual rainfall), and function as mountain reservoirs. The outflow and leakage of water from dikes during periods without rain sustains the flow of water in the upper reaches of the streams, and is a significant hydrogeologic feature of the watersheds.

4.8.2 Basal, Unconfined, Flank Aquifer

The Basal (1), Unconfined (1), Flank (1) Aquifer is located beneath the watersheds from the dike aquifers to the coastline, except where there are sedimentary aquifers in Kahana and along Honolua Stream (Figure 4.27). Basal water is a fresh water layer in contact with seawater. The freshwater in the aquifer is buoyed above the deeper saltwater layer because fresh water is less dense than saltwater. A brackish water zone of varying thickness is usually located between the fresh and salt water layers. In basal aquifers the water table can vary spatially, as can the flow rate of water through the aquifer. Unconfined means that water percolating through soils can recharge the aquifer.

Water from this aquifer may also carry pollutants that can contaminate and degrade the water quality of the aquifer. Due to the slow rate of water movement through basal aquifers, once a contaminant has been introduced it can reside in, and impair aquifer water quality, for a significant amount of time.

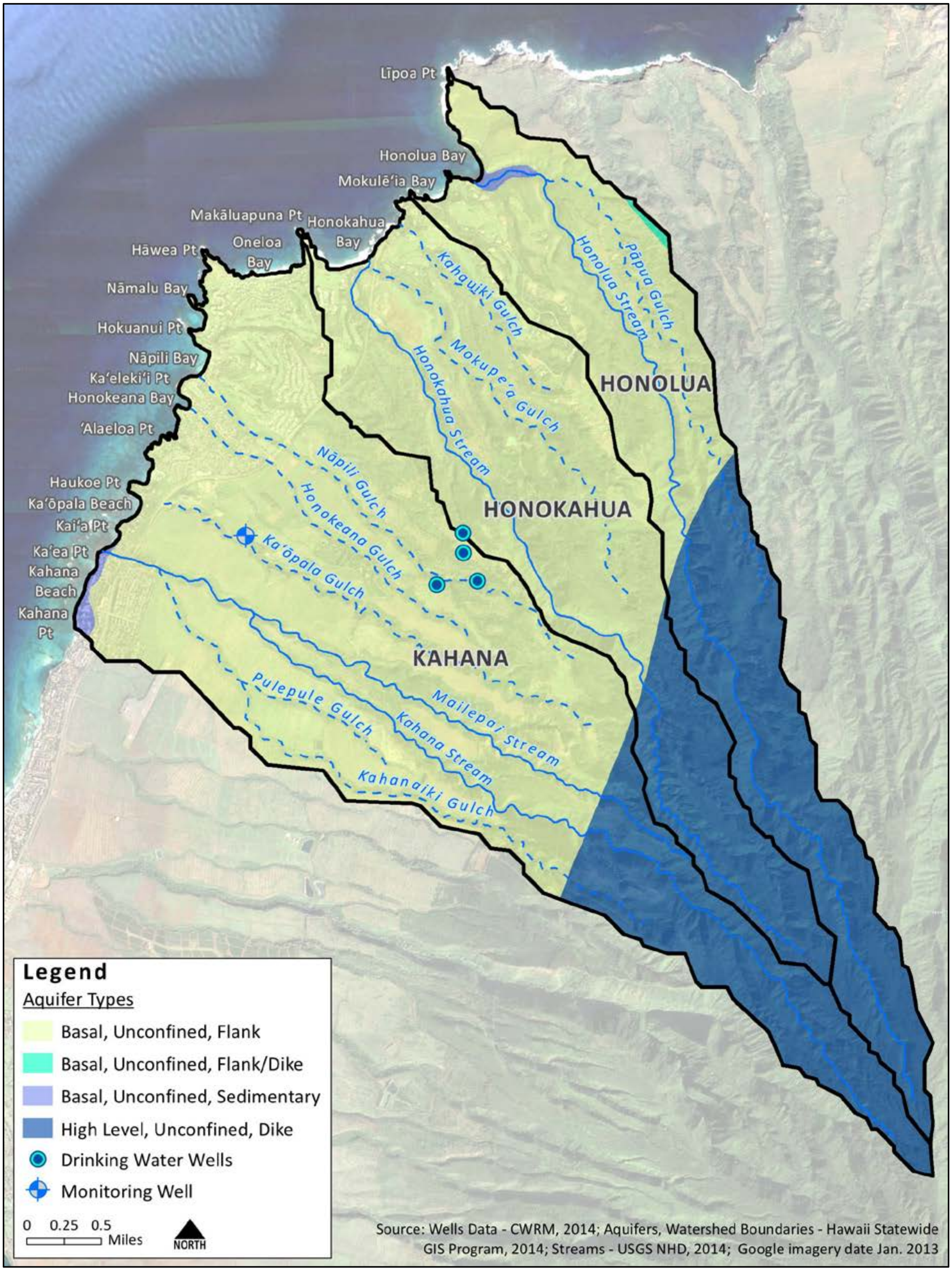


Figure 4.27 Aquifers

The geological descriptor 'flank' refers to lavas that are horizontally aligned. In an idealized setting, lavas comprising the flank would be tilted in the same direction, and with the same slope, as the ground surface. Water percolating into the ground may flow vertically for some distance and encounter a less porous lava layer, causing the water to change direction and flow along the top of the layer. Understanding and quantifying ground water quality and the magnitude and direction of its flow is challenging. The fact that the flow can vary in three spatial dimensions, and is subjected to complex biogeochemical processes that alter its quality, is the primary reason for this complexity.

4.8.3 Basal, Unconfined, Flank/Dike Aquifer

The Basal (1), Unconfined (1), Flank/Dike Aquifer (1/2) includes additional variability in ground water flow as it can have both dike and flank formations. Figure 4.27 shows a very small portion of this aquifer along the north boundary of Honolua Watershed.

4.8.4 Basal, Unconfined, Sedimentary Aquifer

The Basal (1), Unconfined (1), Sedimentary (6) Aquifer is located beneath the watersheds in Kahana along the shoreline and in the lowest reaches of Honolua Stream to the shoreline (Figure 4.26). The water in this aquifer differs from the others primarily in that ground water is contained in sediments. The aquifer is comprised of terrestrial sediments, carried by surface water from land and deposited along the flat coastal zone, and calcareous sediments from coral reefs deposited by ocean waves. The water table in this aquifer varies as well, and its depth below the ground surface is small due to the low elevation of the ground surface. Similar to the flank aquifer, the issue of contamination carried in percolating water is of concern.

4.8.5 Ground Water Supply

Two intertwined services provide potable water from a ground water sources to the Kahana – Kapalua areas. The County of Maui Department of Water Supply utilizes water from Nāpili and Honokahua wells within the watersheds. Hawai'i Water Service Company, a subsidiary of a private investor-owned water utility, acquired Kā'anapali Water Corporation in 2004. As of September 2014, this water utility provides 700 service connections for potable water to hotels, resorts, and private entities. A third water service, the private Kapalua Water Company, provides potable water to Kapalua Resort.

The volume of water discharging along the coast in seeps and springs and offshore as submarine ground water has not been quantified. However, it is generally thought that annual ground water fluxes from beneath the three watersheds to the ocean are small when compared to volumes of water delivered via surface water flows (Soicher and Peterson 1996). Ground water is discharged more consistently and uniformly along the coast and may impose less stress on corals than the variable surface water flow into nearshore waters.

A 2011 USGS study titled *Groundwater Availability in the Lahaina District* assessed several scenarios for future ground water withdrawals due to high existing levels of salinity for selected wells and long term concerns about sustainability of withdrawals from the greater Lahaina area (Ukumehame to Honokōhau). The study found that projected withdrawal could results in salinity in excess of recommended drinking water standards. For the Nāpili and Honokahua wells, the models show threat of increased salinity under full build-out conditions and during drought, although salinity conditions caused by drought could be reversed with increased rainfall.

4.8.6 Water Providers

As noted in 4.8.5, potable water is mainly provided with ground water. The County of Maui Department of Water Supply operates the Māhinahina Water Treatment Facility (WTF) located within Honokōwai Watershed. The WTF utilizes water from Honokōhau/Honolua Ditch which is treated and disinfected by chlorination. The treated surface water and ground water are supplied to Kahana and Nāpili areas.[7] For the Kapalua Resort, Kapalua Water Company provides non-potable water for golf course and ground irrigation from the Honokōhau/Honolua Ditch, in addition to potable water for resort consumption.

4.8.7 Ground Water Quality

Three pesticide contaminants have been identified at detectable levels in the drinking water wells show in Figure 4.27 including 1,2,3-Trichloropropane, Ethylene Dibromide and 1,2-Dibromo-3-Chloropropane, the latter of which had one exceedance of the Hawai'i Administrative Rules standard (5.1.3.1).

4.9 Impacts of Land Use on Watershed Hydrology

Historical and current land uses are discussed in Chapters 2 and 3. Here, land uses that have change hydrology are highlighted. Several of the factors that affect the movement of water are described in this Chapter and summarized below.

4.9.1 Impacts to Conservation Areas on Watershed Hydrology

Most of the Conservation District lands lie in elevation zones above 1,500 feet where rainfall averages above 100 inches annually. Protecting these areas is important for maintaining and restoring native ecosystems and sustaining water resources that are a source of water for developed lands. The West Maui mountain uplands are among the highest groundwater recharge areas for the island, in average climate conditions (USGS 2014). Human activities such as dirt bike riding and illegal trespassing, and feral ungulate activity, have contributed to destruction of vegetation, exposure and erosion of soils, and compaction that reduces water infiltration rates.

Non-native vegetation invades disturbed areas, often forming monotypic stands. It is surmised that non-native trees have higher water demands than native tree species, though research comparing water use by native to non-native vegetation and evapotranspiration rates has not yielded conclusive results. The 2014 *Evapotranspiration of Hawai'i, Final Report* by University of Hawai'i's Department of Geography, states that species have noticeable effect on the evapotranspiration (*ET*) pattern, with an example of Strawberry guava (*Psidium cattleianum*) having a relatively high rate of *ET* in comparison with native trees (Giambelluca et al. 2014).

Results of a 2014 U.S. Geologic Survey study on Maui groundwater recharge indicate precipitation is a critical dataset for estimating recharge. Hydrological processes simulated in the water-budget model used for the study include rainfall, fog interception, irrigation, runoff, and *ET*. Further *ET* measurements for different types of dominant alien and native plants are recommended to develop coefficients for more specific land-cover types (USGS 2014).

[7] Information from http://www.co.maui.hi.us/index.aspx?nid=571

Axis deer (*Axis axis*), a non-native species originally from Asia and introduced to Maui in 1959, are migrating from the forests of East Maui into areas of West Maui. There has been an increase in the number of deer observed in watersheds to the south. Similar to pigs, deer alter ecology and generally degrade native vegetation communities. The cumulative damages to soils from ungulates and monotypic stands of non-native vegetation reduce the ability of forests to efficiently recapture freshwater and recharge ground water aquifers. This damage also results in increased runoff and soil erosion which can increase sediment transported downstream and into nearshore waters.

4.9.2 Impacts of Agriculture on Watershed Hydrology

Agriculture changed watershed hydrology with construction of ditch systems that transported water across watersheds and with construction of agricultural field terraces and roads. Development of silting basins and other measures to reduce sediments and nutrients into nearshore waters further altered hydrology across agricultural lands and affected streams. Changes in groundcover – initially cyclical growth, harvest, and field treatments for crops – and more current expansion of non-native plants across fallow agricultural fields alters infiltration and run-off rates. The resulting increased runoff can bring increased amounts of sediment into streams, gulches and nearshore waters.

4.9.3 Impacts of Urbanization on Watershed Hydrology

Prior to urbanization coastal lowlands in the three watersheds were covered with coastal vegetation, wetlands, and sand dunes that served as flood plain filters and attenuated storm flows. Today, the coastal urbanized and impervious surfaces generate runoff in larger volumes. More than 21% of the Urban District is covered by impervious surfaces (e.g., paved roads, parking lots and roofs).

Grading for new residential and commercial developments and solar farms are altering hydrology in the Urban and Agricultural Districts. The exposed soils, sometimes on steep slopes have increased the runoff over bare ground and increased soil erosion.

The Urban District is serviced by a storm sewer system separate from the sanitary sewer, fitted with inlets and drainage pipes with outfalls that discharge storm water runoff either directly into the ocean or inland into streams and gulches. The separate storm sewer system is designed to collect and rapidly move storm water off the land. Impervious surfaces and a separate storm sewer system increase the magnitude and frequency of storm water runoff and pollutants carried in it. Little has been done to reduce or treat pollutants along the urbanized coastline.

4.10 Coral Reef Ecosystem

4.10.1 Coral Coverage and Benthic Habitat

Available coral coverage data from the National Oceanic and Atmospheric Administration (NOAA) National Ocean Service Biogeography Branch (2007) are shown in Figures 4.28 and 4.29. Using a protocol developed by Monaco, et al 2001, LIDAR (Light Detection and Ranging) data were used to map the coastal habitats and coral coverage. The data is derived entirely from remote sensing imagery and has limited ground truthing.

The coral coverage data is provided in three classifications: 10-<50%, 50%-<90%, and 90-100% coral coverage. No areas offshore of the three watersheds have coverage in the 90-100% classification. Coral coverage is the greatest in Kapalua and Honolua Bays (Figures 4.28 and 4.29).

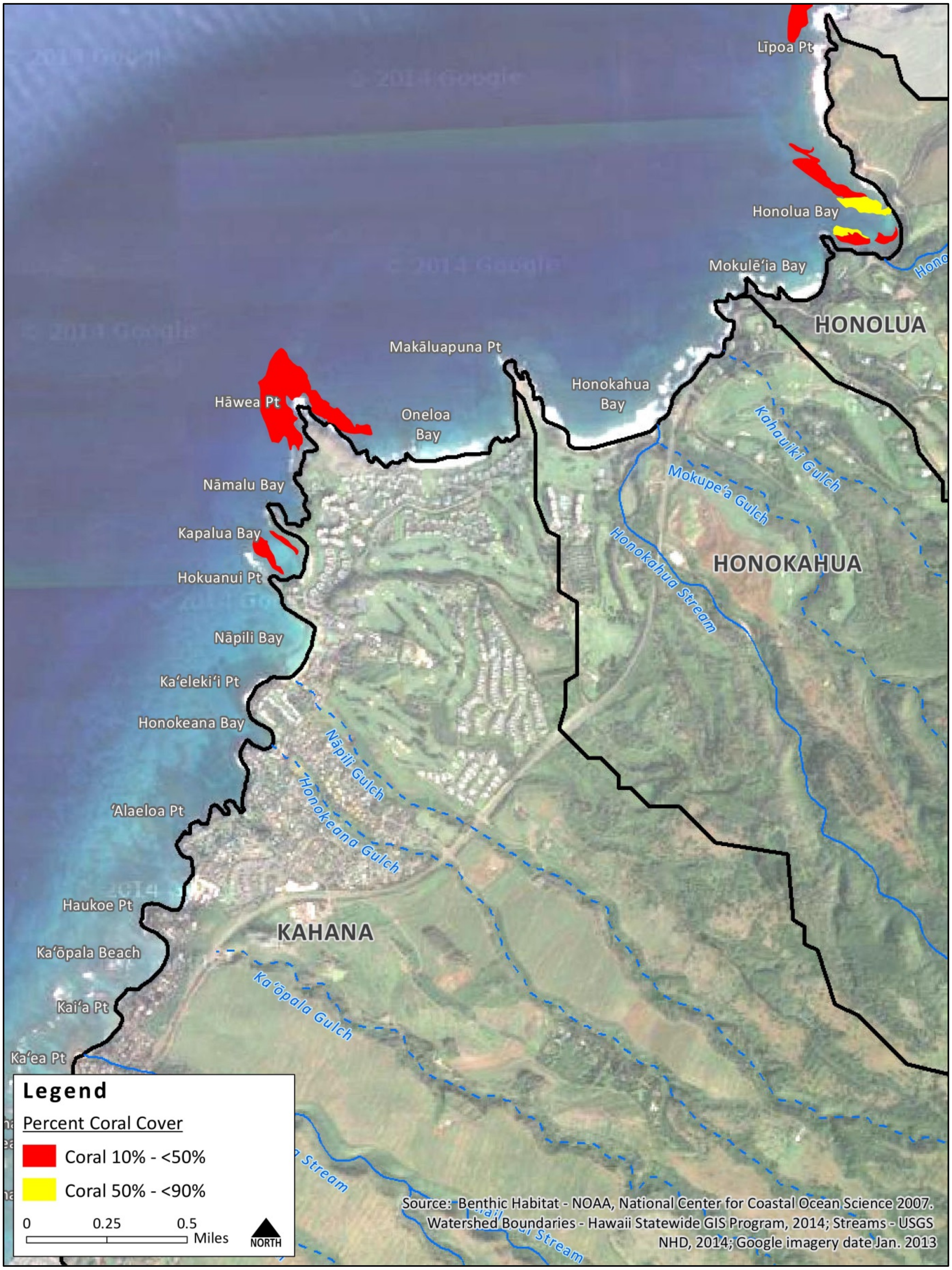


Figure 4.28 Coral Coverage

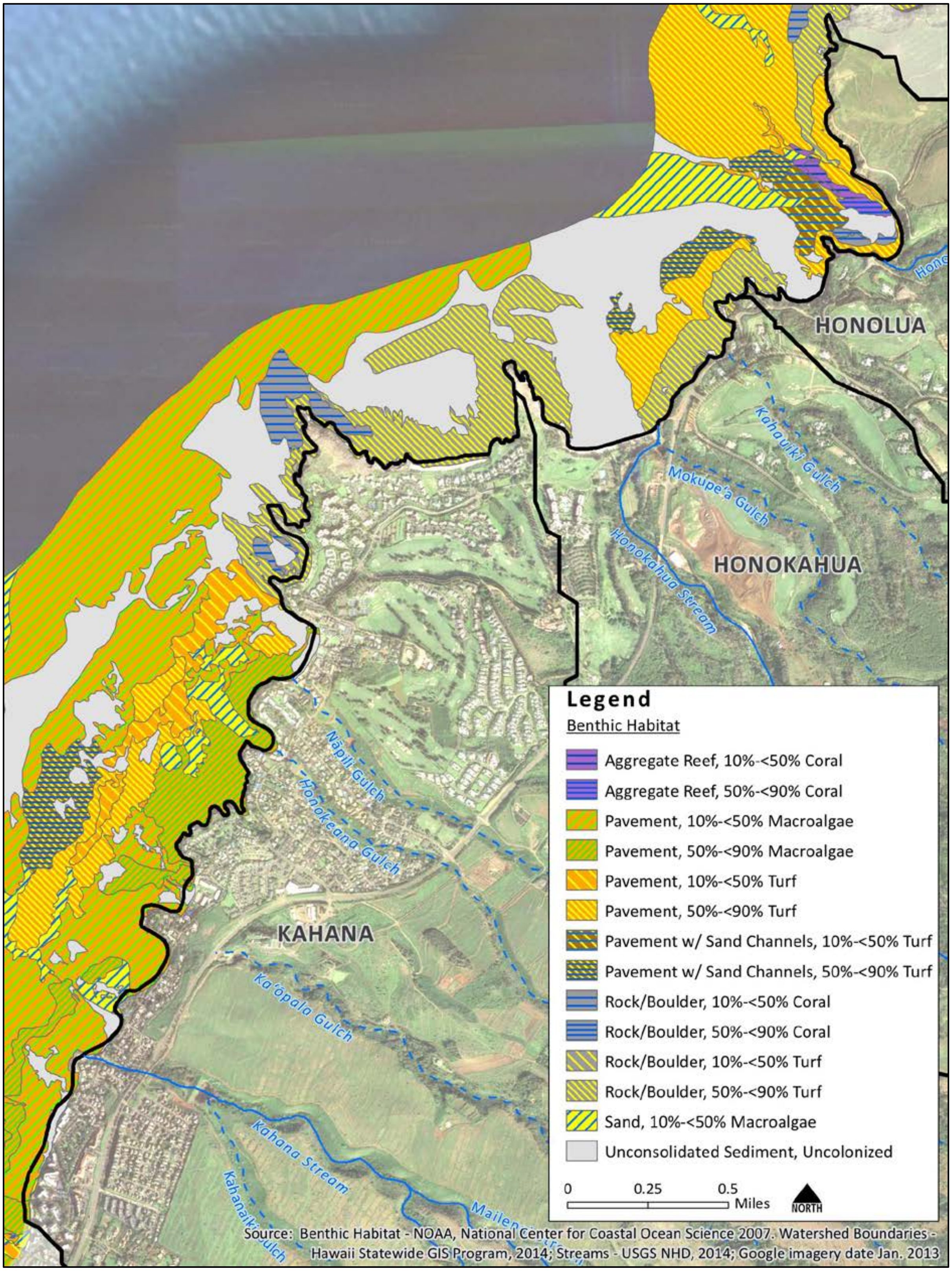


Figure 4.29 Benthic Habitat and Coral Coverage

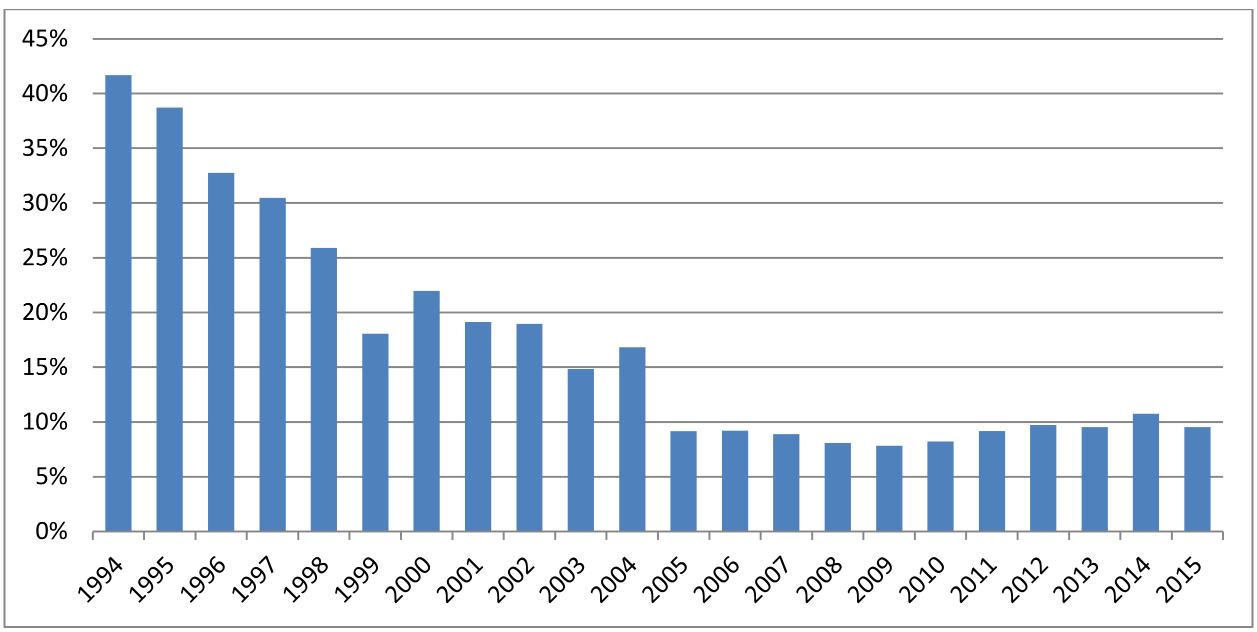
The coral in Honolua Bay is found on both the north and south sides of the bay, and only Honolua Bay has coral coverage in the 50-<90% class, which totals approximately 4.8 acres. Kapalua Bay has coral coverage of 10-<50% on the north and south sides of the bay.

Available ground truthed coral cover data directly contradicts some estimates provided in the NOAA maps. For example, coral cover in Honolua was in the 40% range, but is now mostly below 10%. While coral cover may be higher on reef slopes as they drop down towards the center of the bay, coral cover on both the south and north are down to 10% or less. The NOAA data also overestimates coral coverage in the 10-<50% classification around Hāwea and Līpoa Points. Most likely this is due to remote sensing imagery interpretation.

The one-acre unit data resolution does not capture smaller coral patches and habitat variations. For example, Nāpili Bay has small areas coral that are not captured by the NOAA 2007 data. However, the NOAA data is the most complete set of available coral coverage data for the three watersheds. Ground truthing and further study are needed for a more accurate assessment of coral coverage, and NOAA has plans to acquire the needed data.

4.10.2 Coral Reef Decline

Coral reefs in West and South Maui have been monitored yearly since 1994 (DAR 2006).[8] The combined data from the two Honolua Bay monitoring sites shows a decrease from 42 percent to 10 percent cover by 2013 (Figure 4.30). Given the strong possibility that the sites were already somewhat degraded when monitoring began, recent trends almost certainly underestimate declines over longer timeframes (DAR 2006).



Source: NOAA compilation of data collected by the Hawai'i State Department of Land and Natural Resources Division of Aquatic Resources

Figure 4.30 Honolua Bay Coral Cover

[8] The Pacific Whale Foundation began monitoring in 1994. DLNR-DAR in partnership with CRAMP began annual surveys in 1999.

Heavy rainfall in January of 2005 produced a large sediment plume in Honolua Bay and a nearly 50% decline in coral cover on the south sides of the bay was documented (DAR 2010). DAR report also notes that the Honolua Bay site declines are so severe that the reef "may have experienced a total coral reef ecosystem collapse."

Honolua Bay monitoring by Marine Research Consultants (MRC) in 1990, 1992, 2002, 2006 shows coral coverage decline (Chaston 2007). The coral general present in Honolua Bay include *Leptastrea purpurea*, *Montipora capitata, M. flabellate, M. patula*, *Porites compressa, P. lichen* and *P. lobata* (DAR 2010). Different species were reported from the northern and southern reefs; *Porites* sp. dominate the north reef and *Montipora* sp. dominate the southern reef (Chaston 2007). Decreases in Honolua Bay coral cover were theorized by Eric Brown in 2004 to have been caused by different environmental stressors with the north reef affected by wave action and the southern reef affected by sediments (Chaston 2007). The Storlazzi and Field 2008 water circulation model (Section 4.11) supports that finding. Brown also suggested that the low rates of recruitment, low growth and high mortality could mean that additional stressors would further degrade the reef.

Kapalua Bay has been monitored every few years by DAR and has decreased from 40% coral cover in 2007 to approximately 35% coral cover in 2013. DAR is working to expand marine monitoring efforts based on multi-faceted annual assessments, and DAR staff have collaborated with the Coral Reef Assessment and Monitoring Program (CRAMP), NOAA Humpback Whale Marine National Monument, and researchers from University of Hawai'i, USGS and NOAA.

4.10.3 Invasive Algae Growth

Turf algae are comprised of diverse of algal species and part of a healthy coral reef ecosystem. It is low growing as word "turf" suggests. Some species of macroalgae can be quick growing, very aggressive and contribute to coral decline over time by preventing or limiting coral larvae settlement. The three dimensional macroalgae can be a turf algae when there is ample herbivore grazing (by invertebrates such as sea urchin and herbivorous fish) to keep it two-dimensional.

Beginning in the mid 1980s all along West Maui, episodic algal blooms of macroalgae were problematic with beaches covered with rotting biomass. Blooms generally occur when one or more limiting resources become available, leading to rapid algal growth from shore to depths greater than 100 feet. Algal blooms end once the limiting resource has been exhausted or light levels are sufficiently reduced (Smith et al. 2005). *Hypnea musciformis* and *Cladophora* species were macroalgae associated with blooms from the 1980s into early 2000.

Figure 4.29 shows benthic habitat and percent cover of macroalgae for the area offshore of the three watersheds from 2007 data. A macroalgae survey in 2007 identified macroalgae species including *Ulva fasciata, Asteronema breviarticulatum, Hypnea musciformis*, *Ahnfeltiopsis concinna* (Dailer et. al. 2010).

Hypnea has not been seen washing up on shore in West Maui for a couple years (S. Hau Pers. Comm.). *Cladophora* quantities also seem greatly reduced, and algae blooms in general have seemingly vanished (P. Bennett and U. Keuper-Bennett via Turtle Trax at turtles.org,).

4.10.4 Herbivores

Herbivore grazing by invertebrates and herbivorous fish is a critical part of a healthy coral reef ecosystem. Available data on herbivore species are provided below.

4.10.4.1 Invertebrates

Mobile invertebrates are included in DAR surveys conducted three times each year in the Honolua- Mokulēʻia Marine Life Conservation District (MLCD). Reports related to benthic surveys do not specify abundance, density, or changes for the invertebrates.

An invertebrate survey of Honolua Bay conducted in 1974 by Environmental Consultants Inc. (ECI) found Echinodermata to be the most conspicuous component of the benthic fauna (Chaston 2007). Due to time restrictions, the survey was not thorough for cryptic species. Every common Hawaiian sea urchin was found with the exception of a species restricted to wave washed rocky shores (*Colobocentrotus atratus*) though it was expected this species may occur on Līpoa Point. Of the seven species identified, two were common and abundant, two species were common in areas, two were uncommon and found in restricted areas, and one species was rarely found.

ECI also conducted a reconnaissance survey of the reef and sandy bottom, as well as the rocky coastal boulders at waterline. A variety of gastropod mollusks (with and without shells) were identified, as well as a species of crustacean and echinoderms.

4.10.4.2 Herbivorous Fish

Herbivorous fish, the primary grazers in reef ecosystems, control marine algae growth and enabling new coral recruits to effectively compete for space. Without healthy populations of herbivorous fish, algae grow unchecked and limit coral colonization and growth. The presence of healthy populations of herbivorous fish in their native environment can contribute to the recovery of degraded, algae-dominated reefs.

Monitoring in the Honolua - Mokulēʻia MLCD and surrounding area (south to Kapalua Bay) from 2002 – 2007 show that herbivorous fish accounted for 33% of total numerical abundance in the MLCD and 21% in the adjacent open areas (Friedlander et al. 2010). Modest declines in numbers were observed between 2002 and 2007. Within the MLCD, herbivorous fish comprised 68% of the biomass, with 6.5 times greater biomass than the open area, where herbivorous fish accounted for 43% of the biomass (Friedlander et al. 2010).

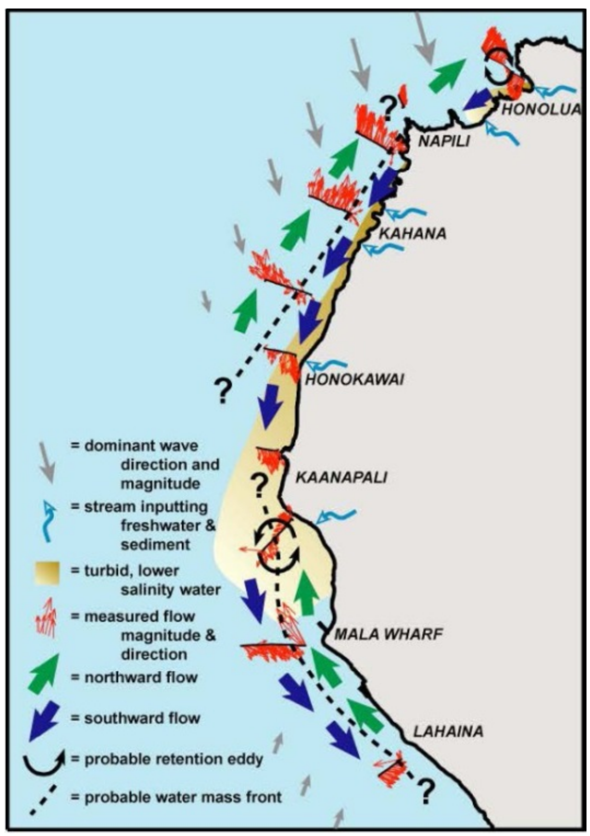
DAR conducts fish surveys three times annually at Honolua - Mokulēʻia MLCD and other sites around Maui to assess effectiveness of marine reserves in relation to open to fishing areas. The results indicate a positive effect of closure to fishing, and Honolua - Mokulēʻia MLCD had significantly higher total food fish biomass than its Kapalua control site (DAR 2010). Large schools of manini (the surgeonfish *Acanthurus triostegus*), a key shallow-water grazer, were observed at sites where fishing pressure was presumed to be low due to relative inaccessibility and low human population density, including Honolua - Mokulēʻia MLCD (DAR 2010).

The largest fish encountered per survey is a simple metric of fish stock health, and has been found useful in other studies (Williams et al. 2006 in DAR 2010). These observed size distribution trends were further investigated by independently looking at four relatively commonly-encountered and heavily-targeted fish species [*Caranx melampygus* (Bluefin Trevally), *Naso unicornis* (Bluespine Unicornfish), *Monotaxis grandoculis* (Bigeye Emperor) and *Scarus rubroviolaceus* (Redlip

Parrotfish)]. In reserve areas, a 60cm or larger fish was observed in 35% of the survey, but fishes of that size were only seen in 14% of surveys in open areas. For all four species, reserves contained more and larger fishes than open areas. The biological implication of these results is important because large individuals are an important component of most targeted species breeding stock. The larger fish produce disproportionally more gametes than smaller fish, and those gametes tend to be more able to survive and become recruits (Birkeland and Dayton 2005 in DAR 2010).

4.11 Currents and Circulation

Storlazzi and Field (2008) created a conceptual model of the West Maui nearshore water circulation. Their study found that the waters closer to shore (inshore waters) are more affected by trade winds and carry the turbid, lower-salinity water south over the shallow reef areas. At the same time the wave energy keeps the fine-grained sediments suspended in the water (Figure 4.31). Honolua Bay was shown to have a higher degree of recirculation within the bay except during the winter months when stream flow is high and there are large wave events. More recent work by Storlazzi on modeling coral larvae shows that the larvae from West Maui provide the coral larvae to seed West Maui areas, as well as other areas in Maui Nui. (C. Storlazzi Pers. Comm.). The general direction of the coral larvae movement is from the south and generally offshore which matches with the offshore current shown with green arrows in Figure 4.31. A new or revised offshore water circulation study to augment USGS 2004 study is needed for better understanding of pollutant transport and effects on the coral reef ecosystem.



Source: Storlazzi and Field, 2008

Figure 4.31 Currents and Circulation

4.12 Summary of Physical and Natural Features

Table 4.8 summarizes some of the physical and natural features for Kahana, Honokahua and Honolua watersheds discussed in this chapter.

Table 4.8 Summary of Physical and Natural Features

Watershed	Kahana	Honokahua	Honolua
Area (acres)	5,863	3,117	3,027
Streams	Kahana	Honokahua	Honolua
Stream Length (miles)	17	9.7	12
Estimated Stream Flow	No flow 50% of the time	No flow 50% of the time	Ma uka to ma kai less than 80% of the time
Impervious Surface: Ag District (acres)	156	72	45
Impervious Surface: Urban District (acres)	308	33	-
Subwatersheds	Kahana A Kahana Kaʻōpala A Kaʻōpala Kaʻōpala B Honokeana Nāpili 4-5 Nāpili 2-3	Honokahua A Honokahua Mokupeʻa Kahauiki	Honolua Līpoa Point
Desilting Basins	Kahana Kaʻōpala Honokeana Nāpili 4-5 Nāpili 2-3	None	None
Coral Cover (NOAA 2007 Data)	Kapalua Bay; possibly around Hawea Point	-	Honolua Bay; possibly around Līpoa Point

5.0 WATERBODY CONDITIONS AND ASSESSMENTS

The waterbody classifications and water quality described in this chapter contribute to understanding the status of Kahana, Honokahua and Honolua watersheds and help in identifying potential pollutant loading sources that contribute to the decline of coral reef ecosystem health. Because of the limited water quality data, this information provides only a snapshot in time.

This chapter begins with an overview of the State of Hawai'i's water quality standards as documented in Hawai'i Administrative Rules (HAR) Title 11, Department of Health Chapter 54 Water Quality Standards (referenced as HAR §11-54). Understanding the standards is the first step toward improving water quality and restoration and protection aquatic life (Chapter 2). Following the discussion of water quality standards, available water quality data for Kahana, Honokahua and Honolua watersheds are presented to provide a picture of current waterbody conditions based on available data. The significant water quality data gaps are summarized at the conclusion of the chapter.

5.1 Hawai'i Water Quality Standards

Hawai'i's Department of Health Clean Water Branch (CWB) administers and enforces statewide water pollution laws and rules. CWB oversees permits for point source discharges, monitors permit compliance, investigates complaints and conducts water quality sampling. The CWB Monitoring and Analysis Section is responsible for sampling and analysis in support of Federal Clean Water Act (CWA) §303(d) assessments, §305(b) integrated reports and §319 polluted runoff control project grants. The Section's major activity is water quality monitoring of beaches as initiated under the Beaches Environmental Assessment and Coastal Health Act of 2000 (BEACH), an amendment to the Federal CWA. Additionally, coastal chemistry monitoring of nearshore and offshore waters is conducted for select indicators of water quality; however, offshore sampling has been suspended due to manpower and funding constraints (CWB 2012a).

Water quality standards are set by designation of the waterbody (e.g. inland freshwater, open ocean, embayment, estuaries). Classification of state waters (inland or marine) and water uses are documented in Hawai'i Administrative Rules (HAR) HAR §11-54. Narrative and numeric criteria are specific to waterbody classification, and provide the basis for evaluating water quality data.

The State Water Code, codified as Hawai'i Revised Statutes 174(c), includes among its policies:

> *...shall... protect and improve the quality of waters of the State and to provide that no substance be discharged into such waters without first receiving the necessary treatment or other corrective action. The people of Hawaii have a substantial interest in the prevention, abatement, and control of both new and existing water pollution and in the maintenance of high standards of water quality.*

Drinking water quality is discussed in this report related to ground water resources; standards to safeguard public health are upheld by the Department of Health (DOH) Safe Drinking Water Branch. The report focuses on surface waters and effects to nearshore waters.

5.1.1 Water Body Use Classifications

5.1.1.1 Inland Water Use Classifications

Inland waters defined in HAR §11-54 may be fresh, brackish, or saline. In the Kahana, Honokahua and Honolua watersheds, inland waters consist of fresh water streams (perennial and intermittent). Inland water uses may be classified as Class 1 or Class 2. The objective for Class 1 waters is to "remain in their natural state... with an absolute minimum of pollution from any human-caused source". Protected uses include scientific and educational purposes, protection of native breeding stock and baseline reference from which human-caused changes can be measured, compatible recreation, aesthetic enjoyment and other non-degrading uses. Domestic water supplies and support and propagation of aquatic life may also be allowable uses.

The objective for Class 2 waters is to "protect their use for recreational purposes, the support and propagation of aquatic life, agricultural and industrial water supplies..." [HAR §11-54-3(b)].

Figure 5.1 shows the upper elevation of Honolua Stream, from the Conservation District boundary at approximately 1,040 feet elevation to the headwaters, is classified as inland waters Class 1. This upper stream stretch lies within the Pu'u Kukui Watershed Preserve. Kahana and Honokahua streams are Class 2 (DOH 2014a).

5.1.1.2 Marine Water Use Classifications

Marine water use Class A has been identified for waters off the Kahana, Honokahua and Honolua (except for Honolua and Mokulē'ia Bays) watershed as shown in Figure 5.1.

The objective of Class A marine waters is: "that their use for recreational purposes and aesthetic enjoyment be protected. Any other use shall be permitted as long as it is compatible with the protection and propagation of fish, shellfish, and wildlife, and with the recreation in and on these waters" (DOH 2013). Wastewater discharge into Class A marine waters is controlled and must be treated to a level compatible with the criteria established for this class [HAR §11-54-3(c)(2)].

The Honolua and Mokulē'ia Bays have been designated at Class AA as show in Figure 5.1 (HAR §13-32). The objective of Class AA 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. To the extent practicable, the wilderness character of these areas shall be protected" [HAR §11-54-3(c)(1)].

5.1.2 Protection Status/Managed Areas

<u>Marine Protected Areas</u>: The Hawaiian Islands Humpback Whale National Marine Sanctuary encompasses approximately 1,218 square nautical miles surrounding the main Hawaiian Islands including area around Maui, Lanai, Molokai, and parts of O'ahu, Kauai and Hawai'i in the relatively shallow (less than 600 feet deep), warm ocean waters. It is co-managed as a Federal-State partnership by DLNR and NOAA's Office of National Marine Sanctuaries. The sanctuary's draft ecosystem-based management plan was released in March 2015 for public review.

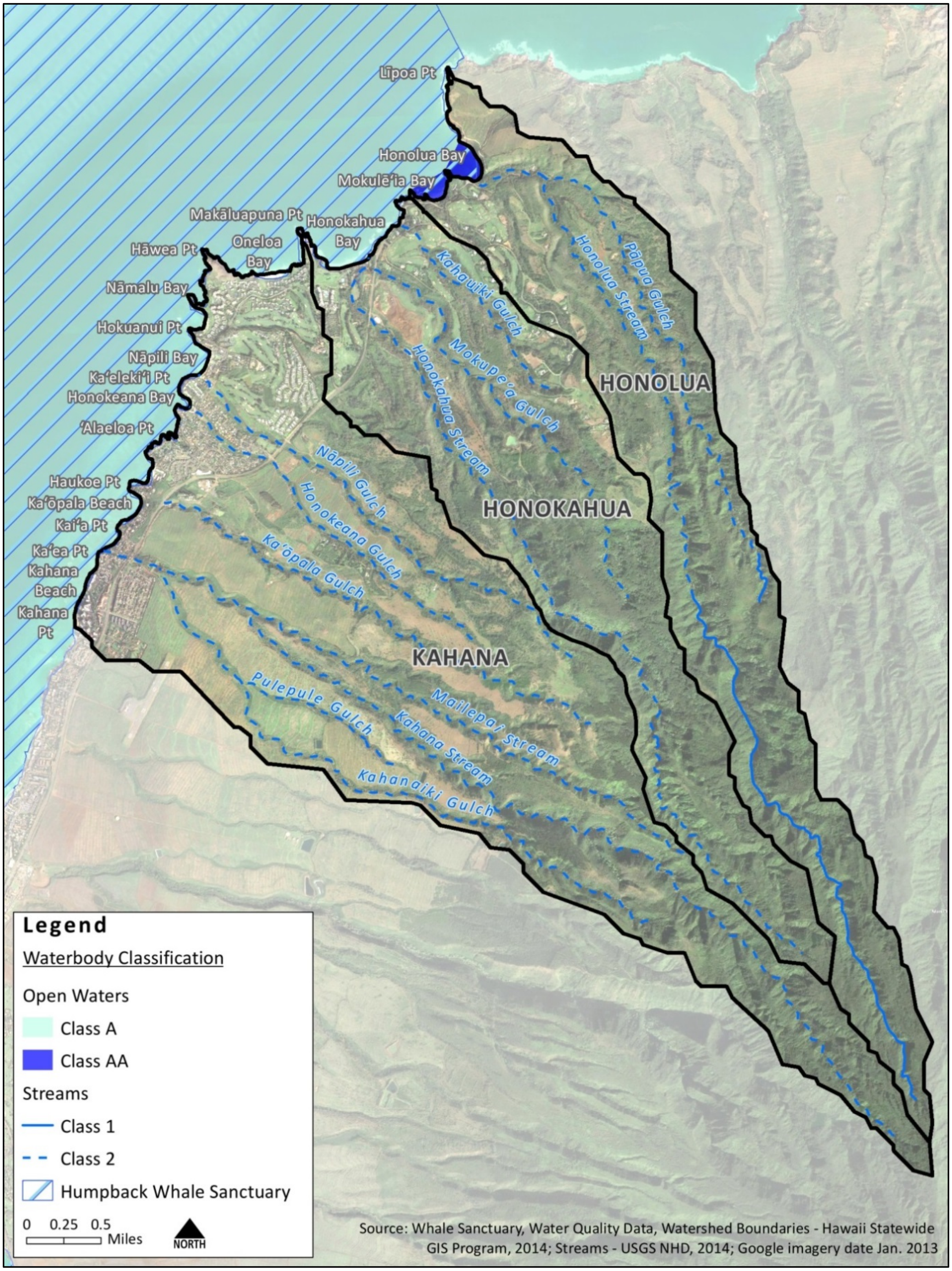


Figure 5.1 Waterbody Classification

Honolua – Mokulēʻia Marine Life Conservation District (MLCD) was established in 1978 as part of a State network of 11 areas designed to conserve and replenish marine resources. In Honolua – Mokulēʻia MLCD, the taking of marine life, sand, coral or other geological specimens is prohibited. Conservation and education objectives in MLCDs have been advanced through research of fish biomass, benthic habitat characteristic, and larval dispersal. Available marine biota assessment is provided in Appendix C.

Terrestrial Protected Areas: The Kahana, Honokahua and Honolua watersheds encompass approximately 6% (2,719 acres) of the West Maui Mountains Watershed Partnership (WMMWP) area. Thirteen landowners and public agency partners work cooperatively to manage the watershed and habitats over 47,319 acres of the summit and slopes of West Maui. The upper elevations Kahana, Honokahua and Honolua watersheds – those in the Conservation District – constitute nearly 32% of the privately-owned Puʻu Kukui Watershed Preserve. Further information on terrestrial biota is provided in Appendix C.

5.1.3 Water Quality Criteria and Available Data

The Monitoring and Analysis Section of CWB collects and analyzes water samples following quality assurance project plans (QAPP) approved by Environmental Protection Agency Region 9 (DOH 2012). Data from sample analyses are intended for use by Section personnel to assess coastal water quality. After internal data validation and quality assurance, data are uploaded into the EPA's STOrage and RETrieval (STORET) online database and to the CWB website http://emdweb.doh.hawaii.gov/CleanWaterBranch/WaterQualityData. Current data (from about 2004) is housed on the CWB website. While the data are publically available, the QAPP includes a disclaimer that uses of the data by other users for other purposes are not supported and the responsibility for determining the appropriateness of any such use lies solely with the user. Any conclusions in this Kahana, Honokahua and Honolua report utilizing DOH CWB data do not necessarily reflect findings of DOH.

As required by Clean Water Act §303(d) and §305(b), the State evaluates surface and marine waters on a two-year cycle and prepares a list of those considered "impaired", meaning water quality is not in compliance with applicable numeric criteria. Commonly referred to as the "Integrated Report" as it combines the §303(d) list with the §305(b) required report, it is titled *State of Hawaii Water Quality Monitoring and Assessment Report*. The most recent Integrated Report was published in 2014 and covers data collected from November 2011 to October 2013 (DOH 2014b). For the Kahana, Honokahua and Honolua watersheds, one stream, marine waters at eight locations and adjacent coastal waters are listed as impaired. Section 5.2 provides further information on the impairment status.

Data from private consulting firms, community monitoring groups and monitoring for compliance with discharge permits may be utilized by CWB if it meets CWB quality assurance/quality control (QA/QC) requirements. A coalition of Maui Nui watershed/community groups, called Hui O Wai Ola, is developing a coastal water-quality monitoring program. The Hui O Wai Ola includes The Nature Conservancy, the Maui Nui Marine Resource Council, University of Hawaiʻi Maui College and West Maui Ridge to Reef Initiative. The goal is to augment the coastal monitoring program of the CWB as limited staff availability and funding affects the spatial extent and frequency of sampling. Through quality-assured sampling and testing, community-based monitoring can help fill the need for reliable data to improve assessment coastal water-quality conditions and detection of trends. Reliable water-quality data depends upon well trained community team members following a comprehensive QAPP, and using a certified analytical laboratory for some analyses.

This section of Chapter 5 summarizes available data for the period 2004 to recent from the CWB website. Data collected since 1999 can be found on the EPA's STORET database: http://www.epa.gov/STORET/index.html. Data collected before 1999 are stored in the "Legacy STORET Database" (DOH 2014b). While results of relevant research conducted prior to 2004 are included in this chapter, only data housed in the CWB website was used for the following water quality characterization. Findings of the DOH 2014 Integrated Report relevant to the Kahana, Honokahua and Honolua watersheds are included in Section 5.2.

5.1.3.1 Fresh Water Quality Data

Inland Water Criteria (Streams): Chapter 4 documents the stream characteristics of Kahana, Honokahua and Honolua streams and tributaries. The HAR §11-54-5.1 criteria for freshwater, which include man-made ditches and flumes, that discharge into any other water of the State and are applicable to the watershed's inland fresh waters. The numeric criteria for nutrient and biogeochemical parameters, defined in HAR §11-54-5.2(b), differ by wet season (November 1 through April 30) or dry season (May 1 through October 31).

No new assessment of water quality within the fresh waters of Kahana, Honokahua and Honolua is available. Assessment under methodology established for the Integrated Report requires a minimum of 10 samples within a single season (wet or dry) collected within the dates specified for assessment (between November 2011 and October 2013). The 2012 Beach Monitoring QAPP by CWB states that stream monitoring was suspended due to budget cuts and reduction in force (CWB 2012a).

Ground water: Ground water affects environmental conditions at the point of discharge, either as surface water or outflow, including submarine discharge. Ground water regulations focus on human health, and as such are governed by DOH Safe Drinking Water Branch (SDWB) and Wastewater Branch. Aquifers and wells in the Kahana and Honokahua watersheds are described in Chapter 4, Section 4.8.

Pollutants identified in drinking water can inform potential transport of pollutants into stream and nearshore waters from anthropogenic sources. DOH SDWB monitors data for public drinking water wells, select non-drinking water wells such as irrigation and industrial wells and fresh water springs. Data are accepted from other testing agencies, including the University of Hawai'i, Hawai'i Departments of Agriculture and Land and Natural Resources and U.S. Geological Survey and are included in DOH SDWB data. Detectable levels of organic contaminants are depicted in Groundwater Contamination Maps maintained by SDWB (see: http://eha-web.doh.hawaii.gov/gw-contam/). Contamination levels are reported for specific sampling dates; the organic detectable contaminants for four wells in the Kahana and Honokahua watersheds are shown in Table 5.1. This data represents the most currently available data for each site and contaminant. The one exceedance for 1,2-Dibromo-3-Chloropropane (DBCP) was detected in the Nāpili A well. DBCP is a fumigant that has been banned from use in Hawai'i since 1985. Ethylene Dibromide (EDB), another detected contaminant, was also used as a fumigant. Its use as fumigant has been banned; however, other uses are still allowable. 1,2,3-Trichloropropane was detected and was allowed for use as a soil fumigant. It is still used today as an industrial solvent.

Table 5.1 Contaminated Ground water Pollutants and Potential Toxicity

Well Site	Date Detected	Level Detected (mg/l)	Organic Contaminant
Honokahua A (Nāpili D) Drinking Water Well Well ID: 6-5838-003	11/30/2005 11/22/2004 10/13/1999	0.00009 0.00001 0.00003	1,2,3-Trichloropropane Ethylene Dibromide (EDB) 1,2-Dibromo-3-Chloropropane (DBCP)
Nāpili A Drinking Water Well Well ID: 6-5838-003	09/23/2014 - 09/23/2014	0.00038 - 0.00013	1,2,3-Trichloropropane Ethylene Dibromide (EDB) 1,2-Dibromo-3-Chloropropane (DBCP)
Nāpili B Drinking Water Well Well ID: 6-5838-004	11/28/1994 - 03/09/2007	0.00003 - 0.000012	1,2,3-Trichloropropane Ethylene Dibromide (EDB) 1,2-Dibromo-3-Chloropropane (DBCP)
Nāpili C Drinking Water Well Well ID: 6-5838-004	09/24/2014 11/28/1994 -	0.00004 0.00003 -	1,2,3-Trichloropropane Ethylene Dibromide (EDB) 1,2-Dibromo-3-Chloropropane (DBCP)

Source: DOH Hawaiʻi Environmental Health Portal: Groundwater Contamination Viewer. Retrieved January 2015 from: http://eha-web.doh.hawaii.gov/gw-contam/

Exceeds HAR Standard

Chemical	Safe Drinking Water Branch Maximum Contamination Level (mg/l)	Source/ Toxicity to Environment
1,2-Dibromo-3-Chloropropane (DBCP)	0.00004	Pesticide/ Toxic to aquatic organisms.
Ethylene Dibromide (EDB)	0.00004	Pesticide/ Highly toxic compound The toxic dose of EDB to non-target organisms range from 10-100 ppm, a range that is much higher than has ever been found in surface waters. No specific lethal dose values for wildlife species were found.
1,2,3-Trichloropropane	0.0006	Pesticide/ Carcinogenic compound. The air concentration of TCP considered an Immediate Danger to Life and Health is 100 ppm.

Source: U.S. Environmental Protection Agency. Technical Fact Sheet –1,2,3-Trichloropropane (TCP). Retrieved from: http://www2.epa.gov/sites/production/files/2014-03/documents/ffrrofactsheet_contaminant _tcp_january2014 _final.pdf

Ground water is generally associated with transporting ammonium and nitrate forms of nitrogen. Research on the link between algae blooms and land use in adjacent and upstream areas was explored by A.J. Soicher and F.L. Peterson in 1996 and 1997. Estimates of subsurface nitrate discharge from sources in the region identified wastewater injection, sugarcane fertilization, and pineapple cultivation as contributors.

Data collected from the ground water study by Soicher and Peterson (1996), largely in and south of Kahana watershed, reflects a period of land use characterized by agriculture. Upcoming collection of data by DOH and CWRM to assess current conditions will be useful to identify changes since cessation of large-scale agriculture in 2008, and expanded development on West Maui since then. Agriculture was the main source of nutrients (nitrogen and phosphorous from fertilizers) for many decades and the transit time through the ground water can best be understood by testing wells previously sampled to compare data. This information may not contribute directly to implementing mitigation measures, as ground water would not necessarily be treated except when used as a drinking water source. However, understanding the ground water contribution, or lack thereof, would improve the understanding of surface water contributions.

<u>Conclusions</u>: Measurement of stream flow with stream gauges would inform the potential surface water impacts to Honolua Bay. Stream turbidity, total suspended solids, and chemical (nutrient) sampling should be collected to assist in identifying upstream pollutant sources.

Legacy pollutants in ground water are assumed to be diminishing with the cessation of agricultural use and movement through the system. Impacts of new contaminants from new formulations of landscaping and industrial chemicals are unknown. Ground water seepage research (available by 2016) will help in identifying where legacy ground water pollutants could be entering nearshore waters.

5.1.3.2 Marine Water Quality Data

Marine water quality is represented by physical, chemical, and bacteriological parameters. HAR §11-54-6 documents numeric nutrient criteria depending on waterbody types; two types are relevant to Kahana, Honokahua and Honolua watershed:

- open coastal waters (marine waters bounded by the 600 foot (100 fathom) depth contour and shoreline, excluding embayments); and
- oceanic waters (outside of the 600 foot, 100 fathom depth contour).

The Beaches Environmental Assessment and Coastal Health Act of 2000 (BEACH Act) amended the CWA to require states to adopt water quality standards for pathogens and indicators to protect human health. CWB monitors the water at beaches throughout the State for concentrations of *Enterococcus*, and *Clostridium perfringens* as a secondary tracer used to confirm the presence of human fecal bacteria (sewage contamination).

Seven beach monitoring sites fall within the Kahana, Honokahua and Honolua watersheds: Honolua (Bay), Mokulēʻia (Bay), DT Flemings Beach (Flemings Beach North), Kapalua (Flemings Beach South), Nāpili Bay, Kaʻōpala Bay and Oneloa. All seven sites were sampled for bacteriological constituents; four of the sites were sampled for chemical constituents. The CWB database includes bacteriological data for Flemings Beach North since 2004, providing the longest span of data points with the watersheds.

Pursuant to Clean Water Act (CWA) §303(d) and §305(b), states are required to provide an assessment every two years on the quality of the waters known as the "Integrated Report" (see Section 5.2). The methodology for ecosystem health (nutrient concentrations and biogeochemical parameters) requires a calculated geometric mean based on a minimum of ten samples over the report period, which is typically two years (DOH 2014). Given the average of four samples per year the data are insufficient to meet CWA §303(d) and §305(b) reporting requirements.

Chemical Constituent Data
For chemical constituents defined in the water quality standard, numerical criteria differ based on the parameters of data analyses, and whether the marine water is considered "wet" or "dry" based on the volume of fresh water inflow from the land. HAR Chapter §11-54-6(b)(3) defines "dry season" for open coastal waters as those receiving less than three million gallons per day of fresh water discharge per shoreline mile. CWB applies the "dry" standard to West Maui, as a1977 report of the Technical Committee on Water Quality Standards defines the West Maui coast off Kahana, Honokahua and Honolua watersheds as "seasonally wet", which means the coast is also seasonally dry. The dry standard provides the most stringent water quality criteria and is used for the following analyses.

Open Coastal Water Quality Analyses
Current water quality standards (December 2013 used in this analysis) are established for Total nitrogen; ammonia nitrogen (NH_4); nitrate + nitrite (NO_3^- + NO_2^-); total phosphorus; and chlorophyll *a*. Table 5.2 summarizes data currently available in the CWB database through 2013.

Data was analyzed against the Hawaiʻi State standard "geometric mean not to exceed the given value"[2] rather than the "not to exceed the given value more that 10%" and "... 2% of the time" due to the small sample size (Appendix B.1.1). Water quality standards for chemical constituents in HAR §11-54 are presented in micrograms per liter; however, constituents are reported in milligrams per liter on the CWB website. The exception is chlorophyll *a*, which is reported in micrograms per liter on the website (A. Nunnally Pers. Comm. 2014). Therefore, summary tables in this section depict the water quality standard converted to milligrams per liter.

The analysis in Tables 5.2 shows the geometric mean for ammonia nitrogen (NH_4) and Nitrate + nitrite (NO_3^- + NO_2^-) were exceeded for all sites. Total nitrogen was exceeded at all sites except Nāpili Bay. Total phosphorus was exceeded for only one location: Honolua Bay. Chlorophyll *a* was exceeded at three of the four sites monitored.

[2] The geometric mean indicates the central tendency or typical value of a set of numbers (Appendix B.1.1).

Table 5.2 Exceedance of State Standard for Selected Chemical Water Quality Parameters Open Coastal Water Standards

Watershed		Ammonia Nitrogen (mg NH_4-N/L)	Nitrate + Nitrite (mg NO3 + NO2 - N/L)	Total Nitrogen (mg N/L)	Total Phosphorus (mg P/L)	Chlorophyll *a* (µg/L)
	State Water Quality Standard (Dry) – Converted†	**0.0020**	**0.0035**	**0.11**	**0.016**	**0.15**
KAHANA	**Ka'ōpala Bay (02/4/2008-12/03/2008: 38 Sample Days)**					
	Geometric Mean	0.006	0.144	0.338	0.016	1.3
	Minimum	0.002	0.030	0.207	0.007	0.480
	Maximum	0.024	0.285	0.701	0.042	6.410
	Nāpili Bay (01/26/2009-03/22/2010: 40 Sample Days)					
	Geometric mean	0.0045	0.0245	0.107	0.016	0.017
	Minimum	0.002	0.005	0.034	0.006	0.006
	Maximum	0.013	0.079	0.191	0.040	0.040
	Flemings Beach (South) (01/07/2008-12/03/2008: 43 Sample Days)					
	Geometric mean	0.0049	0.064	0.303	0.014	0.523
	Minimum	0.002	0.002	0.100	0.005	0.220
	Maximum	0.016	0.300	0.977	0.059	3.220
	Oneloa					
	Data not available	N/A	N/A	N/A	N/A	N/A
HONO-KAHUA	**Flemings Beach (North)**					
	Data not available	N/A	N/A	N/A	N/A	N/A
HONOLUA	**Mokulē'ia**					
	Data not available	N/A	N/A	N/A	N/A	N/A
	Honolua (8/14/2006-12/12/2007: 52 Sample Days)					
	Geometric mean	0.0119	0.005	0.313	0.028	0.838
	Minimum	0.003	0.001	0.055	0. 009	0.23
	Maximum	0.070	0.040	1.27	0.11	3.37

Source: DOH CWB Beach Monitoring Program
† The units have been converted for consistency with the DOH CWB database
Exceeds HAR Standards

Over a five-month period from 2000 and 2001, a study jointly funded by DOH and the University of Hawai'i assessed water quality off 27 beaches in the Kīhei and West Maui-Lahaina districts (Laws et al. 2004). Six sites in the Kahana and Honokahua watersheds were sampled. Samples were collected directly off the mouth of a stream, storm drain, or other potential freshwater input. Constituents analyzed included nitrate (NO_3^-), ammonia nitrogen (NH_4), total dissolved phosphorus, total dissolved nitrogen and chlorophyll *a*, as well as turbidity and total suspended solids (TSS). Wet season criteria was used to evaluate exceedances, based on the months during which sampling was conducted, though the author noted rainfall for the period was anomalously low.

The analysis of ammonium exceeded the standard at one site. Nitrate exceeded standards in five of the six sites sampled. The study's discussion identified research that nitrate concentration in pristine Hawaiian ground water can be relatively high, and a possible source of high nitrate in open coastal waters (Laws et al. 2004). Total dissolved nitrogen exceeded the standard at three of the six sites; total dissolved phosphorous was below standards at all sites. Water quality criteria at the time were written in terms of total phosphorus and total nitrogen but DOH sampling protocols at the time required total dissolved phosphorous and total dissolved nitrogen. Table 5.3 shows results as reported by the researcher (Laws 2004). The discussion noted the importance of distinguishing between total dissolved phosphorus and total phosphorus.

Table 5.3 Water Quality Monitoring 2000 – 2001

		Ammonium (mg NH_4/L)	Nitrate (mg NO_3/L)	Total Dissolved Nitrogen (mg N/L)	Total Dissolved Phosphorus (mg P/L)	Chlorophyll *a* (mg/L)	Turbidity (NTU)
KAHANA WATERSHED	**Kahana Village**						
	Geometric Mean	0.003	0.004	0.507	0.007	0.715	4.3
	Kahana Cove						
	Geometric mean	0.004	0.168	1.470	0.010	1.430	7.5
	Ka'ōpala Bay						
	Geometric mean	0.005	0.132	1.370	0.011	1.340	5.9
	Kahana Sunset						
	Geometric mean	0.002	0.034	0.664	0.010	0.447	2.2
	Honokeana Cove						
	Geometric mean	0.003	0.244	1.563	0.012	0.983	2.0
	Nāpili Bay						
	Geometric mean	0.003	0.011	0.628	0.007	1.162	1.2

Analysis of 15 samples collected between November 2000 and March 2001
Exceeds HAR Standards (for year 2000)
Source: Laws et al. 2004

In March 2015 comprehensive nutrient testing began along the coastline by DOH. Water quality testing will continue for two years, and a report with data analysis will be forthcoming in 2017. Preliminary DOH data analysis shows areas with elevated nitrogen levels. Follow-up testing, or if possible concurrent testing, of nitrogen stable isotopes ratios would help determine nitrogen sources, e.g. cesspool, fertilizers.

Oceanic Water Quality Analyses

Oceanic water testing occurred in 2010 and 2011 offshore of Kahana and Honokahua watersheds (excluding Oneloa Bay), and watersheds further south (*Wahikuli-Honokowai Watershed Management Plan* 2012). The General Random Tessellation Stratified (GRTS) survey design was applied to coastal waters from 0 to 30m depth off the coast. The design was for 50 sample sites at four depth-based strata: 0 – 5 meters (m); 5 – 10m; 10 – 20m; and 20 – 30m. Procedures for statistical analysis of the data account for stratification or unequal probability selection in the design. Results and findings of the study were not yet completed as of June 2016; the report will be available through DOH.

No other oceanic water quality data is in the CWB database. The 2012 Beach Monitoring QAPP by CWB states that oceanic monitoring was suspended due to budget cuts and reduction in force (CWB 2012a).

Chemical Constituent Conclusions
Nearly all the data showed nitrogen and chlorophyll *a* exceedances for the testing done in 2006-2008 when pineapple was still being cultivated. Nāpili Bay was tested in 2009-2010 after the close of pineapple, and did not have exceedances for nitrogen or chlorophyll *a*. Compared to the Laws 2000/2001 data (Laws 2004) where nitrate and chlorophyll *a* exceeded standards, the Nāpili Bay site 2010 data shows exceedances of State standards for total nitrogen, total phosphorous, and chlorophyll *a*. Further data is needed to demostrate that the cessation of agriculture fertilizer applications has reduced water quality standard exceedances. The 2010 and 2011 DOH offshore water quality data analysis will provide additional temporal data on chemical constituents. There may still be significant sources of nutrient inputs from fertilizers used in landscaping and on golf courses.

Bacteriological Constituent Data
Water quality recommendations to protect human health in contact recreation use of coastal waters are set by the EPA and monitored by CWB. *Enterococcus* is used nationally as a bacterial indicator of fecal contamination. The CWB Monitoring and Analysis Section monitors Hawaiʻi beaches for concentrations of *Enterococci* as an indicator of pathogens. Due to background levels of bacteria in Hawaiʻi soils, both naturally occurring and from feral and domestic animals and birds, *Clostridium perfringens* is used as a secondary tracer used to confirm the presence of human fecal bacteria (sewage contamination). Further information is provided in Appendix B, B.1.5.

HAR §11-54-8(b) for marine recreational waters establishes a standard of *Enterococcus* not to exceed a geometric mean of 35 CFU (colony-forming unit) per 100 milliliters (ml) in not less than five samples, which shall be spaced to cover a period between 25 and 30 days. No single sample shall exceed the single sample maximum of 104 CFU per 100 ml. At locations where sampling is less frequent than five samples per 25 to 30 days, no single sample shall exceed the single sample maximum nor shall the geometric mean of samples taken during the 30-day period exceed 35 CFU per 100 ml. The HAR effective December 6, 2013 was applied to data analyzed for this report, however, HAR §11-54 was updated November 15, 2014 to a single standard for all state waters. The standard was revised to be consistent with EPA's 2012 Recreational Water Quality Criteria recommendations, and is now 35 CFU per 100 ml over any 30-day interval and a statistical threshold value (STV) of 130 per 100 ml shall be used for enterococcus. The STV shall not be exceeded by more than 10% of samples taken within the same 30-day interval in which the geometric mean is calculated (HAR 11-54-8(c) from 2014 revision).

Table 5.4 shows the results of water analysis for *Enterococci* at the sites regularly monitored by CWB. In Kahana, Honokahua and Honolua watersheds, the Honolua Bay beach site had the highest percentage of samples in exceedance of water quality standards for *Enterococci* from 2008 to 2013. Five of 22 sampling days exceeded standards in the five-year time period. DT Fleming Beach (North) has the largest dataset, with sampling reported from 2004 to 2013. During the initial three year-period of sampling (2004 – 2007), intensive sampling from 2005 showed one exceedance, with none in the years following. Kaʻōpala Bay had one exceedance during the 2008-2010 time period. *Clostridium* levels, measured as a secondary tracer used to determine contamination from sewage, were at or less than 9 CFU per 100 ml for *Enterococci* exceedances. Periodically *Clostridium* levels at the sites were as high as 32 CFU per 100 ml (at Kaʻōpala Bay), but the single sample maximum of more than 50 CFU per 100 ml was not recorded in the CWB data for 2004 to 2013 at any site within the three watersheds. CWB sampling and analysis indicates sewage was not the primary source of bacteriological exceedances.

Table 5.4 Exceedance of State Standards for *Enterococcus*

Watershed		2004-2007		2008-2010		2011-2013	
		Sample Days (#)	Exceedance † (# days/%)	Sample Days (#)	Exceedance † (# days/%)	Sample Days (#)	Exceedance † (# days/%)
KAHANA	Kaʻōpala Bay	--	--	12	1 / 8%	10	0 / 0%
KAHANA	Nāpili	--	--	12	0 / 0%	10	0 / 0%
KAHANA	Kapalua (Flemings Beach South)	--	--	34	0 / 0%	10	0 / 0%
KAHANA	Oneloa	--	--	12	0 / 0%	10	0 / 0%
HONO-KAHUA	Flemings Beach North	27	1 / 4%	12	0 / 0%	10	0 / 0%
HONOLUA	Mokulēʻia	--	--	12	0 / 0%	10	0 / 0%
HONOLUA	Honolua	--	--	12	1 / 8%	10	4 / 40%

-- no data
† HAR 11-54-8 (b)(2): Not to exceed geometric mean of 35 CFU per 100 ml in 5 or more samples in 30 days or 104 CFU per 100 ml for a single sample
Source: DOH CWB Beach Monitoring Program
Exceeds HAR Standard

A 2013 study on anthropogenic pollutants by Woodley, et al., included sampling for the known human pathogen, *Staphylococcus*. There are no current state water quality standards for this pathogen, which were identified at levels in the study as "too many to count". Results of the study noted that *Enterococcus* levels exceeded State water quality standards at Nāpili (north) Bay and Kapalua (north and south) Bay (Woodley, et al. 2013). Levels of *Serratia marcescens* were also tested because it is associated with sewage and a potential human pathogen. *S. marcescens* is associated with a Caribbean coral disease, acroporid serratiosis (known as "white pox disease").

Bacteriological Constituent Conclusions

The DOH data does not indicate bacteriological issues due to sewage. The limited testing by Woodley, et al. 2013 points to the need for additional testing and monitoring to see if the water quality issues at Nāpili and Kapalua Bays are ongoing.

Physical Constituent Data

Water quality can be affected by various physical constituents. Coral reef ecosystems are affected by sediments (Section 5.5). Water turbidity is one way to measure the amount of suspended sediments and other materials that block sunlight from reaching aquatic life. Turbidity is measured by nephelometric turbidity units (NTUs); available CWB data from 2008 to 2013 are presented in Table 5.5. Turbidity samples and measurements were taken during DOH biological and chemical sampling. Each sample analyzed in Table 5.5 from 2009 to 2015 for the seven sites were taken on the same day. The single day sampling consistency allows for comparison between sites because factors affecting turbidity, namely rainfall, are relatively constant. The 2008 samples do not have single day collection consistency. For most locations the State standard was exceeded by a magnitude of 3 to 40 times the criteria of 0.2 NTU.

Kaʻōpala Bay shows the highest levels of turbidity. There is not a DOH sample site for the Kahana subwatershed during this period. However, south of the Kahana watershed is a sample location offshore of the Honokōwai watershed, Pōhaku (also known as S Turns). The Pōhaku site, Table 5.5, also shows high turbidity.

The 2000 – 2001 water quality testing data from Laws et al. (2004) in Table 5.3 showed that the State turbidity standard at that time was exceeded at every beach in the study area. Sampling sites included Kahana Village, Kahana Cove, Kaʻōpala Bay, Kahana Sunset, Honokeana Cove and Nāpili Bay in the Kahana watershed. Kahana Cove and Kaʻōpala Bay sites had the highest geometric means of turbidity.

Laws et al. noted "there is a dramatic correlation between turbidity and suspended solids. The turbidity of sample filtrates was virtually zero. The implication is that virtually all of the turbidity was caused by particles and none by dissolved substances."

Table 5.5 Turbidity

		2008-2009		2010-2011		2012-2013		2014-2015	
Sample Site		Samples Days (#)	Geometric Mean (NTU)	Samples Days (#)	Geometric Mean (NTU)	Samples Days (#)	Geometric Mean (NTU)	Samples Days (#)	Geometric Mean (NTU)
State Water Quality Standard† (Dry)			0.20		0.20		0.20		0.20
HONO-KŌWAI	Pōhaku (S Turns)	7	4.97	8	3.10	6	5.15	18	3.04
KAHANA	Kaʻōpala Bay	46	7.56	8	4.82	6	8.55	18	5.46
KAHANA	Nāpili	7	1.85	8	1.01	6	1.23	18	1.72
KAHANA	Kapalua (Flemings Beach South)	71	1.91	8	1.54	6	2.24	18	1.81
KAHANA	Oneloa	7	0.58	8	0.67	6	0.94	18	0.90
HONO-KAHUA	Flemings Beach North	7	2.29	8	2.07	6	1.90	18	2.83
HONOLUA	Mokulēʻia	7	2.70	8	2.38	6	1.72	18	1.79
HONOLUA	Honolua	58	3.60	8	1.63	6	3.62	18	3.50

† Geometric mean not to exceed given value
Source: DOH CWB Beach Monitoring Program

Exceeds HAR Standard

Brown water advisories are periodically issued by CWB. "This advisory is typically given when the National Weather service issues a Flash Flood Warning or upon recommendation from Clean Water Branch staff. Coastal waters may become polluted from flood waters and storm water runoff that may possibly contain any combination of matter from overflowing cesspools, pesticides, animal fecal matter, dead animals, chemicals and associated flood debris." (DOH CWB website) The archived advisories from 2010 to 2014 are shown in Table 5.6. The numerous brown water advisories for Honokahua Bay in 2014 can be attributed to reported community observations of runoff that may have been from Mahana development.

Table 5.6 Brown Water Advisories

Date	West Maui (total area)	Honokahua Bay	Honolua Bay
12/23-12/25/2014	X	X	X
7/16-7/18/2014		X	
5/13-5/15/2014		X	
5/2-5/9//2014		X	
4/29-5/1//2014		X	
4/7-4/11/2014		X	
4/1-4/4/2014		X	
3/21-3/25/2014		X	
3/10 - 3/14/2014			X
1/29- 1/31/2014	X	X	X
1/22-1/23/2014		x	
1/13-1/20/2011	X	X	X
12/10-12/13/2010	X	X	X

Source: DOH CWB
(http://emdweb.doh.hawaii.gov/cwb/wqd/viewer/Archive.aspx)

Brown Water Advisory issued for entire West Maui area

Temperature, salinity and pH can affect coral reef ecosystem health. Table 5.7 provides temperature, salinity and pH data collected by DOH CWB. The samples were collected close to the shoreline although coral is typically found further from shore. There are a limited number of samples as these factors vary with daily and seasonal fluctuations. However, the available data provide some insight on physical parameters nearby. The implications of the temperature, salinity and pH on coral growth and reproduction are discussed in Section 5.5.

Table 5.7 Nearshore Temperature, Salinity and pH

Water-shed	2008-2013 Samples	Number of Samples	Temperature (°F)			Salinity (ppt[1])			pH		
	Sample Site		Low	High	Average	Low	High	Average	Low	High	Average
KAHANA	**Kaʻōpala Bay**	60	72.3	78.8	**76.1**	33.0	35.2	**34.0**	7.8	8.3	**8.1**
KAHANA	**Nāpili**	21	72.5	78.8	**75.5**	32.7	35.6	**34.5**	8.0	8.3	**8.2**
KAHANA	**Kapalua (Flemings Beach South)**	85	72.9	78.8	**75.9**	32.0	35.6	**34.2**	7.8	8.3	**8.1**
KAHANA	**Oneloa**	21	72.7	78.8	**75.4**	34.7	35.8	**35.1**	8.0	8.3	**8.2**
HONO-KAHUA	**Flemings Beach North**	21	72.3	78.3	**75.5**	34.6	35.7	**34.9**	7.9	8.3	**8.2**
HONOLUA	**Mokulēʻia**	21	72.5	78.3	**75.2**	31.4	35.5	**34.0**	7.9	8.3	**8.1**
HONOLUA	**Honolua**	21	70.9	77.5	**74.5**	32.7	35.2	**34.2**	7.7	8.2	**8.0**
	TOTAL/WEIGHTED AVERAGE	**250**			**75.7**			**34.3**			**8.1**

[1]ppt = parts per thousand

Source: DOH CWB Beach Monitoring Program

Physical Constituent Conclusions

The DOH CWB turbidity data from 2008-2013 (Table 5.5) and the Laws 2001 turbidity data (Table 5.3) consistently show high turbidity results for Kaʻōpala Bay and for the Kahana coast area south of Kaʻōpala Bay towards Honokōwai. These data match with observations made in July 2014 by Jonathan Stock during a small scale rainfall event. The potential sources of the sediments are discussed in Chapter 6 including legacy sediments and coastal erosion.

Turbidity is the main reason that waterbodies are listed as impaired by DOH CWB. The turbidity data (Table 5.3 and 5.5) are not reflected in the 2012 2014 IR due to insufficient data points as further described in Section 5.2.

5.2 Impaired Waters

The 2014 Integrated Report (DOH) encompasses previous assessments from the 2012 Integrated Report (IR) and documents changes based on new data evaluation. For the Kahana, Honokahua and Honolua watersheds, no waterbodies were added or delisted to the list published in the 2012 report, though the 2014 report states: "the basis for a two year assessment period is the incorporation of *new*, readily available data (post 2012 IR assessment cycle) to determine the current status of State waters while also coinciding with the CWA reporting cycle requirement." As described in Section 5.1.3, field samples and analyses must meet CWB approved QA/QC standards for inclusion.

Assessment in the IR requires a specific number of data points within the two-year assessment period. To determine attainment of biogeochemical parameters for inland freshwaters, a minimum of 10 samples collected within each season (dry and/or wet) is required (CWB 2014b). For marine waters, a minimum of 10 samples is required for a given location, and within a single "season". Per Section 5.1.3.2, for marine waters the wet or dry "season" is based on fresh water inflows per mile of shoreline. No waterbodies in Kahana, Honokahua and Honolua watersheds were sampled with sufficient frequency during the reporting cycle for evaluation in the 2014 IR. Therefore, all waterbodies listed in the Kahana, Honokahua and Honolua watersheds were determined based on the 2012 IR.

Within the three watersheds, Kahana Stream is listed as impaired, as are the coastal waters at six locations off Kahana watershed [Kahana Village, Kahana Cove, Ka'ōpala Bay, Kahana Sunset, Nāpili Bay and Kapalua (Flemings Beach South)], one location off Honokahua watershed (Flemings Beach North), and one location off Honolua Watershed (Honolua Bay). In addition, the entire nearshore waters to 60 feet are also listed as impaired. This section describes the reports and methodology for waterbodies to be listed as impaired as well as the pollutants that are the reason for the listing. Findings from the 2014 IR are shown in the following sections, by each waterbody type: stream and marine.

5.2.1 Impaired Stream Waters

The 2012 Integrated Report analyzed data from January 2006 through October 2011, however the report states "no new data since the 2006 cycle were received and therefore none reviewed for the freshwater portion..." The 2014 report included no Maui stream data. Therefore, the stream impairments for Kahana, Honokahua and Honolua watersheds rely on data prior to 2006.

Table 5.8 summarizes the impaired status for Kahana Stream as shown in the 2014 Integrated Report. Under current methodology, a geometric mean calculated from a minimum of 10 samples is required; however, quantification of constituents (bacterial and biogeochemical) for these streams is unavailable. More information is needed to determine which water quality standards are attained and which are exceeded.

Kahana Stream was listed for turbidity based on a visual assessment between 2001 and 2004; other constituents are listed as "insufficient data". The category for Kahana Stream is Category 3 (not enough data to evaluate) and Category 5 (at least one use not attained; Total Maximum Daily Load (TMDL) needed); the TMDL priority for Kahana Stream is M (medium) for development within the current monitoring and assessment cycle (through October 2013).

5.2.2 Impaired Marine Waters

Waters within the Kahana, Honokahua and Honolua watersheds that are listed in the 2014 Integrated 303(d) List/305(b) Report for Hawaiʻi are shown in Table 5.8. Impairment status, shown in the middle two columns, is based on data assessed for the Integrated Report for 2012. No changes were made for marine waterbodies in the three watersheds between the 2012 and 2014 assessments. Impaired marine waters are shown in Figure 5.2 (data provided by DOH to the US Environmental Protection Agency in 2013). Two marine areas – Honolua Bay and Nāpili Bay – were added to the impaired waters list in 2012 (Georeference sites HI280286 and HI764064, respectively). The list assigns a priority code (low, medium, or high) for initiating TMDL development based on prioritization criteria and resource availability.

The 2014 IR assessment methodology for ecosystem health (nutrient concentrations and biogeochemical parameters) in marine waters requires a minimum of ten samples for a given location within the assessment time period. CWB data reveals no nutrient or biogeochemical samples were taken at Honolua Bay and Nāpili Bay during the period of the 2014 IR (November 2011 to October 2013). For recreational health, seven bacterial samples were taken at each both Honolua Bay and Nāpili Bay during the two-year assessment cycle (no more than one sample per month). These few samples do not allow for analysis per HAR 11-54-8 and therefore provided insufficient data for the 2014 IR.

Table 5.8 Impaired Waters on the Integrated 303(d) List/305(b) Report[3]

Watershed	Geographic Scope of Listing	Water Quality Standards Exceeded	Water Quality Standards Attained	TMDL Priority
KAHANA	**Stream Waters**			
	Kahana Stream	Turbidity (Visual Listing 2001-2004)		M
	Marine Waters†			
	Kahana Watershed			
	Kahana Village	Turbidity, Chlorophyll *a*		M
	Kahana Cove	Total Nitrogen, Nitrate + Nitrite (NO_3^- + NO_2^-), Turbidity, Chlorophyll *a*		M
	Ka'ōpala Bay	Total Nitrogen, Nitrate + Nitrite (NO_3^- + NO_2^-), Chlorophyll *a*, Turbidity, Ammonium (NH_4^+)		M
	Kahana Sunset	Nitrate + Nitrite (NO_3^- + NO_2^-), Turbidity, Chlorophyll *a*		M
	Honokeana Cove	Total Nitrogen, Nitrate + Nitrite (NO_3^- + NO_2^-), Turbidity, Chlorophyll *a*		M
	Nāpili Bay*	Nitrate + Nitrite (NO_3^- + NO_2^-), Total Phosphorus, Chlorophyll *a*, Turbidity, Ammonium (NH_4^+)	*Enterococci* & Total Nitrogen	L
	Kapalua (Flemings Beach South)	Total Nitrogen, Nitrate + Nitrite (NO_3^- + NO_2^-), Chlorophyll *a*, Turbidity, Ammonium (NH_4^+)	*Enterococci* & Total Phosphorus	M
HONO-KAHUA	**Honokahua Watershed**			
	Flemings Beach North	Turbidity, Chlorophyll *a*	*Enterococci*	M
HONO-LUA	**Honolua Watershed**			
	Honolua Bay	Total Nitrogen, Nitrate + Nitrite (NO_3^- + NO_2^-), Total Phosphorus, Chlorophyll *a*, Ammonium (NH_4^+)	*Enterococci*	L
	West Maui Offshore			
ALL	Nearshore waters to 60 feet from Honolua to Lahaina	Total Nitrogen, Nitrate + Nitrite (NO_3^- + NO_2^-), Total Phosphorus, Turbidity and TSS		

*Two entries on 2014 Impaired list for same waterbody were combined

†Dry Criteria standard applied

[3] Impaired constituents on the 2014 Integrated 303(d) List/305(b) Report for Hawaii are available from DOH: http://health.hawaii.gov/cwb/files/2014/11/Final-2014-State-of-Hawaii-Water-Quality-Monitoring-and-Assessment-Report.pdf

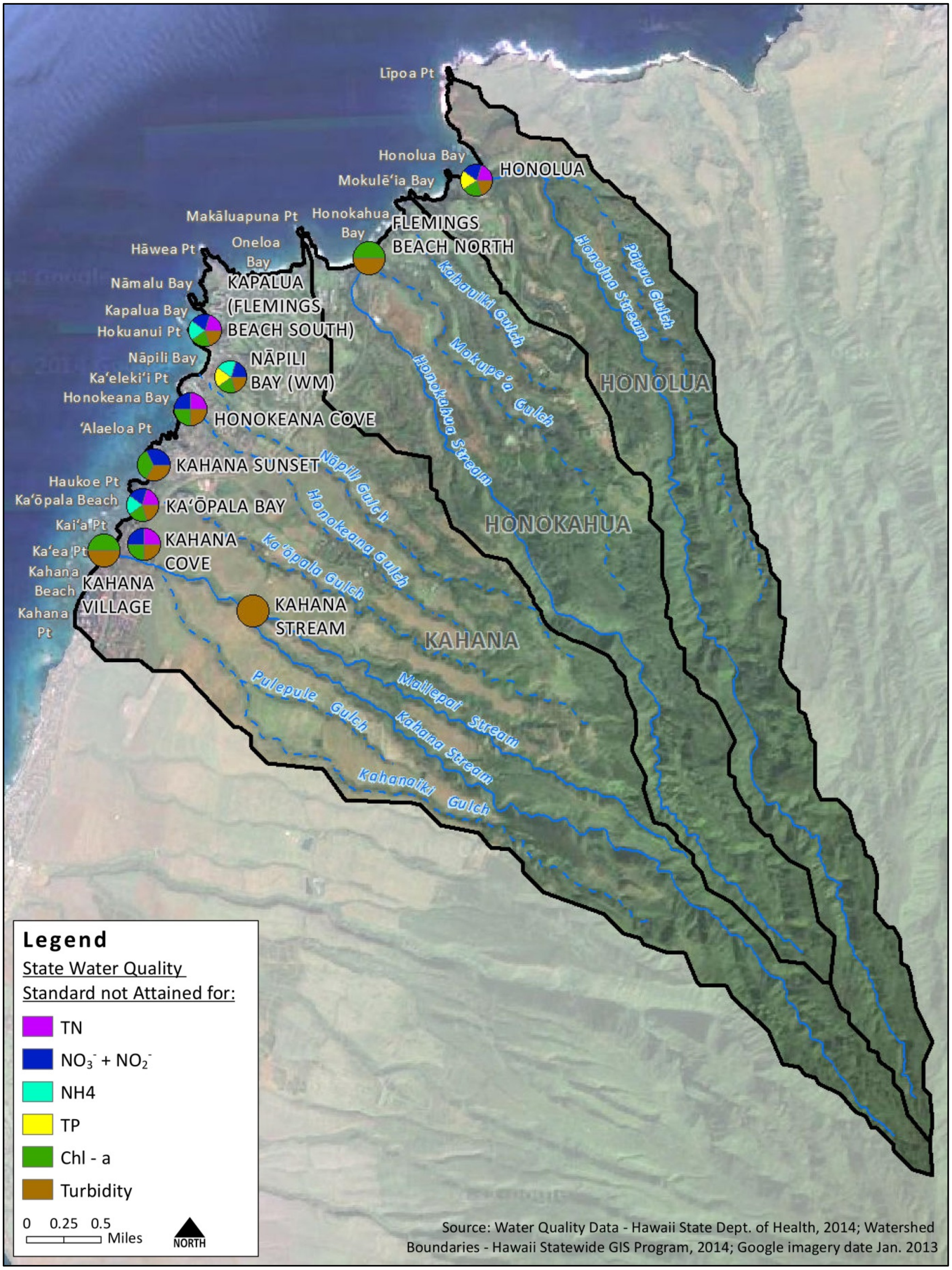


Figure 5.2 Impaired Waters

5.3 Water Quality Data from Other Sources

5.3.1 Honolua Bay

Public perception of increased sediment and potential chemical contamination associated with agricultural and development around Honolua Bay has led to marine biota and water quality research at this popular recreational destination. Hawai'i's Local Action Strategy to Address Land-Based Pollution Threats to Coral Reefs determined that synthesis and analysis of available data on runoff, water quality and the health of the coral reef ecosystem at Honolua Bay was a priority. Undertaken by Dr. Katherine Chaston and Tomas Oberding of the University of Hawai'i at Mānoa's Department of Natural Resources and Environmental Management, the *Honolua Bay Review: A Review and Analysis of Available Marine, Terrestrial and Land-Use Information in the Honolua Ahupua'a Maui 1970 – 2007* is the primary source used in this overview of available water quality data for Honolua Bay.

Between 1990 and 2006, Marine Research Consultants (MRC) conducted 13 surveys under contract to Kapalua Land Company. In 2006, the surveys were extended to include the Līpoa Point area. According to Chaston (2007), no water quality data is available for Honolua Bay prior to 1990.

The MRC surveys were designed to determine ground water and surface water inputs from land to ocean, and data collection was focused on the inner bay. Surveys were generally conducted at low-tide periods, small ocean swell and when freshwater was not flowing from Honolua Stream into the bay. Water quality sampling and analysis focused on the ten criteria applicable to marine waters for embayments under HAR 11-54-6: total nitrogen (TN), ammonium ($NH4^+$), nitrate and nitrite (NO_3^- + NO_2^-), total phosphorus (TP), chlorophyll *a* (Chl *a*), temperature, pH, salinity, and turbidity. Orthophosphate phosphorus (PO_4^{3-}) and silica (Si) were also reported as sensitive indicators of biological activity and the degree of ground water mixing, respectively (MRC 2007 in Chaston 2007).

Long-term water quality trends were reported by MRC in 2007, and reveal consistent water quality over 16-year monitoring period. The water column in Honolua Bay is highly stratified, with the upper layer formed of a low salinity, high nutrient lens originating from ground water discharge along the sides of the bay and fresh water from Honolua Stream. The water column beneath that lens and extending seaward to the reef was less affected by ground water and stream runoff, reflected in its composition of higher salinity and lower nutrient water.

The presence of ground and surface water at the inner shoreline zone, within 30 feet of shore, was shown in relatively high concentrations of Si, NO_3^- and PO_4^{3-}. The central bay zone, from 30 feet to approximately 1,600 feet from the shore along the rocky outcropping at the mouth of the bay, showed lower concentrations of these nutrients. Water quality in the outer bay zone, from the mouth of the bay seaward, was thoroughly mixed with open ocean water by wind, waves and currents. Analysis of the long-term data set shows nutrient input into the bay has been relatively constant, except for a decrease in NO_3^- into the northern part of the bay between 2002 and 2006. Additionally, analysis indicates that inputs of NO_3^- and PO_4^{3-} are likely the result of leaching of agricultural nutrients to ground water (MRC 2007 in Chaston 2007).

5.4 Marine Water Contaminants

Screening for contamination from chemicals, metals and metalloids was conducted in Honolua Bay in 2006 and 2007 with a follow-up study on metals in 2010. As summarized in the *Honolua Bay Review* (Chaston 2007), a study of chemical pollutants in sediments and corals was undertaken to reduce risk to the coral ecosystem by improving management of chemical pollutants and erosion. Screening for metals was intended to develop pollution sensitive bioindicators in corals.

5.4.1 Chemical Contaminants

The chemical pollutant screening in 2006 was designed to investigate the role of sediments and chemical pollutants in a decade of coral cover decline and recruitment failure at Honolua Bay. The research strategy was to determine levels of potential toxicants in coral tissues and to document the health condition of these organisms, and link chemicals used by industries and marine tourism in the watershed with bioaccumulation in organisms. No positive detection of the 288 target analytes was found in sediment and coral tissue samples (Downs in Chaston 2007). Further study was recommended.

The follow-on study by Woodley, et al (2013) investigated marine water quality and toxicity. Sampling and testing was conducted in September 2012 (dry season) and February 2013 (wet season) off Maui's coast and included several sites in the three watersheds. Chemical constituents found in water taken from Kapalua Bay included Atrazin and Malathion, which can be associated with farming and landscaping maintenance. However, Atrazin and Malathion biodegrade and reach a half-life in less than a year's time. If these herbicides were from the pineapple plantation era, they would be at extremely low levels. It is more likely that they are from more recent applications, and given the location to Kapalua resort, probably from landscaping maintenance application. Pentachlorophenol was also detected. It is used in the treatment wood for utility poles, piers and bridges.

Anthropogenic pollutants may be significant factors contributing to coral reef degradation. The study conducted toxicity identification evaluations on sea urchins in the lab using collected water. The testing with Kapalua Bay water resulted in 68% of sea urchin embryos being deformed, and using Honokeana Bay water, 50% were deformed. Embryo deaths were at 50% for water from Honokeana Bay and 18% and 15% for waters from Kapalua Bay (south and north, respectively) (Woodley, et al. 2013).

5.4.2 Metal and Metalloid Contamination

In 2010 study (Hedouin, et al.), Honolua and Honokōhau Bay sediments were found to have high concentrations of cobalt, chromium, magnesium, nickel and vanadium. The sampling of organisms from these bays did not mirror these findings. Due to the limited information on contributing human activities, the elevated concentrations were likely due to natural high background levels. The study also found a correlation between increasing metal concentrations in sediments and decreasing coral cover. However, the authors suggest that a variety of land-based stressors (sediments, metals and nutrients) are affecting coral reef health in Honolua Bay, not just the metals alone.

5.5 Coral Water Quality Requirements

For coral to grow and reproduce suitable conditions are needed including sunlight, clear water, warm temperatures, and clean salt water. Sunlight and clear water are needed to provide light to the zooxanthellae (algae) that grow inside coral and provide nutrients for the coral. This need for light is the reason that corals grow mostly in fairly shallow waters. The clarity of the water is a significant water quality issue in West Maui due to the high turbidity levels (Section 5.1.3.2).

Coral also require nutrient-poor water; the zooxanthellae and coral are extremely efficient at exchanging materials and have evolved to thrive in such waters. Conversely, nutrient rich waters are not conducive to coral growth. Nutrient rich water can facilitate algal growth which blocks light and can smoother corals. Nutrient levels from the plantation era were clearly an issue in nearshore waters and may continue to be an issue (Table 5.2 and 5.3). In addition to blocking sunlight, sediments can have deleterious effects by smothering corals and triggering increased macroalgae growth. In reproduction, coral larvae can be sensitive to pollutants which can affect settlement rates.

Water temperatures conducive for coral growth are found in the tropics and for West Maui these temperatures can change over the course of days and seasons. Table 5.7 shows the temperatures ranging from 70.9 to 78.8 degrees Fahrenheit. If water temperatures become too warm, coral bleaching (loss of the zooxanthellae from coral) can occur from which the coral may not recover.

The amount of dissolved salts in water, salinity, is measured in parts per thousand (ppt). Corals can tolerate a narrow range of salinities, usually between 30 and 40 ppt. Table 5.7 shows salinities ranging from 31.4 to 35.7 ppt with average salinity of 34.3 ppt.

Seawater typically has a pH from around 8.0 to 8.3. In this pH range, the saltwater is fully saturated with carbonate (CO_3^{2-}) ions. Calcium carbonate is the material from which coral build their skeletons. However, as ocean pH declines (becomes more acidic) from carbon dioxide dissolving in water, corals have trouble building their skeleton. Table 5.7 shows average pH of 8.1 with a low of 7.8.

In response to concerns regarding ocean acidification, CWB assessed all readily available pH data for the two-year time frame of the 2014 Integrated Report. The assessment indicated pH meets the numeric water quality criteria as outlined in HAR §11-54. However, CWB notes that the issue of ocean acidification deserves collective decision-making by multiple agencies and stakeholders (DOH 2014b). Long-term monitoring is needed, and efforts to mitigate these impacts from global warming will need to be addressed at a larger scale.

5.6 Water Quality Summary

The impaired waterbodies in the three watersheds are Kahana Stream, eight marine locations (that cover all three watersheds), and the entire West Maui offshore area out to 60 feet. While much of the data used to list the waterbodies is more than seven years old, based on available recent data the water quality issues persist and may continue to affect coral reef ecosystem health.

High levels of turbidity and suspended sediments occur along the coastline. Kahana and Ka‘ōpala subwatersheds and Honokahua and Honolua watersheds have the highest levels of turbidity. A summary of the water quality data is provided in Table 5.9.

Table 5.9 Water Quality Data Summary Since 2008

Watersheds / Urban Sub-Areas		**Turbidity** (State standard = 0.2 NTU)	**Chemical (Nutrients)**	**Bacteriological (*Enterococci*) Exceedances**
		Geometric Mean of 6 samples from 2014-2015 (NTU)	Available data post plantation era (after 2008)	2008-2013
KAHANA	**Kahana**	3.04 (S Turns as proxy)	No Data	None
	Ka'ōpala	5.46	No Data	1
	Honokeana	No Data	No Data	None
	Nāpili	1.72	Significant Exceedances - Nitrate + Nitrite and Ammonia Nitrogen	None
	Kapalua	1.81 Kapalua	No Data	None
		0.90 Oneloa	No Data	None
HONOKAHUA	**Mokupe'a**	2.83 DT Fleming Beach	No Data	None
	Kahauiki	No Data	No Data	None
HONOLUA	**Honolua**	1.79 Mokulē'ia	No Data	None
		3.50 Honolua	No Data	5

Data Gap – Locations of **contributing sources suspended solids in streams and gulches** would help identify upland priority areas for mitigation to reduce the impact of suspended solids on turbidity, water quality and coral reefs. Planned follow-on work by John Stock of the US Geological Survey is anticipated and will add further understanding of sediment sources.

Data Gap – **Streamflow data** for Honolua, Honokahua and Honolua Streams would be useful in understanding actual flows, seasonal fluctuations and impacts on coral reefs. Stream turbidity, total suspended solids, and chemical (nutrient) sampling should be collected to assist in identifying upstream pollutant sources.

Legacy pollutants in ground and surface waters are assumed to be diminishing with the cessation of agricultural use and movement through the system. The impacts of new contaminants from newer formulations of landscaping and commercial chemicals are unknown as are current levels of nutrients entering nearshore waters.

Data Gaps – Testing of chemical constituents and contaminates in nearshore and ground waters is needed. Specifically:

- **Nutrients in nearshore waters** offshore of all three watersheds which could be compared with historic data to establish if changes have occurred in water quality since the plantation era. The testing for Honokahua watershed would be a baseline since DOH testing for nutrients has not previously occurred there. The data would aid in identification of current land use activities that are potentially contributing nutrients into nearshore waters and affecting coral.
- **Current use contaminants in nearshore waters** would assist in understanding these contributors to decreased water quality. As with the nutrient testing, this would help in identification of contributing land use activities that have a potential impact on the coral reef ecosystem.

- **Ground water testing** that replicates the Soicher and Peterson 1996 study would provide a historical comparison and help establish a rate of nutrient movement through the aquifer.

DOH bacteriological data is limited and does not indicate sewer issues. Exceedances for State *Entercocci* standards since 2011 were at Honolua Bay, and these seem not be linked to human contributions. The Woodley, et al. 2013 study tested for additional pathogens and found Kapalua exceedance during the study timeframe.

Data Gap – **Bacteriological testing** may need to be expanded to better capture exceedances and water quality with implications for human and coral reef health.

6.0 POLLUTANT SOURCE ASSESSMENT

The land use characterizations in Chapters 2 and 3, the physical and natural features in Chapter 4, and water quality information in Chapter 5, are used in identifying types of pollutants in the three watersheds. The potential sources are presented for Conservation, Agricultural and Urban Land Use Districts. Estimated impacts are summarized by watersheds and, where data are available, by subwatershed, to provide a ma uka to ma kai view of potential land-based sources of pollutants. Efforts to quantify pollutant loads are relative rather than absolute, and provide rough order of magnitude information for prioritizing pollutant sources and are not suitable for load reduction monitoring.

After presenting the many likely sources of pollutants, both existing and future pollutant sources are summarized and prioritized. While all pollutant sources have the ability to impact water quality, relative prioritization is needed to begin the process of identifying strategies for implementation that will have significant impacts to achieve water quality goals for coral reef ecosystem restoration.

6.1 General Pollutant Information

Pollutants are generated and transported through the Kahana, Honokahua and Honolua watersheds. Pollutants degrade water quality, place stressors on biotic organisms and may render water non-usable or unsafe to humans. Identifying activities and land uses that generate pollutants and transport mechanisms will help locate projects to mitigate generation and/or transport of pollutants. Effectively targeting pollutants is a complex undertaking.

The primary objective of this chapter is to identify the types and sources of activities that generate pollutants which are transported by storm water runoff and or ground water and delivered to the ocean.

Pollutants are generated by land conditions present in the Conservation, Agricultural and Urban Districts, as well as through land use by both humans and animals. Natural environmental processes can generate pollutants (such as stream rock fall). However, the rate at which pollutants are generated and transported to receiving waters is greatly influenced by anthropogenic behavior within a watershed. This section discusses general pollutant sources, resulting impacts and methods of transport into the environment.

Table 6.1 provides an overview of major categories of pollutants, including sources and potential impacts. This table is not specific to the three watersheds but rather uses examples of various pollutant types, sources and related impacts. Pollutants are transported through the watersheds primarily in surface and ground waters. Some pollutants, such as fine sediments, can also be transported via wind to a much lesser degree. The relative amount of each pollutant type carried in surface water and ground water varies based on the physical and chemical properties of the pollutant, the transporting agent and its position within the watershed.

Table 6.1 Major Categories of Pollutants, Sources and Related Impacts[1]

Pollutant	Major Sources	Related Impacts
Solids: Sediment (clean & contaminated)	Agriculture (fields & roads); construction sites; other disturbed and/or non-vegetated lands; stream bank and shoreline erosion; urban runoff	Increased turbidity; reduced clarity; lower dissolved oxygen; deposition of sediments; smothering of aquatic habitat including spawning and settling sites; sediment and benthic toxicity
Nutrients: Nitrogen, Phosphorus	Croplands; nurseries; orchards; livestock operations: gardens; lawns; forests; fertilizers; construction soil losses; waste water effluent; urban cesspools; failing septic systems.	Excessive algal growth which can smoother corals; reduced clarity; lower dissolved oxygen; release of other pollutants; visual impairment; recreational impacts; water supply impairment
Oxygen-depleting substances	Biodegradable organic material such as plant; fish; animal matter; leaves; lawn clippings; sewage; manure; antifreeze; other applied chemicals	Suffocation or stress of adult fish, resulting in fish kills; reduction in fish reproduction by suffocation/stress of sensitive eggs and larvae; increased anaerobic bacteria activity; release of particulate bound pollutants
Metals: Lead, Copper, Cadmium, Zinc, Mercury, Chromium, Aluminum, etc.	Industrial processes; normal wear of automobile brake pads and tires; automobile emissions; automobile fluid leaks; metal roofs; gutters; landfills; corrosion; urban runoff; soil erosion; atmospheric deposition; contaminated soils	Toxicity of water column and sediment; bioaccumulation in aquatic species and through food chain
Hydrocarbons: Oil and Grease, Polyaromatichydro-carbons (PAHs) - e.g., Naphthalenes, Pyrenes	Industrial processes; automobile wear; automobile emissions; automobile fluid leaks; waste oil	Toxicity of water column and sediment; bioaccumulation in aquatic species and through food chain; lower dissolved oxygen; coating of aquatic organism gills/impact on respiration
Organics: Pesticides, Polychlorobiphenyls (PCBs), Synthetic chemicals	Applied pesticides (herbicides, insecticides, fungicides, rodenticides, etc.); industrial processes; nurseries; orchards; lawns; gardens; pharmaceuticals	Toxicity of water column and sediment; bioaccumulation in aquatic species and through food chain contaminated soils/wash-off
Pathogens: Bacteria, Viruses, Protozoans	Domestic and natural animal wastes; urban runoff; failing septic systems; landfills; illegal cross-connections to sanitary sewers; natural generation	Human health risks via drinking water supplies; contaminated shellfish growing areas and swimming beaches; incidental ingestion or contact; swimming
Inorganic Acids and Salts (sulphuric acid, sodium chloride)	Irrigated lands; landfills	Toxicity of water column and sediment

The field observations of April, May and June 2014 aided in identifying pollutant sources and types within each of the land use districts. Pollutant source areas were compiled based on this work and screening of the watershed using high resolution satellite images to determine areas and uses that broadly contribute to sediment, nutrient and other pollutant sources. Specific areas or sites that were obviously generating or transporting pollutants were also noted. The size of the

[1] From Field et al. (2004) and modified by SRGII and Group 70.

areas and sites of concern vary considerably within each land use districts, due to variations in land use, topography and other factors. Some of the land conditions and activities occur in widespread areas of the watersheds and are denoted as such. Since field inspections were comprehensive but not exhaustive, there likely are other areas generating pollutants in the watersheds that have not been specifically identified.

6.2 Conservation and Agricultural District Sources

Conservation and Agricultural sources are described based on field observations, discussions with land managers, conservation management plans, examination of aerial photography, modeling efforts and background research of documented areas of impact. The ma kai conservation lands are included in the Urban District Section 6.3.

6.2.1 Feral Ungulates

In general, stream channels in the upper Conservation District are fairly stable with presence of native flora and fauna. Impacts to the stream channels include natural rates of erosion from rockfall and soil creep (Section 6.2.6). Accelerated rates of erosion stem from the presence of feral ungulates, such as pigs, goats, deer and cattle, which trample vegetation, create of wallows and generally destabilize the channel bed and banks. The eroded sediments can be transported downstream and into nearshore waters.

A TerrAqua Study (2013) for the West Maui Mountains Watershed Partnership (WMMWP) used modeling to examine the effects of feral ungulates on sediment transport and water quality. It concluded that a disturbance of less than 1% of a watershed area can result in significant increase in erosion of 10-25%. The study also verified that feral ungulate disturbance in riparian areas affected water quality more than ridge line disturbance. WMMWP is currently also conducting water quality monitoring to quantify improvements in water quality from feral ungulate management.

One of the primary ways to protect Conservation District lands is by fencing to exclude feral ungulates, and to remove remaining ungulates. Management units within the Pu'u Kukui Watershed Preserve (Preserve) with significant areas of ungulate activity are those where fencing has not been erected. Feral pig activity is monitored in the Preserve to target areas for eradication efforts as pig presence remains an ongoing problem. The Preserve Management Plan (Maui Land & Pineapple [ML&P] 2010) shows monitored areas just ma uka of the lower Preserve boundary where pigs have been present in the last 2 to 4 years (2006 to 2009), and

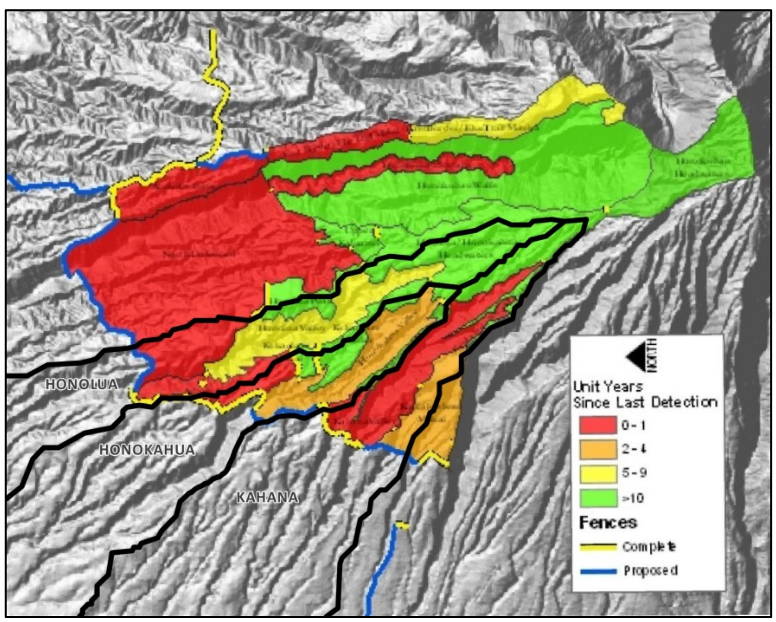


Figure 6.1 Pu'u Kukui Watershed Preserve: Ungulate Management Units & Years Since Last Ungulate Detection (2010)

areas with confirmed pig presence in the last year (2009). In the upper elevation portion of the Preserve, are areas where pigs have not been detected in more than 10 years (Figure 6.1). The Preserve has been managed for feral ungulates since its inception in 1988. Pig removal has been ongoing and needs to be maintained. Through the completion of boundary fencing and management vigilance, recurring and cyclical feral pig impacts to vegetative cover and water quality can be minimized.

The Preserve boundary in the three watersheds, and in the adjacent Honokōhau watershed to the north, is partially fenced (Figure 6.2). The unfenced areas provide avenues for feral ungulates into the fenced conservation areas. Within the three watersheds are more than two miles of Preserve boundary without fencing and over four miles with 4-foot high pig fences. The 4-foot high fences need to be retrofitted to 8-foot fences to prevent movement of the introduced Axis deer from the south into the upper conservation area.

Because feral pigs migrate in search of food and water, it is difficult to determine their impacts by subwatershed. A completed boundary fence, monitoring and population reduction within the fenced area will continue to reduce nutrient and sediment contributions. Table 6.2 shows fencing needs by watershed.

Table 6.2 Fencing Needs by Watershed

Subwatershed	Kahana	Honokahua	Honolua	Total
New 8-Foot Fence	7,000 feet	5,000 feet	-	12,000 feet / 2.3 miles
4-Foot Fence Retrofit to 8-Foot Fence	1,800 feet	13,000 feet	8,500 feet	23,300 feet / 4.4 miles

In the Agricultural District feral ungulates are drawn to stream and gulch areas for cover and water sources. Maui Land and Pineapple has a hunting program for conservation and agricultural areas. However, in nearby residential and golf course areas ma uka of the highway in Honokahua, hunting is restricted due to the proximity to human activities which may create refuges for pigs (Figure 6.3). Management solutions for these areas are needed. Feral pigs multiply in these areas and put pressure on adjacent agricultural and conservation areas.

Figure 6.2 Feral Pig in Mokupeʻa Gulch in Agricultural District

Because feral pig damage in riparian areas can have a greater impact on water quality than ridgeline disturbances (TerrAqua 2013), the Agricultural District riparian areas may need additional protection from feral pigs and deer.

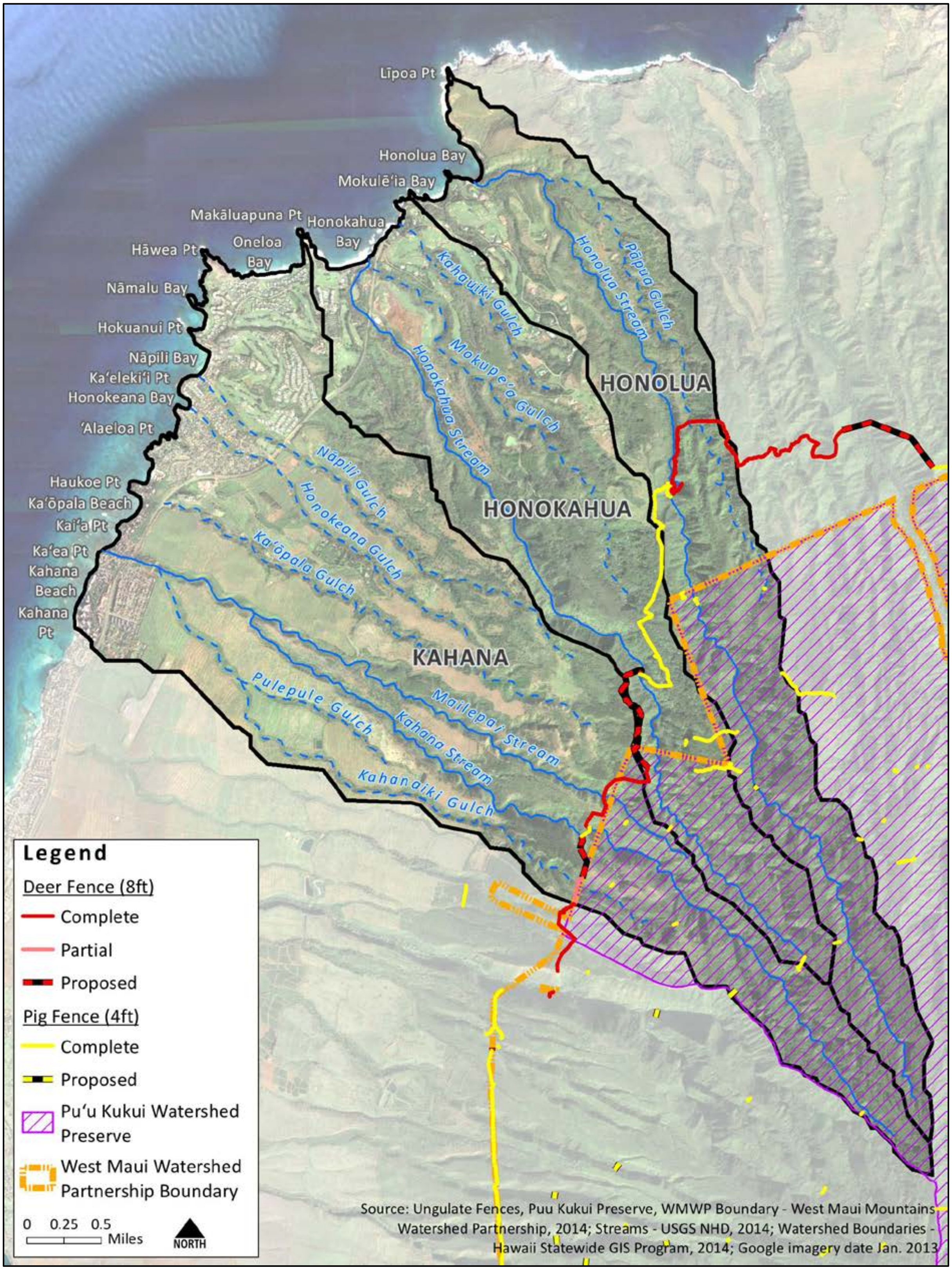


Figure 6.3 Pu'u Kukui Watershed Preserve Ungulate Fencing

6.2.2 Non-native (Invasive) Flora

Clidemia hirta (Koster's Curse)

The transport of invasive plant species occurs via feral ungulates, hikers and dirt bikers as well as by wind and birds. Fire, disease, storms and other disturbances can open gaps in forest canopies where aggressive weeds can gain a foothold. Invasive plants often create monotypic stands and suppress growth of other plants, which reduces canopy layers and groundcovers that protect soils from erosion. Invasive species can have noticeable effect on the evapotranspiration pattern, with an example of Strawberry guava (*Psidium cattleianum*) having a relatively high rate of in comparison to native trees (Giambelluca et al. 2014). While it is surmised that non-native trees have higher water demands than native tree species, research has not yielded conclusive results.

Priority species are numerous and some of the most aggressive in West Maui include *Clidemia hirta* (Koster's Curse), *Tibouchina herbacea* (Cane Tibouchina), *Rubus argutus* (Florida Blackberry) and *Psidium cattleianum* (Strawberry Guava) (ML&P 2010 and WMMWP n.d.).

The specific hotspot areas of non-native and invasive flora are mapped, managed and treated where feasible by the Preserve and the WMMWP. Hot spots for future non-native flora are correlated with areas of feral pigs and other forms of disturbance in the Conservation District.

6.2.3 Unauthorized Human Access (Dirt Biking)

Unauthorized human activity includes the illegal trespassing and recreational use of trails within the Conservation and Agricultural Districts, mainly by dirt bike riders. The creation and repeated use of trails by dirt bike users destroys native vegetation and directly exposes soils, resulting in accelerated erosion and sedimentation. The trails can become drainage ways carrying runoff and sediment and transporting plant debris, alien plant species and nutrients to the streams. These activities may open areas to feral pig damage and set back conservation efforts. Occasionally, fences are cut by dirt bike riders or other trespassers to gain access to the restricted Conservation District. Dirt bike riding can introduce an ignition source for wildfires via cigarette smoking or dirt bikes without their spark arrestor.

Dirt biker usage is highest in dry weather and during periods without ML&P employees on the land (evenings, weekends and holidays). ML&P monitors the dirt bike activity times and locations in order to address this issue. Access plays an important role in the occurrence of dirt bikers, and there may be more dirt bikers that access the upper areas via the Kahana watershed (W. Nohara Pers. Comm.) ML&P has started engaging dirt bikers in conversations about the importance of conservation in the watersheds.

6.2.4 Access Roads

The dirt access roads across most of the fallow pineapple lands are in poor condition and many are no longer maintained (Figure 6.4). With road surfaces compacted from years of vehicular use, the roads effectively function as conduits for runoff and sediment transport during rainfall events, carrying a large volume of sediment and depositing a portion of the load at slope breaks and low points in road grade as flow drops at the end of rainfall events. In several areas, there were indicators that runoff was routed off the road and onto and over adjacent fields towards gulches that drain to the ocean.

Figure 6.4 Unmaintained Ag Road in Kahana Watershed

The lack of maintenance has increased the amount of sediment routed off the roads along fields and gulches. Where there has been maintenance, such as on the road up to Kapalua Ziplines, it has been for drivability and not for sediment/runoff control (Figure 6.5). In some sections runoff is directed onto the upper banks of gulches, which results in direct delivery of runoff and sediment.

The access roads currently used by ML&P are shown in Figure 6.7 and their lengths by subwatershed in Table 6.3. Unused roads should be assessed for possible revegetation or use as fire breaks.

Figure 6.5 Maintained Road with Sediment Kickouts (Kahana Watershed – Zipline Access Road)

The roads of high concern for erosion are steeply sloped roads along gulches and streams, especially roads with "kick-outs", or areas that direct roadway runoff to the adjacent gulch or stream. Steeply-sloped roads that cross streams and gulches are also a concern.

The Oleson Lab at University of Hawaiʻi at Mānoa conducted an analysis of priority access roads that need repairs, and their findings are being submitted for publication.

Table 6.3 Access Road Lengths by Subwatershed

Subwatershed	Kahana	Ka'ōpala	Honokeana	Nāpili 4-5	Nāpili 2-3	Honokahua	Mokupe'a	Kahauiki	Honolua	TOTAL
Access Roads (miles)	26.8	12.2	0.7	6.5	2.9	3.6	6.8	0.8	12.7	73

Note: Road length does not include Honoapi'ilani Highway

6.2.5 Fallow Pineapple Fields

Figure 6.6 Typical Fallow Field (Kahana Watershed)

In the fallow pineapple fields, non-native grasses, shrubs, and trees provide moderate to high density coverage. While pineapple plants are still visible in some fields, most have become overgrown with other vegetation including alien grasses (such as Guinea grass), woody shrubs and small trees (such as Formosa Acacia) (Figure 6.6). The degree of vegetative coverage is a function of rainfall amounts and the length of time the field has been fallow, which increase in the fields going north through the three watersheds. Higher vegetation cover lowers potential erosion rates. However, higher vegetation cover increases fuel loads during dry periods and the possibility for wildfire. Wildfire releases large amounts of sediments with subsequent rainfall and can inundate nearshore waters with the sediments.

6.2.6 Soil Loss

Stream channels and gulches have natural rates of erosion. Rockfall can deposit sediments and woody debris into streams and gulches and is accelerated by land disturbance which destabilizes slopes to accelerate rates of erosion. Feral ungulates, non-native flora, unauthorized human access, access roads, fallow pineapple fields, natural stream and gulch erosion and legacy sediments, all contribute to soil loss. Via overland and streamflow, suspended sediments are transported to nearshore waters and have deleterious effects on coral and other marine and fresh water organisms (Chapters 2 and 5). Understanding the sources and transport of the sediments is essential for addressing the issue. Two quantitative assessments of soil loss efforts are presented in this section.

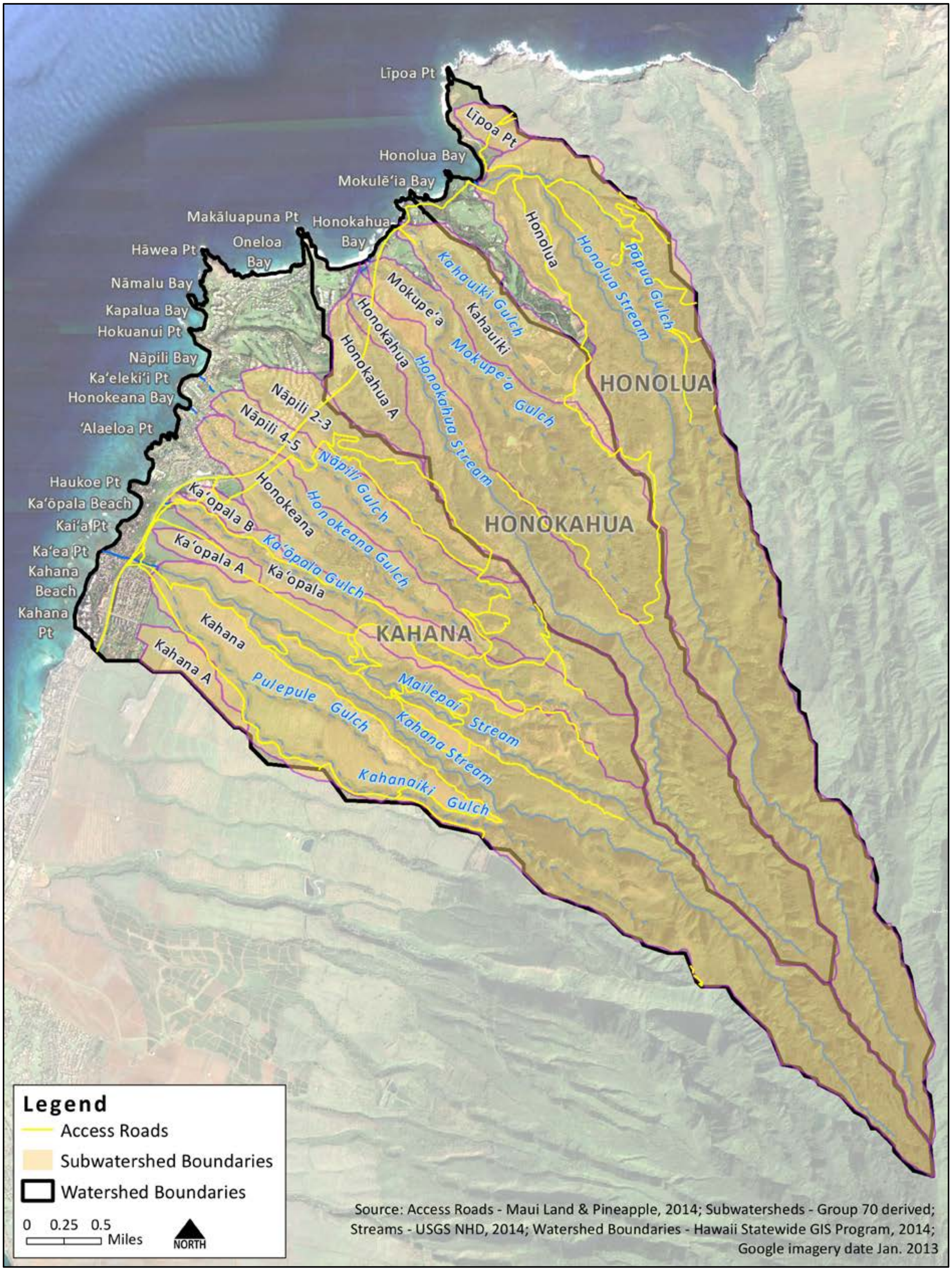


Figure 6.7 Conservation and Agricultural Lands Access Roads

6.2.6.1 NSPECT Model - Relative Potential Surface Soil Loss

The first quantitative effort, conducted for this report, uses the Nonpoint Source Pollution and Erosion Comparison Tool (NSPECT) which is applied over the three watersheds to compute estimates of soil loss from surficial erosion, and to estimate nitrogen and phosphorus losses (Section 6.2.7). NSPECT uses the Revised Universal Soil Loss Equation (RUSLE). The RUSLE includes variables previously addressed in this report including topography (slope length and steepness), soil type, vegetation cover, field management practices as well as rainfall.

There are several limitations of the NSPECT model. The first is that the model is designed to account for soil loss only through sheet erosion and has not been shown to be effective for slopes with greater than a 2:1 ratio (or greater than 26 percent), which occur throughout the upper watersheds. Another limitation is that the model does not estimate soil eroded or "lost" from concentrated flows such as along streams and gulches, nor does it compute sediment transport in streams and delivery to the ocean. The model does not account for rainfall events that are typical in the tropics, nor does it account for broad rainfall distribution in a single watershed. Finally, the model outputs are not verified via ground truthing or empirical data. Because of these limitations, the results from NSPECT are most useful for relative comparison between various land uses and are not reliable as a definitive quantification of soil loss.

Estimates of potential soil loss are computed for each map unit grid and the cumulative values totaled for each grid within a delineated subwatershed. The results yield discrete numeric values. Figure 6.7 graphically displays the NSPECT results and Table 4.5 provides the numerical estimates in tons/year, tons/acre/year and as percentage of total potential loss. These numbers are useful in looking at relative soil loss across the three watersheds.

The NSPECT model predicts that the Kahana watershed lands have greater potential soil loss than those in Honokahua and Honolua. Estimates of soil loss are highest from the former pineapple croplands. The gently sloped agricultural lands in the Kahana watershed contain the majority of the former pineapple fields and an estimated 60% of the potential soil loss (Table 6.4). While Līpoa Point potential surface soil erosion is only 3% of the total potential soil loss estimates, it is at a relatively high rate (85 tons/acres) compared with other areas, in part due to the size of the area of the former pineapple fields. The former pineapple fields in Honokeana and Nāpili 4-5 subwatersheds have higher rates of erosion than other sub-watershed areas.

Erosion from the agricultural roads is considered in the NSPECT model as bare compacted soil surfaces without vegetative protection. The steepest sections which run in the ma uka/ma kai direction appear to be the most vulnerable due to their slope. The vulnerability to erosion is due to historic and current runoff flows which have scoured and dislodged the surface soil particles, combined with soil compaction from vehicle usage during years of field cultivation (Figure 6.8 and Table 6.4).

Table 6.4 Potential Soil Loss Estimates[1]

Watershed/ Subwatershed	Annual Potential Soil Loss (tons)	Area (acres)	Average Rate of Annual Potential Soil Loss (tons/acre)	Soil Loss % of Total
Kahana	**126,000**	**5,365**	**23**	**60%**
Kahana	48,453	3,237	15	23%
Kaʻōpala	16,131	573	28	8%
Honokeana	24,581	484	51	12%
Nāpili 4-5	24,010	597	40	11%
Nāpili 2-3	12,826	475	27	6%
Honokahua	**45,662**	**2,770**	**16**	**22%**
Honokahua	27,202	1,004	27	13%
Mokupeʻa	11,351	999	11	5%
Kahauiki	7,110	767	9	3%
Honolua	**37,607**	**2,610**	**14**	**18%**
Honolua	31,978	2,545	13	15%
Līpoa Point	5,629	66	86	3%
TOTAL	**209,270**	**10,745**	**19**	**100%**

[1] Potential soil loss was derived using the NSPECT model and can be used for comparing potential soil erosion; it does not provide actual soil loss or suspended soil to nearshore waters.

These potential current rates of soil erosion are likely much less than during the pineapple plantation era. One reason is the higher density of ground cover on the fallow fields compared to fields under active cultivation. Another reason is decreased quantities of irrigation water being applied. During the plantation era, surface runoff was routed off the fields via terraces which concentrated flows resulting in decrease of infiltration, increase in erosive energy and increase in sediment transport off the fields. Nearly all irrigation of crops has ceased, and rainfall is now the main contributor of surface runoff.

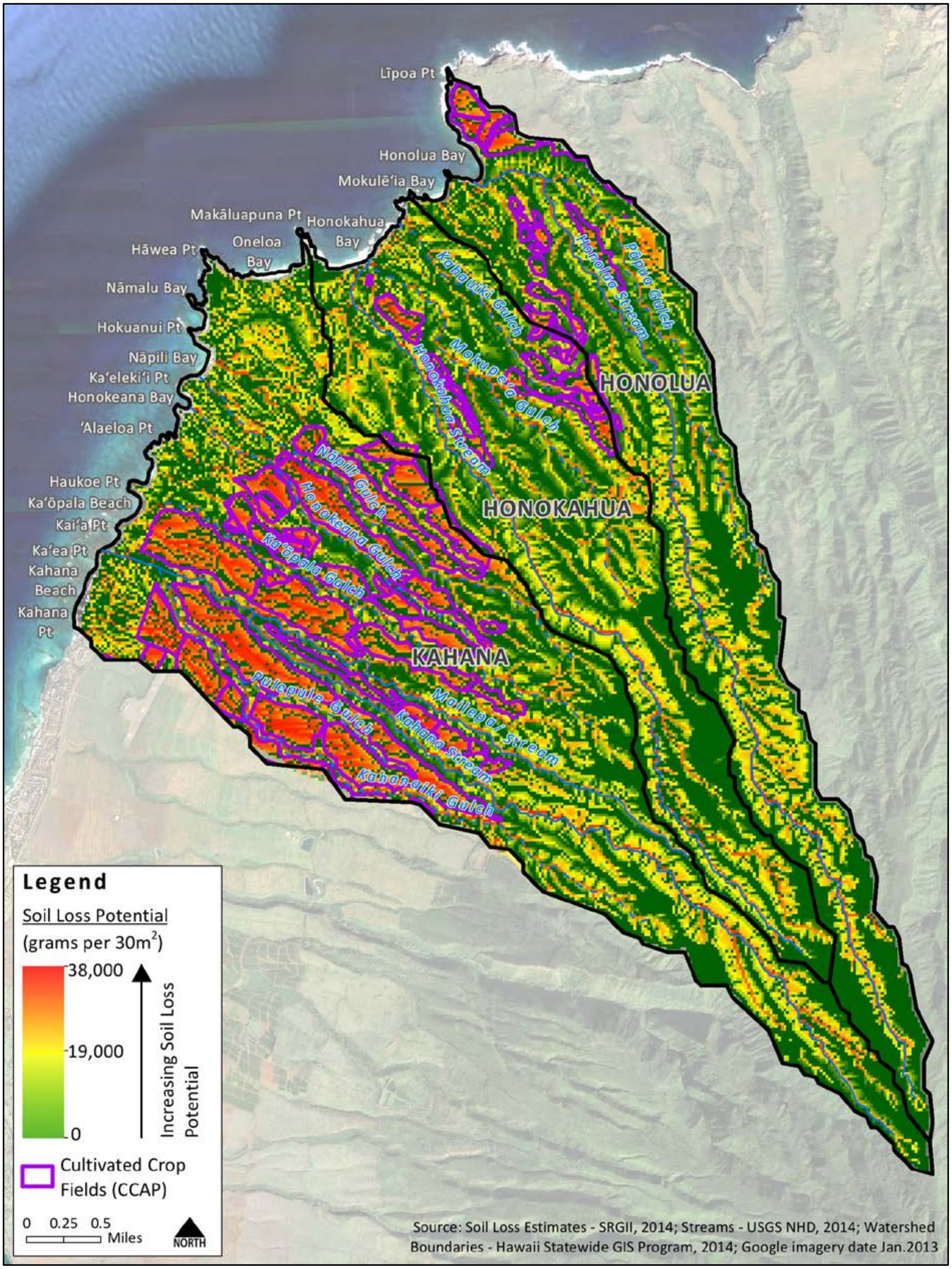


Figure 6.8 Potential Surface Soil Loss from NSPECT Model

6.2.6.2 USGS Reconnaissance Sediment Budget

The preliminary results from the USGS July 2014 site visit provide a sediment budget for the Honolua watershed that considers stream erosion and accumulated sediment deposition and estimates the portion of total sediment load which is from suspended sediments (Stock 2014). The study also provides a sediment budget for the Honokōwai watershed (south of Kahana). The Honokōwai watershed is similar to Kahana in terms of soil types, former cropland practices and proximity to the stream.

Kahana, Honokahua and Honolua watersheds have a history of cultivation which deposited sediments into streams and gulches. During pineapple cultivation numerous terraces and roads routed runoff down slope. The terraces were aligned roughly perpendicular to the slope of the fields with outlets placed along the edge of the fields. Dirt roads were fitted with small earthen berms angled across the roads to prevent road erosion and diverted runoff water along into gulches and swales. The cross block planting and terrace layout used to control surface water is still present today. A majority of the unmaintained terraces have filled with sediment generated from within the fields.

The research question asked by the study is: how much of these legacy sediments still remain in gulches and stream channels and are being transported to the nearshore waters? The predominate processes moving sediment on the landscape are listed in Table 6.5 along with their modeled rates and modeled suspended loads. The Honolua stream and watershed is an example in a conservation area, and Honokōwai stream and water is an example from previously intensively cultivated agricultural lands. These sediment budgets are estimates based on measured rates from analogous geomorphic systems elsewhere in Hawaiʻi.; Further work is needed to refine the soil erosion rates to extend the analysis to other streams and gulches in the Honokahua and Kahana watersheds.

Figure 6.9 Sediment Terrace *(courtesy of Michelle Haynes)*

The modeled erosion rates and suspended load show that valley deposits may play a significant role in the sediments traveling to nearshore waters. The USGS study clarifies that while rock fall and soil creep play a role in sediment movement in the upper watershed, they are not associated with large amounts of fine sediment production. The valley deposits (Figure 6.9) from legacy

Table 6.5 Reconnaissance Sediment Movement Processes & Suspended Load

Sediment movement process	Honokōwai			Honolua		
	% of Area	Modeled erosion rates (mm/a)	Modeled suspended load (tons per year)	% of Area	Modeled erosion rates (mm/a)	Modeled suspended load (tons per year)
Rockfall	47	0.03	192	36	0.03	207
Soil Creep – canopy	27	0.03	110	52	0.03	298
Soil Creep – no canopy	0			4	0.03	19
Overland Flow	18	0.10-1.00	250-2500	0		
Valley Deposits[2]	6	1.00-100.00	3-1839	6	1.00-100.00	2-1530
Terrace	2	0	0	2	0	0
Total	100	0.03	**456**	95		**345**

Source: Stock, Jonathan. 2014. USGS Open File Report, in review.

sediments may have a much higher degree of fine sediment contribution. Understanding not only which streams have the legacy sediments, but also which reaches of streams, would greatly facilitate selection and placement of mitigating measures.

The USGS study infiltration measurements indicated that intense rainfalls above 0.12 to 1.57 inches would cause rain splash and overland flow that would mobilize the field and agricultural road erosion. These types of storm events occur but not always on an annual basis. However, the more frequent low-intensity rainfall events are moving fine-grained sediments from streams and into nearshore waters. During the July 2014 site visit, a low intensity rainfall event occurred and sediment plumes were observed in nearshore waters along the coastline.

6.2.6.3 Soil Loss Findings

A summary of the available soil loss information from the NSPECT model and the USGS reconnaissance sediment budget is provided in Table 6.6.

DEFINITIONS

Pollutant loads refer to estimates of pollutant weight passing into ocean water during a year's time.

Connectivity refers to ability of the pollutant to be transported from the source to nearshore waters. Sediment connectivity can begin with overland flow and often then continues into a gulch or stream before being transported during a storm event into nearshore waters. Other pollutants, which are soluble in water, such as nitrogen, may have connectivity to nearshore waters via ground water.

[2] Valley Deposits have a range of rates and therefore modeled suspended loads.

Table 6.6 Summary of Available Soil Loss Information

Watershed	**Kahana**					**Honokahua**			**Honolua**		**TOTAL**
Subwatershed	Kahana	Ka'ōpala	Honokeana	Nāpili 4-5	Nāpili 2-3	Honokahua	Mokupe'a	Kahauiki	Honolua	Līpoa Point	10,745
Area (acres)	3,237	573	484	597	475	1,004	999	767	2,545	66	
Relative Potential Surface Soil Loss (NSPECT)											
Annual Soil Loss (tons)	48,453	16,131	24,581	24,010	12,826	27,202	11,351	7,110	31,978	5,629	209,270
Soil Loss (% of total)	23%	8%	12%	11%	6%	13%	5%	3%	15%	3%	100%
USGS Study											
Modeled suspended load (tons/year)	-	-	-	-	-	-	-	-	> 345*	-	-
Desilting Basins											
Assessment	Under-sized	Under-sized	Acceptable	Acceptable	Under-sized	Na	Na	Na	Na	sediment basin only	-

*Per the USGS 2014 study, the modeled suspended load for Honokōwai watershed (south of Kahana) is 456 tons per year.

Data Gaps

The connectivity of fields to streams and gulches is still not well understood. Where there are kickouts (places where soil has been pushed to the edge of a gulch or stream to allow the flow of water off the higher ground into the gulch), there is visible connectivity. Kickouts were observed in construction areas and alongside of some access roads. Some agricultural access roads may serve as ma uka-ma kai conduits and bring the soils down onto the highway and from there it is transported via the highway storm water system. A better understanding of the path of sediments to the nearshore waters and the sediment transport triggers will help to estimate the timeframe in which sediments reach nearshore waters. This would also inform understanding of the timeframe in which improvements in water quality might be seen once mitigation measures are implemented.

To date the USGS efforts have been focused on the larger subwatersheds with streams. It has been observed that the higher stream flow subwatersheds have fewer legacy sediments due to the higher amounts of water flow and flushing (W. Nohara Pers. Comm.). The smaller subwatersheds or gulches experience flow only during the certain rainfall events and may have larger stores of fine-grained sediments that are then released during rainfall events. Follow-on efforts should include subwatershed with gulches.

6.2.7 Nutrients

The NSPECT model was also used to provide relative annual nitrogen and phosphorous losses. Various forms of nitrogen are lost via surface overland flow and seepage into ground water and subsequently transported to receiving surface waters. Phosphorus is readily coupled with fine sediments and transported on soil particles during runoff events. Table 6.7 provides the relative potential phosphorous and nitrogen losses by subwatershed. As with the relative potential soil loss, these loading values are relative, not ground truthed, and are not actual losses to nearshore waters because transport mechanisms and connectivity are not factored into the NSPECT model.

Since pineapple production ceased in 2008, the amount of fertilizers and pesticides being applied on agriculture lands has been nearly eliminated as an ongoing source of pollutants. However, it may take many years for nitrogen and phosphorus to flush through the aquifer. Soicher and Peterson 1997 note the difference in timing of nutrient flow from ground water and surface waters into coastal waters. Ground water is fairly constant over time while streamflow inputs are pulses that provide large amounts of nutrients at one time. The study suggests that the impact of sudden large amounts of nutrients and sediments from streamflow exceed those from ground water.

Golf courses and some residential communities are on both agricultural and urban lands. Groundskeeping and golf courses and their potential pollutant contributions are discussed in Section 6.3 Urban District Sources.

Ground water nutrients loading from past agricultural practices are understood to be a minor component of nitrogen contributions to nearshore waters. Well testing for nitrogen as follow-up to the Soicher and Peterson 1996 well testing is needed and listed as a data gap in Chapter 7.

Table 6.7 Relative Potential Phosphorous and Nitrogen Losses

Watershed	Kahana					Honokahua			Honolua		TOTAL
Subwatershed	Kahana	Ka'ōpala	Honokeana	Nāpili 4-5	Nāpili 2-3	Honokahua	Mokupe'a	Kahauiki	Honolua	Līpoa Point	10,745
Area (acres)	3,237	573	484	597	475	1,004	999	767	2,545	66	
Nitrogen											
Annual Nitrogen Loss (lb)	12,480	1,110	1,272	1,161	1,129	5,837	1,640	798	8,001	44	33,471
Average Annual Nitrogen Loss (lb/acre)	3.9	1.9	2.6	1.9	2.4	5.8	1.6	1.0	3.1	0.7	-
Percent Nitrogen Loss (% of total)	37%	3%	4%	3%	3%	17%	5%	2%	24%	0%	100%
Phosphorous											
Annual Phosphorous Loss (lb)	832	139	187	146	165	294	113	109	361	7	2,352
Average Annual Phosphorous Loss (lb/acre)	0.3	0.2	0.4	0.2	0.3	0.3	0.1	0.1	0.1	0.1	-
Percent Phosphorous Loss (% of total)	35%	6%	8%	6%	7%	13%	5%	5%	15%	0%	100%

6.3 Urban District Sources

Urban pollutant sources have high potential contributions during "first flush", the initial surface runoff of a rainstorm, and during extended rainfall events. Sediments moving through the urban area will often have other pollutants attached and be transported into waterbodies (Table 6.1). For example, roadside erosion will cause sediments to enter nearshore waters with associated hydrocarbons and metals from road surfaces.

The Urban District pollutants are in close proximity to the coastline, and can be transported to nearshore waters with minimal to no resident time in soils or vegetation, which can act as a sink for pollutants.

6.3.1 Honoapiʻilani Highway Storm Water System

The embankments and shoulders along segments of Honoapiʻilani Highway are sources of sediments and pollutants associated with motor vehicles. Figure 6.10 shows highway sections exhibiting significant amounts of erosion. The associated storm water system directs runoff from the roadway towards the ocean thereby contributing pollutants into nearshore waters. The Honolua watershed does not have a storm water system and transport of pollutants may have a more circuitous route toward nearshore waters. The length of highway affected equates to three (3) miles and is calculated by totaling eroding segments on both sides of the highway (Table 6.8 and Figure 6.11).

Figure 6.10 Honoapiʻilani Highway Erosion

Table 6.8 Honoapiʻilani Highway Segments with Significant Erosion

Segment	Side of Highway	Shoulder or Embankment	Storm water System	Highway Length (feet)	Eroding Segment Length (feet)
1	Both	Shoulder	No	1,297	2,594
2	Both	Shoulder	No	1,274	2,548
3	Ma kai	Embankments	Yes	384	384
4	Both	Embankments	Yes	527	1,054
5	Ma uka	Embankments	Yes	523	523
6	Both	Embankments	Yes	962	1,924
7	Both	Embankments	Yes	2,407	4,814
8	Ma uka	Shoulders & Embankment	Yes	555	555
9	Ma uka	Shoulders & Embankment	Yes	497	497
10	Ma uka	Shoulders & Embankment	Yes	1,276	1,276
Total				9,702 feet or ~2 mile	16,169 feet or ~3 miles

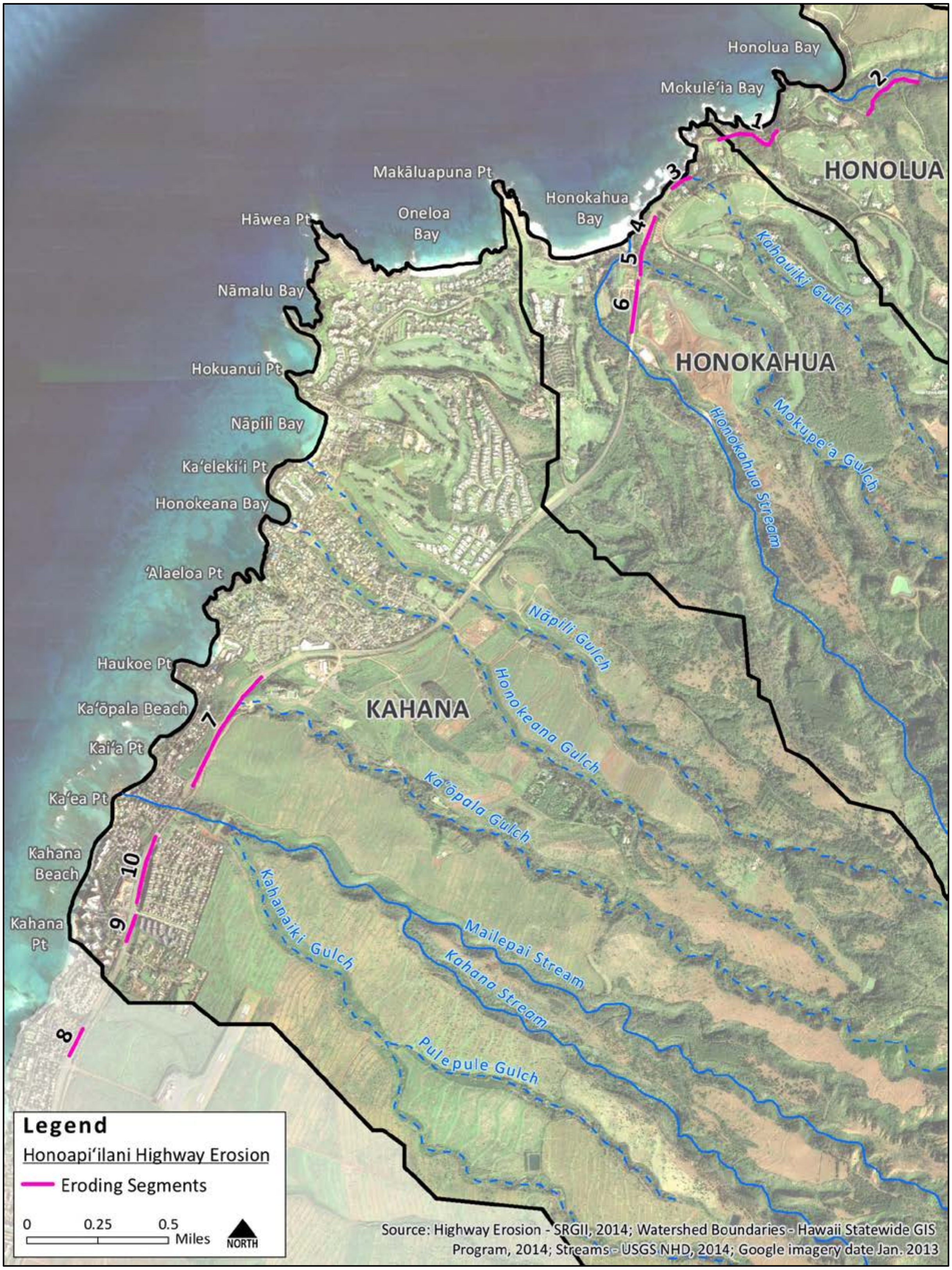


Figure 6.11 Honoapi'ilani Highway Segments with Significant Erosion

6.3.2 Roadways, Parking Lots and Building Complexes

Impervious surfaces in the urban areas impact the amount of runoff and the rate at which it may be transported into nearshore waters. This section provides general descriptions of the urban impervious surfaces and descriptions and locations of selected areas of pollutant generation.

Lower Honoapiʻilani Road, from the airport to Kapalua, functions as the corridor for utilities, including the inlets and subsurface storm water sewers. Curbs and gutters are lacking along most stretches of the road and the road sides have bare soil. Most weekdays a mechanical broom street sweeper operates out of the County of Maui Lahaina base yard and sweeps Lower Honoapiʻilani Road (E. Tihada Pers. Comm.). In the Kapalua Resort area nearly all the roadways have curbs and gutters, and a vacuum street sweeper cleans the main streets throughout the resort daily. (J. Cardoza Pers. Comm.)

A field assessment was conducted by Sustainable Resources Group Intn'l, Inc. (SRGII) in May and June of 2013. Parking lots, roadways, and other impervious surfaces within the urban areas were observed to be generally clean, free of rubbish and a low source of sediment generation. The exception is bare soil shoulders of roadways. Accumulations of sediment and particulate matter were found in small quantities unevenly distributed along roadways, sidewalks and parking lots. Impervious areas directly connected to the separate storm sewer system were noted because they increase the volume of runoff carrying pollutants into drainage channels and out into the ocean.

Visual inspection of numerous properties was conducted to identify areas of potential pollutant sources. Inspection did not occur on all parcels and was not exhaustive. The urban areas in the watersheds, including the residential and resort properties, are mostly well maintained and free of litter, with a well-kept appearance.

Visible portions of the storm drain system were mapped including outfalls and inlets. Both concrete and grate catch basins are identified in the mapping. Catch basins are cisterns located where the street gutter discharges into the storm drain system and are used to catch large debris. Smaller basins used to retain water are also indicated on maps in Figures 6.16 to 6.20.

The following maps show areas with potentially high amounts of runoff and/or high levels of sediment erosion. Specific pollutant generation spots are noted in Figures 6.16 to 6.20 and described by their map locations below.

Kahana Urban Sub-Area (Figure 6.16)

a. The ***Ala Hoku and Kahana Ridge subdivisions*** have issues with runoff. Ala Hoku subdivision (in the Agricultural District) has significant areas of bare soil ground and runoff which can transmit sediments along with various pollutants (Figure 6.12). Neither subdivision has a storm water system and the water flows overland before reaching the ocean.

Figure 6.12 Ala Hoku Subdivision Dirt Road

b. ***Lower Honoapiʻilani Road ma kai of the Kahana Ridge subdivision*** has erosion associated with the road edges.

c. At the ***north end of the Hololani Condominiums*** is a narrow piece of land between Lower Honoapiʻilani Road and the ocean which is experiencing shoreline erosion, and is a source of sedimentation. (Figure 6.13)

d. ***Hui Road D*** has runoff and sediments and with runoff coming from the properties directly ma uka which have large impervious surfaces.

Figure 6.13 Coastal Erosion at Hololani Condominium

Kaʻōpala Urban Sub-Area (Figure 6.17)

e. The ***culverts ma kai of the Kaʻōpala gulch*** at Lower Honoapiʻilani Road are undersized, overgrown, and cause frequent flooding to adjacent properties and road.

f. Ma uka of Haukoe Point and ma kai of the highway is a large area with the exposed dirt that may be contributing sediments into nearshore waters. This is the site where ***Pineapple Ridge development*** was proposed.

Honokeana Urban Sub-Area (Figure 6.18)

g. The large expanse of condo on the south side of ***Nāpilihau Street*** and the homes on the north side of Nāpilihau Street contribute considerable runoff and sediments into the nearshore waters. Both sides of Nāpilihau Street have storm water system inlets and the nearest outfalls to this area are at Honokeana Bay.

h. The oceanfront ***Outrigger Nāpili Shores Resort*** generates a significant amount of runoff which flows directly out into the bay through the nearby outfalls.

Nāpili Urban Sub-Area (Figure 6.18)

i. ***Nāpili Place*** provides public access to Nāpili Bay and is frequently lined with cars (Figure 6.14). The road shoulders are eroding and sediments and pollutants from vehicles are transported directly into the ocean at the south end of Nāpili Bay.

j. The stretch of ***Lower Honoapi'ilani Road around Nāpili Bay*** from Nāpili Place up to Seahorse Restaurant and the tennis courts leading into Kapalua is a source of erosion along the shoulders which are bare soil (Figure 6.15).

k. The housing area ma uka of Lower Honoapi'ilani Road at the north end of Nāpili Bay is a source of runoff and sedimentation. ***The base yard*** in the back of the development serving the golf course is a five acre area that is slated for redevelopment as Pailolo Place with 42 multi-family units.

Figure 6.14 Nāpili Place Road Shoulder Erosion

Honokahua Urban Sub-Area (Figure 6.19)

l. The ***Ritz-Carlton Kapalua*** and Honolua Store parking lot areas are sources of runoff.

m. ***Two base yards*** ma kai of Honoapi'ilani Highway have large areas of exposed dirt and are likely contributing pollutants overland to nearshore waters during rainfall events.

Figure 6.15 Lower Honoapi'ilani Road Shoulder Erosion

Kapalua 2 Urban Sub-Area (Figure 6.20)

n. As previously referenced, the construction of the ***Mahana residential development*** contains significant areas of exposed soil. Several sediment discharge events are correlated with grading activity (Section 6.4.3).

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Figure 6.16 South Kahana Erosion Runoff Map

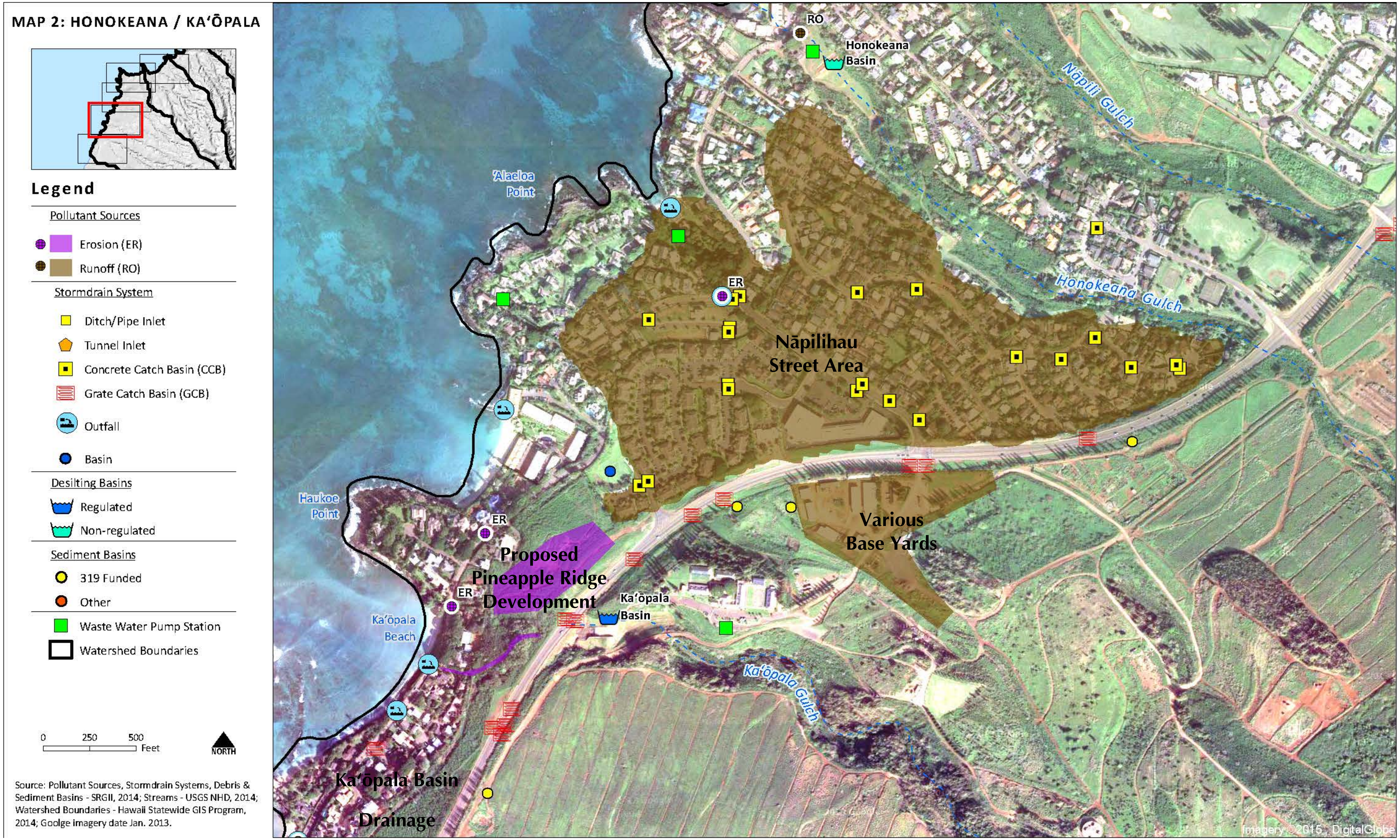

Figure 6.17 Honokeana/Ka'ōpala Erosion Runoff Map

Figure 6.18 Nāpili Erosion Runoff Map

Figure 6.19 Kapalua Erosion Runoff Map

Figure 6.20 Kapalua 2 Erosion Runoff Map

6.3.3 Illicit Discharges

Illicit discharges and/or improper storage of chemicals were observed at multiple locations during the field assessment. Observations included disposal of pool, jacuzzi or hot tub water, and wash waters (from cleaning grounds, vehicles, etc.), and improper disposal and storage of pesticides (Figure 6.21). Improper storage of chemicals, where storage and use areas drain into the storm sewer system instead of sanitary sewer, was observed at commercial businesses. Chemical storage is a concern at base yards as well. These observations are similar to the Woodward and Clyde 1996 study observations of illicit discharges (Table 6.9).

Field inspections were not exhaustive and not every property was inspected. However, it can be reasonably concluded from the site visit observations that these conditions are representative of regularly occurring illicit discharges that occur during maintenance of condos, businesses and homes. Illicit discharges are especially of concern along the coastline where discharges can flow directly out into the ocean without any treatment or residence time.


Figure 6.21 Pool Water Discharge into Storm Water System

To better understand where illicit discharges are occurring, outfall surveying should occur during dry weather to see where water is flowing into the storm drainage network and nearshore waters. Four priority outfalls for investigating potential contributing discharges are shown in Figure 6.22. These locations include outfalls where water has been seen flowing during dry weather on multiple occasions. Two are in south Kahana and one of those is just outside of the Kahana watershed. However, there may be contributions to the outfall from within the Kahana watershed. The other two locations are in the Nāpili area.

The monitoring of these and other outfalls could be done in concert with the training sessions for hotel, condominium associations, business owners and neighborhood groups to encourage behavior changes and self-monitoring of outfalls to reduce illicit discharges to nearshore waters.

6.3.4 Outfall Sediments

Outfalls are points at which storm water is discharged from land to streams, gulches or directly into nearshore waters. The pipes, culverts and channels that convey storm water can accumulate sediments and associated pollutants that settle out when water slows. While this settling initially keeps the sediments and debris from entering the nearshore waters, later it becomes a pollutant source when flowing water passes over it and resuspends sediments and other pollutants. The three outfalls observed to have accumulated sediments are shown in Figure 6.22. Two are in the

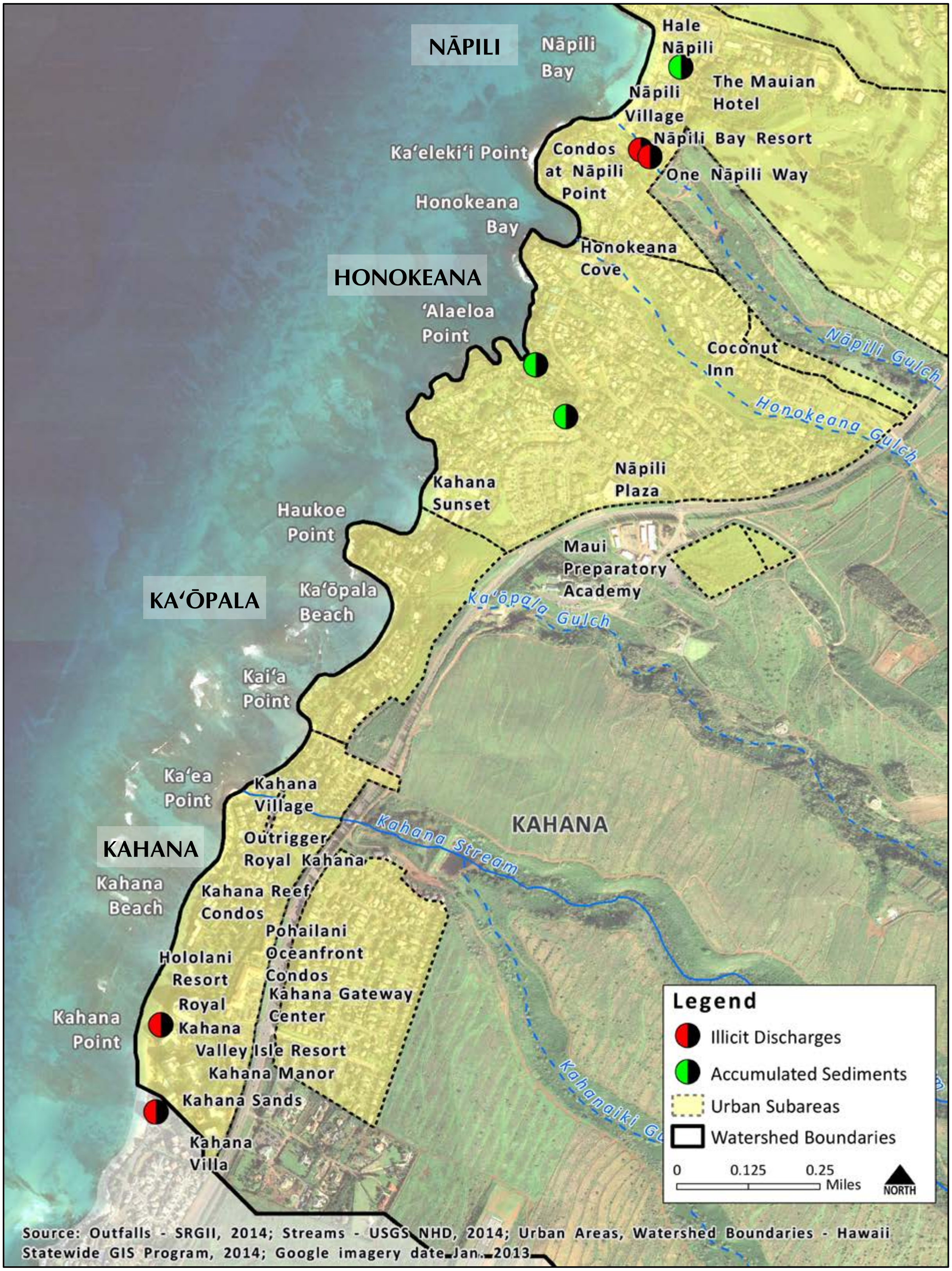

Figure 6.22 Priority Outfalls: Accumulated Sediments and Potential Illicit Discharges

Honokeana urban sub-area and one is in the Nāpili urban sub-area. The optimal remedy is to prevent the sediments from eroding at the source. Until this can be achieved, some storm water outfalls may need to be periodically cleared of sediments.

6.3.5 Coastal Erosion

Coastlines are continually eroding with the primary mechanism being wave action which is highest during the winter. Two locations with significant exposed sediments along the shoreline are Kaʻōpala Bay in Kahana watershed (Figure 6.23) and at S Turns in northern Honokōwai watershed. While coastal erosion is likely a secondary and seasonal sediment source to the bays, it may become more of an issue with climate change and sea-level rise in the future.

Figure 6.23 Kaʻōpala Bay Shoreline

6.3.6 Kapalua Golf Courses

Due to the extensive grass turf covering the two operating Kapalua Golf Courses (Bay and Plantation), erosion and sediment generation are understood to be minimal. Some fraction of total amount of nutrients in fertilizers and pesticides applied to the courses are suspected to leach into soils and ground water and/or be transported during overland flow events.

Elemental sulfur is added as an amendment to bring down the soil pH and make more nutrients available to the plants (D. Smallwood Pers. Comm.). Nitrogen fertilizer is needed, and typical application on the golf courses is 4 lb./1,000 square feet for the golf course and 2 lb./1,000 square feet for the Academy driving range. It is unknown how much, if any, nutrient runoff is being generated and carried to the ocean until water quality testing is conducted.

In 1997, Soicher and Peterson wrote that the Lahaina District's five golf courses added nitrogen and phosphorus to the fairways, greens and tees. "Tetra Tech, Inc. (1993) reported nitrogen application rates of 0.98 lb. N/1,000 sq. ft/month (47.85 kg N/ha/month) on greens and tees, with half that quantity applied to fairways.[3] Phosphorus applications are estimated at 1/10 those of nitrogen." Soicher and

[3] SRGII surmised that Soicher and Peterson (1997) incorrectly state units as 0.98lb N/ac/month instead of 0.98 lb. N/1,000 sq ft/month.

Peterson (1997) go on to say that "Leaching from golf courses is extremely variable with regard to the percentages of leachate (0-84%); mean leakage equal to 10% of the applied nitrogen is typical."

Irrigation water is surface water from the Honokōhau/Honolua Ditch is piped down from ma uka storage reservoirs. Three weather stations, one on the Bay course and two on the Plantation course measure evapotranspiration and guide the amount of irrigation water applied via the irrigation system. Soil moisture tests are also conducted and irrigation amounts may be adjusted up or down from the evapotranspiration readings as needed. These management practices translate to an efficient use of water (D. Smallwood Pers. Comm.).

Pesticide Practices

Herbicides, fungicides, and pesticides are used on the courses sparingly (D. Smallwood Pers. Comm.). Herbicides, mainly pre-emergence, are applied several times a year and supplemented with weed pulling. Fungicides and pesticides are used as needed, typically when a pest reaches a particular threshold. Pests and plant diseases are addressed with chemicals as necessary following recommendations on package labels.

The Village Golf Course in the Kapalua Mauka development area was closed in 2008, and there may be continued movement of legacy nutrients and pesticides through ground water.

6.3.7 Grounds Keeping and Maintenance Practices of Resorts and Condominiums

Resorts and condominiums can also have landscaped grounds which are typically watered, fertilized and kept free of disease with pesticide applications. The chemicals used in landscape maintenance can be transported to the ocean via surface water and ground water. Many condominiums and resorts along the shoreline have drainage system that discharge directly to coastal waters. Water quality testing by DOH and community water quality monitoring can provide information on the quantities and types of pollutants that are reaching nearshore waters.

The specific application rates are not known. It is logical to conclude that some of the fertilizers and other chemicals are transported during rainfall events that result in saturated soil conditions and generation of overland flow, or when irrigation water saturates the soil. The College of Tropical Agriculture & Human Resources (CTAHR) at University of Hawai'i at Mānoa Cooperative Extension Service bulletins on Turf Management, TM-13 *Turf Fertilizers for Hawai'i's Landscapes* (October 2000) recommends a single application of soluble nitrogen fertilizer should not exceed 1 pound of nitrogen during a single application and is best applied before the summer growth. The CTAHR bulletin L-6 *Fertilizers for Trees and Shrubs* (June 1998) recommends 2-6 pounds of N per 1,000 square feet of tree crown or planting bed area.

6.3.8 Cesspools and Other On-site Sewage Disposal Systems

The State of Hawaii Department of Health Safe Drinking Water Branch released a report entitled *Human Health and Environmental Risk Ranking of On-site Sewage Disposal Systems for the Hawaiian Islands of Kauai, Molokai, Maui, and Hawaii* in 2014. The data includes locations of four types of Onsite Sewage Disposal Systems (OSDS) of which cesspools are one type. However, over reporting has already been identified and greater review is needed. There are a number of areas that do not have County sewer lines and likely have OSDS including the Ala Hoku subdivision (in South Kahana ma uka of the Highway), Kapalua Plantation Estates, and Honolua watershed area.

The next step is to confirm the type of OSDS used in order to better identify sources and loading. The County of Maui only has a database of billing locations and is working on a service location database with an unknown completion data. Door-to-door surveys would provide useful data in the near term.

6.3.9 Wastewater Pumping Stations and Sewer Lines

Wastewater from the three watersheds is conveyed to the Lahaina Wastewater Reclamation Facility for treatment. Wastewater pump stations are shown in Figure 6.24. Wastewater pump stations and sewer lines can have leaks that contribute pathogens and nutrients to marine waters. Typically this occurs during the wet season when rainfall moves the leaked effluent through the ground water to the nearshore waters. As discussed in Chapter 5, Section 5.1.3.2, preliminary water quality testing indicated potential wastewater issues in the northern part of Kahana watershed, and additional water quality testing is needed. Monitoring of wastewater system lines and pump stations for leaks is also needed.

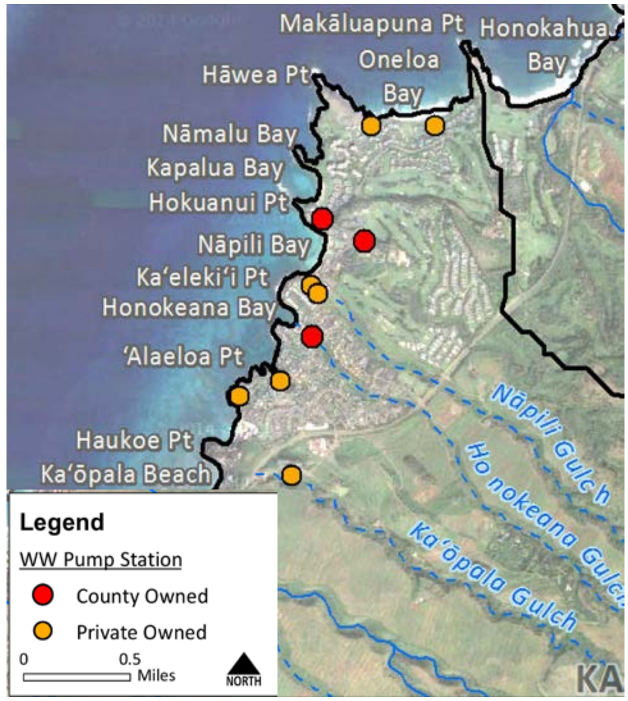

Figure 6.24 Wastewater Pump Station Ownership

6.3.10 Relative Urban Pollutant Loading

Urban areas generate high runoff volume and carry pollutants because of impervious areas that drain runoff via streets, gutters, ditches, or pipes. The surfaces of these built features increase the water velocity on its way to outlets.

Contaminants on impervious surfaces come from both human activity and natural sources. Urban areas contribute nutrients, sediment, vegetative and manmade debris, pesticides, hydrocarbons and bacteria in surface water runoff (Table 6.1). Bare soil and construction activities can generate pollutants, especially sediment. Nutrient contributions are from application of fertilizers onto golf courses and resort, residential, and commercial landscaping and from wastewater. Parking lots and roadways contribute hydrocarbon pollution when rainfall events direct runoff untreated into drainage systems.

A survey conducted by Kinetic Laboratories, Inc. at 83 urban sites in West Maui (March and April 1996) identified sources of non-storm water discharges into storm drains or directly into ocean waters (Woodward-Clyde 1996). Visual observations were taken at each location, with sediment found to be the most persistent pollutant (present at 21.9% of sites), followed by litter (19.5%), oil (12.2%) and landscape vegetation (8.5%) resulting from urban use and activities (Table 6.9). Typical pollutant concentrations from various structures and infrastructure are shown in Table 6.10 from the New York State Stormwater Management Design Manual 2001 Appendix A.

Table 6.9 Categorization and Frequency of Urban Area Pollution Observations

Pollutant Source Category	Frequency of Occurrence (% of Sites)
Sediment	21.9
Litter	19.5
Oil	12.2
Landscape Vegetation	8.5
Storage and Maintenance	7.3
Swimming Pool	6.1
Cleaning Activity	4.9
Concrete/Grout	3.7
Paint	3.7
Other	4.9

Source: Kinetic Laboratories, excerpted from Woodward-Clyde (1996)
Data resulted from a 30-day observation period in the spring of 1996.

Table 6.10 Pollutant Concentrations from Source Areas

Constituent	TSS (mg/L)	TP (mg/L)	TN (mg/L)	Cu (µg/L)	Pb (µg/L)	Zn (µg/L)
Residential Roof	19	0.11	1.5	20	21	312
Commercial Roof	9	0.14	2.1	7	17	256
Residential Street	172	0.55	1.4	25	51	173
Rural Highway	51	-	22	22	80	80
Urban Highway	142	0.32	3.0	54	400	329
Lawns	602	2.1	9.1	17	17	50
Landscaping	37	-	-	94	29	263
Driveway	173	0.56	2.1	17	-	107

Source: New York State Stormwater Management Design Manual 2001 Appendix A

Table 6.11 Concentrations for Chemical Constituents in Storm water

Constituent	Concentration
Total Suspended Solids (TSS)	24.6 mg/L
Total Phosphorus (TP)	0.146 mg/L
Total Nitrogen (TN)	0.676 mg/L
Copper (Cu)	.017 mg/L
Lead (Pb)	.004 mg/L
Zinc (Zn)	.047 mg/L

Source: NPDES Storm Water Monitoring Report for City and County of Honolulu by Oceanit Laboratories with data collected in 1992 & 1993.

Relative amounts of pollutant loading using the Simple Method were estimated for the Urban District. The outputs should not be used as absolute loading. The Simple Method is most appropriate for comparing the relative storm flow pollutant load changes of different land use and storm water management scenarios. Urban sub-areas were designated for calculating pollutant loading (Figure 6.25). The urban sub-areas were drawn to roughly follow the subwatershed areas delineated in Chapter 4 where possible to create consistency for ma uka to ma kai perspective. Grading and storm systems have altered natural drainages in the urban area.

Reliable pollutant concentrations for West Maui are not available and Oʻahu pollutant concentrations (NPDES Storm Water Monitoring Report for City and County of Honolulu by Oceanit Laboratories) are used (Tables 6.11). The relative pollutant loading calculated using the Simple Method is provided in Table 6.12. Kapalua urban sub-area has the highest relative pollutant loading which is largely attributable to it having the largest impervious area of the five urban sub-areas. The next highest loads are sub-areas with the next highest amounts of impervious surfaces, Kahana and Honokeana subwatersheds.

Table 6.12 Annual Relative Loading of Existing Development

Urban Sub-Areas	Kahana	Kaʻōpala	Honokeana	Nāpili	Kapalua
Area (acres)	138	46	172	215	419
Urban Impervious Surface (acres)	77.0	8.9	76.7	57.2	104.6
Urban Impervious Surface (%)	55.8%	19.5%	44.6%	26.6%	25.0%
Annual Rainfall (inches)	30	35	40	40	45
Annual Relative Loading (pounds)					
Total Suspended Solids	25,355	3,995	34,414	27,588	57,422
Total Phosphorus	121	19	164	132	274
Total Nitrogen	930	147	1,263	1,012	2,107
Copper	5	1	7	6	12
Lead	24	4	32	26	53
Zinc	60	9	81	65	136

Source: GIS data provided area and rainfall; impervious surface from 2007 CCAP data. Annual Relative Loading calculated using the Simple Method. Note: The total of the impervious surface acreage is different than those for the total urban area as the urban subwatershed boundaries do not include the entire urban area.

6.3.11 Wastewater Pollutant Loading

Quantification of wastewater pollutant loading for Kahana, Honokahua and Honolua watersheds is difficult to calculate with available information. The number of households on OSDS versus having sewer connections is unknown. Once this data gap is filled, knowing the number and type of OSDS would allow the use of loading information cited in the 2014 State Department of Health (DOH) OSDS report.

The sewer system takes wastewater from the three watersheds to Lahaina Wastewater Reclamation Facility (LWRF) in Wahikuli watershed. The sewer conveyance system of pipes and pump stations may have leaks that contribute nutrients and pathogens into nearshore waters. This is not quantified at this time and should be continually monitored and addressed if issues are found.

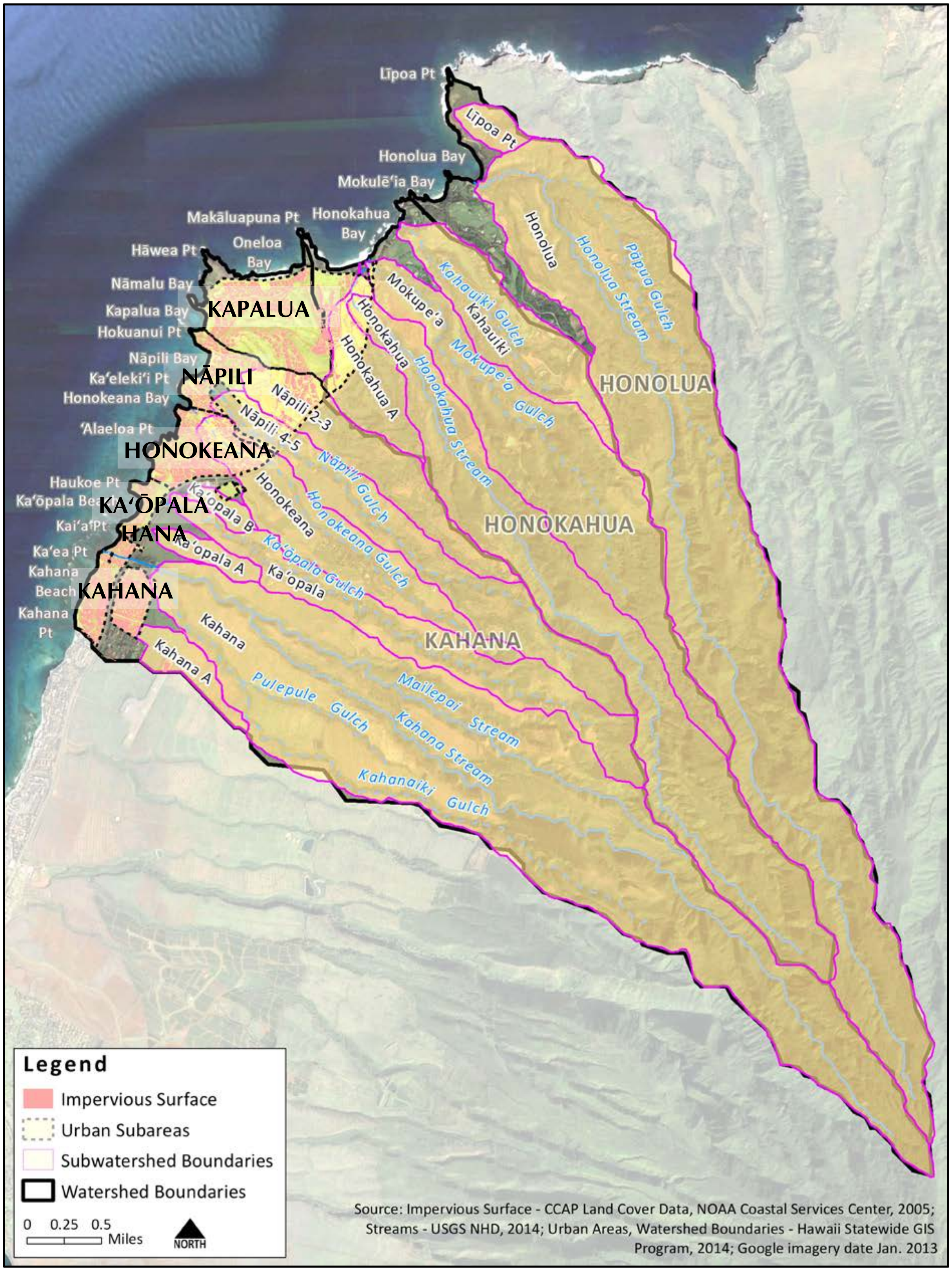

Figure 6.25 Urban Sub-Areas and Impervious Surfaces

6.3.12 Recreational Use of Honolua Bay and Līpoa Point

Honolua Bay and Līpoa Point are popular recreational areas. Honolua Bay is calm and protected in the summer when snorkeling and diving occur, and has high wave action during the winter months when surfing is the predominate activity. Honolua Bay can have hundreds of visitors in a single day and more when a surf competition is being held.

There is no developed parking area and as result numerous vehicles park on the shoulders of Honoapiʻilani Highway. This situation has resulted in barren road shoulders that generate sediment during runoff, which in many sections is carried along the road shoulders and discharged into streams that cross the highway. A former dirt access road that leads out to Līpoa Point on the north side of Honolua Bay is used by surfers and visitors for parking. This access road has severe erosion occurring in several sections.

Save Honolua Coalition has been funding porta-potties to minimize potential nutrients and pathogen source into the bay. The limited Department of Health Clean Water Branch wastewater quality testing data (Chapter 5) in Honolua Bay did not show indicators of human pathogens. Ongoing monitoring is recommended.

Līpoa Point, which includes 280 acres from Honokōhau to the Honolua boat ramp, transferred ownership from Maui Land and Pineapple Company to State of Hawaiʻi ownership in October 2014. The Hawaiian Islands Land Trust and the Save Honolua Coalition are involved in developing a community management plan for the area.

6.4 Future Sources

6.4.1 Wildfire

The high density of non-native vegetation throughout both the Agricultural and Conservation Districts contributes fuel loads with susceptibility to wildfire. Fallow agricultural fields are covered with alien grasses, woody shrubs and small trees (species such as Guinea grass and Formosa Acacia). This vegetation is classified as ‘one hour fuels’, meaning that in one hour, half the moisture content in a plant can be lost. As a result during periods without appreciable rain, these types of plants dry out making them vulnerable to wildfire.

Figure 6.26 Existing Ag Access Road

Roads that dissect the fallow agricultural fields might be widened into fuel breaks to slow or arrest fire spread. Encroachment of alien vegetation on and over the roads is reducing their effectiveness as fire breaks (Figure 6.26). Without fire breaks a fire could quickly move from agriculture lands up into conservation areas. Exposed soil is vulnerable to accelerated erosion rates. Areas covered with native vegetation that are consumed during fires are vulnerable to post fire recruitment of non-native plants.

Drought conditions were a large contributor to a 100 acre wildfire in the Kahana-Kahanaiki Watersheds on WMMWP managed lands in 2012. The burned area exposed the soil surface resulting in accelerated erosion, transport of sediment and nutrients, and may have increased occurrences of mass wasting on steep slopes. The *Western Maui Community Wildfire Protection Plan* (2014) was developed for the entire West Maui area and addresses fire protection, hazard assessment, wildfire mitigation priorities, and community outreach and education needs. It rates the Fire Environment for the three watersheds as moderate hazard based on rainfall, prevailing wind speeds and direction, slope, topographic features, seasonal conditions and ignition risk. A *Wahikuli and Honokōwai Post-Fire Rehabilitation Plan* (2014) was developed for the watersheds south of Kahana as a recommendation of 2012 *Wahikuli-Honokōwai Watershed Management Plan*.

ML&P is conducting their own fire preparedness and post fire planning to assess potential uses for fallow pineapple fields. One effort in the early implementation phase is using cattle to reduce fuel load. A grazing consultant is assessing the lands for the number of head of cattle that can be supported. Some fencing has been constructed in the southern portion of ML&P lands and eventually cattle will be brought onto the land via a lease agreement (P. Kaniaupio-Crozier Pers. Comm.).

6.4.2 Grazing

While grazing can be a part of a wildfire prevention plan in reducing the fuel load, it can also be a pollutant source. Overgrazing can create bare ground that is prone to sediment erosion. Rotating livestock and not allowing grazing of bare ground can help to prevent overgrazing which contributes to polluted runoff. During periods of drought, overgrazing is especially a concern if the number of cattle remains constant while available fodder diminishes. Nutrients are a concern especially if livestock are continually brought to a single area for watering each day, which concentrates their waste instead of rotating watering locations. If cattle have access to stream and gulch valleys, this could increase the impact and transport of pollutants to nearshore waters.

The potential benefit or impact of grazing will depend on the practices used and the number of head of livestock. The *Wahikuli-Honokōwai Wildfire Management Plan* (2014) includes grazing management recommendations.

6.4.3 Construction

Preparing land for development, installing infrastructure and constructing buildings are activities than can impact storm water quality as it flows over a construction site. Storm water can pick up and transport sediments, debris and chemicals to streams and nearshore waters.

Construction activities that disturb more than one acre of land are required to obtain a National Pollution Discharge Elimination System (NPDES) storm water permit. NPDES is one way that Clean Water Act requirements are met. The NPDES permits contain limits on discharges, monitoring and reporting requirements and other provisions to ensure that discharges do not hurt water quality or people's health. NPDES permits are issued by State of Hawaiʻi Department of Health (DOHJ) using rules in Hawaiʻi Administrative Rules (HAR) Chapter 11-55.

Construction projects that involve grubbing and grading must also obtain a permit per the Maui County Code of Ordinances Chapter 20.08 and may be required to have a grubbing and/or grading plan. The County requires that land management to control soil and sediment be in conformance with standards set by the Soil and Water Conservation District.

Maui County has applied for and received municipal separate storm sewer system (MS4) general permit coverage for the Wailuku-Kahului urbanized area. The County of Maui is required to develop, implement, and enforce a program to reduce pollutants in storm water runoff to their MS4 from construction activities that result in a land disturbance of greater than or equal to one acre. These include having an ordinance requiring proper erosion and sediment controls, procedures for reviewing site plans for water quality impacts, procedures for site inspection and enforcement of control measures, sanctions to ensure compliance, procedures for receipt and consideration of information submitted by the public and determination of appropriate best management practices with measurable goals for minimum control. While these are required for the Wailuku-Kahului area, implementation of this program island-wide would have significant benefits for West Maui in reducing construction sources of pollutants. The County has begun training for inspectors in partnership with DOH and plans to expand the training to contractors in the future.

The best management practices to address construction runoff should be tailored to the project location (such as slope, soil type and extent), and implemented proactively as weather conditions and/or construction activities change. The City and County of Honolulu's Storm Water Construction Best Management Practice Manual, November 2011 provides controls for erosion, sediment, wind erosion, vehicle tracking and waste management. The County of Maui enforcement and monitoring of the permit conditions should also be responsive to changing conditions.

Future construction activity from planned development as tracked by the County of Maui is listed in Table 6.13 and described in Section 3.3 Future Land Use. The timing for most of the planned development in Table 6.13 is unknown, except for the West Maui Village Affordable Condominiums which is under construction (Figure 3.7). A one-acre drainage basin abutting the site will capture water from the site. The overflow will be funneled along a concrete drainage-way to the culvert under the highway at the Nāpilihau/Honoapiʻilani intersection (Lahaina News, 20 March 2014).

The future Kapalua Mauka development due to both extent and slope will warrant a carefully detailed and monitored storm water management plan.

Table 6.13 County of Maui: Development Projects Mapping

WATERSHED	KAHANA		HONOKAHUA		HONOLUA		TOTAL	
Proposed Development[1]	**Acres**	**Units**	**Acres**	**Units**	**Acres**	**Units**	**Acres**	**Units**
Kapalua Mauka Residential	394	296[2]	525	394[2]	-	-	919	690
Pailolo Place	4	42	-	-	-	-	4	42
West Maui Village Affordable Condominiums	10	158	-	-	-	-	10	158
Pulelehua (Partially in Honokōwai)	67	191[2]	-	-	-	-	67	191
Total Proposed Development	**475**	**687**	**525**	**394**	**-**	**-**	**1,000**	**1,081**

[1] County of Maui Long Range Planning Division Development Projects Mapping listing of proposed projects as of February 2014. Proposed Development is projects have appropriate conforming Community Plan and zoning entitlements, are approved agricultural subdivisions, or are approved 201G/H (affordable housing). See *Section 3.3 Future Land Use.*

[2] Approximate; where a project crosses watershed boundaries, units were assigned in proportion to the project acreage in each watershed.

In addition to larger developments, construction will continue on individual lots such as those in Honolua Ridge and Mahana Estates subdivisions. NPDES permits and conservation plans will be required.

Mahana Estates

Lessons learned from the Mahana Estates development is included to highlight future opportunities to reduce impacts and pollutant loading from construction.

The Mahana Estates subdivision covers 125 acres with 51 residential lots and is the first phase of Kapalua Mauka development (Figure 6.27). In 2014 roadway and utility infrastructure was being installed prior to lot sales, and observations included large areas of exposed dirt on moderate to steep slopes with limited and insufficient erosion management practices. While best management practices such as silt fences were implemented, they were not sufficient to mitigate the extent of the erosion and runoff. Multiple brown water advisories were issued for Honokahua Bay in 2014 (Chapter 5) and one is shown in Figure 6.28.

The State Department of Health issued a notice of violation of their NPDES permit and the County of Maui issued a stop work order that required detailed assessment and planning to address issues before allowing future work.

Figure 6.27 Mahana Development, June 2014

Lessons Learned

1) Knowledge gaps exist in implementing County ordinances. More technical training, information and access to materials to support the use of best management practices during construction are needed.
2) More detailed guidance on the intent and ways to implement the ordinances would help developers, designers, contractors and homeowners involved in construction.
3) Good designs should be stipulated and incentivized to use natural processes and setting to decrease the movement of soil and vegetation. This includes maintaining buffers along the gulch and designing with the topography to minimize grading.
4) Plans and implementers should be focused on outcomes, not just implementing a plan. For example, if rains are expected, contractors should be checking existing BMPS and adding more if needed to minimize runoff from leaving the site.
5) Construction and post-construction drainage practices should be integrated to maximize gains from both.
6) Enforcement should be a last resort solution. It can be difficult to show connectivity from the construction activity to nearshore waters, and by the time enforcement is being pursued, opportunities will have been missed to reduce the pollutant load.

Courtesy of Multicopter Maui

Figure 6.28 View of Flemings Beach Looking South, April 2014

Solar Farms

Two solar farms were constructed in Honokeana subwatershed (Figure 6.29), and one more is planned above Mahana Estates. Solar farms less than 15 acres and no more than thirty-five percent of a lot are not required to have land use permits. A County grubbing and grading permit is required.

Best management practices should be used to minimize erosion and sediments into streams and gulches. Solar farms on the edges of gulches or streams are of particular concern due to the high likelihood of sediments being transported to nearshore waters.

Figure 6.29 Honokeana Solar Farm Construction

Because vegetation cannot be allowed to shade the PV panels, vegetation control is needed. Manual control is the preferred over herbicides usage.

6.4.4 Future Pollutant Loading

Construction impacts should be minimized with a combination of education, storm water best management practices and regulation enforcement. The acreage of the future developments is noted in Table 6.13.

6.4.4.1 Urban Runoff

Once development has been constructed it will continue to have impacts and pollutant loading impacts. Future potential annual pollutant loading from runoff was estimated using the Simple Method described in Section 6.3.10 and used for existing annual pollutant loading in Table 6.14. The percentage and amount of impervious surface based on density of the future developments and Soil Conservation Service TR-55 *Urban Hydrology for Small Watersheds*, 1986.

Table 6.14 Annual Relative Loading of Future Development

Subwatershed	Kahana	Ka'opala	Nāpili	Honokahua
Project Area (acres)	67	10	398	525
Estimated Percent Impervious Surf	38%	65%	20-65%	20%
Project Area Impervious Surface (acres)	25.5	6.4	85	105.0
Annual Rainfall (inches)	30	35	40	45
Annual Relative Loading				
Total Suspended Solids (TSS) (tons)	2.0	0.6	9.3	13.6
Total Phosphorus (TP) (pounds)	23	7	110	161
Total Nitrogen (TN) (pounds)	108	30	512	747
Copper (Cu) (pounds)	3	1	13	9
Lead (Pb) (pounds)	0.6	0.2	3.0	4.4
Zinc (Zn) (pounds)	8	2	36	52

6.4.4.2 Wastewater

Planned future development (Table 6.13) will ultimately convey wastewater to the LWRF and will affect waters offshore of LWRF versus those in the three watersheds of this report. Based on more than 1,000 planned units and the 2010 Census average household size for Maui County of 2.82 persons per household, the population in the three watersheds will increase the population by approximately 3,000 persons and expand the population in the three watersheds from 6,000 to 9,000 persons. The quantity of wastewater being sent to LWRF from the three watersheds is estimated to increase 50%, proportional to the population increase.

6.5 Pollutant Sources by Subwatershed

A summary of pollutant loading information is provided in Table 6.15. This compilation includes available information and modeled estimates of pollutant loading. This information is used to select priority watersheds/subwatersheds in Section 6.6. Areas without data should not be considered non-priority areas. As data becomes available, priorities should be reassessed. A regional drainage analysis would be helpful to connect pollutant sources with water transport routes to nearshore waters.

Table 6.15 Water Quality Data and Pollutant Sources Summary

Watersheds/Urban Sub-Areas[1]	KAHANA							HONOKAHUA	HONOLUA		
	Kahana	Ka'ōpala	Honokeana	Nāpili		Kapalua			Honolua		Līpoa Point
Water Quality Data[2]											
Turbidity (State standard = 0.2 NTU)[3]											
Geometric Mean of 6 samples from 2014-2015 (NTU)[4]	3.04 (S Turns/Pohaku as proxy)	5.46	No data	1.72		1.81 Kapalua	0.90 Oneloa	2.83 DT Fleming Beach	1.79 Mokulē'ia	3.50 Honolua	na
Nutrients[5]											
Available Data from after 2008 (post plantation era)[6]	No data	No data	No data	Significant Exceedances – Nitrate + Nitrite and Ammonia Nitrogen		No data	No data	No data	No data	No data	na
Existing Urban Pollutant Loading & Sources											
Relative Annual Urban Loading (Modeled using the Simple Method)[7]											
Total Suspended Solids *(tons)*	*6*	*1*	*8*	*6*		*13*		*na*	*na*		*na*
Total Phosphorous *(lb)*	*68*	*11*	*92*	*74*		*153*		*na*	*na*		*na*
Total Nitrogen *(lb)*	*314*	*50*	*427*	*342*		*712*		*na*	*na*		*na*
Related Information											
Area (acres)	138	46	172	215		419		na	na		na
Impervious Surface (acres)[8]	77	9	77	57		105		na	na		na
Impervious Surface (%)[8]	56%	20%	45%	27%		25%		na	na		na
Nutrient Sources (Potential)[9]	Ala Hoku OSDS	OSDS?	OSDS?	OSDS?	Golf Course (54 acres)	Golf Course (128 acres) and Other Landscaping			Golf Course (95 acres) and Other Landscaping		
Other Sources/Opportunities[10]	• Hwy & Lower Rd Erosion • Ala Hoku Area • Illicit Discharges	• Coastal Erosion	• Nāpilihau Area Drainage • Outfall sediments	• Lower Road Erosion • Illicit Discharges • Outfall sediments					• Hwy & Lower Rd Erosion		• Dirt Road

Watersheds/Subwatersheds[1]	KAHANA					HONOKAHUA			HONOLUA	
	Kahana	Ka'ōpala	Honokeana	Nāpili 4-5	Nāpili 2-3	Honokahua	Mokupe'a	Kahauiki	Honolua	Līpoa Point
Existing Conservation and Ag Pollutant Loading & Sources										
Potential Pollutant Losses, Annual (modeled using NSPECT)[11]										
Soil Loss *(tons)*	*48,453*	*16,131*	*24,581*	*24,010*	*12,826*	*27,202*	*11,351*	*7,110*	*31,978*	*5,629*
Phosphorous *(lb)*	*832*	*139*	*187*	*146*	*165*	*294*	*113*	*109*	*361*	*7*
Nitrogen *(lb)*	*12,480*	*1,110*	*1,272*	*1,161*	*1,129*	*5,837*	*1,640*	*798*	*8,001*	*44*
Suspended Load, USGS Study *(tons/year) modeled[12]*	*No data*	*No data*	*No data*	*No data*	*No data*	*No data*	*No data*	*No data*	*>345*	*No data*
Related Information										
Drainage Area (acres)	3,237	573	484	597	475	1,004	999	767	2,545	66
Fallow Crop Area/% of Total Area[13]	795/25%	251/44%	212/44%	147/25%	124/26%	61/6%	46/5%	86/11%	101/4%	57/87%
Access Roads[14] (miles of roads / # of steam and gulch crossings)	26.8 / 4	12.2 / 1	0.7 / 2	6.5 / 2	2.9 / 2	3.6 / 0	6.8 / 1	0.8 / 1	12.7 / 3	
Desilting Basin Assessment[15]	Undersized	Undersized	Acceptable	Acceptable	Undersized	None	None	None	None	Sediment Basin only

Notes: a) No data does not mean no priority. b) Darker fill denotes potentially higher loading or occurrence; brown is for sediment related data and green for nutrient related data; lack of data (and/or color) does not mean no priority. Additional nutrient and sediment data is forthcoming; c) data shown in normal font and modeling/estimations in italics; d) footnote references listed on following pages

Table 6.15 Water Quality Data and Pollutant Sources Summary (Continued)

Watersheds/Urban Sub-Areas[1]	KAHANA					HONOKAHUA	HONOLUA	
	Kahana	Ka'ōpala	Honokeana	Nāpili	Kapalua		Honolua	Līpoa Point
Future Pollutant Loading & Sources								
Grazing	Planned	Unknown	Unknown	Unknown	Unknown	Unknown	na	na
Future Development								
Construction (acres)	• Pulelehua Development (67 acres in Kahana)	• West Maui Village (10 acres)		• Kapalua Mauka (396 acres) • Pailolo Place (4 acres)		• Kapalua Mauka (525 acres) • Solar Farm Mahana Estates (area unknown)		
Relative Annual Urban Loading (Modeled using the Simple Method)[7]								
Total Suspended Solids *(tons)*	*2*	*0.6*		*9.3*		*13.6*		
Total Phosphorous *(lb)*	*23*	*7*		*110*		*161*		
Total Nitrogen *(lb)*	*108*	*30*		*512*		*747*		
Copper *(lb)*	*3*	*1*		*13*		*9*		
Lead *(lb)*	*0.6*	*0.2*		*3.0*		*4.4*		
Zinc *(lb)*	*8*	*2*		*36*		*52*		

Footnotes for Table 6.15 Water Quality Data and Existing Pollutant Sources Summary

[1] See Figure 6.25 for watersheds, subwatershed drainages, and urban sub-areas.

[2] Hawai'i State Department of Health (DOH) Clean Water Branch (CWB) Monitoring and Analysis Section collects and analyzes water samples following quality assurance project plans (QAPP) approved by Environmental Protection Agency Region 9 (DOH 2012). Data from sample analyses are intended for use by Section personnel to assess coastal water quality. After internal data validation and quality assurance, the data is made is publically available on the website http://emdweb.doh.hawaii.gov/CleanWater Branch/WaterQualityData. Per the DOH QAPP uses of the data by other users for other purposes are not supported and the responsibility for determining the appropriateness of any such use lies solely with the user. Any conclusions in this Kahana, Honokahua and Honolua report utilizing DOH CWB data do not necessarily reflect findings of DOH.

[3] Water turbidity is one way to measure the amount of suspended sediments and other materials that block sunlight from reaching aquatic life. Turbidity is measured by nephelometric turbidity units (NTUs). Turbidity samples and measurements taken during DOH CWB biological and chemical sampling from 2014 to 2015 are analyzed and presented. The geometric mean was taken for the Each sample analyzed for the seven sites were taken on the same day. The single day sampling consistency allows for comparison between sites because factors affecting turbidity, namely rainfall and wave action, are relatively constant. The State "dry" water quality standard for is 0.2 NTU. The more stringent "dry" standard is applied to West Maui because the definition of dry open coastal waters is as those receiving less than three million gallons per day of fresh water discharge per shoreline mile (from a 1977 report of the Technical Committee on Water Quality Standards.)

[4] The geometric mean is a special type of average used to characterize the central tendency of a set of numbers. It is calculated by taking the nth root of a product of n numbers. For most locations the State standard was exceeded by a magnitude of 3 to 40 times the criteria of 0.2 NTU.

[5, 6] Nutrients refers to the following chemical constituents: Total nitrogen; ammonia nitrogen (NH4); nitrate + nitrite (NO3- + NO2-); total phosphorus; and chlorophyll *a*. These chemicals can act as nutrient inputs for plant life except for chlorophyll a which is an indicator of algal growth. The above chemical constituents were tested for in three coastal locations (Ka'ōpala Bay, Flemings Beach Out and Honolua Bay) between 2006 and 2008 during a period of pineapple cultivation. Nāpili Bay had testing after the close of pineapple operations (2009-2010). Phosphorous and total nitrogen levels exceeded the State standards only at sites sampled before pineapple closure. Ammonia and Nitrates/Nitrites were exceeded at sites both pre and post pineapple cessation and this is indicated in the table.

[7] "The Simple Method" is a technique used to estimate storm water runoff pollutant loads for urban areas. The key inputs are subwatershed drainage area and impervious cover, storm water runoff pollutant concentrations, and annual precipitation. Because there are no storm water pollutant concentrations for West Maui, concentrations from O'ahu (NPDES Storm Water Monitoring Report for City and County of Honolulu by Oceanit Laboratories) for similar land uses were used for the calculations.

[8] National Oceanic Atmospheric Administration (NOAA) Coastal Change Analysis Program data from 2005 provides estimated impervious surfaces. The total of the impervious surface acreage is different than those for the total urban area as the urban subwatershed boundaries do not include the entire urban area.

9 The State of Hawai'i Department of Health Safe Drinking Water Branch report entitled *Human Health and Environmental Risk Ranking of On-site Sewage Disposal Systems for the Hawaiian Islands of Kaua'i, Moloka'i, Maui and Hawaii* was released in September 2014. The data includes locations of Onsite Sewage Disposal Systems (OSDS) of which cesspools are one type. However, over reporting has already been identified and greater review is needed. There are a number of areas that do not have County sewer lines and likely have OSDS including the Ala Hoku subdivision (in South Kahana ma uka of the Highway), Kapalua Plantation Estates, and Honolua watershed area. The next step is to confirm the type of OSDS used in order to better identify sources and loading.

10 Other sources such as sediments, and pool and wash water discharges are based on site visit observations by Sustainable Resources Group International, Inc. (SRGII) in May 2013.

11 Nonpoint Source Pollution and Erosion Comparison Tool (NSPECT) which is applied over the three watersheds to compute estimates of soil loss from surficial erosion and to estimate nitrogen and phosphorus losses). The model does not estimate soil eroded or "lost" from concentrated flows such as along streams and gulches, nor does it compute sediment transport in streams and delivery to the ocean. The NSPECT estimates are best used as a comparative tool over subwatersheds within the project area in order to derive relative rates of erosion and soil loss. The model outputs have not been verified via ground truthing or empirical data.

12 These are the preliminary results from the USGS July 2014 site visit (Stock 2014). A sediment budget was developed for the Honolua watershed that considers stream erosion and accumulated sediment deposition and estimates the portion of total sediment load which is from suspended sediments.

13 National Oceanic Atmospheric Administration (NOAA) Coastal Change Analysis Program data from 2005 provides former cultivated crop fields.

14 Access road lengths are from access road data provided by Maui Land and Pineapple (ML&P). Stream and gulch crossings are the total number of times the ML&P access road data intersects with a stream or gulch.

15 The desilting basins were assessed by SRGII based on a comparison of the subwatershed drainage area to the potential capacity of the basin to hold the water from the drainage area during a rain event. The capacity of the basin was considered based on both the stated basin size as well as visual inspection of the maintenance of the desilting basin.

6.6 Priority Pollutant Sources

6.6.1 Sediment Source Priorities

Data from Table 6.15 used to prioritize subwatersheds for sediment pollutant contributions is listed below and in Table 6.16.

Turbidity Data: Water turbidity is one way to measure the amount of suspended sediments and other materials that block sunlight from reaching aquatic life. The DOH data along the coastline since 2008 shows that Ka'ōpala and south Kahana subwatersheds and Honolua watershed have consistently had some of the highest turbidity measurements in the three watersheds (Table 5.5). While nearshore turbidity data does not identify sediment sources, it can be used in conjunction with other data.

Fallow Crop Area: The amounts of legacy sediments in streams have not been quantified for all the streams and gulches. Deposited sediments were likely from the creation and use of agricultural fields and roads. The amount of fallow acreage may provide an indication of the amount of sediments.

Dirt Access Roads: Access roads in the agricultural and conservation areas are another source of sediments and accumulated water flow. The access road length and number of stream crossings provides information on potential extents of these sediment sources.

Eroding Road Cuts and Shoulders: Honoapi'ilani Highway road cuts and Lower Honoapi'ilani Road shoulders have been identified as sediment sources and need stabilizing.

Desilting Basin Assessment: The efficacy of desilting basins to retain water and sediments provides information on areas where sediments may pass more readily to nearshore waters than areas with adequately-sized desilting basins.

Future Development Acreage: Construction grubbing and grading can contribute sediments to nearshore waters if proper management practices are not employed. Known development acreage is listed to indicate where this might occur and to what extent.

Cattle Grazing Acreage: Cattle grazing is planned in Kahana watershed. Without proper management, cattle grazing can be a major contributor to sediments via overgrazed land or stream crossings or watering areas.

Other factors considered to a lesser extent include:

- NSPECT potential soil loss is model derived data for agriculture and upper conservation areas. It does not provide actual soil loss data. The fields have a considerable vegetative cover and are not being disturbed (except for construction).
- Estimated soil loss from the urban area, as modeled using the Simple Method, is 1 to 13 tons/year. These are small contributions compared to the upland areas and do not reflect known sediment pollutant sources such as the roadways. Kapalua has the highest estimated urban soil loss at 13 tons annually; however, sediments on Kapalua roadways are mitigated in part by daily street sweeping.

- USGS Sediment Loading is only available for Honolua at this time and is not useful for prioritization across the watersheds.
- Axis Deer: The migration of Axis deer into the watersheds will cause direct soil loss and decrease the vegetative cover that protects soils from erosion. The exact impact is not known or quantified. Fences that are eight feet high are needed to prevent the Axis deer from entering the upper conservation area.

The **priority subwatersheds for sediments are Kahana** and **Kaʻōpala** subwatersheds and **Honokahua** and **Honolua** watersheds based on available data. These watersheds have high turbidity measurements, significant lengths of access roads with some stream crossings, and undersized or no desilting basins. Planned grazing in southern Kahana underscores possible sediment contributions from Kahana and Kaʻōpala subwatersheds.

The subwatersheds of **Honokahua** and **Nāpili** are **priorities** because of the planned Kapalua Mauka development. The development is planned for subwatersheds without existing desilting basins. The lessons learned with the first phase of Mahana Estates should be used to prevent future development on the slopes of former agricultural lands from having such a deleterious effect on water quality.

These priorities should be updated as additional data becomes available such as from the USGS study of legacy stream and gulch sediments.

Table 6.16 Turbidity & Sediment Data Highlights

Watersheds/Subwatersheds[1]	KAHANA						HONOKAHUA			HONOLUA		
	Kahana	Ka'ōpala	Honokeana	Nāpili 4-5	Nāpili 2-3		Hono-kahua	Moku-pe'a	Kahau -iki	Honolua		Līpoa Point
Turbidity (State standard = 0.2 NTU)[3]												
Geometric Mean of 6 samples from 2014-2015 (NTU)[4]	3.04 S Turns / Pohaku	5.46	No data	1.72	1.81 Kapalua	0.90 Oneloa	2.83 DT Fleming Beach			1.79 Mokulē'ia	3.50 Honolua	na
Urban Area												
Area (acres)	138	46	172	215	419		na			na		na
Other Sources / Opportunities[10]	• Hwy & Lower Rd • Ala Hoku Road • Coastal Erosion	• Coastal Erosion	• Nāpilihau Area • Outfall sediments	• Lower Road • Outfall sediments						• Hwy & Lower Road		• Dirt Road
Conservation and Ag Area												
Drainage Area (acres)	3,237	573	484	597	475		1,004	999	767	2,545		66
Fallow Crop Area/% Area[13]	795 / 25%	251 / 44%	212 / 44%	147 / 25%	124 / 26%		61 / 6%	46 / 5%	86 / 11%	101 / 4%		57 / 87%
Access Roads[14] (miles / stream crossings)	26.8 / 4	12.2 / 1	0.7 / 2	6.5 / 2	2.9 / 2		3.6 / 0	6.8 / 1	0.8 / 1	12.7 / 3		
Desilting Basin Assessment[15]	Undersized	Undersized	Acceptable	Acceptable	Undersized		None	None	None	None		Sediment Basin only
Future Sources												
Future Grazing (acres)	Planned	unknown	unknown	unknown	unknown		unk	unk	unk	unknown		unknown
Construction (acres)	**Pulelehua** 67 ac	**West Maui Village** 10 ac		**Kapalua Mauka** 396 ac **Pailolo Place** 4 ac			**Kapalua Mauka** 525 ac					

Notes: a) No data does not mean no priority. b) Darker fill denotes potentially higher loading or occurrence; lack of data (and/or color) does not mean no priority. Additional sediment data is forthcoming; c) data shown in normal font and modeling/estimations in italics; d) footnote references listed with Table 6.15.

6.6.2 Nutrient Source Priorities

The available nutrient information from Table 6.15 is used to prioritize subwatersheds as discussed below and presented in Table 6.17. Data on nutrients is mainly modeled information and potential sources without verification.

Potential Nutrient Sources: Golf courses and landscaping along the coastline require fertilizers and irrigation to maintain the lush resort vegetation. These land uses are likely contributors of nutrients from the fertilizers, and irrigation and storm water transport nutrients to nearshore waters.

Grazing: Waste from cattle can contribute nutrients into stream, gulches and nearshore waters. The quantity could vary by several orders of magnitude based on the number of cattle and management techniques used. The potential pollutant loading could be high.

Other factors considered to a lesser extent included:

- Water Quality Data: Water quality data are limited. However, comprehensive nutrient testing along the coastline by DOH began in March 2015. Water quality testing will continue for a year, and a report with data analysis will be forthcoming in 2017. Preliminary DOH data analysis shows areas with elevated nitrogen levels. Follow-up or concurrent testing of nitrogen stable isotopes ratios would help determine nitrogen sources, e.g. cesspool, fertilizers.
- NSPECT Modeled Data: Ground truthing is needed to confirm nutrient loss. This data is correlated to former cropland area.
- Urban Nutrient Pollutant Loading: The Simple Method is used to estimate nutrients from runoff with the percentage and amount of impervious surface based on density of the future developments. This provides a general indication of future loading.
- OSDS/Cesspool Data: The DOH OSDS data need to be analyzed with information on actual sewer service locations before the number of existing and active cesspools can be known. Existing OSDS data has been acknowledged as an overestimation of current cesspools.

The priority subwatersheds / urban sub-areas for nutrients are **Kapalua, Honokahua and Honolua** due to extensive landscaping.

Ka'ōpala subwatershed is a priority due to the planned grazing and potential to provide high levels of nutrients to the subwatershed, streams and nearshore waters.

DOH water quality data should be analyzed and used to update these priorities and align with priorities with actual sources. Submarine groundwater discharge data and legacy nutrient levels should also be considered to factor out nutrients contributions that are not from current land uses.

Table 6.17 Nutrient and Other Pollutant Sources Summary

<table>
<tr><th rowspan="2">Watersheds / Subwatersheds[1]</th><th colspan="6">KAHANA</th><th rowspan="2">HONOKAHUA</th><th rowspan="2">HONOLUA</th></tr>
<tr><th>Kahana</th><th>Ka'ōpala</th><th>Honokeana</th><th colspan="2">Nāpili</th><th>Kapalua</th></tr>
<tr><td colspan="9">Existing Urban Nutrient and Other Pollutant Loading and Sources</td></tr>
<tr><td>Nutrient Sources (Potential)[9]</td><td>Ala Hoku OSDS</td><td>OSDS?</td><td>OSDS?</td><td>OSDS?</td><td>Golf Course (54 ac)</td><td colspan="2">Golf Course (128 ac) & Other Landscaping</td><td>Golf Course (95 ac) & Other Landscaping</td></tr>
<tr><td>Potential Illicit Discharges</td><td>2</td><td></td><td></td><td>2</td><td></td><td colspan="2"></td><td></td></tr>
<tr><td colspan="9">Relative Annual Urban Loading (Modeled using the Simple Method)[7] (pounds)</td></tr>
<tr><td>Total Phosphorous</td><td>68</td><td>11</td><td>92</td><td colspan="2">74</td><td>153</td><td>na</td><td>na</td></tr>
<tr><td>Total Nitrogen</td><td>314</td><td>50</td><td>427</td><td colspan="2">342</td><td>712</td><td>na</td><td>na</td></tr>
<tr><td>Copper</td><td>8</td><td>1</td><td>11</td><td colspan="2">9</td><td>18</td><td>na</td><td>na</td></tr>
<tr><td>Lead</td><td>2</td><td>0</td><td>3</td><td colspan="2">2</td><td>4</td><td>na</td><td>na</td></tr>
<tr><td>Zinc</td><td>22</td><td>3</td><td>30</td><td colspan="2">24</td><td>50</td><td>na</td><td>na</td></tr>
<tr><td colspan="9">Future Urban Nutrient Loading and Sources</td></tr>
<tr><td>Grazing</td><td>Planned</td><td>unknown</td><td>unknown</td><td colspan="2">unknown</td><td>unknown</td><td>unknown</td><td>unknown</td></tr>
<tr><td colspan="9">Relative Annual Urban Loading (Modeled using the Simple Method)[7]</td></tr>
<tr><td>Total Phosphorous</td><td>23</td><td>7</td><td>na</td><td colspan="2">110</td><td>161</td><td>na</td><td>na</td></tr>
<tr><td>Total Nitrogen</td><td>108</td><td>50</td><td>na</td><td colspan="2">512</td><td>747</td><td>na</td><td>na</td></tr>
<tr><td>Copper</td><td>3</td><td>1</td><td>na</td><td colspan="2">13</td><td>9</td><td>na</td><td>na</td></tr>
<tr><td>Lead</td><td>0.6</td><td>0.2</td><td>na</td><td colspan="2">3.0</td><td>4.4</td><td>na</td><td>na</td></tr>
<tr><td>Zinc</td><td>8</td><td>2</td><td>na</td><td colspan="2">36</td><td>52</td><td>na</td><td>na</td></tr>
</table>

Notes: a) No data does not mean no priority. b) Darker fill denotes potentially higher loading or occurrence; lack of data (and/or color) does not mean no priority. Additional nutrient data is forthcoming; c) data shown in normal font and modeling/estimations in italics; d) illicit discharges are from field observations and more locations may exist; and e) footnote references are listed with Table 6.15.

6.6.3 Other Pollutant Source Priorities

"Other pollutants" refers to a broad array of pollutants besides sediments and nutrients. Tremendous data gaps exist regarding these other pollutants. Baseline testing is needed to even understand the breadth of current use contaminants to nearshore waters.

Many of the land uses that are sources of nutrients are also sources of other pollutants. Landscaping and golf courses are sources of pesticide and herbicide, and existing and future residential developments contribute metals and a host of other contaminants. Illicit discharges were noted during field work in Section 6.3.3 and are sources of other pollutants such as wash waters from cleaning and/or pool water discharges.

Information in Table 6.17 can be used to consider pollutant priorities. However, specific subwatershed and urban sub-areas cannot be prioritized at this time. Further testing is needed. For now, known land use activities can be targeted to reduce of these pollutant sources.

6.6.4 Priority Pollutant Sources Summary

Sediments are primarily due to past ag practices that deposited sediments in stream valleys. Dirt access roads are also contributed sediments. The prioritized Kahana and Kaʻōpala subwatersheds and Honolua and Honokahua watersheds appear to have higher levels of sediment contributions to nearshore waters. These are relative priorities and the other watersheds also contribute sediments to nearshore waters. Sediments from construction of future Kapalua Mauka development in the Honokahua and Nāpili subwatershed are a concern and should be minimzed if not prevented entirely.

Nutrient source priorities are based on land uses that are likely contributors of fertilizers and animal wastes. These include golf courses and landscaping in the Kapalua, Honokahua and Honolua urban sub-areas / watersheds and planned grazing in Kahana (and Kaʻōpala) subwatersheds. With forthcoming DOH water quality monitoring, nutrient source priorities can be verified or updated.

Priorities for other pollutants or contaminants are also prioritized based on land uses. Baseline testing of current use contaminants is needed.

7.0 NEXT STEPS

7.1 Data Gaps

This *Kahana, Honokahua and Honolua (KHH) Watersheds Characterization Report* provides a comprehensive watershed assessment to identify pollutant sources from available information. This chapter summarizes report data gaps in Table 7.1 and describes them below.

The filling of data gaps will improve pollutant sources data and guide selection of projects to mitigate pollutant effects. Data gaps may be filled with ongoing or future studies. As data becomes available, priorities and management decisions can be refined.

7.1.1 Sediments

Sediment contributions from the subwatersheds has begun to be studied, mostly using modeling and erosion rates from other areas in Hawaiʻi. The US Geological Survey (USGS) 2014 study on sediment budgets for the Honolua watershed is a good first step. Characterization of sediment budgets for subwatersheds in Kahana and Honokahua is needed. For all subwatersheds including Honolua, more specific information on contributing reaches of gulches and is needed. Ground truthing would assist in allocation of resources to address the highest occurrences of loading.

The Kahana watershed desilting basins reduce suspended sediments flowing into the nearshore waters. However, **efficacy of the desilting basins** has not been quantitatively studied. This is especially important for the basins identified as undersized: Kahana, Kaʻōpala and Nāpili 2-3. Greater understanding of the ability for these desiliting basins to contain sediments would enhance the overall understanding of the relative sediment contributions from the subwatersheds.

7.1.2 Nutrients and Other Pollutants

Nearshore water quality data for nutrients and current use contaminants are needed to supplement the DOH water quality data being collected and analyzed by 2017. Follow-up testing, or if possible concurrent testing, of nitrogen stable isotopes ratios would help determine nitrogen sources, e.g. cesspool, fertilizers and current land use activities.

Submarine ground water discharge nutrients and contaminant contributions to nearshore water needs to be better understood. The amount and types of nutrients and contaminants entering nearshore waters from submarine ground water discharge would help in understanding pollutant paths and sources.

Well testing for nutrients could be key in understanding the transport of legacy fertilizer through the ground water to understand the extent to which this source affects nearshore waters. Re-sampling of wells to provide a comparison to the Soicher and Peterson 1996 study would inform how the plantation era fertilizer nutrient contributions are migrating through the aquifer.

Wastewater system and connections assessment would identify the degree to which wastewater lines and pump stations leak nutrients and other pollutants to nearshore water.

Onsite Sewage Disposal Systems (OSDS) data needs to be compared with sewer service locations to verify OSDS still in use. The County sewer data is currently limited to billing addresses. Either updated County records or door-to-door surveys could be used to verity OSDS locations and help in attributing the water quality findings to particular land uses.

Current use contaminants are not well understood without data on types, quantities or locations. Data on this source would help with development of strategies to address sources

Bacteriological testing will capture water quality exceedances and inform potential human and coral reef health implications.

7.1.3 Pollutant Transport

A greater understanding of **offshore circulation patterns** would inform linkages of pollutant sources, coral larval dispersion and coral cover. The existing information on currents and circulation is based on sediment modeling from 2008 work by Storrlazzi and Field.

Specific **outfall monitoring** would help in identifying pollutant sources behaviors contributing to the illicit discharges. Monitoring during periods without precipitation will reveal dry weather discharges such as pool, cleaning or excess irrigation water. Four outfalls were identified in Kahana and Nāpili urban sub-areas for priority follow-up.

A **regional drainage analysis** would identify pollutant transport routes to nearshore waters.

Field work for this report included **storm water system mapping** of inlets and outlets. However, below ground storm water piping and connections were not mapped. Supplemental maps would aid in tracing water quality issues back to potential contributors. Further, an inventory of the storm water systems and infrastructure age could assist the County in managing this asset.

7.1.4 Other Data Gaps

Coral cover discussed in Chapters 1, 2, and 4 is based on National Oceanic Atmospheric Administration data for the entire coastline derived from aerial imagery and from DLNR-DAR benthic monitoring at Honolua and Kapalua Bays. More detailed coral coverage for the coastline of all three watersheds is needed. Additional surveys of herbivorous fish and marine invertebrates and their role in benthic communities will aid in a broader understanding of the dynamics affecting coral health. Identification of substrate types throughout the watershed would facilitate application of relevant water quality criteria as discussed above.

The three streams, one in each watershed, are listed as perennial. However, ongoing **streamflow data** is lacking. USGS studied the low flow characteristics (Cheng 2014), but lack of stream gauges means future stream flow information is not available. Streamflow information would be beneficial in understanding actual flows and seasonal fluctuations.

Data on the **hydrological impact of land use-land cover changes** that impact direct runoff, evapotranspiration (ET), infiltration and groundwater recharge would support efforts to predict the hydrological impacts of changes in land use and land cover, including the spread of non-native vegetation and the effects of watershed restoration.

Table 7.1 Data Gap Priorities

Data Gap	Rationale
Sediments	
Sediment Contributions	Sediment loading contributions need to be better understood to direct mitigation efforts.
Desilting Basin Efficacy	Understanding the ability of desilting basins to trap sediments, and the size of sediments trapped would help to direct future strategy location and type.
Nutrients and Other Pollutants	
Nearshore Nutrient Water Quality Data	Nutrient water quality data will assist with pollutant source and pollutant loading identification.
Submarine Ground Water Discharges	The amount and types of nutrients and contaminants from submarine ground water discharge would aid in in understanding pollutant paths and sources.
Well Testing for Nutrients	This data can be compared with 1997 data to track ground water nutrients.
Waste Water System & Connections Assessment	This assessment would help to identify this pollutant source.
Onsite Sewage Disposal Systems	An accurate OSDS inventory will assist in understanding pollutant loading and the amount attributable to this source. It will also help in identifying cesspool conversions eligible for tax credit for conversions.
Current Use Contaminants	Knowledge on current use contaminants for West Maui is virtually non-existent.
Bacteriological testing	Expanded bacteriological testing will capture water quality exceedances and shed light on human and coral reef health implications.
Pollutant Transport	
Offshore Circulation Patterns	Offshore circulation patterns will inform how the water quality pollutants are transported and may be affecting coral reefs.
Outfall Monitoring	Water quality data will assist with pollutant source and pollutant loading identification; these will help in prioritizing where to target outreach efforts to minimize illicit discharges.
Regional Drainage Analysis	A regional drainage analysis would help to identify pollutant transport routes from sources to nearshore waters.
Storm Water System Mapping	This mapping will aid efforts to identify pollutant sources where water quality data and outfall monitoring indicate issues.
Other	
Coral Cover	Coral cover locations will inform placement and prioritization of strategies.
Streamflow Data	Better streamflow data would aid in understanding the amount of freshwater flowing into the nearshore waters.
Land Use / Cover Hydrology Impacts	This data gaps would support efforts to predict impacts of land cover and land use and changes.

7.2 Kahana, Honokahua and Honolua Watersheds Strategies and Implementation Report

The second volume for the Kahana, Honokahua and Honolua watersheds will focus on strategies and implementation that builds on this *Characterization Report*. The *Strategies and Implementation Report* will provide measures (or projects) to mitigate pollutant sources. Prioritization of the projects will use various criteria including the ability to reduce the pollutant loading discussed in this *Characterization Report*. Also included will be possible funding sources for priority measures, recommended education and outreach and an evaluation and monitoring plan. The evaluation and monitoring plan will draw upon the data gaps listed above where appropriate.

Together the *Kahana, Honokahua and Honolua Watersheds Characterization Report* and the *Kahana, Honokahua and Honolua Watersheds Strategies and Implementation Report* will guide management measures to the watersheds in the short term period and contribute to the more comprehensive five-watershed *West Maui Watershed Plan*.

APPENDIX A: REGULATORY ENVIRONMENT

Understanding the regulatory environment is essential for establishing a clear picture of water quality issues and ultimately solutions. Numerous Federal, State and County agencies have responsibility related to implementing activities related to controlling polluted runoff and maintaining water quality. Implementation of management measures is most effectively done through economic incentives or by regulatory drivers. Regulatory approaches work best when adequate mechanisms are in place to provide oversight and enforcement. This section summarizes the key agencies and regulations that address point source and non-point source (NPS) pollutants. A comprehensive list of agencies, their roles in implementing management measures for NPS, and applicable regulatory authority was developed in association with overall guidance for Hawaiʻi (Table A.1). This listing will be expanded to include watershed and coral reef restoration management in the more comprehensive *West Maui Watershed Plan*.

A.1 Coral Reef Conservation

At the Federal level coral reef conservation is primarily addressed by National Oceanic Atmospheric Administration (NOAA) and the U.S. Coral Reef Task Force (USCRTF). The NOAA Coral Reef Conservation Program supports effective management and sound science to preserve, sustain and restore valuable coral reef ecosystems for future generations. NOAA also maintains the Coral Reef Information System website.

The USCRTF was established in 1998 by Executive Order 13089 to lead U.S. efforts to preserve and protect coral reef ecosystems. The USCRTF accomplishes this by helping build partnerships, strategies and support for on-the-ground action to conserve coral reefs. In 2002 the USCRTF called for development of Local Action Strategies (LAS) to help focus action for the reduction of key threats to coral reefs to the local level. The goals and objectives of the Hawaiʻi LAS (climate change and marine debris, lack of public awareness, coral reef fisheries, land-based pollution sources and recreational impacts to reefs and aquatic invasive species) were designed to be in line with those found in the U.S. National Action Plan to Conserve Coral Reefs. The Kāʻanapali-Kahekili region (Wahikuli-Honokōwai watersheds) were initially selected by the USCRTF as a priority partnership site, and the site was later extended to cover Kahana, Honokahua and Honolua watersheds.

At the State level, the primary agency responsible for coordinating Hawaiʻi's coral reef management efforts in the main Hawaiian Islands is the Department of Land and Natural Resources (DLNR) Division of Aquatic Resources (DAR). The Coral Reef Working Group (CRWG) was established to help provide guidance for DAR's coral program. The CRWG contains key members of Federal and State agencies involved in coral reef management. In order to provide a cohesive strategy for coral reef management in Hawaiʻi, DAR and the CRWG developed The Hawaiʻi Coral Reef Strategy for 2010-2020 (State of Hawaiʻi 2010). This strategy incorporates the six multi-agency LAS and identifies four priority goals and five priority objectives for coral reef management.

A.2 Overview of Clean Water Act in Regulating Water Pollution

The first major breakthrough in controlling water pollution in the United States came with the Federal Water Pollution Control Act of 1948. With the growing awareness and the evolving environmental movement of the 1960s, it was extensively amended in 1972 and thereafter known as the Clean Water Act (CWA). Further major amendments came in 1977. The CWA regulates pollution discharges into navigable waters of the United States and sets water quality standards for surface waters with the goal of making them swimmable and fishable and "to restore and maintain the chemical, physical, and biological integrity of the Nation's waters". The first phase of the Act was aimed specifically at point source pollutants. It prohibits the discharge of any pollutant from a point source into navigable waters, unless special permits are obtained under the National Pollution Discharge Elimination System (NPDES) (Section A.3). At the Federal level, the CWA is administered by the EPA. In November of 1974, EPA delegated the administration of the National Pollutant Discharge Elimination System (NPDES) Permit program in Hawai'i to the State of Hawai'i Department of Health (DOH). The passage of Act 249 in 1974, represented Hawai'i's initial attempt to address nonpoint source pollution problems by instructing each of the counties to develop an ordinance requiring grading permits for erosion control in urban areas. In response to Clean Water Act requirements, each of Hawai'i's counties, with assistance from the DOH, developed CWA Section 208 Water Quality Management Plans (mid and late 1970s). The plans were initially approved by the EPA in 1979 and 1980, and updated in 1993 to include descriptions of the Federal, State and County roles in managing water pollution. The DOH receives CWA Section 319 grant money from EPA to assist in the implementation of the State's Polluted Runoff Control Program to address NPS pollution.

A big challenge, however, is the regulation of NPS pollutants because they cannot be specifically identified. This was partially addressed in the amendment known as the Water Quality Act of 1987, which essentially made one big NPS pollutants, stormwater, a regulated point source by regulating industrial and urban stormwater systems via NPDES permits. Other NPS pollution issues are addressed via projects and grants given to states to address agricultural runoff and other NPS problems.

Under CWA Section 305(b), states are required to submit lists to the Environmental Protection Agency (EPA) of impaired waters. These are waters that are too polluted or otherwise degraded to meet water quality standards. The law requires that the states establish priority rankings for waters on the lists and develop Total Maximum Daily Loads (TMDL) for these waters. A TMDL is a pollution budget and includes a calculation of the maximum amount of a pollutant that can occur in a waterbody and allocates the necessary reductions to one or more pollutant sources. A TMDL serves as a planning tool and potential starting point for restoration or protection activities with the ultimate goal of attaining or maintaining water quality standards. Lists of impaired waters and TMDLs are reviewed in EPA's regional offices. New guidance allows for the setting of long-term priorities consistent with State tailored goals and strategies. This new guidance also allows for alternative restoration and protection approaches instead of TMDL development (Benita Best-Wong, EPA Office of Wetlands, Oceans and Watersheds, August 13, 2015, Memo on *Information Concerning 2016 Clean Water Act Sections 303(d), 305(b), and 314 Integrated Reporting and Listing Decisions*).

Section 404 of the CWA establishes a program to regulate the discharge of dredged or fill material into waters of the United States, including wetlands. Activities in waters of the United States regulated under this program include fill for development, water resource projects (such as dams and levees), infrastructure development (such as highways and airports) and mining projects. Section 404 requires a permit before dredged or fill material may be discharged into waters of the United States, unless the activity is exempt from Section 404 regulation (e.g. certain farming and forestry activities). Permit applications must show that steps have been taken to avoid impacts to wetlands, streams, and other aquatic resources; that potential impacts have been minimized; and that compensation will be provided for all remaining unavoidable impacts. Proposed activities are regulated through a permit review process. An individual permit is required for potentially significant impacts. Individual permits are reviewed by the US Army Corps of Engineers (USACE), which evaluates applications under a public interest review, as well as the environmental criteria set forth in the CWA Section 404(b)(1) Guidelines, regulations promulgated by EPA. However, for most discharges that will have only minimal adverse effects, a general permit may be suitable.[1]

A.3 Point Source Pollution Regulations

Point source pollution is primarily controlled using regulatory approaches. Amendments to the CWA in 1972 (Section 402), introduced a permit system for regulating point sources that discharge pollutants into the ocean and other water bodies. Point source pollutants have identifiable sources and discharge locations such as the outfall of a wastewater treatment plant. The amendments provided the statutory basis for the NPDES permit program, which prohibits the discharge of any pollutant from a point source into navigable waters, unless special permits are obtained. This applies to industrial and municipal polluters and excludes homes on cesspools and septic systems. In 1987, Congress added Section 402(p) to the CWA, requiring the regulation of storm water discharges. In 1990, Phase I of the NPDES storm water program was established, requiring a NPDES permit to discharge storm water runoff from the Municipal Separate Storm Sewer System (MS4) in large or medium municipalities that had populations of 100,000 or more. A ruling in 1999 created Phase II, which expanded the NPDES program to apply to all urbanized MS4. The Stormwater NPDES Permitting Program is managed by EPA and implementation has been delegated to State agencies in most parts of the country, including Hawai‘i. In Hawai‘i, the Department of Health (DOH) is the permitting authority for the NPDES program. Kahului, Maui has been designated by the US 2010 Census as an urbanized area, and per Phase II of the storm water regulation program under the CWA the County of Maui is now required to obtain an NPDES permit for the Kahului MS4.

Effluent disposal at wastewater treatment facilities may involve injection of wastewater into the groundwater table using Class V shallow injection wells, a process known as Underground Injection Control (UIC). These groundwater inputs are regulated under the Safe Drinking Water Act (SDWA) (Section A.5.6).

[1] http://water.epa.gov/lawsregs/guidance/cwa/dredgdis/

A.4 Non-Point Source Pollution Regulations

NPS pollutants, such as excessive amounts of sediment, nutrients, and bacteria, come from a variety of diffuse sources such as storm water, agricultural and urban runoff, erosion, feral animals and leaking septic tanks. According to EPA, NPS pollution is the nation's largest source of water quality problems. At present, about 40% of freshwater surface waters in the country are not meeting standards of swimmability and fishability, mostly due to the challenges of remediating NPS pollution. Regulating NPS pollutants via permits is impossible due to their diffuse nature, so alternative methods such as enlisting communities to take responsibility are used. Since many large MS4s are now under permitting programs, stormwater problems have been reduced on a nationwide basis.

Kahului area is now a Census defined "urbanized area" that has a population greater than 50,000 people. As part of the NPDES permit for the MS4 the County of Maui must develop and implement a storm water management program, develop measurable goals and evaluate program effectiveness. While the West Maui area is outside of the Kahului urbanized area, there may be storm water management program elements developed for Kahului that could be applied island wide with benefits for West Maui water quality.

The State of Hawai'i has two programs specifically to implement polluted runoff controls. The Polluted Runoff Control Program[2], administered by the DOH Clean Water Branch (CWB) and funded under CWA Section 319, and the Coastal Nonpoint Pollution Control Program, funded under CZARA Section 6217 (Section A.5.1). To meet the program components required under Section 6217, the State developed the *Hawai'i's Coastal Nonpoint Pollution Control Program Management Plan* (CZMP 1996) and the updated *Management Measures for Hawai'i's Coastal Nonpoint Pollution Control Program (2009 & 2010)*. The Hawai'i Watershed Guidance (2010) provides an overview of watershed planning and resources, describes how to apply the EPA Nine Key Elements for Watershed Plans and incorporates the updated *Management Measures for Hawai'i's Coastal Nonpoint Pollution Control Program* as an appendix. In an effort to guide coordination between the DOH and Coastal Zone Management (CZM) pollution control programs, the State established a plan entitled *Hawai'i's Implementation Plan for Polluted Runoff Control* (DOH and CZMP 2000). In 2015, Hawai'i's Nonpoint Source Management Plan (2015-2020) was developed. This updated plan sets forth a more coordinated approach among federal, state and local water quality agencies to implement NPS projects and target pollutants and their sources more effectively. Specifically, this plan focuses on establishing partnerships to align goals and leverage resources in three priority watersheds (Hanalei Bay, He'eia and West Maui) to maximize water quality benefits.

NPS pollutants that are impairing the water quality are the result of the condition of the landscape, natural processes and the activities that occur on it. Projects eligible for CWA Section 319 funding must be part of a watershed based plan or comprehensive implementation that addresses EPA's nine elements (Figure A.1). The two reports for Kahana, Honokahua and Honolua watersheds will be in accordance with the USACE watershed planning regulations and policies and the EPA's Nine Key Components for a Watershed Based Plan.

[2] Formerly known as the Nonpoint Source Pollution Control Program. Established through 1987 Water Quality Act amendments to the CWA.

1. Identification of causes of impairment and pollutant sources or groups of similar sources that need to be controlled to achieve needed load reductions, and any other goals identified in the watershed plan.
2. An estimate of the load reductions expected from management measures.
3. A description of the NPS management measures that will need to be implemented to achieve load reductions, and a description of the critical areas in which those measures will be needed to implement this plan.
4. 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.
5. An information and education component 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.
6. Schedule for implementing the NPS management measures identified in this plan that is reasonably expeditious.
7. A description of interim measurable milestones for determining whether NPS management measures or other control actions are being implemented.
8. A set of criteria that can be used to determine whether loading reductions are being achieved over time and substantial progress is being made toward attaining water quality standards.
9. A monitoring component to evaluate the effectiveness of the implementation efforts over time, measured against the criteria established.

Figure A.1 Nine Key Components for Watershed-Based Plans

A.5 Other Regulations

A.5.1 Coastal Zone Management Act

In 1990, while reauthorizing the CZMA, Congress enacted Section 6217 of CZARA entitled "Protecting Coastal Waters". Section 6217 requires States with approved CZM programs, including Hawaiʻi, to develop programs to implement NPS pollutant controls. CZM programs have been developed pursuant to Federal requirements by States with coastal lands in order to manage their coastal and ocean resources. States with approved CZM Programs are eligible for Federal funds.

At the Federal level, the CZM Program is administered by NOAA's Office of Ocean and Coastal Resource Management. State and local governments are responsible for the day-to-day implementation of programs designed to meet the requirements of the CZARA. The Coastal Nonpoint Pollution Control Program is part of the State CZM Program and is administered jointly by the State Office of Planning and DOH CWB. The Hawaiʻi CZM Program is a broad management framework incorporating regulatory authorities of state and county agencies to provide greater coordination of existing laws. County governments play a crucial role in implementing the Hawaiʻi CZM Program by regulating development in geographically designated Special Management Area (SMA). Through their respective SMA permit systems, the Counties assess and regulate development proposals in the SMA for compliance with the CZM objectives and policies and SMA guidelines set forth in Chapter 205A, Hawaiʻi Revised Statutes (HRS). No development can occur in the SMA unless the appropriate agency first issues an approval. Development is defined to include most uses, activities and operations on land and in the water.[3]

The Hawaiʻi CZM Program also has jurisdiction over the State's Ocean Resource Management Plan, mandated by Chapter 205A, HRS, which focuses on facilitating comprehensive ocean resources management throughout the State. The network of government (Federal, State, County), academic and community partners is working across physical and jurisdictional boundaries to improve management of activities affecting Hawaiʻi's ocean and coastal resources. The West Maui Watershed Plan is an example of on-the-ground implementation efforts coordinated in part through this program.

A.5.2 National Environmental Policy Act

The National Environmental Policy Act (NEPA) requires Federal agencies to integrate environmental values into their decision making processes by considering the environmental impacts of their proposed actions and reasonable alternatives to those actions. To meet NEPA requirements, Federal agencies prepare a detailed statement known as an Environmental Impact Statement (EIS). EPA reviews and comments on EISs prepared by other Federal agencies and maintains a national filing system for all EISs.

A.5.3 National Historic Preservation Act of 1966

The National Historic Preservation Act of 1966 (NHPA) is legislation intended to preserve historical and archaeological sites in the United States. The act created the National Register of Historic Places and the list of National Historic Landmarks, and the State Historic Preservation Offices. Amendments to the NHPA include an act that requires federal agencies to evaluate the impact of all federally funded or permitted projects on historic properties (buildings, archaeological sites, etc.) through a process known as Section 106 Review.

A.5.4 Endangered Species Act

The Endangered Species Act (ESA) passed in 1973, out of concern that many of our nation's native plants and animals were in danger of becoming extinct. The purpose of the ESA is to protect and recover imperiled species and the ecosystems upon which they depend. It is administered by the US Fish and Wildlife Service and the Commerce Department's National Marine Fisheries Service. The Fish and Wildlife Service has primary responsibility for terrestrial and freshwater organisms, while the responsibilities of National Marine Fisheries Service are mainly marine wildlife.

Species may be listed as either endangered or threatened under the ESA. "Endangered" means a species is in danger of extinction throughout all or a significant portion of its range. "Threatened" means a species is likely to become endangered within the foreseeable future. All species of plants and animals, except pest insects, are eligible for listing as endangered or threatened. For the purposes of the ESA, Congress defined species to include subspecies, varieties and, for vertebrates, distinct population segments.

[3] http://planning.hawaii.gov/czm/

Section 7 of the ESA requires Federal agencies to use their legal authorities to promote the conservation purposes of the ESA and to consult with the Fish and Wildlife Service and National Marine Fisheries Service, as appropriate, to ensure that effects of actions they authorize, fund or carry out are not likely to jeopardize the continued existence of listed species.

Federal agencies are required to avoid "destruction" or "adverse modification" of designated critical habitat. Critical habitat may include areas that are not occupied by the species at the time of listing but are essential to its conservation.

A.5.5 Essential Fish Habitat

Essential Fish Habitat (EFH) includes all types of aquatic habitat—wetlands, coral reefs, seagrasses, rivers—where fish spawn, breed, feed or grow to maturity. NOAA Fisheries works with the regional fishery management councils to identify the essential habitat for every life stage of each federally managed species using the best available scientific information.

Federal agencies must consult with NOAA on all actions, or proposed actions, authorized, funded or undertaken by the agency, that may adversely affect EFH as required by the Magnuson-Stevens Fishery Conservation and Management Act.

A.5.6 Safe Drinking Water Act

The SDWA, enacted in 1974, regulates all current and potential drinking water sources, above and below ground. EPA is responsible for determining minimum quality standards to protect tap waters from contaminants that are detrimental to human health. Underground injection is used for many industrial discharges. Since underground injection wells have the potential to contaminate aquifers, injection wells are regulated under the SDWA. Under this legislation, EPA established the UIC Program that federally mandates minimum standards that must be adopted by each state's individual UIC program. In Hawai'i, the implementation of SDWA standards has not been delegated to the State. However, DOH Safe Drinking Water Branch has developed a program to address many sources of UIC that are permitted by rule by EPA. There are multiple statutory requirements, both Federal and State, which regulate the implementation.[4]

The State UIC program was established under Hawai'i Administrative Rules (HAR) §11-23 and 23A, with the intent of:

- Protecting the quality of Hawai'i's underground sources of drinking water from chemical, physical, radioactive and biological contamination that could originate from injection well activity.
- Processing permits and project reviews for new and renewal permits, modifications and abandonment of injection wells.

[4] **Federal:** Safe Drinking Water Act of 1974, 92-523; Safe Drinking Water Act Amendments of 1986, 99-339; Lead Contamination Control Act of 1988; Safe Drinking Water Act Amendments of 1996, 104-182; 40 Code of Federal Regulations (CFR) Parts 35, 124, 141, 142, 144, 145, 146, and 148; **Hawai'i Revised Statues:** Chapter 340 E, Chapter 340F; **Hawai'i Administrative Rules:** HAR Title 11, Chapter 19, Emergency Plan for Safe Drinking Water; HAR Title 11, Chapter 20, Potable Water Systems; HAR Title 11, Chapter 21, Backflow and Cross-Connection Control; HAR Title 11, Chapter 23, Underground Injection Control, 1991; HAR Title 11, Chapter 23a, 12/21/2000 Amendment, Underground Injection Control; HAR Title 11, Chapter 25, Certification of Operating Personnel in Water Treatment Plants.

- Evaluating geologic logs of soil and rock, injectivity tests, geologic maps and ground water quality profiles to determine the viability of subsurface injection.
- Maintaining inventory and database of all injection well files.
- Organizing and conducting site inspections to verify the location and performance of injection wells and to verify compliance with all testing or well closure plans.
- Conducting site investigations to identify problems such as unpermitted facilities and correction of deficiencies.
- Enforcing UIC rules and permit conditions.
- Serving the public by providing information and technical assistance.

According to HAR §11-23 and 23A, injection well operators are required to obtain a UIC permit from Hawai'i DOH and comply with the conditions of the permits. According to §11-23, Section 18A ("Monitoring and Reporting Requirements"), "the operator of any injection well or wells shall keep detailed records of the operation of the well or wells, including, but not limited to, the type and quantity of injected fluids, and the method and rate of injection for each well". According to the Code of Federal Regulations §144.51, the conditions for each permit shall be written into the permit either expressly, or by reference. Conditions are specified for each permit and include explicit monitoring and reporting requirements.

The Hawai'i DOH, Environmental Management Division, Wastewater Branch formulates and enforces all wastewater rules and regulations in Hawai'i. HAR §11-62 'Wastewater Systems' is the codification of these regulations and covers all public wastewater treatment and disposal systems as well as private waste water treatment plants and Onsite Wastewater Treatment Systems throughout the State, from individual cesspools to major municipal wastewater treatment plants.

A.5.7 County of Maui Planning and Zoning

Three plans, the *Countywide Policy Plan*, the *Maui Island Plan* and the *West Maui Community Plan*, were developed to provide general guidance on how growth will be accommodated in Maui County. The *Maui County Code* provides ordinances with more specific details on land use planning and zoning in terms of development.

A.5.7.1 Countywide Policy Plan (2010)[5]

HRS Chapter 46 grants the counties the power to regulate land development through zoning, though zoning must be based on a general plan. On Maui, the General Plan has been updated by the *County of Maui 2030 General Plan Countywide Policy Plan*, the *Maui Island Plan*, and nine *Community Plans*. The *Countywide Policy Plan* provides broad goals, objectives, policies and implementing actions to set forth the desired direction of the County's future as well as a policy framework for the *Maui Island Plan* and the nine *Community Plans*.

A.5.7.2 Maui Island Plan (2012)[6]

The *Maui Island Plan* is a blueprint that provides direction for future growth, the economy, social and environmental decisions on the island through the year 2030. Chapter 7, *Land Use*, provides an overview of Maui's past and current land use patterns and explores future land use challenges and opportunities. The chapter provides policy direction that will "enhance Maui's agricultural lands and protect the rural character and scenic beauty of the countryside". Chapter 8, *Directed*

[5] The Countywide Policy Plan can be viewed at http://www.co.maui.hi.us/index.aspx?NID=420.
[6] The Maui Island Plan can be viewed at http://www.co.maui.hi.us/index.aspx?nid=1503.

Growth Plan, outlines how Maui will grow over the next two decades, including the location and general character of new development, taking population projections into account. Urban and rural growth boundaries are established for the County with the intent of protecting farms and natural areas from sprawl and promoting efficient use of land, and the efficient provision of public facilities and services. According to the land use forecast, approximately 3,500 additional residential units are needed to accommodate projected growth in the West Maui region.

"The urban growth and rural growth boundaries take into account growth projections through 2030, the availability of infrastructure and services, environmental constraints and an approximate density of land development to determine the placement of the boundary". The space inside the two boundary types, referred to as Urban and Rural Growth Areas, are separated into 1) Agricultural land overlay districts, 2) Protection area types and 3) Growth boundary types. Each is further broken down into twelve distinct types with a description of characteristics, purpose and implementation strategies. For example, within the Agricultural land overlay districts, the Community Ag type includes a mixture of lot sizes and small commercial and subsistence agricultural operations interspersed with residential uses. Although delineated land types and boundaries designated by the county do not always coincide with the State Land Use District boundaries, three of the four growth boundary types that include some type of town center, are located in the Urban State Land Use District. The plan spells out implementation of the directed growth strategy for specific areas of the island, including West Maui.

A.5.7.3 West Maui Community Plan (1996)[7]

The *West Maui Community Plan*, prepared by the Maui County Council (1996), details planning goals, objectives, policies and implementation considerations regarding land use and activities taking place in the Lahaina Judicial District, and their relation toward reaching the goals that have been set within the plan. The plan includes a land use map with the zoning designations for 16 categories. The categories include conservation, agriculture, rural, several related to residential and business, public facilities, open space and park and areas reserved for future growth. All zoning requests and/or proposed land uses and developments must be consistent with the *West Maui Community Plan*.

While the plan was intended to guide decision making in the region through the year 2010, and thus is due to be updated, much of the content (goals, objectives, policies and implementation considerations regarding land use and activities) is still relevant. The plan contains 13 objectives for the West Maui region in general including: protect and enhance the quality of the marine environment; ensure that appropriate lands are available to support the region's present and future agricultural activities; establish an appropriate supply of urban land within the region to meet the needs of the community over the next 20 years; and preserve the current State Conservation District and State Agricultural District boundaries. The plan specifically discusses the importance of the natural environment and the threat that developments or projects may have potentially adverse impacts on water quality, whether it be potable or nearshore and off shore waters.

[7] The West Maui Community Plan can be viewed at
http://www.co.maui.hi.us/documents/Planning/Long%20Range%20Division/Maui%20Community%20Plans/westmaui.pdf

A.5.7.4 Maui County Code[8]

The Maui County Code contains specific ordinances related to planning and zoning. Titles 16 (Buildings and Construction), 18 (Subdivisions), and 19 (Zoning) cover details of land use and development including permitted uses, design standards, and building requirements. Two new ordinances related to development and storm water were approved in December 2011. Chapter 16.26, effective July 7, 2012, requires that "post-construction stormwater quality best management practices, as may be required by the director of public works, shall be implemented for property on which any new structure(s) will be situated or for any work such as remodeling, reconstruction, repairs, additions and similar work where the cost of the work of a period of twelve months exceeds fifty percent of the replacement value of the existing structure(s) before work is started". There are some exceptions to this ordinance. Chapter 18.20.135, effective July 7, 2012, requires "post-construction stormwater quality best management practices, as may be required by the director, shall be implemented for all subdivisions". Requirements do not apply to any subdivision that received preliminary subdivision approval prior to the effective date.

Title 20 covers Environmental Protection including topics such as soil erosion, sedimentation control and wastewater. For example per Maui County Code Chapter 20.08.080 Grubbing and Grading Permit Review, a review of drainage and erosion control plans for land use changes, developments and subdivisions must be submitted to the Soil and Water Conservation Districts (SWCD) and DLNR Historic Preservation Division.

A.5.7.5 Conservation District

HAR Title 13, Chapter 5 regulates land use in the State's 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 the public health, safety and welfare. Conservation lands are further subdivided into five subzones.[9] Four of these subzones are arranged in a hierarchy based on environmental sensitivity ranging from the most environmentally sensitive to the least sensitive. They are: protective (most sensitive); limited; resource; and general (least sensitive). The fifth is the special subzone and is applied in special cases to allow a unique land use on a specific site. For each subzone, the chapter describes the objective of the level of protection and identifies permitted uses along with the procedures necessary to obtain permission to engage in that use.

A.5.7.6 Agricultural District

HRS §205 (Land Use Commission), the *Countywide Policy Plan*, the *Maui Island Plan*, the *West Maui Community Plan* and *Maui County Code* all discuss land use and development in the Agricultural District with an emphasis on preserving and protecting agricultural resources. Chapter 19.30A of the *Maui County Code* details district standards (e.g. lot area, setbacks maximum developable area), limitations on resubdivision, permitted uses, special uses, private agricultural uses, agricultural leases, substandard agricultural lots and exemptions. The district standards specify that within the Agricultural District the maximum developable area is ten percent of the total lot area. This restriction applies to farm dwellings, but does not apply to other structures used to support agriculture. The *Maui Island Plan* recommends that the district standards regarding two

[8] The Maui County Code can be viewed at
http://library.municode.com/index.aspx?clientID=16289&stateID=11&statename=Hawaii
[9] http://hawaii.gov/dlnr/occl/frequently-asked-questions-1

acre lots be changed to avoid increased fragmentation of agricultural lands and require either fewer two acre lots per maximum number of permitted lots or clustering of two acre lots.

A.5.7.7 Rural District

Similar to the Agricultural District, HRS §205 (Land Use Commission), the Countywide Policy Plan, the Maui Island Plan, the West Maui Community Plan and Maui County Code all discuss land use and development in the Rural District as a place for small farms intermixed with low-density residential lots with a minimum size of one-half acre. Chapter 19.29A of the Maui County Code details district standards (e.g. lot area, setbacks maximum developable area), and principal and accessory uses and lists the district purpose as allow for low density development that preserves the country character of the area, allows for small-scale agricultural operations and serves as a transition between urban density development and agricultural lands. The Maui Island Plan recommends that the regulations be revised to encourage more creative design and sustainable communities.

A.5.7.8 Urban Lands

The *Countywide Policy Plan*, the *Maui Island Plan*, the *West Maui Community Plan*, and *Maui County Code of Ordinances* set forth specific policies for Urban lands regarding density, development of commercial and recreational facilities, residential dwellings and urban services (e.g. wastewater treatment facilities) and maintenance of open space and scenic roadway corridors. Policies provide specifics on uses, structures, parcel and lot area, setback requirements, minimum distance between buildings, parcel dimension requirements, access/driveways, building height, utilities and service, public access and permit requirements. Specific requirements may be written into permits.

A.5.8 County of Maui BMP Regulations

In 1998, the County of Maui revised their grading ordinance to require all projects (including those not requiring grading permits) to use Best Management Practices (BMPs) for the control of erosion, sedimentation and dust to maximum practicable extent. Several other major changes were also made to the ordinance, such as stricter requirements for grading permits for projects within the SMA, and requiring that grading permit applications be accompanied by an erosion control plan showing BMPs.[10]

The County of Maui requires a Grading Permit for any excavation or fill, or temporary storage of sand, soil, gravel, rock or other similar materials.[11] The grading permit system is broken down into major and minor permits, which must be submitted to the Department of Public Works.

A Minor Grading Permit applies to sites less than one acre in size and having a maximum height/depth of excavation or fill less than 15 feet. Sites meeting these requirements must submit a Grading Plan, BMP Plan, and if necessary, an Engineering Slope Hazard Report. A Major Grading Permit is required when an area larger than one acre is disturbed, or a maximum height/depth of excavation or fill greater than 15 feet is proposed. Sites meeting these requirements must submit the following plans prepared by a Licensed Engineer: a Grading Plan, an Erosion Control Plan, A Drainage Plan and Report, an Engineer's Soils Report (only if the maximum height of excavation or fill exceeds 15 feet) and, if necessary, an Engineering Slope Hazard Report.

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[10] http://water.epa.gov/polwaste/nps/success319/innov_hi.cfm
[11] http://www.co.maui.hi.us/index.aspx?NID=1223

A Grubbing Permit is required for any areas greater than one acre in size that have ground cover uprooted from the surface of the ground and do not incorporate grading changes. A Grubbing Plan and BMP Plan are required for all Grubbing Permits. Additional requirements apply to properties along the shoreline.

In 2012, an amendment was made to the Uniform Building Code to include post-construction stormwater quality BMPs as required by the director of public works for applicable remodeling and reconstruction projects. This amendment excluded single-family dwellings and accessory structures unless they were part of subdivisions (Chapter 16.26, Maui County Code).

A.6 Community-Based Initiatives

Parallel to Federal and State programs, and often supported by available funding, community-based initiatives are an important mechanism for both preventive and treatment control of NPS pollutants. Community engagement, education and volunteer programs are an integral part of a comprehensive solution to reduce NPS pollutants. The conservation lands of West Maui benefit from the efforts of the West Maui Mountains Watershed Partnership and their partners, many of which are private landowners. Some of these same landowners have land in the agricultural and urban districts. Condominium and resorts owners also have a vested interest in ensuring the health of the region's waters. A Watershed Coordinator is the on-the-ground resource and facilitator of watershed planning and implementation efforts in the West Maui region.

Table A.1 Agencies with Responsibility for Controlling Polluted Runoff and Monitoring and Maintaining Water Quality

Federal Agencies
US Army Corps of Engineers (USACE) The mission of the USACE is to deliver vital public and military engineering services; partnering in peace and war to strengthen our Nation's security, energize the economy and reduce risks from disasters. It administers the CWA Section 404, River and Harbors Act Section 9 &10 and Marine Protection, Research, and Sanctuaries Act Section 103. The USACE Civil Works programs include water resource development activities including flood risk management, navigation, recreation, and infrastructure and environmental stewardship.
NOAA Jointly administers Coastal Nonpoint Pollution Control Program, which falls under CZARA Section 6217, with EPA. Administers Coral Program to address threats to coral reef ecosystems, including land-based pollutants.
US Coast Guard Responsible for administration of a maritime protection program to prevent and control pollution in US navigable waters. Enforces laws against individuals and companies that pollute marine waters.

US Department of Agriculture (USDA) Farm Services Agency Responsible for most of the Federal financial support regarding farming activities such as farm plans to reduce erosion or control animal impacts on water.
USDA Natural Resources Conservation Service (NRCS) Provides technical assistance for agricultural production and cultivation, conservation activities, and economic management. Advocates proper agricultural production methods and the use of management practices to minimize adverse environmental impacts. Works closely with the 16 SWCD in Hawaiʻi. Assists in developing conservation plans to treat existing and potential resource problems and has funding to assist with the installation of management practices. Provides permitting expertise and coordination with permitting agencies. Sponsors the Environmental Quality Incentives Program, a voluntary program that provides financial and technical assistance to agricultural producers through contracts up to a maximum term of ten years. These contracts help plan and implement conservation practices that address natural resource concerns and provide opportunities to improve soil, water, plant, animal, air and related resources on agricultural land and non-industrial private forestland.
US Environmental Protection Agency (EPA) (Region 9) Responsible for providing clean and safe surface water, ground water, and drinking water and protecting and restoring aquatic ecosystems (Office of Water). Provides funding and technical support for implementation of the Hawaiʻi Polluted Runoff Control Program through CWA Section 319. For Hawaiʻi, permitting activities have been delegated to the State. Jointly administers Coastal Nonpoint Pollution Control Program, which falls under CZARA Section 6217, with NOAA.
USGS Pacific Islands Water Science Center Collects information needed to understand U.S. water resources and provide access to water data, publications and maps. Collect, analyze, and interpret water-quality data and information on the transport, fate and remediation of contaminants.

State Agencies
DOH Environmental Planning Office Water Quality Management Program: Responsible for setting the State's water quality goals (Water Quality Standards), evaluating the progress in achieving these goals and long-range planning to solve water quality problems. Planning Review Program: Reviews development projects with potential environmental impacts and coordinates departmental evaluations on mitigative measures. Implements environmental policies and standards at the earliest stages of the planning process for statewide project developments.
DOH Environmental Management Division: Clean Water Branch Responsible for enforcing and revising water quality standards. Water quality standards are maintained through monitoring and enforcement, sponsorship of polluted runoff control projects, review of permit issuance and public education. Administers Section 319 grants programs and NPDES permit process, regulates sewage treatment and disposal, hazardous waste and solid waste and reviews and issues permits for industrial storm water discharge, construction storm water discharge, MS4 permits and NPDES.
DOH Environmental Management Division: Safe Drinking Water Branch Responsible for enforcing the Federal Safe Drinking Water Act, which covers waters that are potential sources of drinking water, both surface and underground. Administers UIC as required by SDWA and directed by EPA. Administers Groundwater Protection Program, which is a non-regulatory program whose goal is to protect human health and sensitive ecosystems by protecting groundwater resources. Its focus is on water quality assessment and developing pollution prevention and protection measures.
DOH Environmental Management Division: Wastewater Branch Administers engineering and financial functions related to water pollution and municipal and private wastewater treatment. In charge of reviewing/approving and monitoring of all sewage and wastewater treatment systems including septic tanks and cesspools. Provides engineering, design, facility approval/audit, environmental assessment, grant/loan award, inspection of new facilities. Implements Statewide Wastewater Operator Training Center and supports the State board Operating Personnel in Wastewater Treatment Facilities. The three sections within the Wastewater Branch are: Planning/Design, Construction/Operations and Grants Management.
Department of Transportation Responsible for the developing and implementing strategies to control polluted runoff from transportation facilities (i.e. public highways and trails, airports and commercial harbors). Authorized to enforce polluted runoff control mechanisms for commercial harbors, highways, roads and bridges, including through NPDES permits.

DBEDT Office of Planning Oversees the Hawai'i CZM Program. This program guides appropriate land and water uses and activities through coordination of State and county agencies and ensuring compliance with laws, regulations and management policies, including the requirements of the CZMA. The CZM Program employs a variety of regulatory and non-regulatory techniques to address coastal issues and uphold environmental laws.
Department of Land and Natural Resources (DLNR) Manages State-owned terrestrial and submerged lands and regulates uses in the designated conservation districts. Administers the State's designated marine life conservation districts, marine and freshwater fisheries management areas, wildlife sanctuaries and natural area reserves. Provides funding to the 16 local SWCDs through the Hawai'i Association of Conservation Districts.
DLNR Commission on Water Resource Management The Commission's staff is comprised of the Surveying, Planning, Ground-Water Regulation, and Stream Protection and Management Branches. Oversees the instream use protection program, which recommends appropriate interim and final instream flow standards. Issues permits for well construction, modification of existing well or pump installation, and alterations of stream channels and diversions.
DLNR Engineering Division Oversees the flood and dam safety program. Provides for the inspection and regulation of construction, enlargement, repair, alteration, maintenance, operation and removal of dams or reservoirs to protect the health, safety and welfare of the citizens of the State by reducing the risk of failure of the dams or reservoirs.
DLNR Division of Aquatic Resources Manages the state's aquatic resources and ecosystems through programs in commercial fisheries and resource enhancement; aquatic resources protection, habitat enhancement and education; and recreational fisheries. Sets overall water conservation, quality and use policies; defines beneficial and reasonable uses; protects ground and surface water resources, watersheds and natural stream environments; establishes criteria for water use priorities while assuring appurtenant rights and existing correlative and riparian uses and establishes procedures for regulating all uses of Hawai'i's water resources.

DLNR Division of Forestry and Wildlife Responsible for the management of State-owned forests, natural areas, public hunting areas, and plant and wildlife sanctuaries. Program areas cover watershed protection; native resources protection, including unique ecosystems and endangered species of plants and wildlife; outdoor recreation; and commercial forestry. Manages State Forest Reserve System and Natural Area Reserves System in part to protect upper watershed areas.
DLNR Land Division Responsible for managing State-owned lands in ways that will promote the social, environmental and economic well-being of Hawai'i's people and for ensuring that these lands are used in accordance with the goals, policies and plans of the State. Responsible for leasing State agricultural lands to agricultural operators under Chapter 171, HRS. One of the lease conditions is that the operators work with the local soil and water conservation districts to develop and implement a conservation plan.
Department of Agriculture Regulates activities to protect agricultural industries and natural resources against insects, diseases and pests. Controls all eradication services directed against weed and insect pests and controls the sale and use of pesticides. 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, was transferred from DLNR to the State Department of Agriculture (Section 171-3(b), HRS).
Soil and Water Conservation Districts (SWCD) Conducts soil and water conservation activities within their respective boundaries. Works closely with the USDA NRCS to assist the needs of agricultural producers and the community through conservation planning, and technical assistance with management or conservation practices.
Maui County Agencies
Department of Planning Offers technical advice to the Mayor, County Council and commissions; proposes zoning legislation; drafts updates to the General Plan, Maui Island Plan and Community Plans; presents reports and recommendations on development proposals; and oversees programs on cultural resources, census and geographic information, flood plain permits and other special projects and permits. The Maui Planning Department is responsible for virtually all county land use-related permits. This includes shoreline setback variances and Special Management Area permits.

Department of Planning – Long Range Division Responsible for formulating long range planning activities to meet Department goals to facilitate the development of a desirable living environment through dialogue with the community and the application of professional planning principles. Coordinates long range planning activities with other County departments, State and Federal agencies to meet the Long Range goals of the department and to maintain cooperation between the various agencies.
Department of Environmental Management – Wastewater Reclamation Division Wastewater Administration manages short and long term tasks and projects related to the wastewater system (sewers, cesspools, wastewater capital improvement projects). The Wastewater Facilities program is responsible for the management, operation, maintenance and repair of all County wastewater and pumping facilities in order to provide the consistent and reliable level of performance necessary to protect public health and the environment. The Wastewater Collection System is responsible for the management, installation, maintenance and repair of all County wastewater collection lines, force mains and manholes.
Department of Water Supply – Water Resources and Planning Division Conducts permit and environmental reviews, regulatory compliance, planning information systems, water resource management and conservation.
Department of Water Supply – Engineering Division Develops and maintains water supply standards and conduct studies for feasibility of pipeline alignment and sites for reservoirs, pump stations and other facilities. Reviews all development plans for conformity with departmental standards, prepares plans and specifications for water supply projects, coordinates and prepares plans and specifications for projects to be advertised for competitive bidding. Administers Department of Water Supply Capital Improvement Projects and coordinates consultant contracts, prepares and administers agreements with public agencies and private developers, prepares plans and specifications for in-house projects, conducts studies, tests and investigations on water resources.
Department of Public Works Protects the public's health, safety, property, and environment by developing and operating the County's infrastructure and administering its building codes. Directs and oversees the three operating divisions in the Department: Development Services Administration, Engineering Division, and Highways Division. Administers County grading ordinances.

APPENDIX B: BACKGROUND INFORMATION ON WATER QUALITY AND NONPOINT SOURCE POLLUTANTS

B.1 Understanding Water Quality Hawai'i

The impacts of pollutants on water quality and ultimately coral reef health, is a driving force behind the *Kahana, Honokahua and Honolua Watershed Characterization Report*. This section provides basic information about water quality and how pollutant sources affect various water quality parameters and watershed resources.

B.1.1 Water Quality Standards

As defined by the Federal Water Quality Standards Regulation (40 CFR §131.2) a water quality standard defines the water quality goals for a waterbody, or portion thereof, by designating the use or uses to be made of the water. States adopt water quality standards to protect public health or welfare, enhance the quality of water, and serve the purposes of the Clean Water Act (CWA). The Regulation describes requirements and procedures for states to develop, review, revise and adopt water quality standards, and Environmental Protection Agency (EPA) requirements and procedures to review, approve, disapprove, and promulgate water quality standards as authorized by CWA Section 303(c).

Hawai'i Administrative Rules (HAR) Chapter §11-54 defines the general policy of water quality antidegradation, as well as the state standards for particular pollutants for Hawai'i waters. The state standards for pollutants are defined by both narrative and numerical criteria (Appendix B.2). §11-54-1.1 defines a general policy of water quality antidegradation for all water types

a) Existing uses and the level of water quality necessary to protect the existing uses shall be maintained and protected.

b) Where the quality of fish, shellfish, and wildlife and recreation in and on the water, that quality shall be maintained and protected unless the director finds, after full satisfaction of the intergovernmental coordination and public participation provisions of the state's continuing planning process, that allowing lower water quality is necessary to accommodate important economic or social development in the area in which the waters are located. In allowing such degradation or lower water quality, the director shall assure water quality adequate to protect existing uses fully. Further, the director shall assure that there shall be achieved the highest statutory and regulatory requirements for all new and existing point sources and all cost-effective and reasonable best management practices for nonpoint source control.

c) Where high quality waters constitute an outstanding national resource, such as waters of national and state parks, and wildlife refuges and waters of exceptional recreational or ecological significance, that water quality shall be maintained and protected.

State waters are classified as either inland waters or marine waters with specific water quality criteria set forth for streams, estuaries, embayments, open coastal waters and oceanic waters. For this area of West Maui, criteria for streams, open coastal waters, and oceanic waters are applicable. “Streams” means seasonal or continuous water flowing unidirectionally down altitudinal gradients in all or part of natural or modified channels as a result of either surface water runoff or ground water influx, or both. Streams may be either perennial or intermittent and include all natural or modified watercourses. “Open coastal waters” means marine waters bounded by the 183 meter or 600 foot (100 fathom) depth contour and the shoreline, excluding bays named in subsection (a) of HAR Chapter §11-54-6.

The format of Hawai‘i’s water quality standards differs from other state standards in that many of the criteria are expressed as geometric means of a representative data set, and are not intended for comparison with single sample values. The geometric mean indicates the central tendency or typical value of a set of numbers. The geometric mean normalizes the range being averaged so that no range dominates the weighting.

The criteria also contain allowances for rainfall events in the form of less strict “10 percent” and “2 percent” criteria. The “not to exceed the given value 10% of the time” means that the standard is exceeded if greater than 10% of the samples are higher than the appropriate standard for the season of interest. A sample size of 50 to 90 to show exceedance of the corresponding “10% of the time” criterion is preferred by State Department of Health (DOH). The “not to exceed the given value 2% of the time” means that the standard is exceeded if greater than 2% of the samples are higher than the appropriate standard for the season of interest. A sample size of 250 to 450 to show exceedance of the corresponding “2% of the time” criterion is preferred.

Hawai‘i’s water quality standard categories are further refined by inclusion of a wet or dry criterion, defined either by calendar date or by levels of freshwater input. Inland waters including springs and seeps, ditches and flumes, natural freshwater lakes, reservoirs, low wetlands, coastal wetlands, saline lakes and anchialine pools, define wet and dry season based on the calendar date. “Wet” season is November 1 through April 30 and “dry” season is May 1 through October 31. For estuaries, there is no specification for “wet” and “dry” season. For open coastal waters, “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.

B.1.2 Background versus Above Background Levels

Quantifying the amount of a substance, often reported as a concentration and expressed as mass per volume, is necessary to determine if its concentration is polluting the waters. In many instances it is necessary to sample a substance over time to determine if the level of the substance is increasing, and/or if it is higher than natural background levels. Background levels, often referred to as ambient conditions, exist for living and non-living substances in, and phenomena occurring on, the watershed. Background inherently implies reference to a time frame that may be difficult to quantify. Above background levels are simply levels of a substance that are higher than background.

Issues concerning the comparison and reporting of background versus above background levels occur when background levels are unknown or vary with time and space across the watershed. Water quality sampling has been limited in Kahana, Honokahua, and Honolua over the last two decades. However, when compared to water quality standards, the concentrations of several parameters have often exceeded these standards.

B.1.3 Physical Water Quality

Various physical parameters are tested when water quality monitoring is performed. These are not necessarily introduced contaminants, but normal parameters that are a function of the hydrologic cycle and biogeochemical processes taking place in the watershed. Parameters may fluctuate naturally with time and space or due to human alterations and activities in the watershed. Physical parameters such as pH, total suspended solids (TSS), and temperature are tested to assess whether levels are normal or unusual, for either natural or unnatural reasons. Results of such testing are looked at holistically because combinations of factors and types of pollutants can cause certain problems due to synergistic effects. For example, if there is an influx of agricultural runoff into a waterbody, the excess nutrients may result in an algal bloom. This causes an increase in plant biomass and then plant die-off and decomposition, leading to higher levels of suspended solids. The decomposing bacteria in turn increase the biological oxygen demand (BOD) and reduce the amount of dissolved oxygen (DO) in the water column, making it difficult for other aquatic organisms to survive. Physical water quality parameters typically tested for are shown in Box B.1.

Box B.1 Physical Water Quality Parameters

pH: pH is a measurement of Hydrogen ions and refers to a liquid's level of acidity or alkalinity. It is presented on a logarithmic scale of 0-14, with levels lower than 7 meaning acidic and levels higher than 7 meaning alkaline. pH has a direct effect on the solubility and biological availability of nutrients and toxic metals. Lower pH levels make toxic metals more soluble. pH is extremely important in water quality due to these synergistic effects.

Total suspended solids (TSS): This is a measurement of particulate matter in the water. Water samples are filtered and the weight of the remaining particulates provides a measurement of particulate matter in the water column.[1]

Turbidity: This parameter is linked to many things, e.g. directly to the amount of TSS in the water. Turbidity is a measure of water clarity. It is measured in "Nephelometric Turbidity Units" or NTU, which is a measurement of how light is scattered by particulates in the water. Turbid waters can be caused by sediments, phytoplankton and other particulates. High turbidity reduces light penetration which affects plant photosynthesis. Settling particulates can also kill hatching larvae and clog fish gills.

Total dissolved solids: These are minerals or salts and trace elements that occur naturally, as well as plant nutrients such as nitrogen and phosphorus. The former generally affect the taste and clarity of water without having negative ecological impacts. The latter can cause ecological problems.

[1] TSS concentrations and turbidity both indicate the amount of solids suspended in water. However, TSS is a measure of the suspended solids in wastewater, effluent, or waterbodies determined by tests for "total suspended non-filterable solids", whereas turbidity is a measure of water clarity and how much the material suspended in water decreases the passage of light through the water (EPA 2012). TSS allows for the calculation of the total quantities of material within or entering a waterbody, turbidity does not.

Salinity: This measures the amount of salt in water. There are certain salinity levels that are healthy for certain ecosystems and an influx of freshwater into estuaries or the ocean can have a negative impact on the aquatic organisms. Even treated wastewater, when directly released into the ocean, is sometimes considered pollution not just because of the nutrients and bacteria but because of the dilution it causes in the seawater.

Electrical conductivity: This measurement is an estimate of the total dissolved ions/minerals in the water and varies naturally depending on the geology and other factors in a watershed. Electrical conductivity measurements can help determine possible pollution problems in water as various pollutants from wastewater, agricultural and urban runoff may cause an increase in electrical conductivity.

Dissolved oxygen (DO): This is the amount of oxygen in the water column. In order for an aquatic ecosystem to be balanced, there are certain DO levels required to sustain aquatic organisms. If the level of DO is unusually low, this could indicate an unbalanced state such as eutrophication, where excess plant matter and its decomposition has caused a hypoxic environment.

Biological oxygen demand (BOD): BOD is an indirect measure of organic pollution. It measures the amount of DO needed for aerobic bacteria to decompose the organic material in a given water sample. If the BOD is high, this can point towards an increase in plant matter so this is an indirect indicator of eutrophication.

Temperature: Temperature varies naturally based on daytime and season. However, there are certain temperature ranges that are healthy for an aquatic ecosystem. If the temperature falls below or above that range, it affects the biological activity in that ecosystem. Wastewater effluent, runoff and other discharges can affect the temperature of a waterbody.

Chlorophyll a: This measures the amount of chlorophyll, the cell component of plants that makes them green. This measurement is an indirect way of estimating plant (algae) biomass in the water.

Stream flow: Stream flow is a measure of water velocity. It is subject to seasonal variation. Stream flow has a direct effect on several water quality parameters as it affects temperature, DO and the distribution of various substances. Problems can arise during storm events when heavy rainfall causes high velocity and stream bank erosion, which in turn affects the amount of TSS and turbidity. It can also physically damage habitat. Stormwater runoff is a contributor to variable flows that can negatively impact aquatic ecosystems.

B.1.4 Chemical Water Quality

Nutrients such as nitrogen and phosphorus are used as chemical water quality parameters since nutrient pollution can lead to disturbances in fresh and saltwater ecosystems. Nitrogen and phosphorus are natural elements with their own respective biogeochemical cycles.

Nitrogen is naturally present in the environment, in soil, in the atmosphere and all living things. It makes up 78% of air. It is present in multiple organic and inorganic forms such as ammonium, nitrite and nitrate and nitrogen gas. The nitrogen cycle is a complex sequence of conversions of various nitrogen states to other states as it moves through the environment, ground water and atmosphere (Box B.2). Nitrogen is an important source of food for plants, and in order for them to use it, bacteria "fix" the nitrogen, i.e. convert it to a usable form. For example, ammonium (NH_4^+)

present in the soil from decomposed animal excretions gets converted to nitrite and later nitrate, which can be absorbed by plants. These ionic forms are later converted back into nitrogen gases that enter the atmosphere, completing the cycle.

Phosphorus is a mineral that is present in the terrestrial environment in water, soil and sediments and whose biogeochemical cycle excludes any atmospheric stage. Phosphorus is most commonly found in rocks and ocean sediments in the form of phosphate salts. The phosphate salts are released through weathering of rocks and move through the system tightly bound to soil molecules and delivered with sediments because phosphorus is not highly soluble. Phosphorus moves from the land to the ocean, but a considerable amount is deposited in ocean sediment from the shells and bones of marine organisms and by precipitation and settling of phosphates. In most soils the phosphorus absorbed by plants comes from organic molecules that undergo decomposition and release phosphorus in plant-available inorganic forms. Phosphorus is an important nutrient for plants.

Nutrients become a problem in the environment when excess amounts are present in watersheds and are eventually delivered to the ocean. While nitrogen and phosphorus are extremely important nutrients for terrestrial and aquatic plants, excess concentrations disrupt the ecological balance of aquatic ecosystems. The atomic ratio of carbon, nitrogen and phosphorus, is relatively consistent for all marine biomass (dead and living) from coastal to open ocean regions. The ratio, called the Redfield ratio, is C:N:P = 106:16:1. The Redfield ratio may be used to estimate carbon and nutrient fluxes and which nutrient is the limiting factor for growth.

Nutrients support the growth of aquatic plants, including algae, which provide a food source for other aquatic organisms and produce oxygen via photosynthesis. However, when nutrient levels are high, they can lead to eutrophication, which is an excessive production of plant biomass in the water, leading to decomposition and a hypoxic environment. An example is the stimulation of algae growth that can block sunlight from reaching other aquatic organisms and leads to a die-off of larger amounts of algae, which is decomposed by bacteria in a natural process. These bacteria use more oxygen than under normal conditions, reducing the amount of oxygen available to other aquatic organisms. The reduction in sunlight and oxygen makes it difficult for other aquatic organisms to survive.

Because nitrogen and phosphorus stimulate plant growth, they are used as chemical fertilizers in agricultural production to increase yield. Agricultural runoff is a significant contributor of nutrients to the Nation’s waterbodies. The EPA has ranked nitrogen and phosphorus pollution as one of the top causes of degradation in U.S. waters for over a decade. Sources of these nutrients are agricultural runoff as well as wastewater from leaking septic tanks and wastewater treatment effluent.

Box B.2 Understanding Nitrogen

The Forms of Nitrogen. Nitrogen load inputs into the ocean are of concern due to their potential to adversely impact waterbodies by stimulating primary productivity of the food chain and triggering harmful algal blooms. Nitrogen from treated waste water effluent, fertilizers, human and animal waste and decomposing vegetation (including food waste) are all likely sources of nitrogen found in the ocean.

Nitrogen in Living Things. Nitrogen is a component of amino acids and urea. Amino acids are the building blocks of all proteins. Proteins comprise not only structural components such as muscle, tissue and organs, but also enzymes and hormones essential for the functioning of all living things. Urea is a byproduct of protein digestion. The term "organic nitrogen" is used to describe a nitrogen compound that had its origin in living material. The nitrogen in protein and urea is organic nitrogen. Organic nitrogen can be introduced to the environment from sanitary waste systems including waste water treatment plants, septic and cesspool systems, from humans and animals, as discarded food material, or as ingredients of cleaning agents.

Ammonification. Many of the transformations of nitrogen in both soluble and particulate forms are mediated by bacteria that use different forms of nitrogen. During the processes of decomposition, the nitrogen in proteins is transformed eventually to ammonia (NH_3) or ammonium by certain kinds of bacteria. These processes are called ammonification. Nitrogen in the liquid or leachate from waste water systems is primarily ammonium. Some of the leachate discharged into the ground becomes adsorbed to soil particles and is effectively immobilized from further transport.[2]

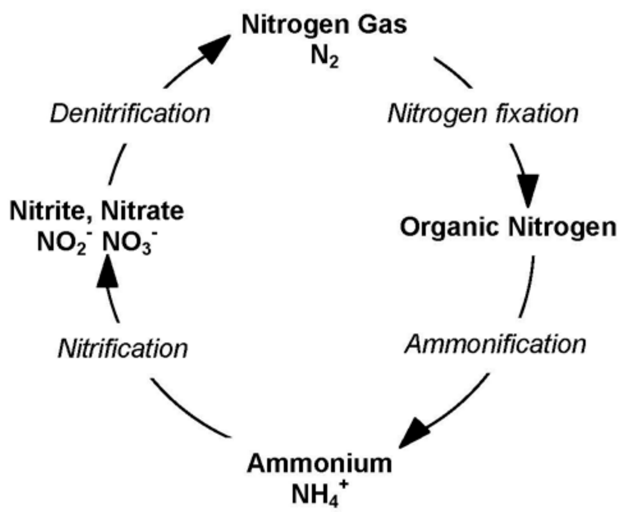
Nitrification. Some kinds of bacteria change ammonia (NH_3) to nitrite or nitrite to nitrate. These processes are called nitrification. Nitrification is an aerobic process and can occur only in the presence of oxygen.[3] The nitrate form of nitrogen is the one most used for plant growth, and is the most mobilized form in ground water. Nitrate in ocean waters is often the primary reason for triggering algal blooms, which can create nuisance mats of floating algae in and on the water, and lead to stress on fishes and other aquatic organisms due to the use of oxygen in the water by bacteria that "feed" on the algae. The ammonium form of nitrogen is also used by plants, but is not as mobile in water and therefore not as problematic with respect to triggering algal blooms in the ocean.

Denitrification. Some bacteria species in soils can take nitrate and change it back to nitrogen gas through a process called denitrification. Denitrification is an anaerobic process. This means it only takes place when no oxygen or extremely low concentrations of oxygen are available and a source of carbon for the bacteria is present in the soil. The amount of nitrate in ground water that is denitrified prior to entering the ocean is unknown, as is the amount in nitrate form. In general, denitrification probably lowers some of the nitrate reaching the ocean, which reduces the potential threat of algal blooms.

[2] Absorbed means taken into soil particle. Adsorption means to stick to the outside of a soil particle.
[3] Aerobic means occurring in the presence of oxygen. Anaerobic means in an environment of little to no oxygen.

Box B.2 Understanding Nitrogen (continued)

Simplified Nitrogen Cycle. In summary, nitrogen cycles through the air, water, and soils, with many transformations controlled by the actions of specialized bacteria. Some of these transformations require aerobic conditions while others occur only under anaerobic conditions. Under the best case scenario bacteria will regulate the amount of nitrogen in forms transported in surface water and ground water discharged in the ocean that can potentially disrupt the food chain and trigger algal blooms.



Simplified nitrogen cycle, *italics* denote processes and bold the different forms of nitrogen.

B.1.5 Biological Water Quality

Microbes in fresh and salt water can come from a variety of sources within a watershed, and be contained in both surface water and ground water. Suspected sources are feral ungulates contributing fecal matter, birds, domestic animals (i.e. dogs, cats), livestock, and human sewage via leaking septic tanks or wastewater seepage. Some bacteria strains occur naturally in the environment. Microbial contamination is an environmental health concern as different types of bacteria and other microorganisms such as *Giardia*, *Cryptosporidium* and *Staphylococcus* can transmit disease and cause infections in humans. Transmission of water borne diseases is through contact with contaminated water (i.e. during surfing or swimming), or ingesting contaminated water. According to EPA, pathogens are the second most frequent cause of water quality impairments under the CWA. The increased interaction of humans and domestic and feral animals is stimulating the evolution of new pathogens. Several microorganisms that used to live only within animals have evolved to infect humans (e.g. avian flu).

B.1.5.1. Enterococci

Pollutants from sewage-related sources are both an environmental issue and a public health concern, since sewage can contain harmful pathogens that cause a variety of illnesses in humans. Sewage can affect ocean and freshwater systems through point and non-point sources (i.e. sewage treatment facilities [point source] and cesspools [non-point source]) (Hartz et al. 2008). To decide whether coastal waters are safe for swimmers, Hawaiʻi DOH monitors bacteria levels in ocean waters. There are multiple disease-causing agents that can be present in sewage and it is unfeasible to test for each one. Therefore, agencies throughout the world, including the World Health Organization, EPA, and DOH, use fecal indicator bacteria to determine if sewage contamination is present. Past indicators include fecal coliform and *Escherichia coli* (*E. coli*).

In 1988, the Federal standard for assessing marine water health risks officially became bacteria of the genus *Enterococcus* (DOH FAQs and Hartz et al. 2008). Indicator bacteria are not pathogens themselves, but rather they are bacteria naturally present in the feces of warm-blooded birds and mammals. Finding high levels of *enterococci* in water is an indicator that fecal contamination may have occurred near the testing site. *Enterococci* is used as an indicator and studies over many years have shown a positive correlation between high levels of *enterococci* and gastrointestinal illnesses caused by sewage-related bacteria and viruses. *Enterococci* is also a good indicator in saltwater. *Enterococci* die off in the water column at about the same rate, making it a useful tool in determining when waters are swimmable.

The Federal standard for *enterococci* is set at 35 CFU/100ml. The 2013 HAR standard used to determine safe swimming conditions in Hawaiʻi are: Inland waters – 33 CFU/100ml in 5 or more samples spaced within a 25- to 30-day period, single sample maximum 89 CFU/100ml; coastal waters within 300m of the shore – 35 CFU/100 ml in 5 or more samples spaced within a 25- to 30-day period, single sample maximum 104 CFU/100ml (HAR §11-54). One important consideration is that *enterococci* have also been found to naturally occur in Hawaiian soils where they are able to survive longer than in water (up to 28 days in laboratory conditions) (Craig et al. 2002; Fujioka & Hardina 1991). In the event of heavy rains, stream bank erosion can cause increased levels of *enterococci* in streams and the ocean that are not from a sewage-related source. DOH Clean Water Branch uses *Clostridium perfringens* as a secondary tracer of human sewage. Other modern tools used by scientists in the past few years have been DNA markers to trace contaminated waters by their fecal source, e.g. pig, human or ruminant.

B.2 State of Hawai'i Water Quality Standards[4]

(Source: Department of Health - Amendment and Compilation of Chapter 11-54 of Hawai'i Administrative Rules, November 15, 2014)

Toxic Pollutants - Applicable to ALL WATERS

	Freshwater		Saltwater		
Pollutant	Acute (μ/L)	Chronic (μ/L)	Acute (μ/L)	Chronic (μ/L)	Fish Consumption (μ/L)
Acenapthene	570	ns	320	ns	ns
Acrolein	23	ns	18	ns	250
Acrylonitrile*	2,500	ns	ns	ns	0.21
Aldrin	3	ns	1.3	ns	0.000026
Aluminum	750	260	ns	ns	ns
Antimony	3,000	ns	ns	ns	15,000
Arsenic	360	190	69	36	ns
Benzene*	1,800	ns	1,700	ns	13
Benzidine*	800	ns	ns	ns	0.00017
Beryllium*	43	ns	ns	ns	00.038
Cadmium	3+	3+	43	9.3	ns
Carbon tetrachloride*	12,000	ns	16,000	ns	2.3
Chlordane*	2.4	0.0043	0.09	0.004	0.00016
Chlorine	19	11	13	7.5	ns
Chloroethers					
ethy (bis-2)*	ns	ns	ns	ns	0.44
isopropyl	ns	ns	ns	ns	1,400
methyl (bis)*	ns	ns	ns	ns	0.0006
Chloroform*	9,600	ns	ns	ns	5.1
Chlorophenol (2)	1,400	ns	ns	ns	ns
Chlorpyrifos	0.083	0.041	0.011	0.0056	ns
Chromium (VI)	16	11	1,100	50	ns
Copper	6+	6+	2.9	2.9	ns
Cyanide	22	5.2	1	1	ns
DDT*	1.1	0.001	0.013	0.001	0.000008
metabolite TDE*	0.03	ns	1.2	ns	ns
Demeton		0.1	ns	0.1	ns
Dichloro-					
benzenes*	370	ns	660	ns	850
benzidine*	ns	ns	ns	ns	0.007
ethane (1,2)*	39,000	ns	38,000	ns	79
ehenol (2,4)	670	ns	ns	ns	ns
propanes	7,700	ns	3,400	ns	ns
propene (1,3)	2,000	ns	260	ns	4.6

[4] Although the State standards for most parameters are presented in micrograms per liter (μg/L), tables throughout the characterization report (except for Toxic Pollutants) show standards in milligrams per liter (mg/L) to be consistent with how data are presented in the DOH Clean Water Branch Database.

Dieldrin*	2.5	0.0019	0.71	0.0019	0.000025
Dinitro- o-cresol (2,4)	ns	ns	ns	ns	250
toluenes*	110	ns	200	ns	3
Dioxin	0.003	ns	ns	ns	$5.0x10^{-9}$
Diphenyl- hydrazine (1,2)	ns	ns	ns	ns	0.018
Endosulfan	0.22	0.056	0.034	0.0087	52
Endrin	0.18	0.0023	0.037	0.0023	ns
Ethylbenzene	11,000	ns	140	ns	1,070
Fluoranthene	1,300	ns	13	ns	18
Guthion	ns	0.01	ns	0.01	ns
Heptachlor*	0.52	0.0038	0.053	0.0036	0.00009
Hexachloro- benzene*	ns	ns	ns	ns	0.00024
butadiene*	30	ns	11	ns	16
Cyclohexane- alpha*	ns	ns	ns	ns	0.010
beta*	ns	ns	ns	ns	0.018
technical*	ns	ns	ns	ns	0.014
cyclopentadiene	2	ns	2	ns	ns
ethane*	330	ns	310	ns	2.9
Isophorone	39,000	ns	4,300	ns	170,000
Lead	29+	29+	140	5.6	ns
Lindane*	2	0.08	0.16	ns	0.020
Malathion	ns	0.1	ns	0.1	ns
Mercury	2.4	0.55	2.1	0.025	0.047
Methoxychlor	ns	0.03	ns	0.03	ns
Mirex	ns	0.001	ns	0.001	ns
Napthalene	770	ns	780	ns	ns
Nickel	5+	5+	75	8.3	33
Nitrobenzene	9,000	ns	2,200	ns	ns
Nitrophenols*	77	ns	1,600	ns	ns
Nitrosamines*	1,950	ns	ns	ns	0.41
Nitroso- dibutylamine-N*	ns	ns	ns	ns	0.19
diethylamine-N*	ns	ns	ns	ns	0.41
dimethylamine-N*	ns	ns	ns	ns	5.3
diphenylamine-N*	ns	ns	ns	ns	5.3
Pyrrolidine-N*	ns	ns	ns	ns	30
Parathion	0.065	0.013	ns	ns	ns
Pentachloro- ethanes	2,400	ns	130	ns	ns
benzene	ns	ns	ns	ns	28
phenol	20	13	13	ns	ns

Phenol	3,400	ns	170	ns	ns
2,4-dimethyl	700	ns	ns	ns	ns
Phthalate esters dibutyl	ns	ns	ns	ns	50,000
diethyl	ns	ns	ns	ns	590,000
di-2-ethylhexyl	ns	ns	ns	ns	16,000
dimethyl	ns	ns	ns	ns	950,000
Polychlorinated biphenyls*	2.0	0.014	10	0.03	0.000079
Polynuclear aromatic hydrocarbons*	ns	ns	ns	ns	0.01
Selenium	20	5	300	71	ns
Silver	1+	1+	2.3	ns	ns
Tetrachloro- ethanes	3,100	ns	ns	ns	ns
benzene (1,2,4,5)	ns	ns	ns	ns	16
ethane (1,1,2,2)*	ns	ns	3,000	ns	3.5
ethylene*	1,800	ns	3,400	145	2.9
phenol (2,3,5,6)	ns	ns	ns	440	ns
Thallium	470	ns	710	ns	16
Toluene	5,800	ns	2,100	ns	140,000
Toxaphene*	0.73	0.0002	0.21	0.0002	0.00024
Tributylin	ns	0.026	ns	0.01	ns
Trichloro- ethane (1,1,1)	6,000	ns	10,400	ns	340,000
ethane (1,1,2)	6,000	ns	ns	ns	14
ethylene*	15,000	ns	700	ns	26
phenol (2,4,6)	ns	ns	ns	ns	1.2
Vinylchloride*	ns	ns	ns	ns	170
Zinc	22+	22+	95	86	ns

ns - No standard has been developed
* - Carcinogen
+ - The value listed is the minimum standard. Depending on hardness of receiving waters ($CaCO_3$), higher standards may be calculated using formula from EPA Water Quality Criteria (EPA 440/5-86-001)

Compounds listed in plural are mixtures of isomers. Numbers listed refer to total allowable concentration of any combination of isomers in compound.

Criteria for All Streams

Parameter†	Geometric Mean not to exceed given value	Not to exceed given value more than 10% of the time	Not to exceed given value more than 2% of the time
Total Nitrogen (mg/L)			
Wet season*	0.25	0.52	0.8
Dry season**	0.18	0.38	0.6
Nitrate + Nitrite Nitrogen (mg/L)			
Wet season	0.07	0.18	0.3
Dry season	0.03	0.09	0.17
Total Phosphorus (mg/L)			
Wet season	0.05	0.10	0.15
Dry season	0.03	0.06	0.08
Total Suspended Solids (mg/L)			
Wet season	20.0	50.0	80.0
Dry season	10.0	30.0	55.0
Turbidity (N.T.U.)			
Wet season	5.0	15.0	25.0
Dry season	2.0	5.5	10.0

† State standards are presented in micrograms per liter (μg/L) but are converted here to milligrams per liter (mg/L) for consistency with data presented in the DOH Clean Water Branch Database
* - Wet season: November 1 - April 30
** - Dry season: May 1 – October 31
L - Liter
N.T.U. - Nephelometric Turbidity Units. Comparison of intensity of light scattered by sample under equal conditions. Higher intensity = higher turbidity
mg - Milligram or 0.001 grams

Additional stream water quality parameters:

Enterococci	33 CFU/100ml in 5 or more samples, 89 CFU/100ml in single sample
pH Units	Not to deviate more than 0.5 units from ambient conditions; not to be lower than 5.5 or higher than 8.0
Dissolved Oxygen	Not less than 80%, determined as a function of water temperature
Temperature	Not to vary more than one degree Celsius from ambient conditions
Specific Conductance	Not to exceed 300 micromhos/centimeter

Criteria for Open Coastal Waters

Parameter†	Geometric Mean not to exceed given value	Not to exceed given value more than 10% of the time	Not to exceed given value more than 2% of the time
Total Nitrogen (mg/L)			
Wet season*	0.15	0.25	0.35
Dry season**	0.11	0.18	0.25
Ammonia Nitrogen			
Wet season	0.0035	0.0085	0.015
Dry season	0.002	0.005	0.009
Nitrate + Nitrite Nitrogen (mg/L)			
Wet season	0.005	0.014	0.025
Dry season	0.0035	0.010	0.020
Total Phosphorus (mg/L)			
Wet season	.02	.04	.06
Dry season	.016	.03	.045
Light Extinction Coefficient (k units)			
Wet season	0.2	0.50	0.85
Dry season	0.10	0.30	0.55
Chlorophyll a (µg/L)			
Wet season	0. 3	0. 9	1.75
Dry season	0. 15	0. 5	1.00
Turbidity (N.T.U.)			
Wet season	0. 50	1.25	2.00
Dry season	0. 20	0. 50	1.00

† State standards are presented in micrograms per liter (µg/L) but are converted here to milligrams per liter (mg/L) for consistency with data presented in the DOH Clean Water Branch Database
* - Wet season criteria apply when the open coastal waters receive more than three million gallons per day of fresh water discharge per shoreline mile.
** - Dry season criteria apply when the open coastal waters receive less than three million gallons per day of fresh water discharge per shoreline mile.
L - Liter
N.T.U. - Nephelometric Turbidity Units. Comparison of intensity of light scattered by sample under equal conditions. Higher intensity = higher turbidity
mg - Milligram or 0.001 grams

Additional water quality parameters:

Enterococci — 35 CFU/100ml in 5 or more samples, 104 CFU/100ml in single sample

Clostridium perfringens — >50CFU/100ml

pH Units — Not to deviate more than 0.5 units from a value of 8.1, except at coastal locations where and when freshwater from stream, storm drain or ground water discharge may decrease pH to 7.0

Dissolved Oxygen Not less than 75%, determined as a function of water temperature and salinity

Temperature Not to vary more than one degree Celsius from ambient conditions

Salinity Not to vary more than 10% from natural or seasonal changes considering hydrologic input and oceanographic factors

State of Hawaiʻi Effluent Monitoring Standards

(Source: Department of Health - Amendment and Compilation of Title 11, Chapter 62 of Hawaiʻi Administrative Rules, January 14, 2004)

Parameter	Standard	Sampling Schedule
BOD	Not to exceed 30 mg/L for arithmetic mean of composite samples Not to exceed 60 mg/L for grab sample	Large facilities**: Composite sampling at least weekly Small Facilities: Grab sampling at least monthly
TSS	Not to exceed 30 mg/L for arithmetic mean of composite samples Not to exceed 60 mg/L for grab sample	Large facilities: Composite sampling at least weekly Small Facilities: Grab sampling at least monthly
Total Daily Flow	Specified in permit	Monitored weekly
Pathogens in sludge: Fecal coliform OR Salmonella sp.	Not to exceed 1000 MPN/g of total solids (based on dry weight) Not to exceed 3 MPN/g of total solids (based on dry weight)	Seven samples must be analyzed before sludge is used, disposed, etc.

* Composite sample results are based on one or more analyses in a 30-day period. For this, at least eight samples are required. They have to be done under flow proportional conditions (i.e. either the time interval between each aliquot or the volume of each aliquot must be proportional to either the stream flow at the time of sampling or the total stream flow since the collection of the previous aliquot).

** Large facilities have a design flow higher than 100,000 gallons per day. Small facilities have a design flow of less 10 than 100,000 gallons per day.

B.3 Effects of Erosion and Vegetation on Hydrology

B.3.1 Erosion and Sedimentation

Soil is formed by chemical weathering and to a lesser degree, physical weathering of rock material. Soils develop horizons or layers that contain different levels of organic material, chemical concentrations, texture, colors and thickness.

Sediment is material that includes soils and fragments of rocks and other debris that were transported from their original locations via wind and water. Thus, sediments are a depositional feature. After long periods, some sediment can weather and develop into soils. Sediments generally do not contain horizons but may contain graded zones or layers differentiated by particle sizes.

This distinction between soil and sediment is critical when designing restoration and erosion control bioengineering strategies. For example, installing vegetative cover to an area that has a developed soil profile may only require planting of seed or container stock and supplemental water, while an area with sediments would require soil amendments such as fertilizers and physical site preparation to support plant establishment. Additionally, the location and volume of sediments can yield clues to diagnosing or discovering the sediment source location.

B.3.2. Non-native (Introduced) Vegetation

Non-native plants species, introduced purposefully or inadvertently, have displaced native plants that evolved in the Hawaiian Islands over millions of years. Some scientists hypothesize that non-native forest canopy structure and plant types are less effective than a forest covered with native vegetation in controlling erosion rates, capturing rainfall, and maintaining recharge to high level aquifers. Removal of vegetation and physical disturbance to the ground surface changes the ratio of rainfall to runoff. In forested areas dominated by native plants, the canopy structure is typically dense and multi-storied with a vegetative ground cover. Rain drops are more likely intercepted or reduced by vegetation in a multi-storied forest, thus protecting the ground surface from direct erosion from rainfall.

Hydrological processes simulated in a water-budget model used for a 2014 U.S. Geologic Survey study on Maui groundwater recharge included rainfall, fog interception, irrigation, runoff and evapotranspiration (*ET*). *ET* measurements for different types of dominant alien and native plants were recommended to refine models elements for specific land-cover types (USGS 2014). Improved understanding of the spatial and daily variability of fog on Maui, and fog-interception rates for different types of vegetation, are recommended to better predict groundwater recharge.

The 2014 *Evapotranspiration of Hawai'i, Final Report* by University of Hawai'i's Department of Geography, states that species have noticeable effect on the *ET* pattern, with an example of Strawberry guava (*Psidium cattleianum*) having a relatively high rate of *ET* in comparison with native trees (Giambelluca et al. 2014). It is surmised that non-native trees have higher water demands than native tree species, though research related to water use by native to non-native vegetation and evapotranspiration rates has not yielded conclusive results.

B.3.3. Climatic Controls on Plants and Erosion

Weather patterns and the climate regime that affect the project area have a significant impact on the erosion process. For most of the year trade winds dominant the weather pattern and rainfall amounts from individual trade showers is often low (<0.01 inch). During dry periods between the brief trade showers evapotranspiration often exceeds rainfall. This causes soil moisture to drop to levels that make it difficult for plants to pull water from the soil. This may cause plants to become stressed, and dormancy and die off may occur. Plants that evolved in this type of climatic regime developed growth strategies to accommodate dry periods in order to maintain vigor and root tensional strength. Following the dry period, winter rains frequent the island chain. Plants such as annual invasive grasses that have died off and lost stems have a reduced canopy, which exposes ground surfaces surrounding the plants. Additionally, roots lose tensional strength and their ability to hold soil particles is reduced. The winter rainfall events during the early part of the rainy season occur when soil is most vulnerable and erodibility is high. The frontal winter storms differ from the summer trade wind dominated showers in that precipitation intensity and amounts are higher and more erosive.

B.3.4. Effects of Fire on Plants and Erosion

Following fire, the landscape is often bare and expose, which increases vulnerability to accelerated erosion and, in steep areas, landslides. This scenario is exacerbated by non-native vegetation that is not drought tolerant and dies back during the dry summer months or other periods of drought. In watersheds where this scenario has occurred, erosion rates and sediment loads carried by runoff have been observed to be extreme (A. Hood, pers. comm.).

The potential indirect adverse effects are a consequence of the alteration of the natural fire regime. This includes the alteration of the vegetation at the local ecosystem and landscape levels of the affected watersheds. Combined with the direct effects on soil and its biota, the result could be the overall degradation of watershed health and native biodiversity. These indirect effects could also include reduced water quality and available water resources, and of the loss of ecosystem level watershed services, such as ground water infiltration, aquifer recharge, flood control, nutrient cycling and others.

B.4 Pollutant Transport

Pollutant transport and delivery to receiving waters is a function of several variables that ultimately determine their fate and condition. The distance between the pollutant source and the receiving water body, as measured along the pathway the pollutant is carried, plays a major role in determining the travel time and condition of the NPS pollutant. For example, nitrogen discharged in effluent water at the WWRF in its nitrate form (NO_3^-) is denitrified due to the relatively long travel time it takes for water to flow from the WWRF to the ocean.

Sediment load is not only a function of the area of erodible soil, but also a function of factors such as proximity of the source to drainage courses, rainfall patterns, and condition of the flow path it is transported along. Therefore, a single moderately sized hotspot sediment source that is located in immediate proximity to a receiving water can contribute a significant load compared to multiple or larger sites that are farther from the receiving water or that are attenuated[5] during transport over the watershed.

Many pollutants are associated with sediments that are transported primarily in surface water. Thus sediment laden runoff from a farm field likely is likely transporting a portion of chemicals applied to fields (e.g. fertilizers and pesticides). Several forms of phosphorus attach directly onto sediment particles, and sediment movement is the primary transport mechanism.

Nutrients migrate into the soils via ground water infiltration and surface water runoff. During rainfall events, nutrients, sediment, chemicals, and bacterial pollutants are carried overland into the stream channels, where they are carried in runoff to the ocean.

Several classes of pollutants, including nutrients, can be found in two forms: dissolved and particulate matter. Dissolved forms of pollutants are so small that they are in solution and move at the rate of the solution (water) they are dissolved in. The dissolved form is primarily associated with pollutant transfer through soils and contamination of ground water, though it can also be readily carried in surface runoff. Particulate matter is a mobile form of substrate and is the form most commonly transported in surface water runoff. Control and sequestration of pollutants, either dissolved or in particulate form, is a challenge. The most effective approach to reducing pollutant loads to the ocean is source prevention to reduce their generation at the source.

B.4.1. Agricultural Activities

Farming activities can expose soil and change surface water flow patterns, both of which can increase rates of erosion and loads of sediments and other pollutants delivered into the ocean. Application of fertilizers and pesticides introduces nutrients and chemicals to fields, which can be leached into ground water via irrigation water (Table B.1). Leaching occurs when irrigation rates are higher than plant uptake. Fertilizers that leach below the root zone are not available to plants, are wasteful to the applicator, and costly to the ground water. It is unknown if fertilizer application rates in the project area are applied based on information such as soil nutrient levels, plant requirements and irrigation applications.

Under certain weather conditions wind picks up dust and soil particles and carries them to downwind locations. In addition, fugitive dust generated by motorized vehicles can be transported from the ground into the air.

B.4.2. Urban Activities

Due to the storm water system and impervious surfaces in the urban areas, NPS pollutants can be quickly routed off the landscape during rainfall and rapidly delivered to the ocean. A certain portion of pollutants, such as the ammonium and nitrate forms of nitrogen, are carried in ground water to the ocean. Runoff generated in the Conservation and Agricultural Districts that makes its way to the Urban District is routed rapidly due to the storm water system. The water received into the Urban District is not detained and pollutants are not attenuated.

[5] Attenuation of sediment occurs as flow carrying the particles encounters vegetated areas where sediment can be filtered by plant material, and deposited along the flow paths in flat and depression areas, commonly referred to as sinks.

Large amounts of pollutants are associated with a phenomenon referred to as the first flush. During dry periods, impervious surfaces accumulate pollutants generated by human activities or from atmospheric dry fall. The time interval between runoff-generating rainfall events is referred to as the accumulation phase. The first flush is the first big rainfall event occurring after the accumulation phase. It contains the highest concentration of contaminants and generates the highest pollutant loads at its receiving waters (Scholze et al. 1993).

Table B.1 Land Based Pollutants and Potential Toxicity

Chemical	Sources	Location Documented	Toxicity to Environment
1,2-Dibromo-3-Chloropropane (DBCP)	Pesticide	• Honokahua Drinking Water Well • Nāpili A Drinking Water Well • Nāpili C Drinking Water Well	Toxic to aquatic organisms.
Ethylene Dibromide (EDB)	Pesticide	• Honokahua Drinking Water Well • Nāpili B Drinking Water Well • Nāpili C Drinking Water Well	Highly toxic compound The toxic dose of EDB to non-target organisms range from 10-100 ppm, a range that is much higher than has ever been found in surface waters. No specific lethal dose values for wildlife species were found.
1,2,3-Trichloropropane	Pesticide	• Honokahua Drinking Water Well • Nāpili A Drinking Water Well • Nāpili C Drinking Water Well	Carcinogenic compound. The air concentration of TCP considered an Immediate Danger to Life and Health is 100 ppm.
State of Hawaiʻi Department of Health (DOH). 2015. Hawaiʻi Environmental Health Portal: Groundwater Contamination Viewer. Retrieved January 2015 from: http://eha-web.doh.hawaii.gov/gw-contam/			
U.S. Environmental Protection Agency (EPA). 2014. Technical Fact Sheet –1,2,3-Trichloropropane (TCP). Retrieved from: http://www2.epa.gov/sites/production/files/2014-03/documents/ffrrofactsheet_contaminant _tcp_january2014_final.pdf			

B.5. Causal Impacts of Land-Based Pollutants on Selected Ocean Resources

Coral reef ecology is primarily based on processes of reproduction and recruitment, which are dependent on water and substratum quality. Pollutants and related synergistic[6] effects can cause mortality and disease in species; hinder ecological functions; impede growth, reproduction and larval development; and cause trophic structure and dynamic changes (NOAA Coral Program 2009). The casual relationship between coral reef ecosystems and impacts from ocean-based extractive and contact activities such as fishing, swimming and diving and the deposition of land based activities in ocean waters is complex. Research by scientists and anecdotal observations by persons who utilize the ocean for economic gain and/or recreational opportunities are in agreement that policies to prevent overfishing and protection of key fish resources, limit inputs of

[6] Synergy is the interactions of two or more activities or materials that combine to create a single result.

land-based pollutants, and minimize physical impacts to coral reef are necessary to protect and maintain healthy coral reefs (Davidson et al. 2003).

This section provides some specific examples of adverse impacts that land-based pollutants have on the ocean environment within the project area. While this is not a comprehensive list of pollutants and their impacts, it presents examples of the cause and effect relationship that activities within the watershed are currently having on the coastal ocean environment in West Maui.

B.5.1 Sediment

Within the main Hawaiian islands, sediment is probably the leading pollutant from land-based sources that causes the alteration of reef community structure (Friedlander et al. 2008). Sediment delivery to nearshore waters during runoff events has increased as coastal areas are developed, floodplains filled, storm drains constructed, and streams channelized (Friedlander et al. 2008). Studies conducted on the transport rate of suspended sediments carried in storm water runoff have found that flows that occur 2% of the time are responsible for delivering up to 90% of the total annual load (Soicher and Peterson 1996). Suspended sediments carried in streams and gulches to the ocean are known locally as 'red dirt', and the resulting plumes can often be seen for days or weeks.

Fine terrigenous sediment entering the nearshore ocean affects corals in two ways: (1) suspended in seawater, the sediment drastically reduces the amount of light reaching coral reefs and other shallow benthic systems; and (2) as the sediment settles, it can bury corals or cause them to expend a large amount of energy keeping their surfaces clean. This can result in changes to community structure, reduced species richness and reductions in colony size (Fabricus 2005). Sediment within the ocean environment induces mortality of coral polyps and limits coral colonization. Accumulated sediments prevent coral recovery through resuspension and interference with fertilization, larval development and settlement in corals (NOAA Coral Program 2009). In addition, sediment particles often carry nutrients attached via sorption[7], encouraging algal growth (Davidson et al. 2003) (Section B.5.2). Terrigenous sediments have also been found to act as flocculants, meaning they attract bacteria suspended in the water that attach to the sediment particles. When the sediment particles become weighted down by the bacteria, they sink to ocean floor where the bacteria can become concentrated and use up the available oxygen. This results in an anoxic layer along the floor of the ocean. The anoxic layer adversely impacts organisms that normally dwell on and just above the ocean floor.

B.5.2 Nutrients

Nutrients, including nitrogen and phosphorus, are sourced from sewage, wastewater and fertilizer runoff from agricultural fields, urban lawns and golf courses. Research into the effects of nutrients on coral reefs and green sea turtles is discussed in this section.

B.5.2.1 Effects on Coral Reefs

Nutrient inputs from external sources must be very low in order to promote productive and species rich coral reefs (Global Coral Reef Alliance 2012). In a study performed on the Great Barrier Reef,

[7] Sorption is a process by which one substance attaches to another through either chemical or physical bonding.

Kinsey and Davies (1979) estimated that long term nitrogen and phosphate enrichment caused a greater than 50% rate of suppression of coral reef calcification, inhibiting coral growth.

Excessive amounts of nutrients, particularly nitrogen and phosphorus, promote the rapid growth of algae that compete with juvenile and adult corals for space on benthic reef surfaces, can affect success of coral settlement, and in extreme cases can result in eutrophication of reef waters (Global Coral Reef Alliance 2012, NOAA Coral Program 2009, McClanahan et al. 2002).

Soicher and Peterson (1997) researched possible contributing factors to severe algae blooms in the Lahaina District of Maui. Although they could not confirm a definitive causal relationship between algal growth and terrestrial nutrients, they reported elevated loads of nutrients being supplied to coastal waters from agricultural activities and disposal of treated domestic sewage effluent into subsurface injection wells. Subsequent to this research much of the active agriculture in the area has ended.

B.5.2.2 Effects on Green Sea Turtles

A study of 3,939 stranded Hawaiian green sea turtles over a 28-year period found that the rate of incidence of fibropapillomatosis, a tumor-forming disease linked to a herpesvirus, increases in watersheds with high eutrophication levels, and in particular watersheds with high nitrogen footprints (Van Houtan et al. 2010). While further analysis revealed “strong epidemiological links” between disease rates and presence of invasive macroalgae that the turtles feed on, new research disputes the finding.

B.5.3. Effect of Chemical Pollutants on Coral Reefs

There are a wide range of anthropogenically derived chemical pollutants that may affect coral reef ecosystems. The range of compounds includes: pesticides, trace metals, petroleum hydrocarbons and pharmaceuticals. van Dam et al. (2011) conclude that while short-term pulse-like pollution, such as an oil spill, can have a direct and severe impact on a coral reef system, recurring pollution may exert subtle effects on lower trophic levels of the system, affecting species fitness and adaptation.

van Dam et al. (2011) collated and assessed available information on different chemical stressors in the marine environment and the effects on reef-building corals. Using that information they summarized the main contaminant groups, sources, and concerns in regards to tropical coral reefs (Table B.2).

Pesticides (insecticides, herbicides and fungicides) interfere with coral reproduction and growth (NOAA 2006). Markey et al. (2007) studied the effects of four classes of insecticides on corals and determined that even at very low levels, insecticides inhibited the settlement and metamorphosis stages of corals. Lewis et al. (2009) contend that exposure to herbicides reduces productivity of coral reefs. A study conducted by Råberg et al. (2003) confirms that in laboratory experiments Porities cylindrica exposed to low levels of 2,4-D and diuron, two commonly used herbicides, demonstrated reduced primary production rates.

Most scientists agree that although more studies on the effects of long term exposure of coral reefs to chemical pollutants are needed, prolonged low level exposure to this type of pollution reduces the resilience of coral reef organisms to other forms of environmental stress (van Dam et al. 2011, Lewis et al. 2009).

Table B.2 Potential Effects of Chemical Pollutants on Coral Reefs[8]

Contaminant Group	Sources	Main Concerns
Insecticides	Agricultural and urban runoff	Survival, reproduction, early life transitions and genetic effects. (Bioaccumulation for persistent OC pesticides)
Herbicides	Agricultural and urban runoff, antifouling applications, ballast water discharge	Photosynthesis and calcification
Metals	Agricultural runoff, various urban and industrial sources, and antifouling applications	Bioaccumulation, survival, reproduction, growth and behavior

B.5.4 Pathogens

Microbial (bacterial and viral) assemblages are normally found in sewage effluent (Dailer et al. 2010). In the Ka'anapali region, there is evidence of sewage effluent from the Lahaina WWTF encompassing the nearshore marine environment that is used for recreation (*Wahikuli-Honokowai Watershed Management Plan* 2012). The presence of bacteria in ocean waters poses serious threats to human health. Sewage effluent can be successfully disinfected with ultraviolet light (UV, 254 nm) irradiation which kills more than 99% of coliform, fecal coliform, fecal streptococci and heterotrophic bacteria.

Land-based inputs may both directly contribute land-derived pathogens and/or exacerbate the effect of in situ pathogens on coral reef ecosystems. As coral reefs become stressed, they are more susceptible to viral and bacterial infections.

B.5.5 Sunscreen

The tourism industry brings recreational ocean users to West Maui and exposes the sensitive coastal habitat to sunscreen that has been applied to the skin. Sunscreen has been documented as a contributor to bleaching of hard corals in areas where there is a high level of human recreational use, by promoting viral infections (Danovaro et al. 2008). During laboratory tests, sunscreen even in low quantities caused large amounts of coral mucous (zooxanthellae and coral tissue) release within 18-48 hours, with complete coral bleaching within 96 hours. Four typical sunscreen ingredients were found to cause complete coral bleaching at very low concentrations: butylparaben, ethylhexylmethoxycinnamate, benzophenone-3, and 4-methylbenzylidene camphor (Danovaro et al. 2008). Most recently, oxybenzone in sunscreens has been found to be harmful to coral reefs (NPR, October 20, 2015).

[8] Excerpted from van Dam et al. (2011).

APPENDIX C: TERRESTRIAL AND MARINE BIOTA

C.1 West Maui Mountains Watershed Partnership and Puʻu Kukui Preserve

The upper elevations of Kahana, Honokahua and Honolua Watersheds form part of the Puʻu Kukui Watershed Preserve. The largest privately-owned preserve in the state, it is part of the larger West Maui Mountains Watershed Partnership (WMMWP). The WMMWP encompasses more than 47,319 acres of the summit and slopes of West Maui and involves the management efforts of 13 landowners and public agency partners (WMMWP 2013). WMMWP provides habitat for more than 100 rare plants (including endangered species), 6 rare arthropod and 30 invertebrate species (including species listed as endangered), 5 rare bird species (including 2 listed as endangered), 1 native fish species (a stream goby considered a species of concern), and the Hawaiian hoary bat, the state's only native land mammal (and federally listed as endangered) (WMMWP 2013).

The Kahana, Honokahua and Honolua Watersheds constitute less than 6 percent (2,719 acres) of the WMMWP, and more specifically constitute nearly 32 percent of the Puʻu Kukui Watershed Preserve. Definitive lists of native, rare and endangered species for each watershed unit have not been compiled, but reflect those found for the relevant habitats within the preserve. The Puʻu Kukui Watershed Preserve contains 15 terrestrial native communities, 36 species of rare plants (8 endangered), 3 native forest birds, several tree snails and invertebrates, and the endangered Hawaiian hoary bat (ML&P 2010).

Threats to the native plant communities and associated rare species are likewise common between watershed areas. Habitat destruction and the introduction of invasive species have been the prominent causes of the loss of biodiversity in Hawaiʻi for over a century (El-Kadi et al. 2008). Invasive plant and feral animals in these upper elevation watershed areas pose a threat to the water resources and soils within the watersheds, and the WMMWP coordinates management efforts to reduce the threats.

The WMMWP has a West Maui Mountains Watershed Management Plan (2013) with eight major priorities for watershed management in West Maui. These are 1) invasive animal management and control, 2) invasive plant control, 3) human activities management, 4) water and watershed monitoring, 5) wildfire management, 6) protection of rare species and habitat, 7) public education and awareness of watershed management, and 8) watershed management coordination.

The Puʻu Kukui Watershed Preserve has a Fiscal Years 2012-2018 Management Plan (2010) for the Natural Area Partnership Program. The key plan components address feral ungulate control, weed control, monitoring and research, rare species protection, community outreach and educational opportunities, watershed partnerships, and facilities and operating expenses.

C.2 Plant Species and Communities

C.2.1 Native Plant Communities

The assemblage of plants found together, typically associated with specific elevation and rainfall patterns, are known as a “natural community”. Native-dominated plant communities typically associated with the elevation range of Kahana, Honokahua and Honolua Watersheds include lowland mesic forests dominated by ʻōhiʻa (*Metrosideros*), or lama (the native ebony, *Diospyros*)/ ʻōhiʻa. Papala/papala kepau (*Charpentiera*/*Pisonia*)-dominated forest may occur along the riparian corridors in some sections. Lowland wet forest, typically at higher elevation than the mesic forests, are again dominated by native ʻōhiʻa, or in combination with koa (*Acacia*) or ʻōlapa (*Cheirodendron*), and also in association with uluhe (*Dicronopteris*) fern forest.

In Kahana Watershed, the native Hawaiian sandalwood (*Santalum freycninetianum*) occurs along Kahana ridge. The endemic jade vine (*Strongylodon ruber*) known as *nunuku ʻiʻiwi* (“beak of the ʻiʻiwi bird”) for its curved, red flowers is also found. Plant species of concern, *Joinvellea ascendens* ssp *ascendens* and *Myrsine vacciniodies* occur in Honolua near the stream headwaters (ML&P 2010).

C.2.2 Non-native (Introduced) Plants

Non-native invasive plants can impact native plant communities by altering the environment (e.g., changing the fire regime, inhibiting native plant growth, attracting or supporting increased populations of herbivores). Each of these conditions can negatively affect water quality, mainly through increased potential for erosion.

Over 200 non-native weed species have been recorded in the WMMWP area, including strawberry guava (*Psidium cattleianum*), apple guava (*Psidium guajava*), soapbush (*Clidemia hirta)*, Pampas Grass (*Cortaderia jubata*), *Tibouchina spp*., Ironwood (*Casuarinas spp.)*, and java plum (*Syzygium cumini*). WMMWP works to monitor and control established and new occurrences of non-native and invasive plant populations in the intact native communities, as well as restore areas that are a mixture of native and invasive species. Strawberry guava is a well-established species and a focus of the majority of control efforts.

Non-native plants dominate lower elevations below the watershed preserve. Both productive and fallow fields harbor non-native plants; cultivated land provides open space where non-native plants readily colonize and reproduce, providing a seed bank that allows non-natives to persist even after herbicides have been applied.

C.3 Fauna

C.3.1 Non-native (Introduced) Fauna

Wild ungulates damage vegetation and threaten water quality by destroying native plants, accelerating erosion, spreading weeds and depositing feces. Monitoring for ungulates is conducted frequently. Observations of deer within the WMMWP management area occurred for the first time in 2010 (except for a historic sighting and capture about 10 years ago), although not yet in the Kahana, Honokahua and Honolua watersheds. Pigs have been present for many years, and although the population has significantly decreased, they remain the most prevalent ungulate. As of 2012, over 21,000 acres in the WMMWP managed areas are fenced (SRGII 2012).

Mongoose, feral cats and dogs, rodents are known to be present throughout the project area. The presence of these small mammals can negatively impact waterbodies in a watershed by: disturbing native plant populations by trampling, rooting and eating seeds; dispersing seeds of non-native plants on fur and in feces; and depositing feces. Cats and rodents also prey on native birds contributing to the overall degradation of the ecosystem.

C.3.2 Avian Species

At least four native forest birds have been recorded in the West Maui Mountains: ʻapapane (*Himatione sanguinea*), ʻiʻiwi (*Vestiaria coccinea*), ʻamakihi (*Hemignathus virens*), and pueo (*Asio flammeus sandwichensis*). ʻUaʻu (*Pterodroma sandwichensis*) have been heard. ʻApapane are reliant on native forests for feeding and nesting, specifically ʻōhiʻa (*Metrosideros polymorpha*), and are important pollinators of ʻōhiʻa flowers. ʻIʻiwi, which is currently being reviewed for listing as a threatened and endangered species by the USFWS, serves an important role as a pollinator of native plant species including ʻōhiʻa. ʻAmakihi, like ʻapapane and ʻiʻiwi, is a Hawaiian honeycreeper that serves as a pollinator of native plants, but also forages on select non-natives. The endangered pueo is a subspecies of short-eared owl endemic to Hawaiʻi that inhabits both grasslands and forests. Confirmed in the upper elevations, the owl is likely also utilizing resources in the agricultural lands. Hawaiian petrel or ʻuaʻu, is an endangered species that has been heard in the area but sightings are difficult to confirm. Petrels likely utilize the upper elevations for nesting.

Non-native birds are also present in the project watersheds. They are thought to play an important role in the dispersal of non-native invasive plant species in Hawaiʻi (Stone 1985, Woodward et al. 1990). Non-native birds can hinder population growth of native birds through competition for resources and by enhancing the feral cat and rat population by providing a food source.

C.3.3 Aquatic Fauna

Honolua Stream was studied in 2006 by SWCA. A large number of endemic ʻoʻopu nake (*Awaous guamensis*), ʻoʻopu nopili (*Slcyopterus stimpsoni*), ʻoʻopu alamoʻo *(Lentipes concolor*), the endemic mountain shrimp (*Atyoida bisulcata*) and the introduced Tahitian prawn (*Macrobrachium lar*) were identified in the stream between 750 and 850 feet elevation. No invasive species were observed in the stream at that time. This study was done after the Honolua intake was closed in 2004 (Chaston 2007). Hawaiʻi native stream fishes belong to the Gobioid family, the largest family of fishes in the world. The species of gobies found in Hawaiʻi are only found in the islands, with the exception of one more wide-ranging species. Adapted to rocky, steep streambeds, these fish use their muscular fins to maintain their position in areas of high flow, and to climb waterfalls.

Unfortunately, *The Atlas of Hawaiian Watersheds & Their Aquatic Resources* (DLNR-DAR 2008), contains no information on aquatic biota associated with Kahana, Honokahua or Honolua streams.

C.3.4 Marine Biota

Coral species present in the Honolua Bay have been monitored in two study sites for the Coral Reef Assessment and Monitoring Program (CRAMP) since 1994. Species that have been observed include: *Leptastrea purpurea, Montipora capitata, M. flabellate, M. patula*, *Porites compressa, P. lichen* and *P. lobata.*

Native and non-native fish species identified in Honolua Bay have been documented. Species utilizing the reefs off Kahana and Honokahua Watersheds are likely similar. At the Honolua CRAMP survey sites, at least 19 fish species have been observed. Among 60 reefs surveyed by CRAMP, Honolua North site ranked third in species richness, forty-ninth in density, thirtieth in biomass, and third in diversity. Honolua South ranked first in species richness, thirty-fourth in density, twenty-first in density and seventh in diversity (CRAMP 2014).

Green sea turtles (*honu*, *Chelonia mydas*) are a federally listed species (threatened in Hawai'i) that are commonly seen in the nearshore waters of West Maui and occasionally basking on the beaches. Although green sea turtles nest in the Northwestern Hawaiian Islands, they spend much of the year in the main Hawaiian Islands feeding on seagrass and algae. Several resting areas for the green sea turtle have been identified on both the north and south reefs of Honolua, and the majority of turtles appear to reside on the northwestern section just inside the Marine Life Conservation District (CRAMP 2014). Bottlenose dolphins (*Tursiops truncatus*) and pilot whales (*Globicephala macrorhynus*) are two other large marine species that are seen frequently off West Maui, although they do not forage in the nearshore waters.

Other species that move through the waters of West Maui but are likely not foraging in the area are spinner dolphins (*Stenella longirostris*), humpback whales (*Megaptera novaeangliae*), false killer whales (*Pseudorca crassidens*) and melon-headed whales (*Peponocephala electra*).

Large episodic blooms of oceanic algae species have been a problem in West Maui for over two decades (Section 4.10.3). Non-native species that have been increasingly recorded are *Acanthophora spicifera* and *Hypnea musciformis*. Two algae species thought to be native, *Ulva* spp. and *Cladaphora* spp., can also be invasive. Research indicates that land-based sources of nutrients, including those from agriculture and wastewater are providing support for the continued algal blooms (Dailer 2010, Smith et al. 2005, Morand and Merceron 2005).

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D.2 List of Persons Consulted

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