Instream Flow Standard Assessment Report

Island of Maui
Hydrologic Unit 6054
Ohia

December 2009 **PR-2009-07**

State of Hawaii
Department of Land and Natural Resources
Commission on Water Resource Management

COVER
The hydrologic unit of Ohia (Waianu) is very small. Ohia Stream is fed by Ohia Spring that is located near Hana Highway [Google Earth, 2009].

Note: This report is intended for both print and electronic dissemination and does not include diacritical marks in spelling of Hawaiian words, names, and place names due to problems associated with its use electronically. However, Commission staff has made attempts to include diacritical marks in direct quotations to preserve accuracy.

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Acronyms and Abbreviations

A&B	Alexander & Baldwin
AG	agricultural
ALISH	Agricultural Lands of Importance to the State of Hawaii
ALUM	agricultural land use maps [prepared by HDOA]
BFQ	base flow statistics
BLNR	Board of Land and Natural Resources (State of Hawaii)
C-CAP	Coastal Change Analysis Program
cfs	cubic feet per second
Code	State Water Code (State of Hawaii)
COM	commercial
Commission	Commission on Water Resource Management (DLNR)
CPRC	Compilation of Public Review Comments (PR-2008-07, CWRM)
CWA	Clean Water Act (EPA)
CWRM	Commission on Water Resource Management (State of Hawaii)
DAR	Division of Aquatic Resources (State of Hawaii)
DBEDT	Department of Business, Economic Development and Tourism (State of Hawaii)
DHHL	Department of Hawaiian Home Lands (State of Hawaii)
DLNR	Department of Land and Natural Resources (State of Hawaii)
DOH	Department of Health (State of Hawaii)
DWS	Department of Water Supply (County of Maui)
EA	Environmental Assessment
EIS	Environmental Impact Statement
EMI	East Maui Irrigation Company
EMWP	East Maui Watershed Partnership
EPA	United States Environmental Protection Agency
FEMA	Federal Emergency Management Agency (Department of Homeland Security)
FILEREF	File Reference [in the Commission's records of registered diversions]
ft	feet
gad	gallons per acre per day
GIS	Geographic Information Systems
G.L.	Government Lease
GOV	government
gpm	gallons per minute
Gr.	Grant
HAR	Hawaii Administrative Rules
HC&S	Hawaiian Commercial and Sugar Company
HDOA	State Department of Agriculture (State of Hawaii)
HI-GAP	Hawaii Gap Analysis Program
HOT	hotel
HRS	Hawaii Revised Statutes
HSA	Hawaii Stream Assessment
IFS	instream flow standard
IFSAR	Instream Flow Standard Assessment Report
IND	industry
IRR	irrigation requirements
IWREDSS	Irrigation Water Requirement Estimation Decision Support System
LCA	Land Commission Award
LUC	Land Use Commission (State of Hawaii)
MECO	Maui Electric Company
MF	multi-family residential
mgd	million gallons per day
mi	mile

MLP	Maui Land and Pineapple Company, Inc.
MOU	Memorandum of Understanding
na	not available
NAWQA	National Water Quality Assessment (USGS)
NHLC	Native Hawaiian Legal Corporation
NIR	net irrigation requirements
NPDES	National Pollutant Discharge Elimination System
NPV	Net Present Value
NRCS	Natural Resource Conservation Service (USDA)
NVCS	National Vegetation Classification System
OED	Office of Economic Development (County of Maui)
Park	Kula Agricultural Park
por.	Portion
REL	religious
RMT	R.M. Towill Corporation
SCS	Soil Conservation Service (United States Department of Agriculture) Note: The SCS is now called the Natural Resources Conservation Service (NRCS)
SF	single family residential
SPI	Standardized Precipitation Index
sq mi	square miles
TFQ	total flow statistics
TFQ_{50}	50 percent exceedence probability
TFQ_{90}	90 percent exceedence probability
TMDL	Total Maximum Daily Load
TMK	Tax Map Key
UHERO	University of Hawaii's Economic Research Organization
USDA	United States Department of Agriculture
USFWS	United States Fish and Wildlife Service (Department of the Interior)
USGS	United States Geological Survey (Department of the Interior)
WQS	Water Quality Standards
WRPP	Water Resource Protection Plan (Commission on Water Resource Management)
WTF	water treatment facility

1.0 Introduction

1.1 General Overview

Ohia means "Ohia tree" in the Hawaiian language (Pukui et al., 1974). The hydrologic unit of Ohia, also known as Waianu, is located north of the East Maui Volcano (Haleakala), which forms the eastern part of the Hawaiian island of Maui (Figure 1-3). It covers a small drainage area of 0.3 square miles[1] from the 410 feet altitude[2] to the sea (Figure 1-4). Ohia Stream is 0.6 miles[3] in length, traversing north from its headwaters at Ohia Spring near the Hana Highway at 230 feet elevation to the ocean. The stream is gentle sloped with no major waterfalls. Most of the hydrologic unit is agricultural lands. Landcover consists of alien-dominated forests and grasslands, with no major forest reserves (Figure 1-6). The most northern point of the hydrologic unit lies within the Pauwalu Point Wildlife Sancturary.

1.2 Current Instream Flow Standard

The current interim instream flow standard (IFS) for Ohia Stream was established by way of Hawaii Administrative Rules (HAR) §13-169-44, which, in pertinent part, read as follows:

> Interim instream flow standard for East Maui. The Interim Instream Flow Standard for all streams on East Maui, as adopted by the commission on water resource management on June 15, 1988, shall be that amount of water flowing in each stream on the effective date of this standard, and as that flow may naturally vary throughout the year and from year to year without further amounts of water being diverted offstream through new or expanded diversions, and under the stream conditions existing on the effective date of the standard.

The current interim IFS became effective on October 8, 1988. Streamflow was not measured on that date; therefore, the current interim IFS is not a measurable value.

1.3 Instream Flow Standards

Under the State Water Code (Code), Chapter 174C, Hawaii Revised Statutes (HRS), the Commission on Water Resource Management (Commission) has the responsibility of establishing IFS on a stream-by-stream basis whenever necessary to protect the public interest in the waters of the State. Early in its history, the Commission recognized the complexity of establishing IFS for the State's estimated 376 perennial streams and instead set interim IFS at "status quo" levels. These interim IFS were defined as the amount of water flowing in each stream (with consideration for the natural variability in stream flow and conditions) at the time the administrative rules governing them were adopted in 1988 and 1989.

The Hawaii Supreme Court, upon reviewing the Waiahole Ditch Contested Case Decision and Order, held that such "status quo" interim IFS were not adequate to protect streams and required the Commission to take immediate steps to assess stream flow characteristics and develop quantitative interim IFS for affected Windward Oahu streams, as well as other streams statewide. The Hawaii Supreme Court also emphasized that "instream flow standards serve as the primary mechanism by which the Commission is to

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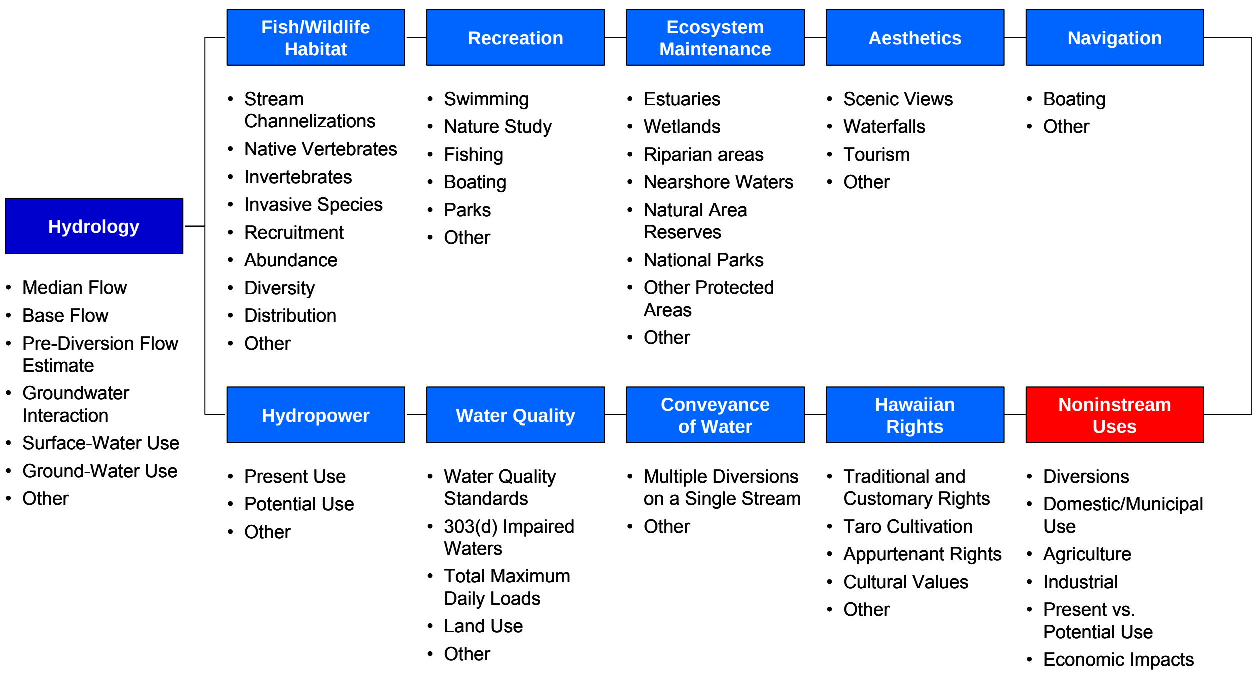
[1] Area of the hydrologic unit is derived from the surface water hydrologic unit GIS data file (State of Hawaii, Commission on Water Resource Management, 2005c).
[2] Elevation data is derived from the 100 foot contours GIS data file (State of Hawaii, Office of Planning, 1997) unless otherwise noted.
[3] Length of the stream is derived from the National Hydrography Dataset (U.S. Geological Survey, 2001b).

discharge its duty to protect and promote the entire range of public trust purposes dependent upon instream flows."

To the casual observer, IFS may appear relatively simple to establish upon a basic review of the Code provisions. However, the complex nature of IFS becomes apparent upon further review of the individual components that comprise surface water hydrology, instream uses, noninstream uses, and their interrelationships. The Commission has the distinct responsibility of weighing competing uses for a limited resource in a legal realm that is continuing to evolve. The following illustration (Figure 1-1) was developed to illustrate the wide range of information, in relation to hydrology, instream uses, and noninstream uses that should be addressed in conducting a comprehensive IFS assessment.

Figure 1-1. Information to consider in setting measurable instream flow standards.

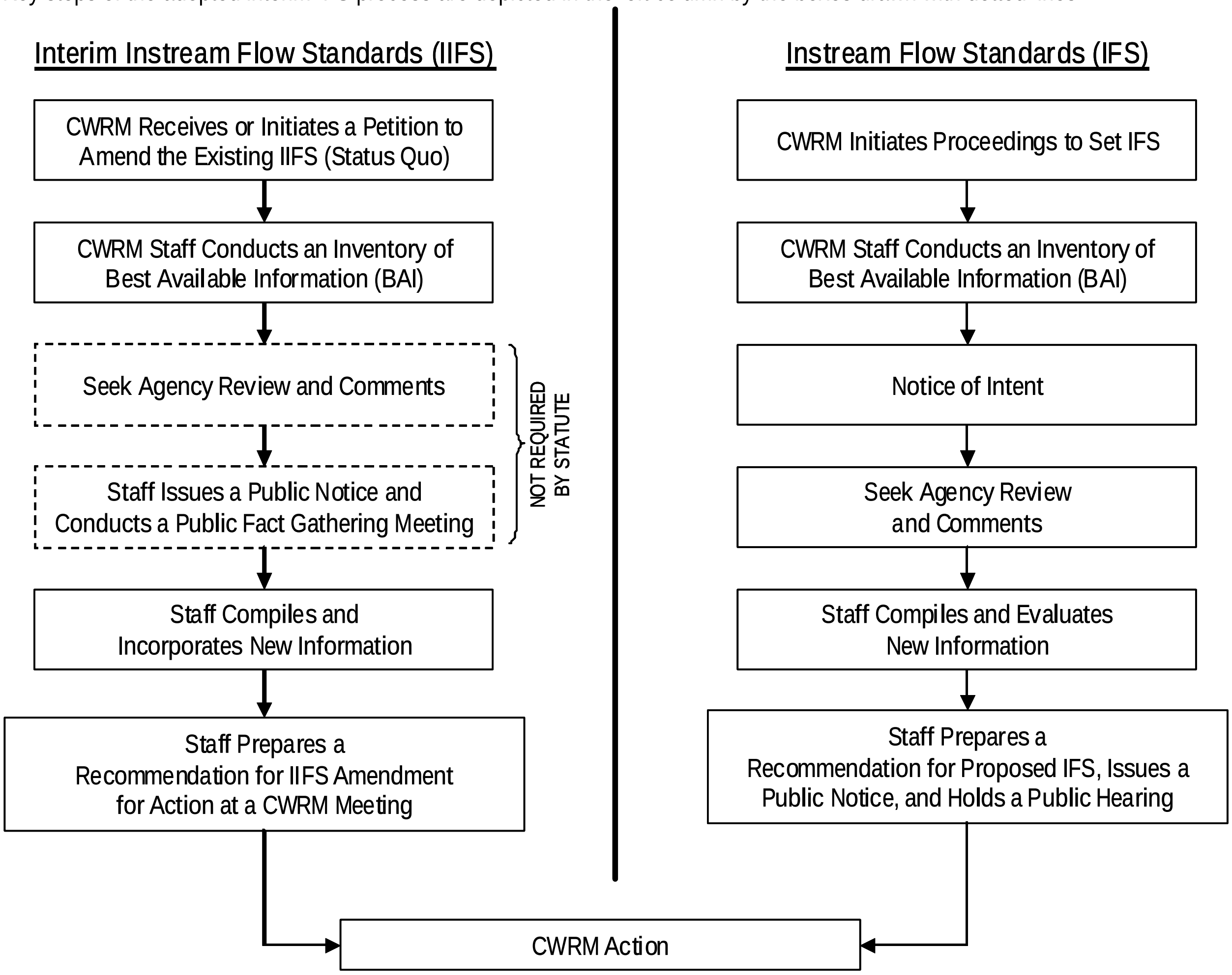


1.4 Interim Instream Flow Standard Process

The Code provides for a process to amend an interim IFS in order to protect the public interest pending the establishment of a permanent IFS. The Code, at §174C-71(2), describes this process including the role of the Commission to "weigh the importance of the present or potential instream values with the importance of the present or potential uses of water for noninstream purposes, including the economic impact of restricting such uses."

Recognizing the complexity of establishing measurable IFS, while cognizant of the Hawaii Supreme Court's mandate to designate interim IFS based on best available information under the Waiahole Combined Contested Case, the Commission at its December 13, 2006 meeting authorized staff to initiate and conduct public fact gathering. Under this adopted process (reflected in the left column of Figure 1-2), the Commission staff will conduct a preliminary inventory of best available information upon receipt of a petition to amend an existing interim IFS. The Commission staff shall then seek agency review and comments on the compiled information (compiled in an Instream Flow Standard Assessment Report) in conjunction with issuing a public notice for a public fact gathering meeting. Shortly thereafter (generally within 30 days), the Commission staff will conduct a public fact gathering meeting in, or near, the hydrologic unit of interest.

Figure 1-2. Simplified representation of the interim instream flow standard and permanent instream flow standard processes. Key steps of the adopted interim IFS process are depicted in the left column by the boxes drawn with dotted lines.



1.5 Instream Flow Standard Assessment Report

The Instream Flow Standard Assessment Report (IFSAR) is a compilation of the hydrology, instream uses, and noninstream uses related to a specific stream and its respective surface water hydrologic unit. The report is organized in much the same way as the elements of IFS are depicted in Figure 1-1. The purpose of the IFSAR is to present the best available information for a given hydrologic unit. This information is used to determine the interim IFS recommendations, which is compiled as a separate report. The IFSAR is intended to act as a living document that should be updated and revised as necessary, thus also serving as a stand-alone document in the event that the Commission receives a subsequent petition solely for the respective hydrologic unit.

Each report begins with an introduction of the subject hydrologic unit and the current IFS status. Section 2.0 is comprised of the various hydrologic unit characteristics that, both directly and indirectly, impact surface water resources. Section 3.0 contains a summary of available hydrologic information, while Sections 4.0 through 12.0 summarize the best available information for the nine instream uses as defined by the Code. Noninstream uses are summarized in Section 13.0. Maps are provided at the end of each section to help

illustrate information presented within the section's text or tables. Finally, Section 14.0 provides a comprehensive listing of cited references and is intended to offer readers the opportunity to review IFSAR references in further detail.
Following the preparation of the IFSAR and initial agency and public review, information may be added to the IFSAR at any time. Dates of revision will be reflected as such. Future review of the IFSAR, by agencies and the public, will only be sought when a new petition to amend the interim (or permanent) instream flow standard is pending. Recommendations for IFS amendments are prepared separately as a stand-alone document. Thus, the IFSAR acts solely as a compendium of best available information and may be revised further without the need for subsequent public review following its initial preparation.

1.6 Surface Water Hydrologic Units

Early efforts to update the Commission's Water Resource Protection Plan (WRPP) highlighted the need for surface water hydrologic units to delineate and codify Hawaii's surface water resources. Surface water hydrologic units served as an important first-step towards improving the organization and management of surface water information that the Commission collects and maintains, including diversions, stream channel alterations, and water use.

In developing the surface water hydrologic units, the Commission staff reviewed various reports to arrive at a coding system that could meet the requirements for organizing and managing surface water information in a database environment, and could be easily understood by the general public and other agencies. For all intents and purposes, surface water hydrologic units are synonymous with watershed areas. Though Commission staff recognized that while instream uses may generally fall within a true surface drainage area, noninstream uses tend to be land-based and therefore may not always fall within the same drainage area.

In June 2005, the Commission adopted the report on surface water hydrologic units and authorized staff to implement its use in the development of information databases in support of establishing IFS (State of Hawaii, Commission on Water Resource Management, 2005a). The result is a surface water hydrologic unit code that is a unique combination of four digits. This code appears on the cover of each IFSAR above the hydrologic unit name.

1.7 Surface Water Definitions

Listed below are the most commonly referenced surface water terms as defined by the Code.

Agricultural use. The use of water for the growing, processing, and treating of crops, livestock, aquatic plants and animals, and ornamental flowers and similar foliage.

Channel alteration. (1) To obstruct, diminish, destroy, modify, or relocate a stream channel; (2) To change the direction of flow of water in a stream channel; (3) To place any material or structures in a stream channel; and (4) To remove any material or structures from a stream channel.

Continuous flowing water. A sufficient flow of water that could provide for migration and movement of fish, and includes those reaches of streams which, in their natural state, normally go dry seasonally at the location of the proposed alteration.

Domestic use. Any use of water for individual personal needs and for household purposes such as drinking, bathing, heating, cooking, noncommercial gardening, and sanitation.

Ground water. Any water found beneath the surface of the earth, whether in perched supply, dike-confined, flowing, or percolating in underground channels or streams, under artesian pressure or not, or otherwise.

Hydrologic unit. A surface drainage area or a ground water basin or a combination of the two.

Impoundment. Any lake, reservoir, pond, or other containment of surface water occupying a bed or depression in the earth's surface and having a discernible shoreline.

Instream Flow Standard. A quantity of flow of water or depth of water which is required to be present at a specific location in a stream system at certain specified times of the year to protect fishery, wildlife, recreational, aesthetic, scenic, and other beneficial instream uses.

Instream use. Beneficial uses of stream water for significant purposes which are located in the stream and which are achieved by leaving the water in the stream. Instream uses include, but are not limited to:

(1) Maintenance of fish and wildlife habitats;
(2) Outdoor recreational activities;
(3) Maintenance of ecosystems such as estuaries, wetlands, and stream vegetation;
(4) Aesthetic values such as waterfalls and scenic waterways;
(5) Navigation;
(6) Instream hydropower generation;
(7) Maintenance of water quality;
(8) The conveyance of irrigation and domestic water supplies to downstream points of diversion; and
(9) The protection of traditional and customary Hawaiian rights.

Interim instream flow standard. A temporary instream flow standard of immediate applicability, adopted by the Commission without the necessity of a public hearing, and terminating upon the establishment of an instream flow standard.

Municipal use. The domestic, industrial, and commercial use of water through public services available to persons of a county for the promotion and protection of their health, comfort, and safety, for the protection of property from fire, and for the purposes listed under the term "domestic use."

Noninstream use. The use of stream water that is diverted or removed from its stream channel and includes the use of stream water outside of the channel for domestic, agricultural, and industrial purposes.

Reasonable-beneficial use. The use of water in such a quantity as is necessary for economic and efficient utilization, for a purpose, and in a manner which is both reasonable and consistent with the state and county land use plans and the public interest.

Stream. Any river, creek, slough, or natural watercourse in which water usually flows in a defined bed or channel. It is not essential that the flowing be uniform or uninterrupted. The fact that some parts of the bed or channel have been dredged or improved does not prevent the watercourse from being a stream.

Stream channel. A natural or artificial watercourse with a definite bed and banks which periodically or continuously contains flowing water. The channel referred to is that which exists at the present time, regardless of where the channel may have been located at any time in the past.

Stream diversion. The act of removing water from a stream into a channel, pipeline, or other conduit.

Stream reach. A segment of a stream channel having a defined upstream and downstream point.

Stream system. The aggregate of water features comprising or associated with a stream, including the stream itself and its tributaries, headwaters, ponds, wetlands, and estuary.

Surface water. Both contained surface water--that is, water upon the surface of the earth in bounds created naturally or artificially including, but not limited to, streams, other watercourses, lakes, reservoirs, and coastal waters subject to state jurisdiction--and diffused surface water--that is, water occurring upon the surface of the ground other than in contained water bodies. Water from natural springs is surface water when it exits from the spring onto the earth’s surface.

Sustainable yield. The maximum rate at which water may be withdrawn from a water source without impairing the utility or quality of the water source as determined by the Commission.

Time of withdrawal or diversion. In view of the nature, manner, and purposes of a reasonable and beneficial use of water, the most accurate method of describing the time when the water is withdrawn or diverted, including description in terms of hours, days, weeks, months, or physical, operational, or other conditions.

Watercourse. A stream and any canal, ditch, or other artificial watercourse in which water usually flows in a defined bed or channel. It is not essential that the flowing be uniform or uninterrupted.

Figure 1-3. Topographic map of the Ohia hydrologic unit in east Maui, Hawaii (Source: USGS, 1996).

Figure 1-4. Elevation range and the location of Ohia hydrologic unit. (Source: State of Hawaii, Office of Planning, 1983; USGS, 2001b).

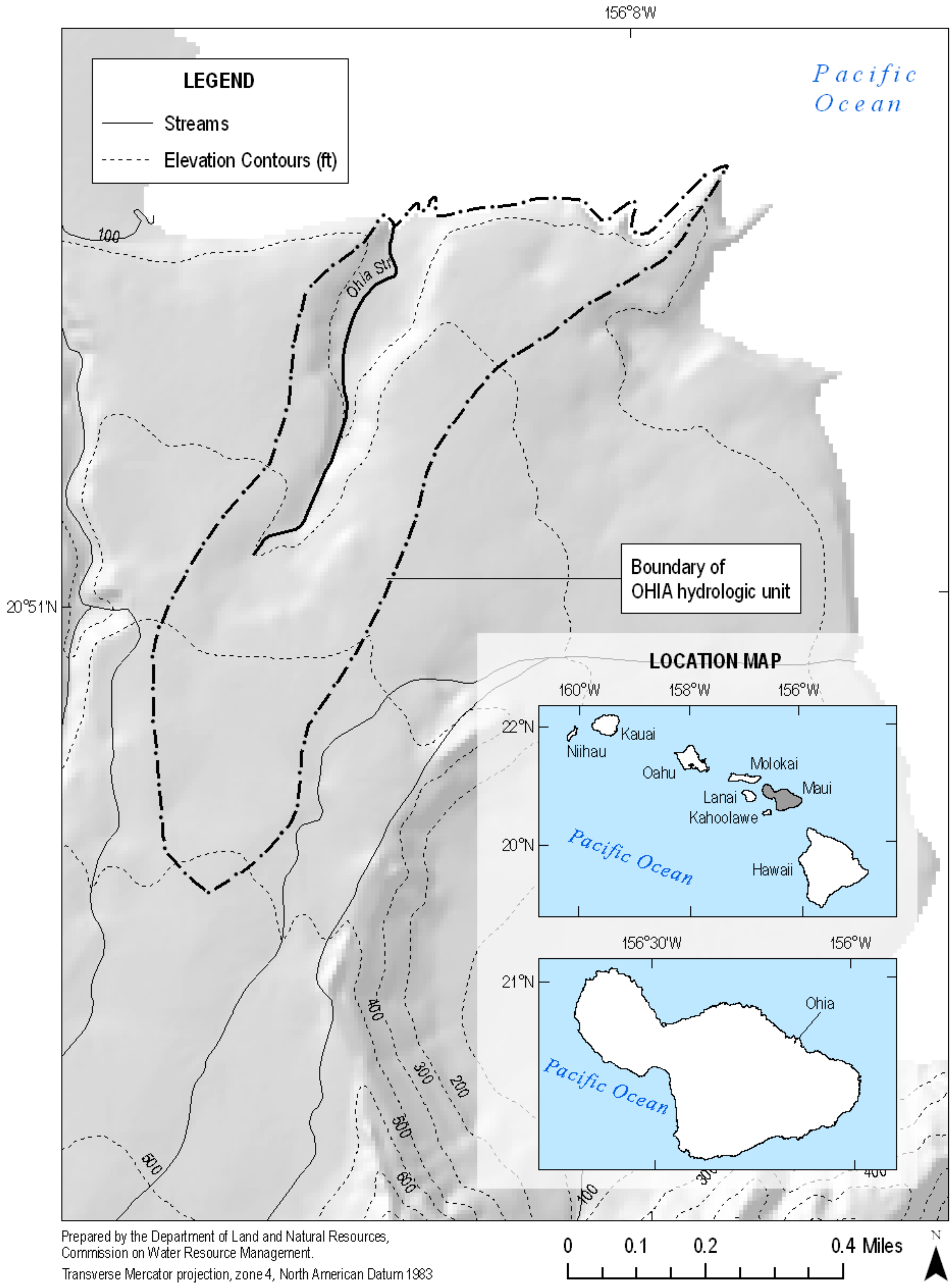


Figure 1-5. Major and minor roads and Tax Map Key (TMK) parcel boundaries for Ohia hydrologic unit (Source: County of Maui, 2006; County of Maui, Geographic Information Systems [GIS] Division, Department of Management, 2006; USGS, 2001b).

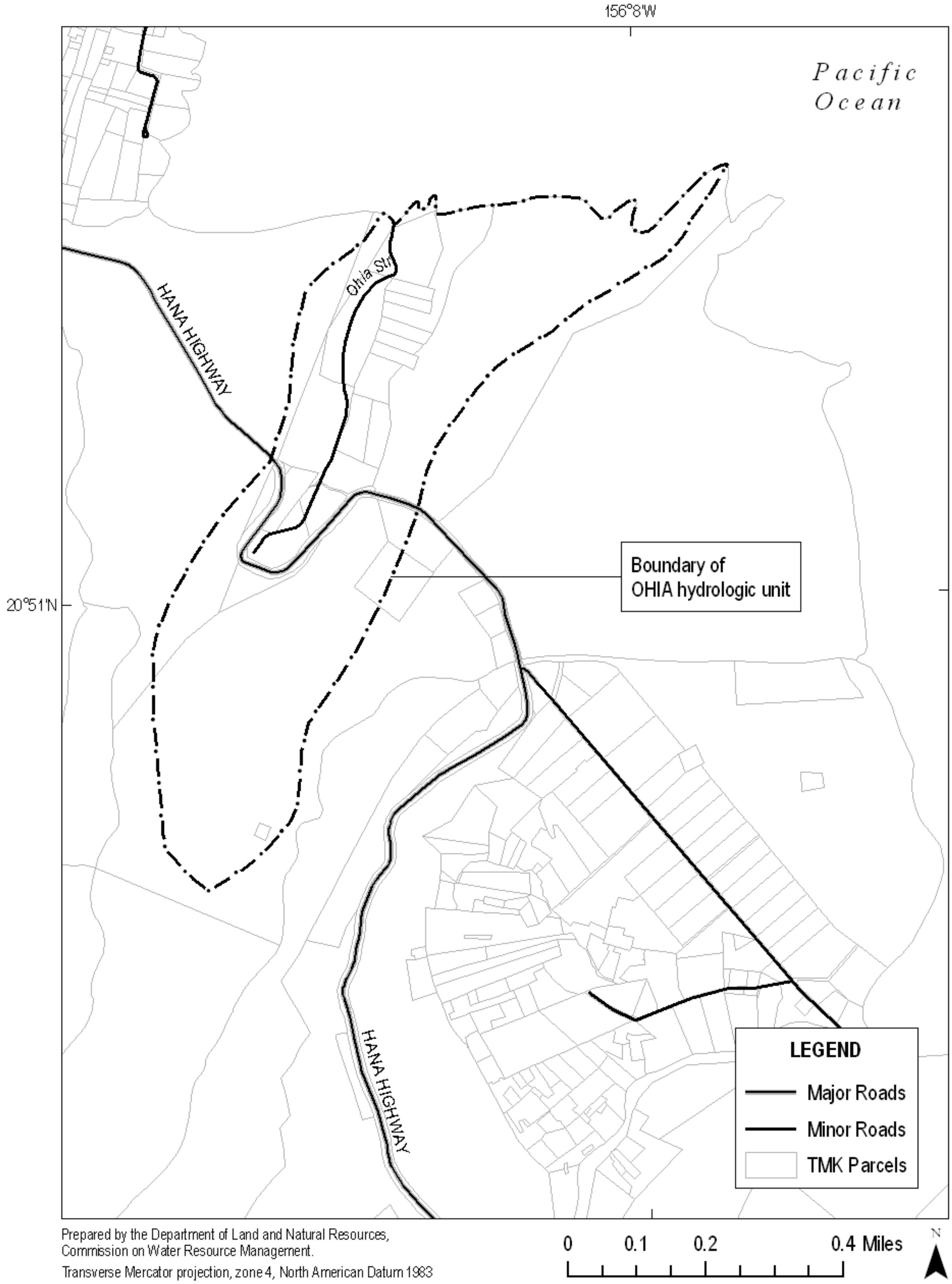
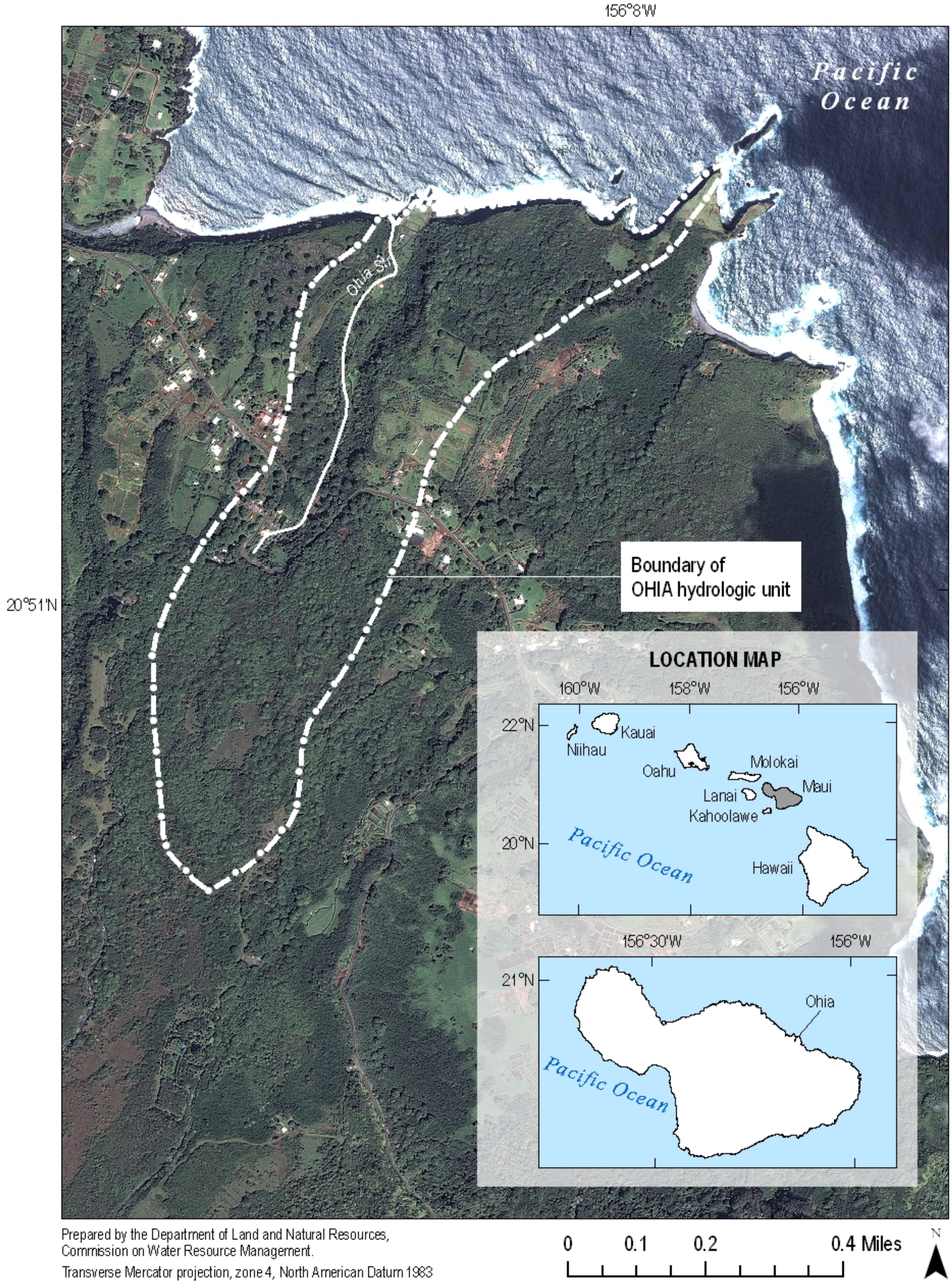


Figure 1-6. Quickbird satellite imagery of Ohia hydrologic unit (Source: County of Maui, Planning Department, 2004; USGS, 2001b).



2.0 Unit Characteristics

2.1 Geology

Ohia Stream drains a small watershed that has about 1 square mile of coverage area, and registers its highest elevation at 400 feet above mean sea level near the southernmost tip of the hydrologic unit boundary. It incised an incipient stream valley along a lithologic contact bounded by Hana Volcanics (Qhn1) and older alluvium (QTao) located at the coastal opening of Keanae Gulch.

Hana Basalt, which is characterized by high alkali content, was mainly composed of aa lava flow deposits that were erupted from the southwest and east rift zones on summit areas and from isolated cinder cones on the flanks of Haleakala Volcano. It is widely distributed on the south and east slopes of Haleakala, but confined in deeply eroded gulches on the north slopes. Occasionally, the lava flow sequence is interstratified with ash layers. At Keanae Gulch, the young Hana Basalt can be found in uncomformable contact with much older Honomanu Basalt, where Hana lava flow was plastered to gulch walls in deeply eroded sections. Newly established radiocarbon and K-Ar[4] dates placed the age range for Hana Volcanics from 140 Ka[5] to A.D. 1633 (Sherrod and others, 2003; Sherrod and others, 2006). The extended range of eruptions of Hana lavas, which culminated to near historic activities, and its coeval relationship with the period of deep erosion of Haleakala slopes led to earlier belief that it was part of the rejuvenated volcanic stage. However, the short hiatus in radiometric dates and the large overlap in geochemical characteristics between Kula and Hana lavas argue strongly for Hana eruptive episodes to belong to the waning phase of the post-shield volcanism at Haleakala (Sherrod and others, 2007). Since the Hana Volcanics (i.e., Qhn1, 30 to50 Ka) in the immediate vicinity of Ohia stream was formed at the same time during the early alluvial deposition in Keanae Gulch, it is very likely to find these lithologies in conformable contact or old alluvial deposits sandwiched between early and late Hana lava flow deposits. Some coastal sections of Keanae Gulch show Hana lava flow deposits directly underlain by block-rich alluvial deposits.

The slopes of Haleakala have been subjected to rapid erosion since the end of Kula eruptive episodes (i.e., 140 ka), generating extensive alluvial deposits in and at the termini of deeply eroded gulches. Moderately consolidated gravels (i.e., conglomerates) and thick block-rich layers at the base of coastal cliffs, some of which were overlain by a lava flow sequence that belongs to Hana Volcanics, reveal the spatial and temporal extent of Quaternary Alluvium within Keanae Gulch. Springs emanating from older alluvial layers and vanishing stream courses that run through exposed alluvial deposits hint the important hydrological role that these deposits play in the development of ground water resources, as well as the evolution of surface water hydrology. The extent of geological control in the ground water and stream interaction may be significant in Ohia, even with a limited exposure of alluvial deposits, constituting about 10 percentof the hydrologic unit.

The generalized geology of the Ohia hydrologic unit is described in Table 2-1 and depicted in Figure 2-2.

Table 2-1. Area and percentage of surface geologic features for Ohia hydrologic unit.

Symbol	Name	Rock Type	Lithology	Area (mi^2)	Percent of Unit
Qhn1	Hana Volcanics	Lava flows	Aa	0.16	57.8
Qhn0	Hana Volcanics	Lava flows	Aa	0.09	31.3
QTao	Older alluvium	Sand and gravel, lithified		0.03	10.7

[4] Potassium-Argon dating.
[5] Thousand years ago.

2.2 Soils

Approximately 85 percent of Ohia is made of stony alluvial land. This type of soil consists of stones, boulders, and soil deposited by streams along the bottom of gulches. It usually occurs on gently sloping land and is subject to occasional flooding. A portion of the stream lies on Honolua silty clay, which is a well-drained soil developed in material weathered from basic igneous rock. This soil is strongy acidic (U.S. Department of Agriculture, Soil Conservation Service, 1972)

The U.S. Department of Agriculture's Natural Resources Conservation Service (formerly known as the Soil Conservation Service) divides soils into hydrologic soil groups (A, B, C, and D) according to the rate at which infiltration (intake of water) occurs when the soil is wet. The higher the infiltration rate, the faster the water is absorbed into the ground and the less there is to flow as surface runoff. Group A soils have the highest infiltration rates and group D soils have the lowest. The entire hydrologic unit of Ohia cosists of group B soils, indicating that the soils have relatively high infiltration rates and are less prone to surface runoff as compared with the groups C and D soils (U. S. Department of Agriculture, Natural Resources Conservation Service, Conservation Engineering Division, 1986)

Table 2-2. Area and percentage of soil types for the Ohia hydrologic unit.

Map Unit	Description	Hydrologic Group	Area (mi^2)	Percent of Unit
rSM	Stony alluvial land	B	0.24	85.4
HwC	Honolua silty clay, 7 to 15 percent slopes	B	0.04	13.9

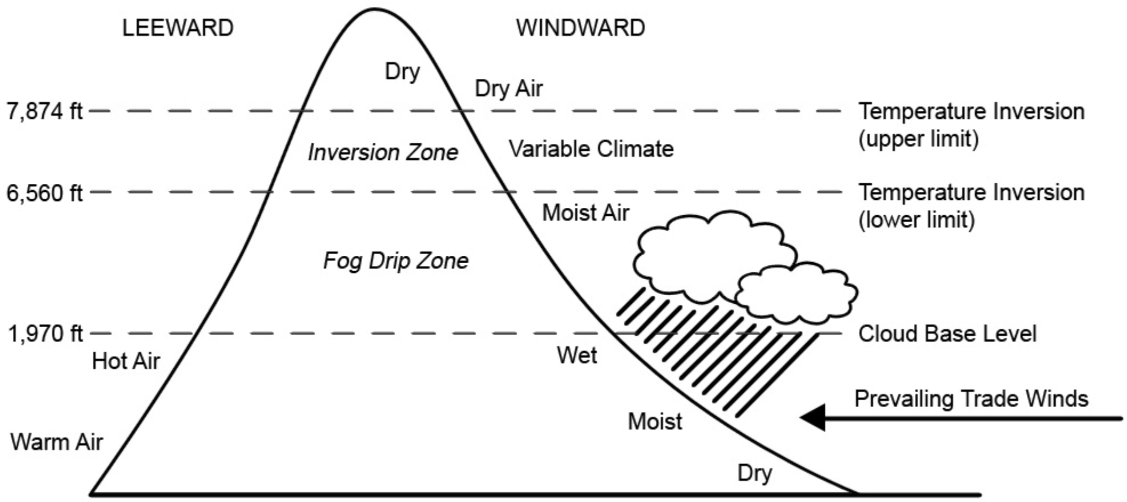
2.3 Rainfall

Rainfall distribution in Ohia is governed by the orographic[6] effect (Figure 2-1). Orographic precipitation occurs when the prevailing northeasterly trade winds lift warm air up the windward side of the mountains into higher elevations where cooler temperatures persist. As a result, frequent and heavy rainfall is observed at the windward mountain slopes. Once the moist air reaches the fog drip zone, cloud height is restricted by the temperature inversion, where temperature increases with elevation, thus favoring fog drip over rain-drop formation (Shade, 1999). Fog drip is a result of cloud-water droplets impacting vegetation (Scholl et al., 2002) and it can contribute significantly to ground water recharge. The fog drip zone on the windward side of East Maui Volcano (Haleakala) extends from the cloud base level at 1,970 feet to the lower limit of the most frequent temperature inversion base height at 6,560 feet (Giambelluca and Nullet, 1992).

A majority of the mountains in Hawaii peak in the fog drip zone. In such cases, air passes over the mountains, warming and drying while descending the leeward mountain slopes. When the mountains are at elevations higher than 6,000 feet (e.g. Haleakala), climate is affected by the presence and movement of the inversion. The temperature inversion zone typically extends from 6,560 feet to 7,874 feet. This region is influenced by a layer of moist air below and dry air above, making climate extremely variable (Giambelluca and Nullet, 1992). Above the inversion zone, the air is dry and sky is frequently clear (absence of clouds) with high solar radiation, creating an arid atmosphere with little rainfall.

[6] Orographic refers to influences of mountains and mountain ranges on airflow, but also used to describe effects on other meteorological quantities such as temperature, humidity, or precipitation distribution.

Figure 2-1. Orographic precipitation in the presence of mountains higher than 6,000 feet.



The hydrologic unit of Ohia is situated on the windward flank of the East Maui Volcano. Ohia receives near-daily orographic rainfall of 118 inches per year at the coast to 165 inches per year in the upper slopes (Giambelluca et al., 1986). Since the hydrologic unit is relatively small, the spatial variability in rainfall is not as prominent as that in the neighboring units. Nevertheless, average annual rainfall increases by 50 inches from sea level to the highest point of the hydrologic unit at about 400 feet altitude. Rainfall is highest during the month of March where the mean monthly rainfall across the hydrologic unit is approximately 13 inches. For the rest of the year, the mean monthly rainfall ranges from 5 inches to 12 inches. The driest month is June during which an average of 4 inches of rain per month fall at the coast.

Currently, fog drip data for east Maui are very limited. Shade (1999) used the monthly fog drip to rainfall ratios for the windward slopes of Mauna Loa on the island of Hawaii (Table 2-3) to calculate fog drip contribution to the water-budget in windward east Maui. The fog drip to rainfall ratios were estimated using 1) the fog drip zone boundaries for east Maui (Giambelluca and Nullet, 1992), and 2) an illustration that shows the relationship between fog drip and rainfall for the windward slopes of Mauna Loa, island of Hawaii (Juvik and Nullet, 1995). In the hydrologic unit of Ohia, fog drip does not contribute to total rainfall because the unit does not lie within the fog drip zone.

Table 2-3. Fog drip to rainfall ratios for the windward slopes of Mauna Loa on the island of Hawaii.

Month	Ratio (%)
January-March	13
April-June	27
July-September	67
October-November	40
December	27

2.4 Solar Radiation

Solar radiation is the sun's energy that arrives at the Earth's surface after considerable amounts have been absorbed by water vapor and gases in the Earth's atmosphere. The amount of solar radiation to reach the land surface in a given area is dependent in part upon latitude and the sun's declination angle (angle from the sun to the equator), which is a function of the time of year. Hawaii's trade winds and the temperature inversion layer greatly affect solar radiation levels, the primary heat source for evaporation. High mountain ranges block moist trade-wind air flow and keep moisture beneath the inversion layer (Lau and

Mink, 2006). As a result, windward slopes tend to be shaded by clouds and protected from solar radiation, while dry leeward areas receive a greater amount of solar radiation and thus have higher levels of evaporation. Since Ohia is a small drainage basin with a relatively flat slope gradient, the estimated daily solar radiation is about 300 calories per square centimeter throughout the hydrologic unit (Figure 2-4).

2.5 Evaporation

Evaporation is the loss of water to the atmosphere from soil surfaces and open water bodies (e.g. streams and lakes). Evaporation from plant surfaces (e.g. leaves, stems, flowers) is termed transpiration. Together, these two processes are commonly referred to as evapotranspiration, and it can significantly affect water yield because it determines the amount of rainfall that becomes streamflow. On a global scale, the amount of water that evaporates is about the same as the amount of water that falls on Earth as precipitation. However, more water evaporates from the ocean whereas on land, rainfall often exceeds evaporation. The rate of evaporation is dependent on many climatic factors including solar radiation, albedo[7], rainfall, humidity, wind speed, surface temperature, and sensible heat advection[8]. Higher evaporation rates are generally associated with greater net radiation, high wind speed and surface temperature, and lower humidity.

A common approach to estimating evaporation is to employ a relationship between potential evaporation and the available water in the watershed. Potential evaporation is the maximum rate of evaporation if water is not a limiting factor, and it is often measured with evaporation pans. In Hawaii, pan evaporation measurements were generally made in the lower elevations of the drier leeward slopes where sugarcane was grown. These data have been compiled and mapped by Ekern and Chang (1985). Unfortunately, pan evaporation data are available only for the lower slopes of west and central Maui. This makes estimating the evaporative demand on the watersheds in windward east Maui challenging.

Most of the drainage basins in Hawaii are characterized by a relatively large portion of the rainfall leaving the basin as evaporation and the rest as streamflow (Ekern and Chang, 1985). Based on the available pan evaporation data for Hawaii, evaporation generally decreases with increasing elevation below the temperature inversion[9] and the cloud layer (Figure 2-1). At low elevations near the coast, pan evaporation rates are influenced by sensible heat advection from the ocean (Nullet, 1987). Pan evaporation rates are enhanced in the winter by positive heat advection from the ocean, and the opposite occurs in the summer when pan evaporation rates are diminished by negative heat advection (Giambelluca and Nullet, 1992). With increasing distance from the windward coasts, positive heat advection from dry land surfaces becomes an important factor in determining the evaporative demand at the slopes (Nullet, 1987). Shade (1999, Fig. 9) estimated pan evaporation rates of 30 inches per year below 2,000 feet elevation to 80 inches per year near the coast. Within the cloud layer, evaporation rates are particularly low due to the low solar radiation (i.e., from high cloud cover) and high humidity caused by fog drip. Pan evaporation rates drop below 30 inches per year in this area as reported in Shade (1999, Fig. 9). Near the average height of the temperature inversion, evaporation rates are highly variable as they are mainly influenced by the movement of dry air from above and moist air from below (Nullet and Giambelluca, 1990). Above the inversion, clear sky and high solar radiation at the summits cause increased evaporation, with pan evaporation rates of about 50 to 70 inches per year (Shade, 1999, Fig. 9). Ekern and Chang (1985) reported evaporation increased to 50 percent more than surface oceanic rates near the Mauna Kea crest on the island of Hawaii.

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[7] Albedo is the proportion of solar radiation that is reflected from the Earth, clouds, and atmosphere without heating the receiving surface.
[8] Sensible heat advection refers to the transfer of heat energy that causes the rise and fall in the air temperature.
[9] Temperature inversion is when temperature increases with elevation.

2.6 Land Use

The Hawaii Land Use Commission (LUC) was established under the State Land Use Law (Chapter 205, Hawaii Revised Statutes) enacted in 1961. Prior to the LUC, the development of scattered subdivisions resulted in the loss of prime agricultural land that was being converted for residential use, while creating problems for public services trying to meet the demands of dispersed communities. The purpose of the law and the LUC is to preserve and protect Hawaii's lands while ensuring that lands are used for the purposes they are best suited. Land use is classified into four broad categories: 1) agricultural; 2) conservation; 3) rural; and 4) urban.

Land use classification is an important component of examining the benefits of protecting instream uses and the appropriateness of surface water use for noninstream uses. While some may argue that land use, in general, should be based upon the availability of surface and ground water resources, land use classification continues to serve as a valuable tool for long-range planning purposes.

As of 2006, the LUC designated 94 percent of the land in Ohia as agricultural district and the rest as conservation district (State of Hawaii, Office of Planning, 2006d). No lands were designated as rural or urban districts. The conservation district is the shoreline of the hydrologic unit (Figure 2-5).

2.7 Land Cover

Land cover for the hydrologic unit of Ohia is represented by two separate 30-meter Landsat satellite images. One of the datasets, developed by the Coastal Change Analysis Program (C-CAP), provides a general overview of the land cover types in Ohia, e.g. forest, shrub land, grassland, developed areas, cultivated areas, and bare land (Table 2-4, Figure 2-6). The second is developed by the Hawaii Gap Analysis Program (HI-GAP), which mapped the National Vegetation Classification System (NVCS) associations for each type of vegetation, creating a more comprehensive land cover dataset (Table 2-5, Figure 2-7). Based on the two land cover classification systems, the land cover of Ohia consists mainly of alien forests and grasslands, with very little native vegetation.

The land cover maps (Figures 2-6 and 2-7) provide a general representation of the land cover types in Ohia. Given that the scale of the maps is relatively large, they may not capture the smaller cultivated lands or other vegetation occupying smaller parcels of land. Land cover types may also have changed slightly since the year when the maps were published.

Table 2-4. C-CAP land cover classes and area distribution in Ohia Source: National Oceanographic and Atmospheric Agency, 2000).

Land Cover	Description	Area (mi^2)	Percent of Unit
Evergreen Forest	Areas where more than 67 percent of the trees remain green throughout the year	0.14	51.6
Grassland	Natural and managed herbaceous cover	0.07	25.7
Scrub/Shrub	Areas dominated by woody vegetation less than 6 meters in height	0.03	12.2
Low Intensity Developed	Constructed surface with substantial amounts of vegetated surface	0.01	4.1
Water	Areas of open water with less than 30 percent of trees, shrubs, persistent emergent plants, or other land cover	0.01	3.1
Bare Land	Bare soil, gravel, or other earthen material with little or no vegetation	0.01	2.7
Unconsolidated Shoreline	Material such as silt, sand, or gravel that is subject to inundation and redistribution by water	< 0.01	0.9

Table 2-5. HI-GAP land cover classes and area distribution in Ohia (Source: HI-GAP, 2005).

Land Cover	Area (mi^2)	Percent of Unit
Alien Forest	0.21	75.6
Uncharacterized Open-Sparse Vegetation	0.03	9.0
Low Intensity Developed	0.01	4.3
Alien Grassland	0.01	3.9
Very Sparse Vegetation to Unvegetated	0.01	2.9
Closed Ohia Forest (uluhe)	< 0.01	1.5
Closed Ohia Forest (native shrubs)	< 0.01	1.0
Uluhe Shrubland	< 0.01	1.0
Undefined	< 0.01	0.2

2.8 Flood

Floods usually occur following prolonged or heavy rainfall associated with tropical storms or hurricanes. The magnitude of a flood depends on topography, ground cover, and soil conditions. Rain falling on areas with steep slopes and soil saturated from previous rainfall events tends to produce severe floods in low-lying areas. Four types of floods exist in Hawaii. Stream or river flooding occurs when the water level in a stream rises into the flood plain. A 100-year flood refers to the probability of the flood happening once in a hundred years, or 1 percent chance of happening in a given year. Flash floods occur within a few hours after a rainfall event, or they can be caused by breaching of a flood safety structure such as a dam. Flash flooding is common in Hawaii because the small drainage basins often have a short response time, typically less than an hour, from peak rainfall to peak streamflow. They are powerful and dangerous in that they can develop quickly and carry rocks, mud, and debris in their path down to the coast, causing water quality problems in the near shore waters. Some floods can even trigger massive landslides, blocking off sections of a stream channel. One of the major historic flash flooding events occurred on December 5-6, 1988, when rainfall was at the average annual maximum, causing significant flash flooding in many parts of Maui (Fletcher III et al., 2002). Sheet flooding occurs when runoff builds up on previously saturated ground, flowing from the high mountain slopes to the sea in a shallow sheet (Pacific Disaster Center, 2007). Coastal flooding is the inundation of coastal land areas from excessive sea level rise associated with strong winds or a tsunami.

The Federal Emergency Management Agency (FEMA) developed maps that identify the flood-risk areas in an effort to mitigate life and property losses associated with flooding events. Based on these maps, FEMA did not identify any flood-risk zones in the hydrologic unit of Ohia.

2.9 Drought

Drought is generally defined as a shortage of water supply that usually results from lower than normal rainfall over an extended period of time, though it can also result from human activities that increase water demand (Giambelluca et al., 1991). The National Drought Mitigation Center (State of Hawaii, Commission on Water Resource Management, 2005b) uses two types of drought definitions — conceptual and operational. Conceptual definitions help people understand the general concept of drought. Operational definitions describe the onset and severity of a drought, and they are helpful in planning for drought mitigation efforts. The four operational definitions of drought are meteorological, agricultural, hydrological, and socioeconomic. Meteorological drought describes the departure of rainfall from normal based on meteorological measurements and understanding of the regional climatology. Agricultural drought occurs when not enough water is available to meet the water demands of a crop.

Hydrological drought refers to declining surface and ground water levels. Lastly, socioeconomic drought occurs when water shortage affects the general public.

Impacts of drought are complex and can be categorized into three sectors: water supply; agriculture and commerce; and environment, public health, and safety sectors (State of Hawaii, Commission on Water Resource Management, 2005b). The water supply sector encompasses urban and rural drinking water systems that are affected when a drought depletes ground water supplies due to reduced recharge from rainfall. The agriculture and commerce sector includes the reduction of crop yield and livestock sizes due to insufficient water supply for crop irrigation and maintenance of ground cover for grazing. The environmental, public health, and safety sector focuses on wildfires that are both detrimental to the forest ecosystem and hazardous to the public. It also includes the impact of desiccating streams, such as the reduction of instream habitats for native species.

Droughts have affected the islands throughout Hawaii's recorded history. The most severe events of the past 15 years are associated with the El Niño phenomenon. In January 1998, the National Weather Service's network of 73 rain gauges throughout the State did not record a single above-normal rainfall, with 36 rain gauges recording less than 25 percent of normal rainfall (State of Hawaii, Commission on Water Resource Management, 2005b). One of the more recent drought occurred in 2000-2002, affecting all islands, especially the southeastern end of the State. During that period, east Maui streams were at record low levels and cattle losses projected at 9 million dollars (State of Hawaii, Commission on Water Resource Management, 2005b). According to the National Drought Mitigation Center (2009), the State of Hawaii has been in a severe drought condition since June 2008. The percentage of area categorized as severe drought increased from 3 percent in June to almost 55 percent in December of 2008. Drought conditions worsened in the last three months of 2008 that about 12 percent of the State was categorized as extreme drought. Currently, 23 percent of the State is in severe drought.

With Hawaii's limited water resources and growing water demands, droughts will continue to adversely affect the environment, economy, and the residents of the State. Aggressive planning is necessary to make wise decisions regarding the allocation of water at the present time, and conserving water resources for generations to come. The Hawaii Drought Plan was established in 2000 in an effort to mitigate the long-term effects of drought. One of the projects that supplemented the plan was a drought risk and vulnerability assessment of the State, conducted by researchers at the University of Hawaii (2003). In this project, drought risk areas were determined based on rainfall variation in relation to water source, irrigated area, ground water yield, stream density, land form, drainage condition, and land use. Fifteen years of historical rainfall data were used. The Standardized Precipitation Index (SPI) was used as the drought index because of its ability to assess a range of rainfall conditions in Hawaii. It quantifies rainfall deficit for different time periods, i.e. 3 months and 12 months. Results of the study for Maui are summarized in Table 2-6. Based on the 12-month SPI, the Kula region has the greatest risk to drought impact of the Maui regions because of its dependence on surface water sources, which is limited by low rainfall. The growing population in the already densely populated area further stresses the water supply.

Table 2-6. Drought risk areas for Maui (Source: University of Hawaii, 2003).

[Drought classifications of moderate, severe, and extreme have SPI values -1.00 to -1.49, -1.50 to -1.99, and -2.00 or less, respectively]

Sector	Drought Classification (based on 12-month SPI)		
	Moderate	Severe	Extreme
Water Supply	Kula, Kahului, Wailuku, Hana, Lahaina	Kula, Hana	Kula
Agriculture and Commerce	--	--	--
Environment, Public Health and Safety	Kula	Kula	Kula

Figure 2-2. Generalized geology of Ohia hydrologic unit (Source: Sherrod et al., 2007; State of Hawaii, Office of Planning, 2006a, and State of Hawaii, Commission on Water Resource Management, 2008d; USGS, 2001b).

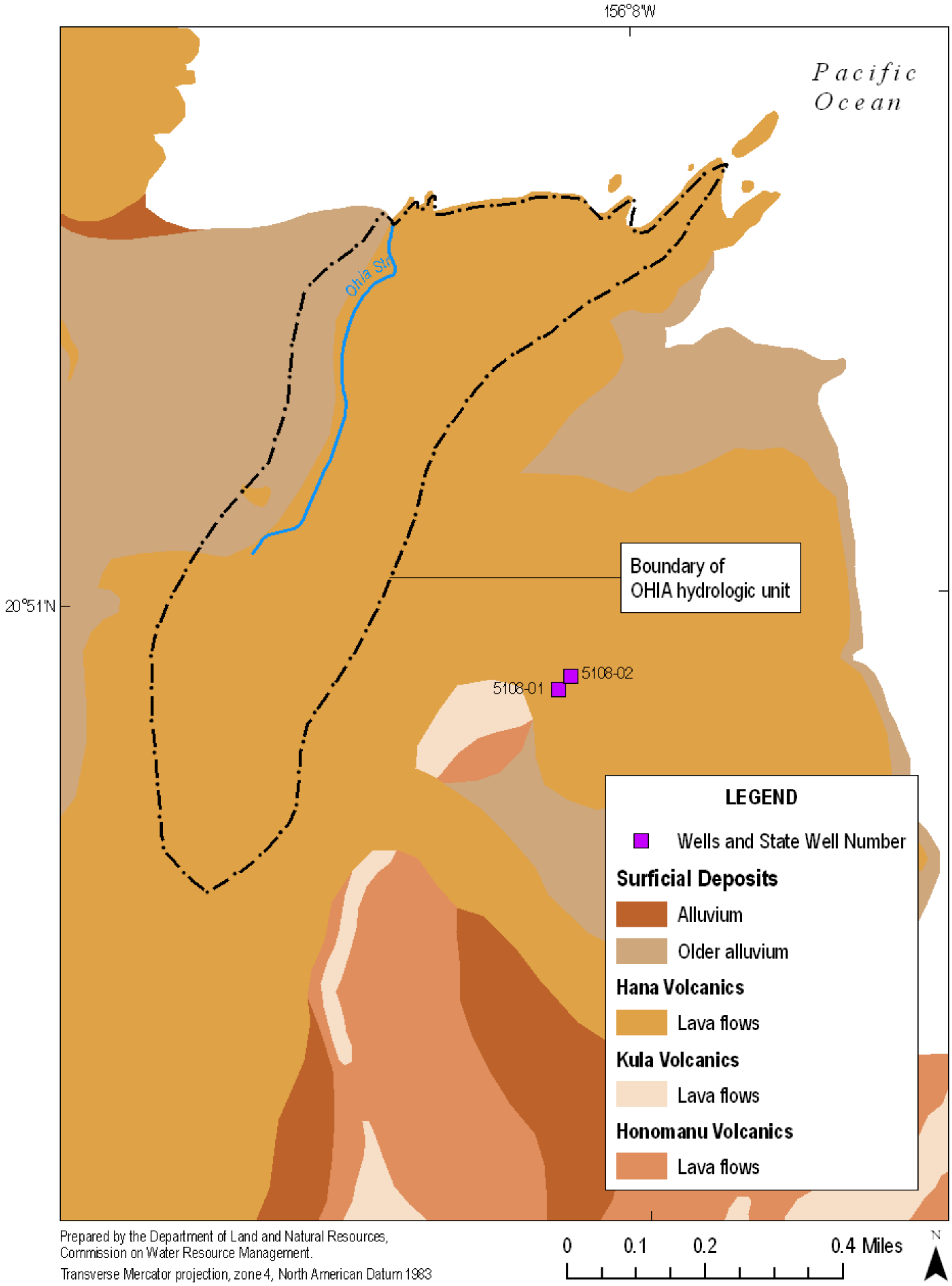


Figure 2-3. Soil classification in Ohia hydrologic unit (Source: State of Hawaii, Office of Planning, 2007c; USGS, 2001b).

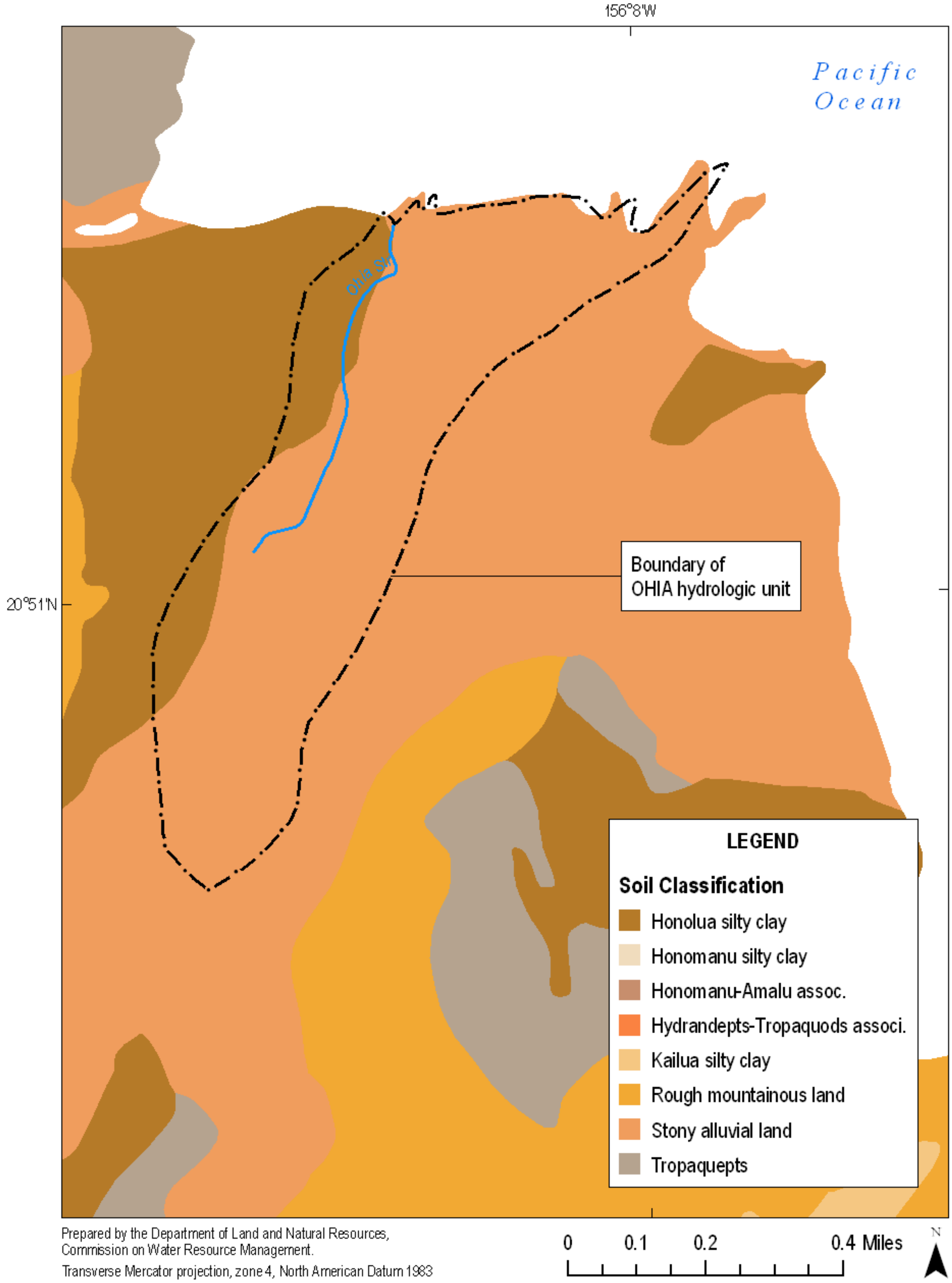


Figure 2-4. Mean annual rainfall and fog area in Ohia; and solar radiation for Ohia and the island of Maui, Hawaii (Source: Giambelluca et al., 1986; State of Hawaii, Office of Planning, 2006b; 2006c; USGS, 2001b).

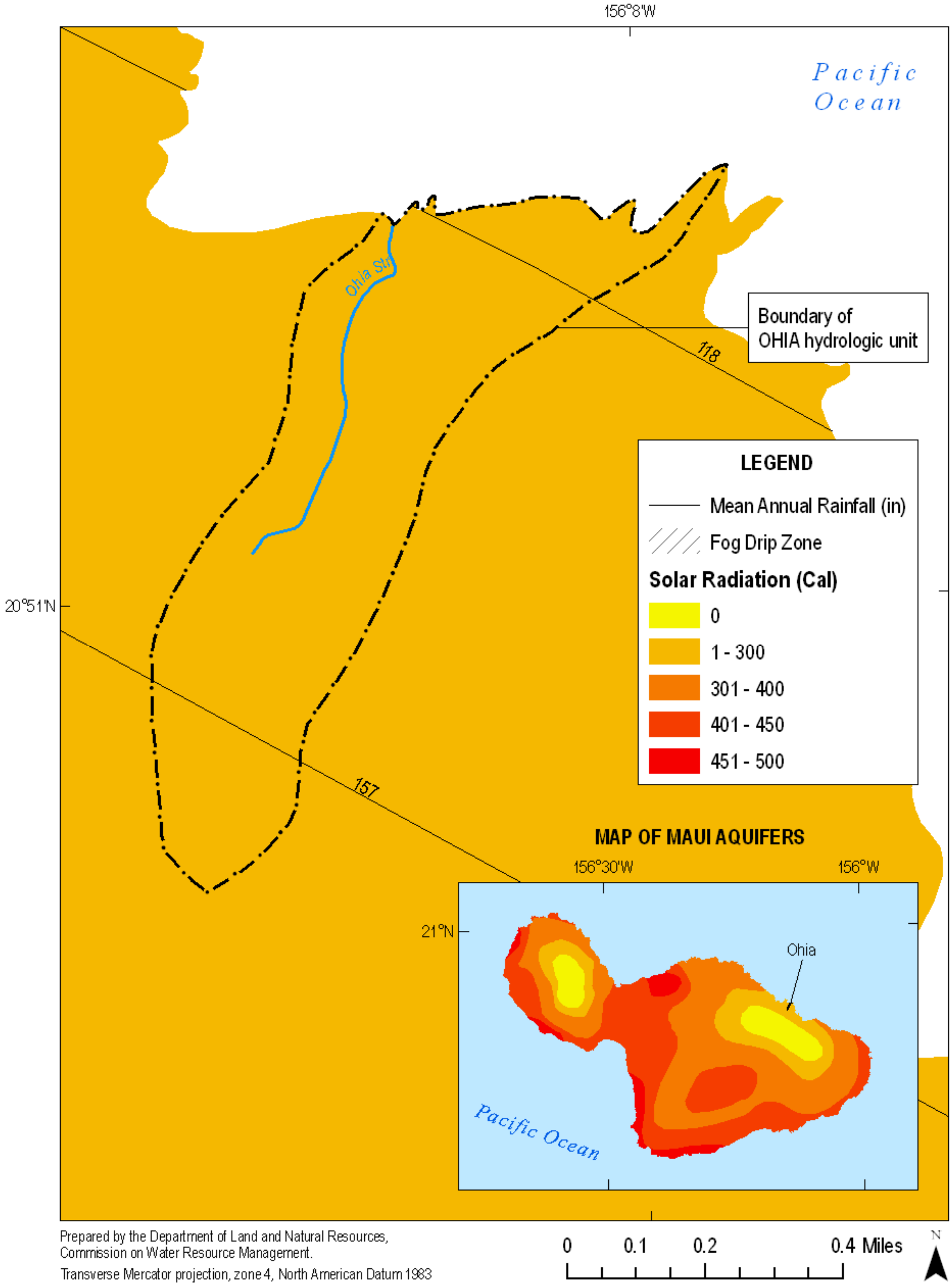


Figure 2-5. State land use district boundaries in Ohia hydrologic unit (Source: State of Hawaii, Office of Planning, 2006d; USGS, 2001b).

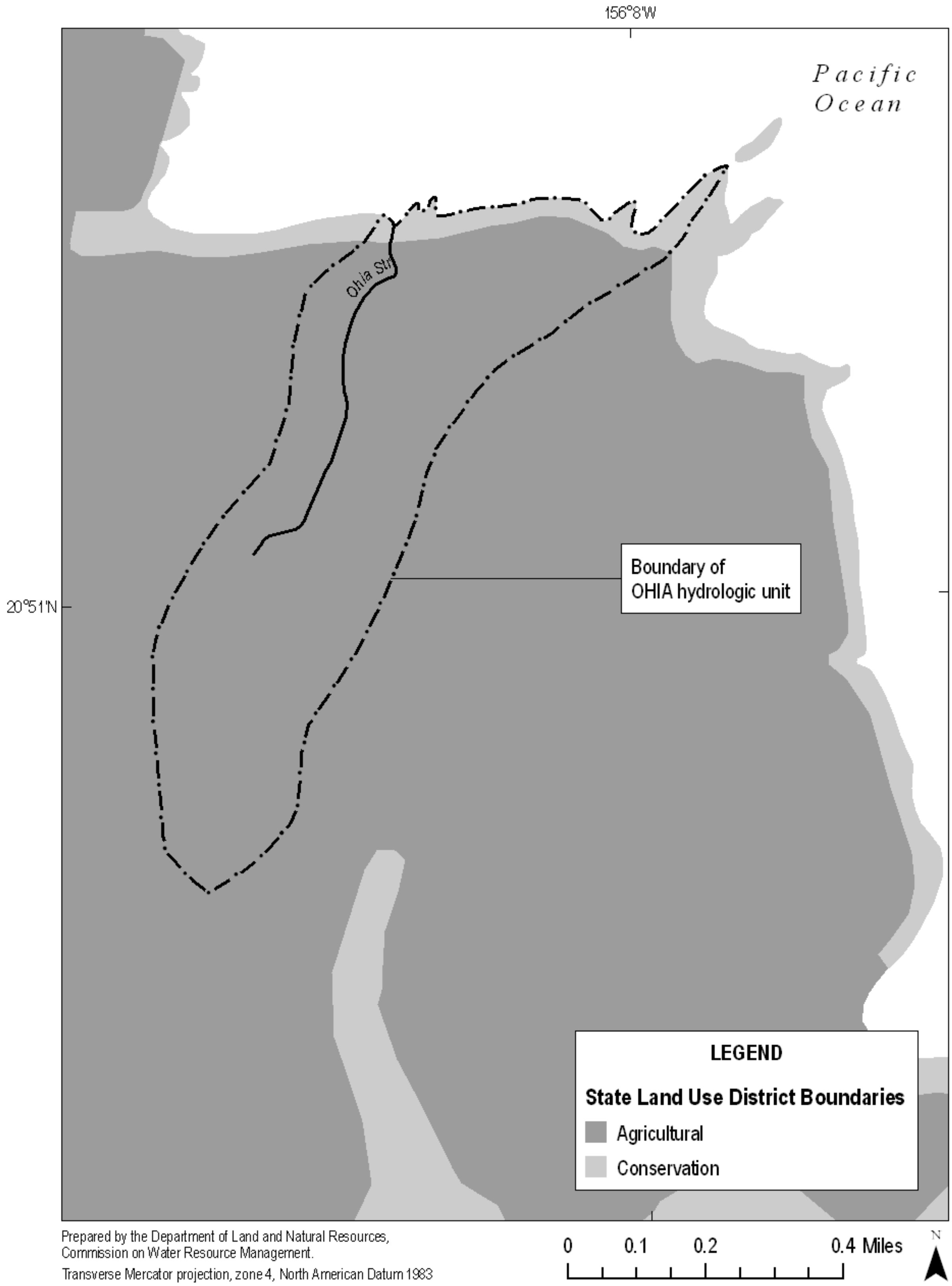


Figure 2-6. C-CAP land cover in Ohia hydrologic unit (Source: National Oceanic and Atmospheric Administration, Coastal Services Center, 2000; USGS, 2001b).

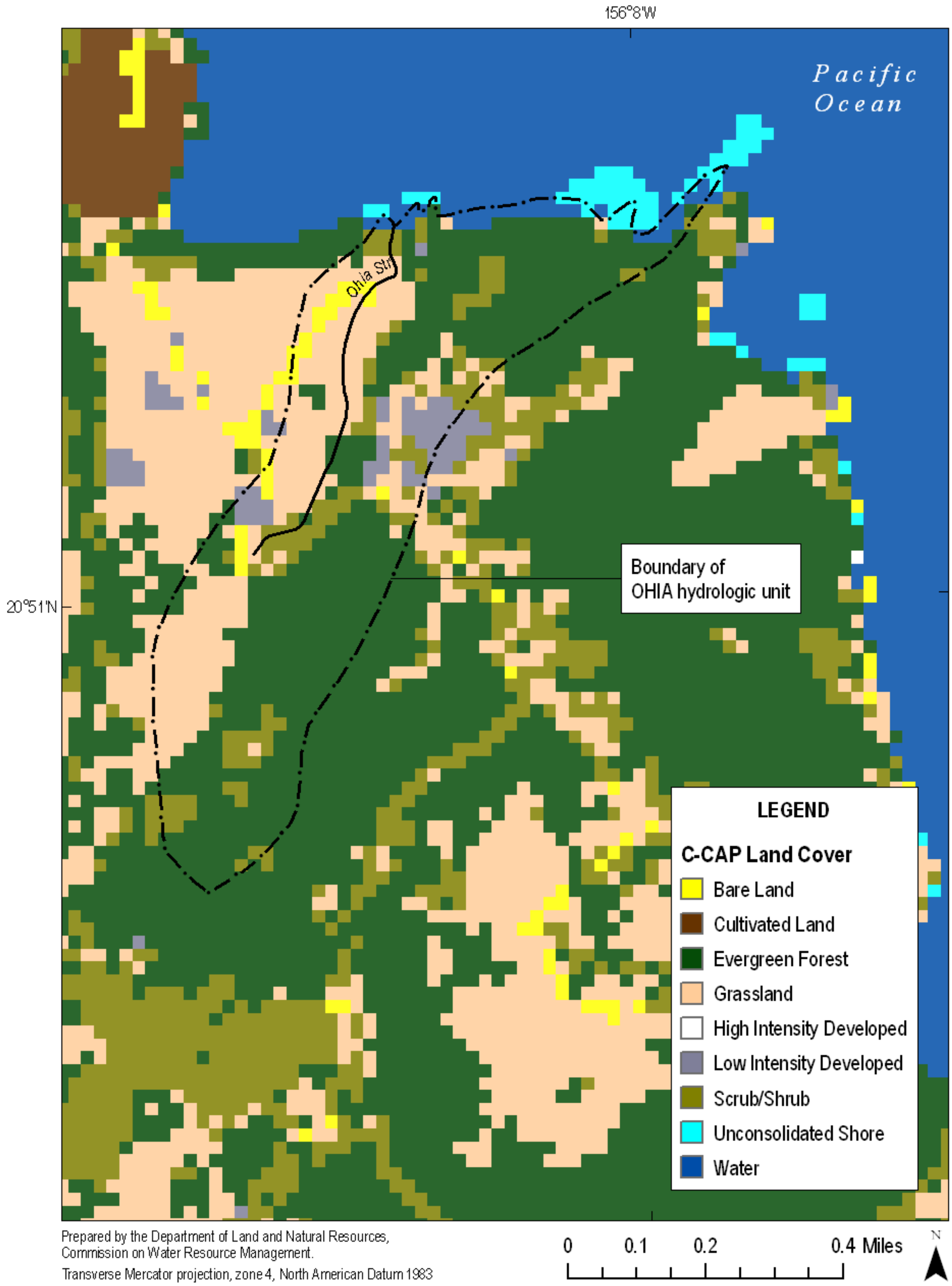
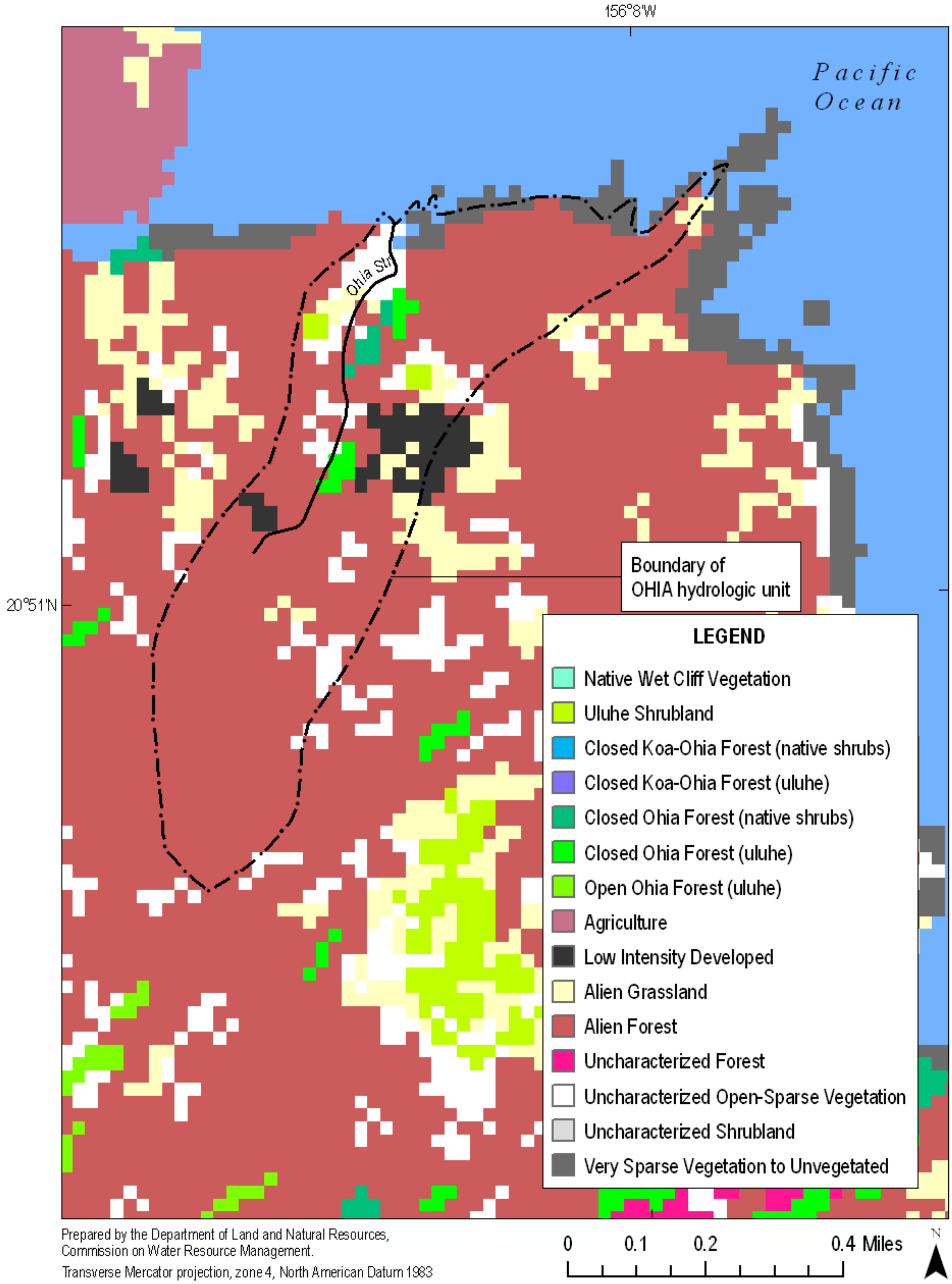


Figure 2-7. Hawaii GAP land cover classes in Ohia hydrologic unit (Source: Hawaii GAP Analysis Program, 2005; USGS, 2001b).



3.0 Hydrology

The Commission, under the State Water Code, is tasked with establishing instream flow standards by weighing "the importance of the present or potential instream values with the importance of the present or potential uses of water for noninstream purposes, including the economic impact of restricting such uses." While the Code outlines the instream and offstream uses to be weighed, it assumes that hydrological conditions will also be weighed as part of this equation. The complexity lies in the variability of local surface water conditions that are dependent upon a wide range of factors, including rainfall, geology, and human impacts, as well as the availability of such information. The following is a summary of general hydrology and specific hydrologic characteristics for Ohia Stream.

3.1 Streams in Hawaii

Streamflow consists of: 1) direct surface runoff in the form of overland flow and subsurface flow that rapidly returns infiltrated water to the stream; 2) ground water discharge in the form of base flow; 3) water returned from streambank storage; 4) rain that falls directly on streams; and 5) additional water, including excess irrigation water discharged into streams by humans (Oki, 2003). The amount of runoff and ground water that contribute to total streamflow is dependent on different components of the hydrologic cycle[10], as well as man-made structures such as diversions and other stream channel alterations (e.g. channelizations and dams).

Streams in Hawaii can either gain or lose water at different locations depending on the geohydrologic conditions. A stream gains water when the ground water table is above the streambed. When the water table is below the streambed, the stream can lose water. Where the streambed is lined with concrete or other low-permeability or impermeable material, interaction between surface water and ground water is unlikely. Whether a stream is gaining or losing flow can be determined by taking flow measurements at the endpoints of a channel reach. Another way that ground water influences streamflow is through springs. A spring is formed when a geologic structure (e.g., fault or fracture) or a topographic feature (e.g., side of a hill or a valley) intersects ground water either at or below the water table. It can discharge ground water onto the land surface, directly into the stream, or into the ocean. Figure 3-1 illustrates a valley that has been incised into a high-level water table, resulting in ground water discharges that contribute directly to streamflow and springs. At places where erosion has removed the caprock, ground water discharges either as springs or into the ocean as seepage.

3.2 Ground Water

Ground water is an important component of streamflow as it constitutes the base flow[11] of Hawaiian streams. When ground water is withdrawn from a well, the water level in the surrounding area is lowered. Pumping wells near streams commonly cause stream water to flow into the underlying ground water body, affecting the quality of ground water (LaBaugh and Rosenberry, 2008). Nearby wetlands or ponds may shrink or even dry up if the pumping rate is sufficiently high (Gingerich and Oki, 2000). The long-term effects of ground water withdrawal can include the reduction of streamflow, which may cause a

[10] Hydrologic cycle (i.e. water cycle) represents the processes and pathways involved in the circulation of water between the atmosphere and land either on a global scale or within a hydrologic unit. The components of the hydrologic cycle include the following main processes: evaporation, precipitation, interception, transpiration, infiltration, and runoff.

[11] Base flow is the water that enters a stream from persistent, slowly varying sources (such as the seepage of ground water), and maintains stream flow between water-input events (i.e., it is the flow that remains in a stream in times of little or no rainfall).

decrease in stream habitats for native species and a reduction in the amount of water available for irrigation. The interaction between surface water and ground water warrants a close look at the ground water recharge and demand within the State as well as the individual hydrologic units.

In Hawaii, ground water is replenished by recharge from rainfall, fog drip, and irrigation water that percolate through the plant root zone to the subsurface rock. Recharge can be captured in three major fresh ground water systems: 1) fresh water-lens system; 2) dike-impounded system; and 3) perched system. The fresh water-lens system provides the most important sources of ground water. It includes a lens-shaped layer of fresh water, an intermediate transition zone of brackish water, and underlying salt water. In northeast Maui, a vertically extensive fresh water-lens system can extend several hundreds or even thousands of feet below mean sea level. A dike-impounded system is found in rift zones and caldera of a volcano where low-permeability dikes compartmentalize areas of permeable volcanic rocks, forming high-level water bodies. On Maui, dikes impound water to as high as 3,300 feet above mean sea level. A perched system is found in areas where low-permeability rocks impede the downward movement of percolated water sufficiently to allow a water body to form in the unsaturated zone above the lowest water table (Gingerich and Oki, 2000).

The hydrologic unit of Ohia lies within the Keanae aquifer system that has an area of about 56 square miles. A general overview of the ground water occurrence and movement in this area is described in Gingerich (1999b) and illustrated in Figure 3-1. Ohia Stream lies on lava flows of the Hana Volcanics from its headwater to the coast (Gingerich, 1999b). The freshwater-lens system of the Keanae aquifer system is vertically extensive, in which the saturated zone extends from the Honomanu Basalt at sea level through the Kula Volcanics and into the Hana Volcanics. Streams that intersect the water table continue to gain water as they descend to sea level. Ground water withdrawals from wells open to any part of the aquifer will reduce streamflow and discharge to the ocean (Gingerich, 1999b). Based on available data, there are no wells in the hydrologic unit of Ohia. As of June 2008, the ground water demand of the Keanae aquifer system is only 0.162 million gallons per day, which is well below the aquifer's current sustainable yield of 83 million gallons per day (State of Hawaii, Commission on Water Resource Management, 2008c). Estimated total ground water recharge without accounting for fog drip contribution is 171 million gallons per day, which represents 37 percent of total rainfall (Shade, 1999).

Ground water use information is only available by island. Among the major Hawaiian Islands, Maui has the second highest number of production wells following Oahu. Of the 450 productions wells in Maui, 191 are low-capacity wells with a pumping rate of less than 25 gallons per minute. Assuming all the low-capacity production wells in Maui are pumping at 1,700 gallons per day, the island-wide withdrawal rate would be 0.32 million gallons per day. The cumulative impacts of small, domestic wells become particularly important when assessing areas where municipal water is unavailable (State of Hawaii, Commission on Water Resource Management, 2008c). A majority of the reported ground water use in Maui is for agricultural (54 percent) and municipal (34 percent) uses (Table 3-1).

Figure 3-1. Diagram illustrating the ground water system in and east of Keanae Valley, northeast Maui, Hawaii. Arrows indicate general direction of ground water flow (Source: Gingerich, 1999b).

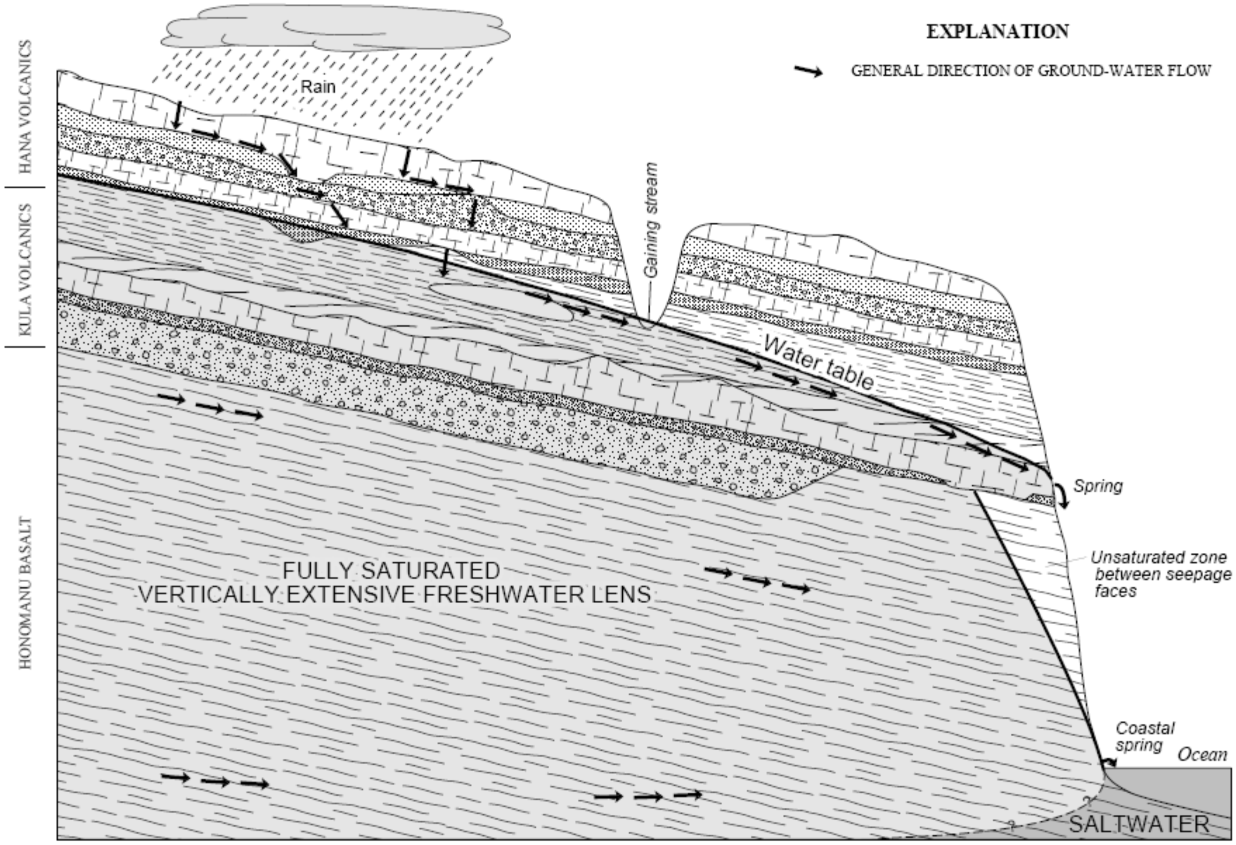


Table 3-1. Summary of ground water use reporting in the island of Maui (Source: State of Hawaii, Commission on Water Resource Management, 2008c).

[Agriculture category includes water use for crops, livestock, and nursery plants; irrigation category includes water use for golf courses, landscape features, and other infrastructures. Mgd is million gallons per day.]

Use Category	Use Rate (mgd)	Percent of Total (%)
Agriculture	48.134	53.7
Domestic	0.001	0
Industrial	1.683	1.9
Irrigation	9.611	10.7
Military	0	0
Municipal	30.172	33.7
Total	89.601	100

3.3 Streamflow Characteristics

Ohia Stream is one of the shortest streams in east Maui. It is 0.6 miles in length, traversing north from its headwaters at Ohia Spring near the Hana Highway at 230 feet elevation to the ocean. The stream is gentle sloped with no major waterfalls.

One of the most common statistics used to characterize streamflow is the median value of flow in a particular time period. This statistic is also referred to as the flow at 50 percent exceedence probability, or the flow that is equaled or exceeded 50 percent of the time (TFQ_{50}). The longer the time period that is used to determine the median flow value, the more representative the value is of the normal flow conditions in the stream. Median flow is typically lower than the mean or average flow because of the bias in higher flows, especially during floods, present when calculating the average flow. The flow at the 90 percent exceedence probability (TFQ_{90}) is commonly used to characterize low flows in a stream. In Hawaii, the base flow is usually exceeded less than 90 percent of the time, and in many cases less than 70 percent of the time (Oki, 2003).

In cooperation with the Commission on Water Resource Management, the USGS conducted a study (Gingerich, 2005) to assist in determining reasonable and beneficial noninstream and instream uses of surface water in northeast Maui. The purpose of the study was to develop methods of estimating natural (undiverted) median streamflow, total flow statistics (TFQ), and base flow statistics (BFQ) at ungaged sites where observed data are unavailable. The study area lies between the drainage basins of Kolea Stream to the west and Makapipi Stream to the east. Basin characteristics and hydrologic data for the study area were collected and analyzed. One of the products of the study is a set of regression equations that can be used to estimate natural (undiverted) TFQ_{50}, BFQ_{50}, TFQ_{95}, and BFQ_{95} at gaged and ungaged sites. The subscripts indicate the percentage of time the flow, either total or base flow, is equaled or exceeded.

Streamflow data for Ohia Stream is limited because there are no stream gaging stations within the hydrologic unit. According to Gingerich (2005), the average flow at Ohia Spring is 4.7 cubic feet per second. Downstream from the spring, the stream is losing flow to infiltration and evaporation from agricultural lands. As a result, very little flow reaches the ocean. Base flow estimates are not available to determine the amount of flow losses. Ohia Stream is not diverted at any major surface water diversion systems. However, water from an unnamed spring is diverted for irrigating taro, watercress, ti plants, and flowers (see Section 13.0).

Despite the lack of measured streamflow data, the regression equations were applied to a selected ungaged site (OL) near the mouth of Ohia Stream (Figure 3-3). Results are presented in Table 3-2. The estimated flow is 8.7 cubic feet per second, which is much higher than the spring discharge of 4.7 cubic feet per second because the regression equations do not account for infiltration or evaporation losses. On the other hand, the estimated TFQ_{95} of 4.6 cubic feet per second is a close estimate of the spring discharge. Accuracy of the regression equations could not be assessed due to the lack of measured streamflow data. It is unknown whether the stream will go dry during low-flow conditions.

Table 3-2. Stream flow statistics estimated using regression equations, lower and upper confidence intervals, standard errors, measured flow, and relative errors for ungaged site in Nuaailua (Gingerich, 2005, Table 10).

[Flows are in cubic feet per second (cfs); 90% LCL and 90% UCL is 90 percent lower and upper confidence level; Standard error is in percent; Relative error is the percent difference between the measured statistic and the estimated statistic; Measured flows in ***bold italic*** fall within the lower and upper 90 percent confidence interval]

Stream location	Statistic	TFQ_{50}	BFQ_{50}	TFQ_{95}	BFQ_{95}	Source of measured flow estimates
Ohia lower (OL)	Estimated flow	8.7	8.6	4.6	6.1	Ohia Spring average flow is 4.7 cubic feet per second (Stearns and Macdonald, 1942) but little flow reaches the ocean due to infiltration and agricultural evapotranspiration losses
	90% LCL	5.5	4.3	1.5	1.8	
	90% UCL	14	17	14	21	
	Standard error	26.6	40	69.1	79.3	
	Measured flow	--	--	--	--	
	Relative error	--	--	--	--	

Mathematical models and equations are commonly used to represent hydrologic occurrences in the real world; however, they are typically based on a set of assumptions that oftentimes render their estimates questionable in terms of accuracy and precision. This does not mean the public should entirely discount the estimates produced by these mathematical tools because they do provide quantitative and qualitative relative comparisons that are useful when making management decisions. Objections have been raised by several agencies in regards to the use of regression equations to estimate flow statistics. While the estimated statistics are presented to fulfill the purpose of compiling the best available information that will be considered in determining the interim IFS recommendations, the Commission staff does not intend to rely exclusively on the regression equations to make such important management decisions. The limitations and potential errors of the regression equations must also be considered.

One of the limitations of the regression equations is that they do not account for variable subsurface geology, such as those of intermittent streams and where springs discharge high flow to streams. The equations may overestimate flow statistics in intermittent streams as they do not account for losing reaches. On the other hand, the equations may underestimate the additional streamflow gained from springs. Furthermore, the equations may produce poor results when applied to sites that have basin characteristics outside the range of values used to develop the equations. The regression equations tend to predict more accurately the higher flow statistics, TFQ50 and BFQ50, rather than the lower flow statistics, TFQ95 and BFQ95. According to Gingerich (2005), the most reliable estimates of natural and diverted streamflow duration statistics at gaged and ungaged sites in the study area were made using a combination of continuous-record gaging station data, low-flow measurements, and values determined from the regression equations.

3.4 Long-Term Trends in Streamflow

In a different study, the USGS examined the long-term trends and variations in streamflow on the islands of Hawaii, Maui, Molokai, Oahu, and Kauai, where long-term stream gaging stations exist (Oki, 2004). The study analyzed both total flow and estimated base flow at 16 long-term gaging stations. For the 90-year period 1913-2002, monthly mean base flows generally followed an increasing trend above the long-term average from 1913 to early 1940s, and a decreasing trend after the early 1940s to 2002 (Figure 3-4). Monthly mean total flows follow a similar pattern with the exception that the monthly mean total flow increased from mid-1980s to mid-1990s, and decreased from mid-1990s to 2002. Downward trends in the annual total low flow percentiles, TFQ_{75} and TFQ_{90}, were statistically significant at the 5 percent level of significance. This is consistent with the annual base flow percentiles (Oki, 2004). In summary, the available long-term streamflow data suggest that streamflow is generally decreasing.

Figure 3-2. Aquifer system area and well locations in Ohia hydrologic unit (Source: State of Hawaii, Office of Planning, 2006b; State of Hawaii, Commission on Water Resource Management, 2008d; USGS, 2001b).

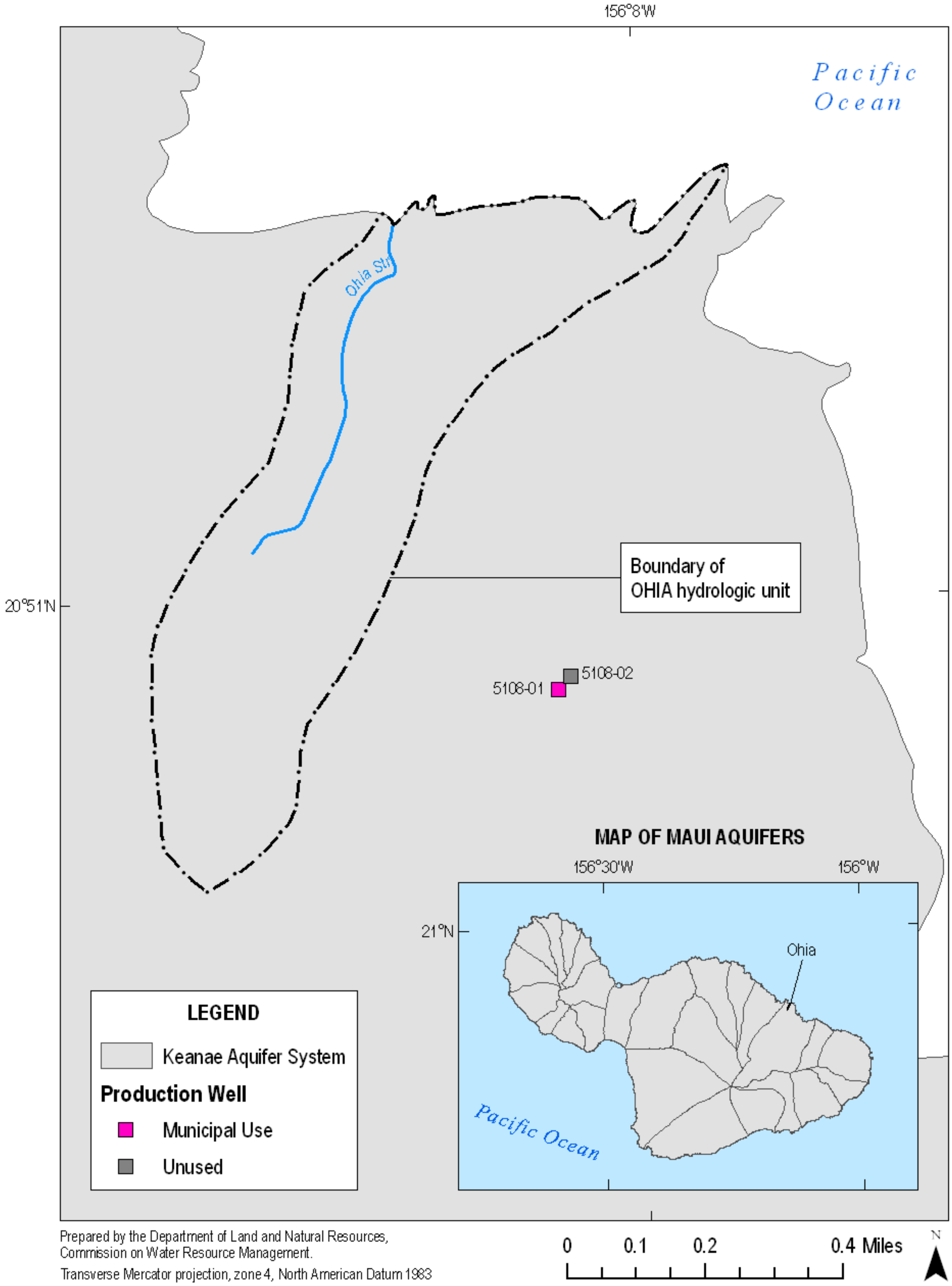


Figure 3-3. Location of diversions, irrigation systems, USGS gaging stations, and selected ungaged sites in Ohia hydrologic unit (Source: State of Hawaii, Office of Planning, n.d.; 1996, 2004c; 2005; USGS, 2001b).

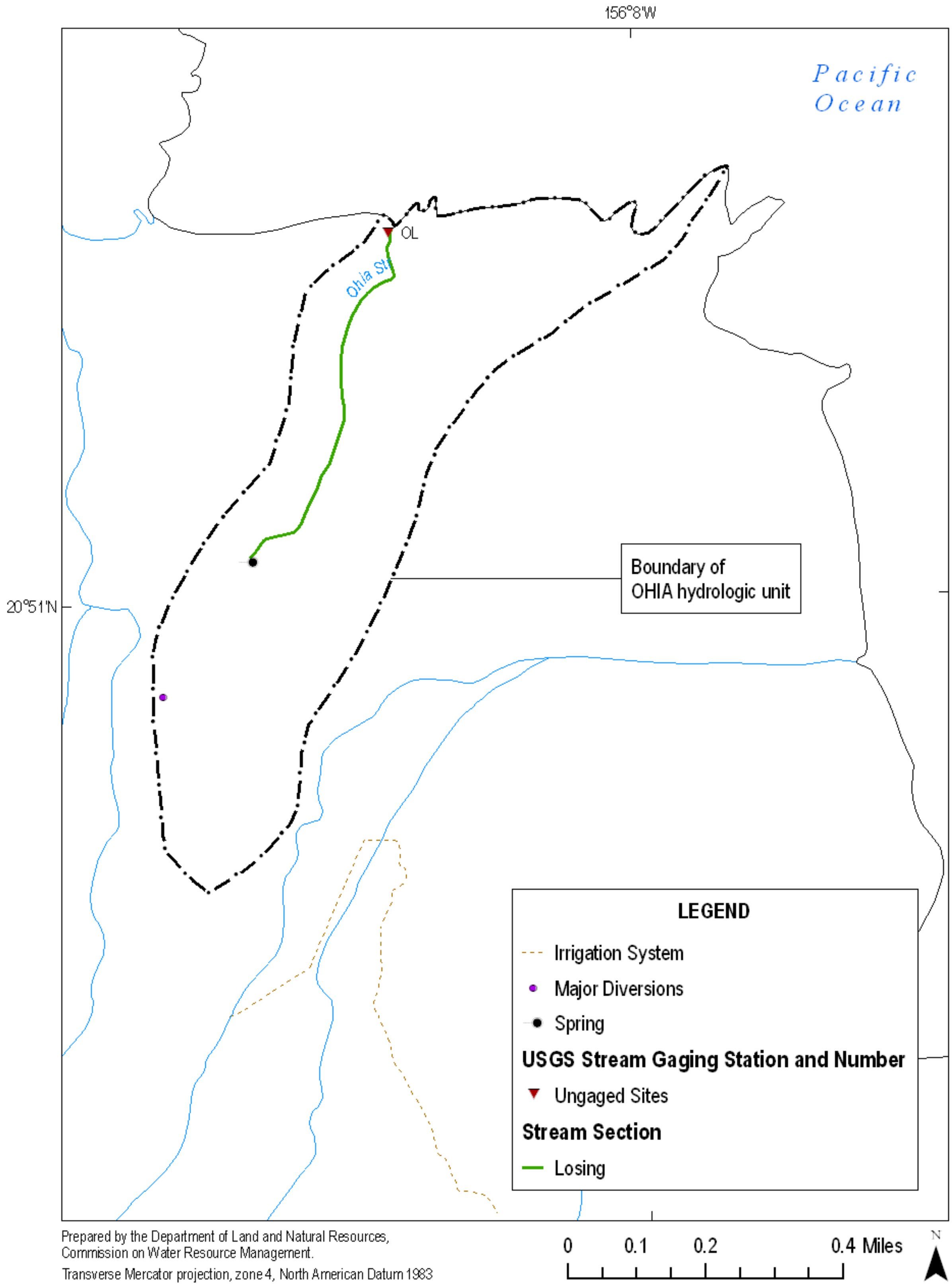
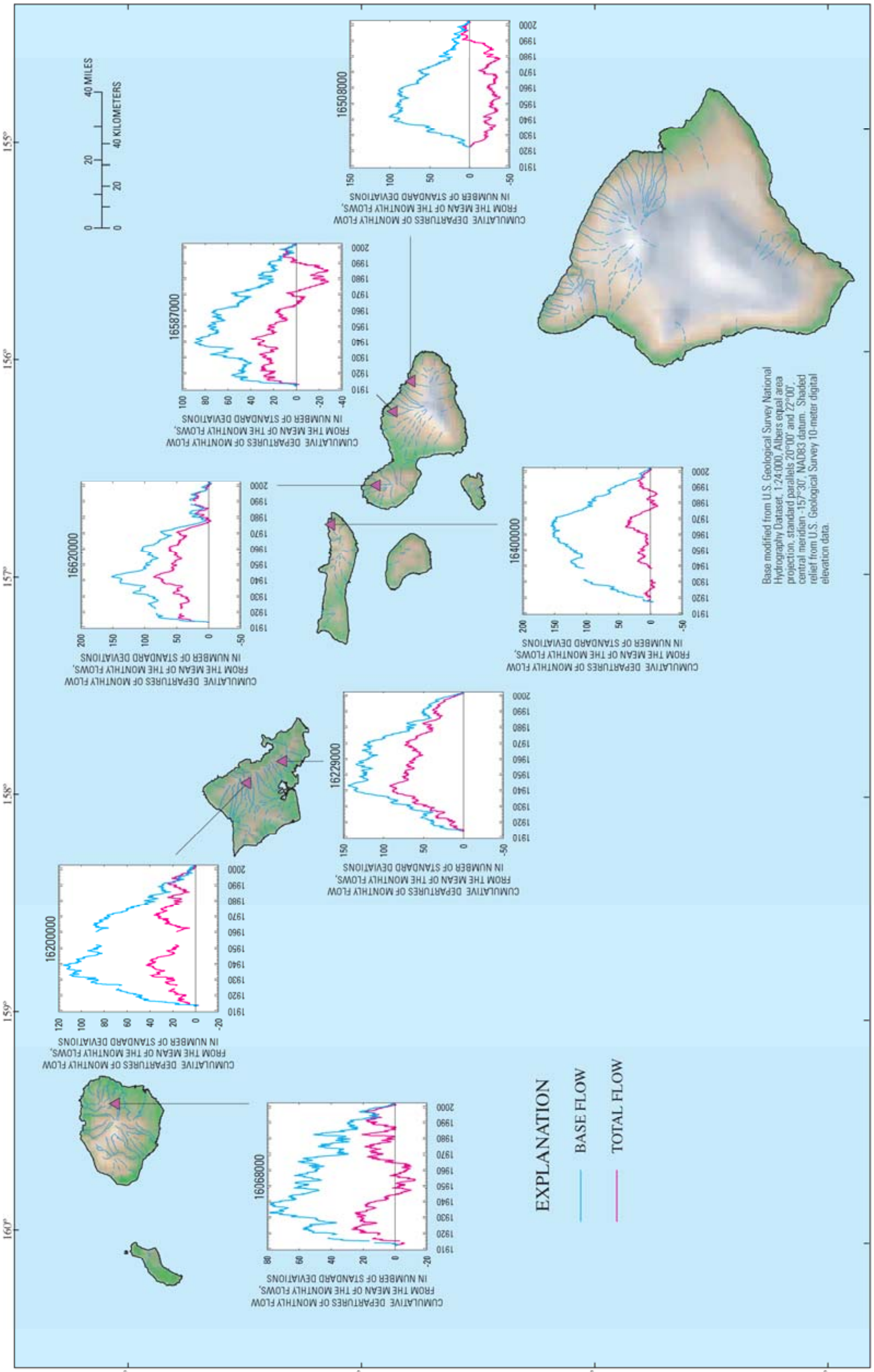


Figure 3-4. Cumulative departures of monthly mean flow from the mean of the monthly flows, Hawaii. This data is based on complete water years from 1913 through 2002. (Oki, 2004, Figure 4).



4.0 Maintenance of Fish and Wildlife Habitat

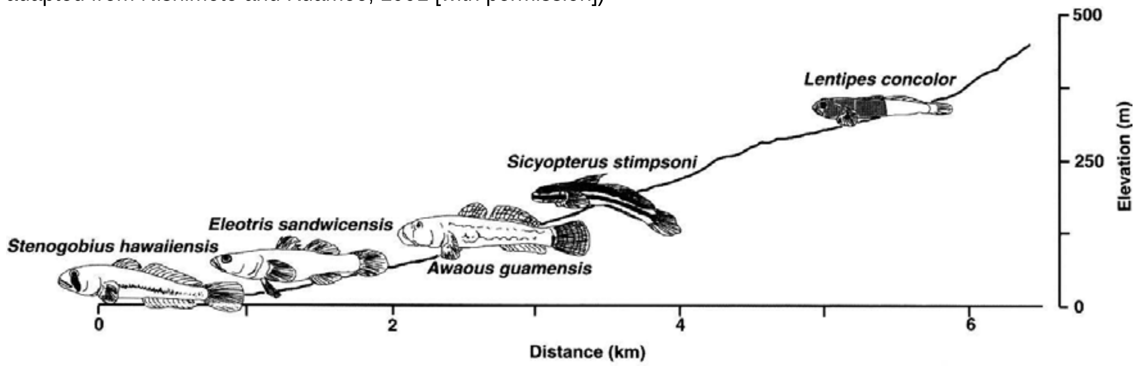
When people in Hawaii consider the protection of streamflows for maintaining fish habitat, their thoughts generally focus on a handful of native species, including five native fishes (four gobies and one eleotrid), two snails, one shrimp, and a prawn (Table 4-1). Four of the fish species - *Stenogobius hawaiiensis* (Goby), *Sicyopterus stimpsoni* (Goby), *Eleotris sandwicensis* (Eleotrid), and *Lentipes concolor* (Goby) - are endemic (found only in Hawaii), and the *Awaous guamensis* is an indigenous (native to Hawaii and elsewhere) goby. Only the *Lentipes concolor* was considered a "category 1 candidate for listing in the National Register for Endangered Species…but has since been reclassified as a Species of Concern" (as cited in Gingerich and Wolff, 2005). The crustaceans (*Macrobrachium grandimanus* (prawn) and *Atyoida bisulcata* (shrimp)), and mollusks (*Neritina vespertina* and *Neritina granosa* (snail)) are both endemic to Hawaii.

Hawaii's native stream animals have amphidromous life cycles (Ego, 1956), meaning that they spend their larval stages in the ocean (salt water), then return to fresh water streams to spend their adult stage and reproduce. Newly hatched fish larvae are carried downstream to the ocean where they become part of the planktonic pool in the open ocean. The larvae remain at sea from a few weeks to a few months, eventually migrating back into a fresh water stream as juvenile *hinana*, or postlarvae (Radtke et al., 1988). Once back in the stream, the distribution of the five native fish species are largely dictated by their climbing ability (Nishimoto and Kuamoo, 1991) along the stream's longitudinal gradient. This ability to climb is made possible by a fused pelvic fin which forms a suction disk. *Eleotris sandwicensis* lacks fused pelvic fins and is mostly found in the lower stream reaches. *Stenogobius hawaiiensis* is also found in the lower reaches because while it has fused pelvic fins, it lacks the musculature necessary for climbing (Nishimoto and Kuamoo, 1997). *Awaous guamensis* and *Sicyopterus stimpsoni* are able to ascend moderately high waterfalls less than 20 meters in height, while *Lentipes concolor* has the greatest climbing ability and has been observed at elevations higher than 3,000 feet (Fitzsimons and Nishimoto, 1990) and above waterfalls more than 900 feet in vertical height (Englund and Filbert, 1997). Figure 4-1 illustrates the elevational profile of these native fresh water fishes.

Table 4-1. List of commonly mentioned native stream organisms and their generalized distribution within natural undiverted streams. (Source: State of Hawaii, Division of Aquatic Resources, 1993; Ford et al., 2009).

Scientific Name	Hawaiian Name	Type	Biogeographic status	Distribution		
				Lower	Middle	Upper
Stenogobius hawaiiensis	ʻOʻopu naniha	Goby	Endemic	●		
Awaous guamensis	ʻOʻopu nakea	Goby	Indigenous	●	●	
Sicyopterus stimpsoni	ʻOʻopu nopili	Goby	Endemic	●	●	
Eleotris sandwicensis	ʻOʻopu akupa (okuhe)	Eleotrid	Endemic	●	●	
Lentipes concolor	ʻOʻopu hiʻukole (alamoʻo)	Goby	Endemic	●	●	●
Macrobrachium grandimanus	ʻOpae ʻoehaʻa	Prawn	Endemic	●		
Atyoida bisulcata	ʻOpae kalaʻole	Shrimp	Endemic	●	●	●
Neritina vespertina	Hapawai	Snail	Endemic	●		
Neritina granosa	Hihiwai	Snail	Endemic	●	●	

Figure 4-1. Elevational profile of a terminal-estuary stream on the Big Island of Hawaii (Hakalau Stream). (Source: McRae, 2007, adapted from Nishimoto and Kuamoo, 1991 [with permission])



Amphidromy has many advantages, the most important being "the potential for repopulating a stream with a full compliment of its formerly predominant vertebrate and invertebrate species" (as cited in Ford et al., 2009). Streams in Hawaii experience many natural disturbances in the stream ecosystem, including floods, landslides, hurricanes, and drought. Post-larvae oceanic recruitment (amphidromy) "allows rapid recolonization of streams after catastrophic events...and prevents genetic isolation of populations". In addition, the periodic drying of lower stream reaches and the flashy nature of Hawaii's streams with the sudden peak flows that allow for flushing of debris from the streambed, encourage "migration and spawning by aquatic organisms." There has also been evidence that the timing of reproduction and recruitment is strongly influcened by freshets and periods of heavy rain.

Damselflies also depend on healthy freshwater ecosystems for their survival. Most of the damselflies native to Hawaii are aquatic as immatures, and return to the water only to mate (Polhemus and Asquith, 1996). Of the native Hawaiian damselflies, the *Megalagrion* species is endemic and found only in Hawaii. In July of 2009, the U.S. Fish and Wildlife Service proposed two of the *Megalagrion* damselflies, the flying earwig Hawaiian damselfly (*Megalagrion nesiotes*) and the Pacific Hawaiian damselfly (*Megalagrion pacificum*), to be listed as endangered species (Foote, 2009, July 8). Both damselflies species have been candidates for protection since the 1990s. Currently, the flying earwig Hawaiian damselfly can only be found in Maui, and the Pacific Hawaiian damselfly in the islands of Molokai, Oahu, and Maui (Foote, 2009, July 8).

4.1 Impacts on Native Species Distribution

Gingerich and Wolff (2005) discussed "bottlenecks" as dry reaches in the stream that prevent upstream migration of native species. While surface water diversions are not considered as "bottlenecks", the dry reaches that are often found immediately downstream from the diversions can function as "bottlenecks" that inhibit species migration. With a few exceptions, the diversions capture almost all base flow and an unknown amount of total streamflow in each stream, decreasing flow downstream of the diversion and sometimes causing streams to go dry. This prevents the upstream migration of native stream animals, restricts surviving adult animals to the disconnected deep pools, and causes postlarvae recruits to be stranded at the stream mouth. Changes in flow volume may influence the physical and chemical characteristics of stream water and flow (e.g. temperature, pH, velocity), hence altering the stream ecosystem. While Ford et al. (2009) suggested that the presence of amphidromous species upstream of diversions is an indication of restored continuity in streamflow from periodic freshets, continued dewaterment of streams by diversions, especially during low flow conditions, could possibly result in longer stream reaches with prolonged dry periods, limiting overall habitat for native species.

Large waterfalls are obvious "bottlenecks" in the stream ecosystem that restrict the upstream migration of most native aquatic species, except the alamoo and opae. These species have fused pelvic fins and the musculature for climbing high vertical walls and inhabiting the upper stream reaches. Therefore, streams with terminal waterfalls may habor a lower diversity of native aquatic species than those without. On the other hand, terminal estuaries and pools downstream of waterfalls are known to carry a diversity of native species and are ideal spots for traditional gathering.

Irrigation ditches serve as lateral conduits between watersheds, which may contribute to the spread of both native and alien species. The Commission does not condone the release of ditch flows as the correct means of flow restoration, but rather have streamflow bypass the diversion structure and continue to flow downstream. However, streams may be used to convey diverted flow from one ditch to another, introducing alien species from one stream to another. Furthermore, overflow in the ditch could also introduce invasive species into the stream. The potential for introducing species from invasive-dominated terminal reaches to native-dominated mid- and headwater reaches is not a major problem in east Maui due to the presence of large waterfalls. Ford et. al. (2009) discussed how ditches may also be "sinks" where "larvae cannot reach the sea and/or where recruits may not survive to reproduce." This is especially the case when native amphidromous species inhabit waters upstream of the ditches. The location and types of diversion structure also affect the ability of ability of amphidromous species to migrate upstream.

Diversions have significantly reduced baseflows in the stream, limiting overall habitat for native species. While restoration of streamflow and increased connectivity could lead to the development of a richer and more native-dominated community in the stream, many other factors must also be considered in balancing the benefits of flow restoration to overall stream life versus providing water for agricultural and domestic uses. In addition to dewaterment, predation by native and non-native animals is also an important negative impact on the distribution on the native aquatic species. Some of the potentially harmful non-native species in east Maui include guppies, mosquitofish, swardtails, carp, oriental weatherfish (dojo), goldfish, Louisiana crayfish, apply snails (harmful to taro), and Asian clam (Ford et. al., 2009). In addition, the "aholehole are known to attack nests of goby eggs and may also consume returning post-larval gobies" (as cited in Ford et. al., 2009). Irrigation ditches may contribute to the spread of alien species; on the other hand, they aid in dispersing the native aquatic species, strengthing the overall population and continued survival of the native freshwater species.

Another factor that affects the distribution of native species is the condition of the streambed. Stream channels are often overgrown with alien grasses and shrubs. Vegetation along the stream bank has exposed roots that take up large amounts of water when sufficient flow is in the stream. Thus, during a high flow event, streams that are normally dry become only partially wetted because invasive plants and water thirst roots eventually absorb much of the water. In addition, fallen trees and other debris are found to block sections of the stream, which may reduce streamflow and even divert flow away from the main stream channel in the long term. Without proper maintenance of the streambed, restored streamflow in the upper elevations may not reach the ocean. Plans to rebuld healthy streambeds should be considered to help maximize the flow in the stream.

As stated in Ford et. al. (2009), the "synergistic effects of human alterations have led to a decline in the populations of native freshwater species statewide." Steamflow has also decreased over the past decade (see Section 3.4) and this has resulted, as generally believed, in less native stream species. While traditional gathering continues in east Maui, area residents are limited to certain areas with adequate streamflow to gather these resources (multiple residents in east Maui, personal communication, October 2008). Streams in east Maui are recognized as important habitats for native Hawaiian stream animals (Gingerich and Wolff, 2005). The maintenance, or restoration, of stream habitat requires an understanding of and the relationships among the various components that impact fish and wildlife habitat, and ultimately, the overall viability of a desired set of species. These components include, but are not limited to, species distribution and diversity, species abundance, predation and competition among native species, similar impacts by alien species, obstacles to migration, water quality, and streamflow.

The Commission does not intend to delve into the biological complexities of Hawaiian streams, but rather to present basic evidence that conveys the general health of the subject stream.

4.2 Brief Overview of Literature

The biological aspects of Hawaii's streams have an extensive history, and there is a wealth of knowledge that continues to grow and improve. Ford et al. (2009) provided a general summary of the existing literature on native stream ecology since 1960. The earlier studies focused on the life histories and population biology of native amphidromous species. During the period of 1970s to 1980s, "the *Awaous guamensis* and *Sicyopterus stimpsoni* were listed along with *Lentipes concolor* by both the American Fisheries Society and the IUCN Red List of Threatened and Endangered Species" based on limited distribution and data availability. In 1996, "the USFWS delisted *Lentipes concolor* as candidate endangered species in response to statewide stream surveys" that indicated healthy and stable populations of the species. More recent studies focused on biological organization at the community and ecosystem levels, reproductive ecology (as cited in Ford et al., 2009), and habitat availability (Gingerich and Wolff, 2005).

One of the earliest statewide stream assessments was undertaken by the Commission in cooperation with the National Park Service's Hawaii Cooperative Park Service Unit. The 1990 Hawaii Stream Assessment (HSA) brought together a wide range of stakeholders to research and evaluate numerous stream-related attributes (e.g., hydrology, diversions, gaging, channelizations, hydroelectric uses, special areas, etc.). The HSA specifically focused on the inventory and assessment of four resource categories: 1) aquatic; 2) riparian; 3) cultural; and 4) recreational. Though no fieldwork was conducted in its preparation, the HSA involved considerable research and analysis of existing studies and reports. The data were evaluated according to predefined criteria and each stream received one of five ranks (outstanding, substantial, moderate, limited, and unknown).

Due to the broad scope of the HSA's inventory and assessment, it continues to provide a valuable information base for the Commission's Stream Protection and Management Program and will continue to be referred to in various sections of this report. Unfortunately, the HSA did not assess Ohia Stream.

4.3 Analysis of Habitat Availability

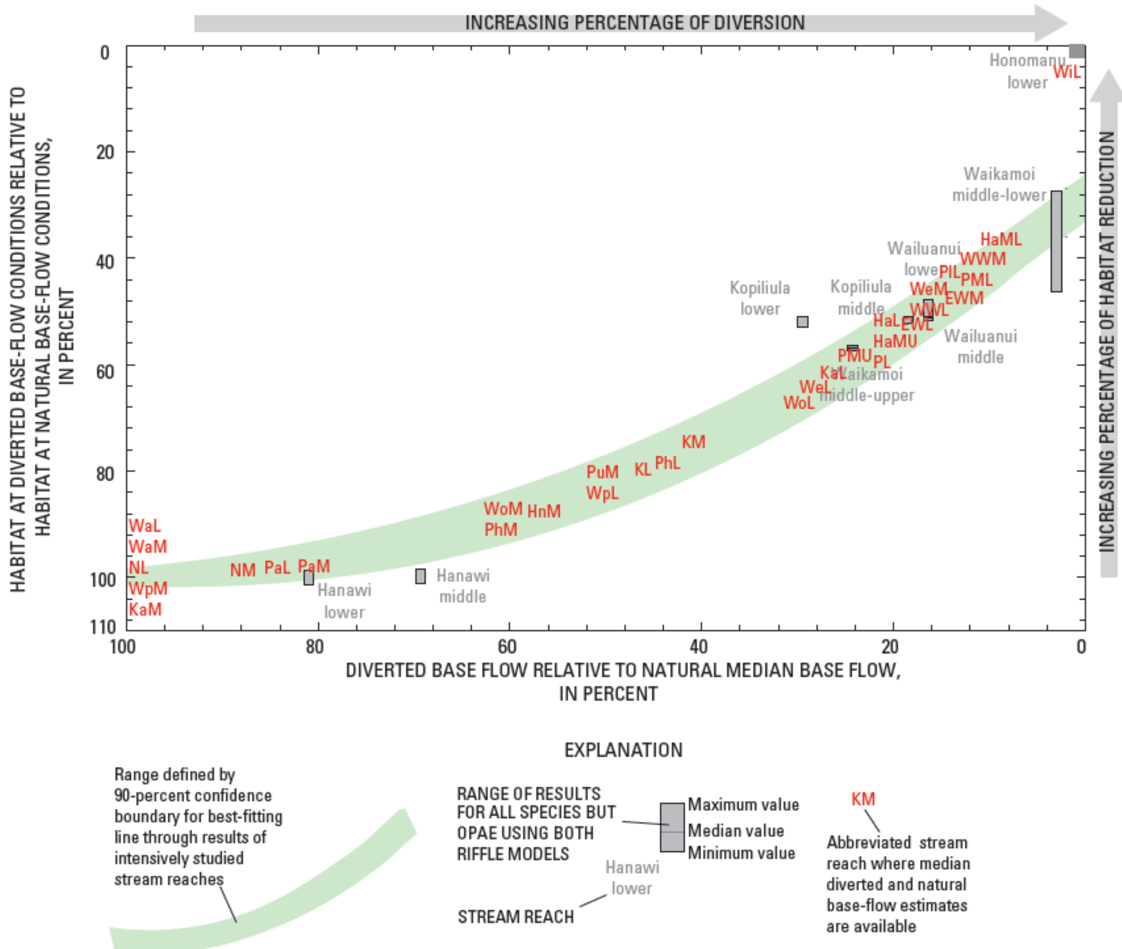
In cooperation with the Commission on Water Resource Management and others, the USGS conducted a study to assess the effects of surface water diversion systems on habitat availability for native stream species in northeast Maui. The goal was to determine a relationship between streamflow and habitat availability using a habitat selection model. Five out of 21 streams in the study area were selected for intensive study because they represented a range of hydrologic conditions (i.e., geograhic location, drainage area, terminal waterfall, estuary, human impacts, data availability, and access) present in the study area. By incorporating hydrology, stream morphology, and habitat characteristics, the model simulated habitat and streamflow relations for various species and life stages (Gingerich, 2005) in the 5 representative streams. Results of this habitat model, along with additional data from field reconnaissance surveys, aerial images, and GIS analyses, were extrapolated to estimate habitat availability in the remaining 16 streams. The outcome of the study was ultimately a map (Gingerich and Wolff, 2005, Plate 1) describing the habitat availability for native stream fauna in 21 streams in northeast Maui.

The study focused on certain native fish, snail and shrimp species found in Hawaiian streams. Three fish species of the Gobiidae family, also known as gobies, were considered: 1) alamoo (*Lentipes concolor* (Gill)); 2) nopili (*Sicyopterus stimpsoni* (Gill)); and 3) nakea (*Awaous guamensis* (Valenciennes)). The gobies of interest have a fused pelvic fin, allowing them to climb upstream. One of the fresh water snail species, *Neritina granosa* (Sowerby), commonly referred to as hihiwai, and the mountain shrimp, *Atyoida bisulcata* (Randall), also known as opae kalaole or mountain opae, were also considered in the study. Since opae and alamoo (adult and juvenile) do not typically live in the lower reaches, they were evaluated only in the middle and upper sites. The lower sites were evaluated for adult and juvenile nopili, adult nakea, and hihiwai.

Due to the limited data on streamflow (both diverted and natural conditions), the habitat availability for Ohia Stream cannot be determined. Nevertheless, results of the habitat simulation model for the other east Maui streams is summarized in Figure 4-2. The plot shows the relationship between diverted base flow (x-axis) and habitat availability (y-axis). The colored band indicates the range of values as defined by the 90 percent confidence level. If results from a particular site lie within this colored band, then there is only a 10 percent chance that the results will not be as predicted by the plot. In general, the plot shows that as base flow increases, the area of estimated usable streambed habitat for all interested species also increases. It also shows that "the addition of even a small amount of water to a relatively dry stream can have a significant effect on the amount of habitat available." For instance, when 20 percent of the natural base flow is returned to a dry reach, natural habitat availability increases to 60 percent. Estimates of expected habitat availability are representative for opae and alamoo upstream of large waterfalls.

Of the 70 miles of stream length within the study area, 36 miles have retained 75 to 100 percent of the natural habitat availability, 8 miles with 25 to 50 percent of the natural habitat, and 11 miles with no habitat at all because the stream reaches were dry (Table 4-3). Of the 36 miles with more than 75 percent natural habitat, 20 miles of the stream length were upstream from major diversion ditches. Figure 4-3 describes the habitat availability for Ohia Stream. As previously stated, information was insufficient to characterize the habitat availability of Ohia Stream.

Figure 4-2. Relative habitat available for given relative base flow at studied streams. Relative change is the difference between natural and diverted conditions divided by natural conditions (Gingerich and Wolff, 2005).



ABBREVIATIONS

EW East Wailuaiki
Ha Haipuaena
Hn Honomanu
Hw Hanawi
K Kapaula
Ka Kolea
N Nuaailua
P Puohokamoa
Pa Paakea
Ph Palauhulu
Pl Punalau
Pu Puakaa
Wa Waiaaka
We Waiohue
Wi Waikamoi
Wo Waiokomilo
Wp Wahinepee
WW West Wailuaiki

M middle L lower

Table 4-2. Summary of estimated aquatic habitat distribution at diverted base flow relative to natural conditions, calculated using GIS from Gingerich and Wolff (2005).

Habitat Availability	Stream Length (miles)
100 percent (no reduction)	26
75 to 100 percent	10
50 to 100 percent	10
25 to 50 percent	8
0 percent (dry)	11
Insufficient Information	5
Total *	70

* The total linear miles of stream length differs from that presented in Ford et al. (2009) probably due to differences in digitization of the stream reaches from Gingerich and Wolff (2005), Plate 1.

4.4 Distribution of Native Freshwater Species

The HSA inventory was general in nature, resulting in major data gaps, especially those related to the distribution and abundance of aquatic organisms – native and introduced – inhabiting the streams. The State of Hawaii Division of Aquatic Resources (DAR) has since continued to expand the knowledge of aquatic biota in Hawaiian streams. Products from their efforts include the compilation and publication of an *Atlas of Hawaiian Watersheds and Their Aquatic Resources* for each of five major islands in the state (Kauai, Hawaii, Oahu, Molokai, and Maui). Each atlas describes watershed and stream features, distribution and abundance of stream animals and insect species, and stream habitat use and availability. Based on these data, a watershed and biological rating is assigned to each stream to allow comparison with other streams on the same island and across the state. The data presented in the atlases are collected from various sources, and much of the stream biota data are from stream surveys conducted by DAR. Currently, efforts have been focused on updating the atlases with more recent stream survey data collected statewide, and developing up-to-date reports for Commission use in determining the interim IFS recommendations for east Maui. The following is a brief summary of findings for Ohia Stream.

- **Point Quadrat Survey.** Native oopu alamoo (*Lentipes concolor*), opae kalaole (*Atyoida bisulcata*), and hihiwai (*Neritina granosa*) were observed in Ohia Stream. During the more recent surveys, the oopu alamoo and opae kalaole were observed in the middle reach. Introduced species such as guppies (*Poecilia reticulata*) and river prawns (*Macrobrachium lar*) were observed in the stream as well. The poeciliid fishes dwell in the deep pools created above diversion structures and are known to transmit parasites to native fishes.

- **Insect Survey.** No insect survey was conducted in Ohia Stream.

- **Watershed and Biological Rating.** Ohia watershed rates below average (score of 4 out of 10) for Maui and statewide. A combination of small watershed size, moderate rainfall amounts, and no stream reach diversity contribute to the low rating of this watershed. The stream rates average (score of 5 out of 10) on biota due to the limited number of native species observed in the stream.

Overall, Ohia Stream had excellent instream habitat for native species due to the spring input at the head of the watershed. The limited diversity of native species observed in the stream may be a result of the heavy vegetation (i.e., hau) blocking streamflow. Removal of the vegetation in the stream to allow for continuous flow would help to improve the recruitment and migration of juvenile species, as well as the diversity of stream animals.

The SWCA Environmental Consultants, at the request of Hawaiian Commercial and Sugar Company, conducted a literature review of the existing data collected by DAR, USGS, and other investigators (Ford et. al., 2009). The objective of this document was to present biological information that may help the Commission in determining reasonable and beneficial instream and offstream uses of the surface water in east Maui. The authors stressed that no data exists to suggest "any of the nine native Hawaiian amphidromous species is at risk of either endangerment and/or extinction in east maui streams or else where in the State", and that dry reaches in diverted streams are periodically wetted by freshets, allowing streamflow continuity and the upstream migration of native species. On the other hand, there is no proof that continued habitat degradation in some of the streams due to dewaterment will not affect species survival (PR-2009-18, 85.0). Other investigators have reported that "hihiwai were limited to about 185 meters and 223 meters in the lower reaches of Waiohue and Waikolu Streams [Maui], respectively…and suggested this was due to the effect of dewaterment on habitat availability" (as cited in Ford et. al., 2009). It was also important to note that frequent changes in stream community structure, such as a change in the streambed composition due to a high flow event, that may result in absence of native stream animals should not be interpreted as a negative indicator of stream health.

Results of the studies analyzed by SWCA Environmental Consultants are presented in the following tables. The consultant summarized data mainly from the USGS habitat availability study (Gingerich and Wolff, 2005) and DAR's Atlas of Hawaiian Watersheds and Their Aquatic Resources. Please note that Commission staff is awaiting updated data from DAR and will supplement the following tables with new data. Only the hihiwai was present in Ohia Stream and it was observed in the lower reach of the stream channel (Tables 4-3 and 4-4). Since Ohia Stream is not a heavily diverted stream, dewaterment does not explain the absence of other native amphidromous species in the stream. Based on available water quality data (see Chapter 10), Ohia Stream is listed as category 5 as having one or more designated use non-attainments or water quality impairment. Trash was recorded as one of the other pollutants in the stream. Thus, the limited number of native aquatic species in the stream could be attributed to poor water quality.

Table 4-3. Known distribution of amphidromous species in east Maui streams (Ford et. al., 2009, Table 3).

[X = present; ND = no data]

East Maui Streams (T) = terminal falls	*Kuhlia spp.*	*Eleotris* sandwicensis	*Stenogobius hawaiiensis*	*Awaous guamensis*	*Sicyopterus stimpsoni*	*Lentipes concolor*	*Neritina granosa*	*Neritina vespertinus*	*Macrobrachium lar (Alien amphidromous)*	*Macrobrachium grandimanus*	*Atyoida bisulcata*
Honopou		X		X	X	X			X	X	X
Hanehoi											X
Kolea (T)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Waikamoi (T)									X		X
Wahinepe'e (T)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Haipua'ena (T)						X			X		X
Puohokamoa				X		X			X		X
Punalau				X	X	X			X		
Honomanū											X
Nua'ailua				X	X	X	X	X	X		X
Palauhulu/Pi'ina'au	X	X	X	X	X	X	X	X	X	X	X
'Ohia							X				
Waiokamilo (T)				X					X		X
Wailua Nui	X	X		X		X			X		X
W. Wailua Iki	X			X		X	X		X		X
E. Wailua Iki	X	X		X		X	X		X		X
Kopiliula	X	X		X	X	X	X		X		X
Waiohue	X	X	X	X	X	X	X	X	X	X	X
Pa'akea (T)				X		X	X		X		X
Kapaula											X
Hanawī	X	X	X	X	X	X	X		X		X
Makapipi	X	X		X	X	X			X		X

Table 4-4. Distribution of amphidromous species in lower, middle, and upper reaches of east Maui streams within the USGS stydt area summarized from USGS and DAR sources. (Source: Ford et. al., 2009, Table 4)

STREAM	Number of Amphidromous Species Reported			Terminal Waterfall	Number of Non-Native Species Reported
	Lower	Middle*	Upper**		
Kolea	ND	ND	ND	√	ND
Waikamoi		1	2	√	5
Waikamoi – Alo***			1		
Wahinepe'e	ND	ND	ND	√	ND
Puohokamoa	4	3	2		1
Haipua'ena	1	3	1	√	4
Punalau	2	1	1		2
Honomanu	1		1		
Nua'ailua	6	5	2		2
Pi'ina'au / Palauhulu	10	6	4		9
'Ōhi'a	1				
Waiokamilo		2	2	√	8
Wailuanui	10	6	5		5
West Wailuaiki	4	4	1		7
East Wailuaiki	5	2	1		1
Kopiliula / Puaka'a	4	7	6		3
Waiohue	10	5	4		2
Pa'akea	5	2	1	√	1
Waia'aka	ND	ND	ND		
Kapā'ula			1		
Hanawi	7	7	2		2
Makapipi	4	5	2		6

Key to Table:

ND = no data

* Above diversion structures in some reaches

** Above diversion structures

*** Waikamoi and its tributary Alo are counted as one stream.

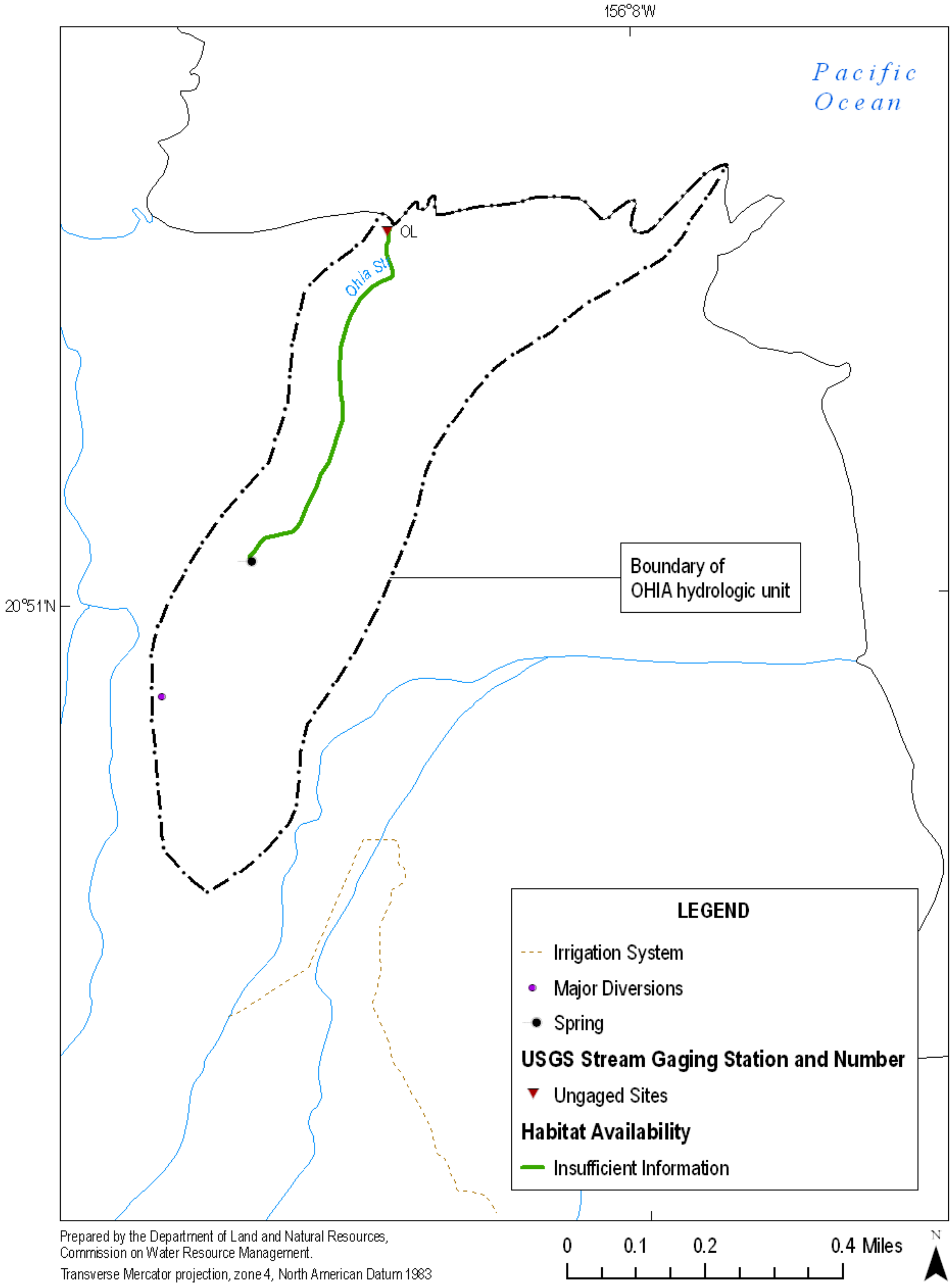
4.5 Other Critical Habitats

Another important consideration of fish and wildlife habitat is the presence of critical habitat. Under the Endangered Species Act, the U.S. Fish and Wildlife Service is responsible for designating critical habitat for threatened and endangered species. Though there are very few threatened or endangered Hawaiian species that are directly impacted by streamflow (e.g., Newcomb's snail), the availability of surface water may still have indirect consequences for other species. Based upon current designations, there are no known critical habitat areas for fish and wildlife associated with Ohia Stream.

In addition to critical habitat, the presence of native bird habitat should not be overlooked. Bird habitat ranges from urban environments and grasslands, to wetlands and native rainforests. Within these habitat ranges, streams provide an important source of food and water for native birds. Springs flow into loi and fishponds where native waterbirds, such as the *aukuu* (black-crowned night-heron) and the *koloa* (Hawaiian duck), search for food and locations to build a nest for their young. Streams are also valuable indicators of forest health. Since the headwaters of streams typically originate from forested areas, a forest with dense vegetation, especially along the stream bank would help prevent erosion, thus yielding cleaner fresh water for fish and wildlife as well as water demands in the lowland areas.

A diversity of native birds can be found in east Maui. Some of the notable species found in Haleakala National Park include the Hawaii (Dark-rumped) Petrel, *Nene* (Hawaiian Goose), and Common *Amakihi* (Pratt, 1993). Within Waikamoi Preserve and the northeast slope of Haleakala above 4,000 feet, the species found are the Maui Parrotbill, Maui Creeper, and *Akohekohe* (Crested Honeycreeper). The *Iiwi*, Red-billed Leiothrix, and *Apapane* are more common in Waikamoi Preserve. The U.S. Fish and Wildlife Service (n.d.) estimated the habitat ranges for native Hawaiian forest birds based on vegetation boundaries. Since Ohia is located in the lower slopes where there are no forest preserves or reserve, no known native forest bird habitats exists in the hydrologic unit.

Figure 4-3. Estimated habitat availability in Ohia hydrologic unit (Source: Gingerich and Wolff, 2005; USGS, 2001b).



5.0 Outdoor Recreational Activities

Water-related recreation is an integral part of life in Hawaii. Though beaches may attract more users, the value of maintaining streamflow is important to sustaining recreational opportunities for residents and tourists alike. Streams are often utilized for water-based activities, such as boating, fishing, and swimming, while offering added value to land-based activities such as camping, hiking, and hunting. Growing attention to environmental issues worldwide has increased awareness of stream and watershed protection and expanded opportunities for the study of nature; however, this must be weighed in conjunction with the growth of the eco-tourism industry and the burdens that are placed on Hawaii's natural resources.

The State of Hawaii Department of Health (DOH) maintains water quality standards (HAR 11-54) for recreational areas in inland recreational waters based on the geo-mean of *Enterococcus*, a fecal indicator: 33 colony-forming units per 100 mL of water or a single-sample maximum of 89 colonies per 100 mL. This is for full-body contact (swimming, jumping off cliffs, etc.). If *Enterococcus* exceeds those values, the water body is considered to be impaired. DOH also has a standing advisory for *Leptospirosis* in all freshwater streams. The marine recreational zone, which extends from the shoreline seaward to 1,000 feet from shore, requires an *Enterococci* geo-mean of less than 7 colony-forming units per 100 mL of water, to protect human health.

The recreational resources of Ohia Stream were classified as "substantial" by the HSA's regional recreation committee. The HSA identified opportunities for fishing and scenic views related to Ohia, and only scenic views was considered to be a high-quality experience (National Park Service, Hawaii Cooperative Park Service Unit, 1990) (Table 5-1).

Table 5-1. Hawaii Stream Assessment survey of recreational opportunities by type of experience.

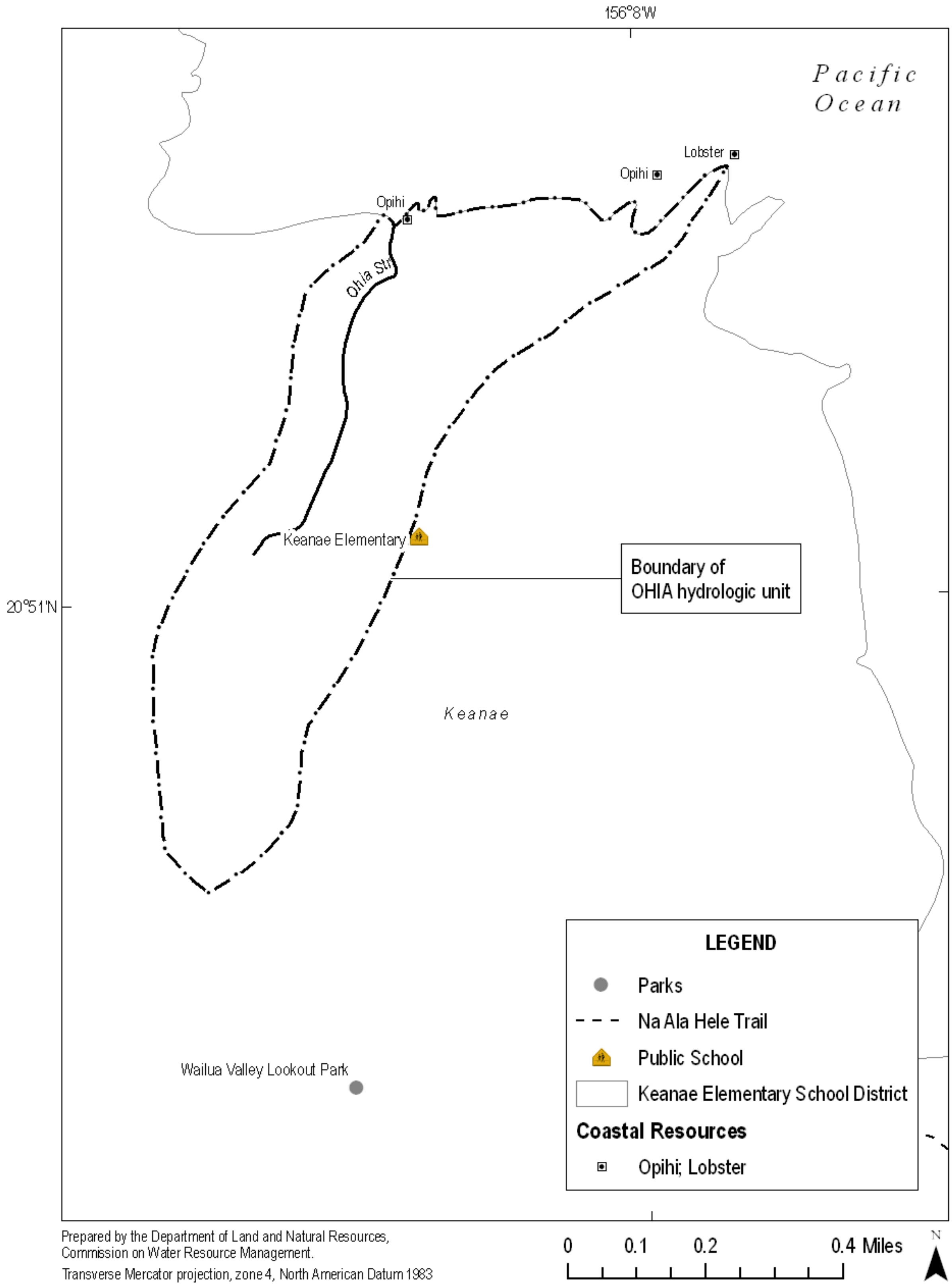
	Urban		Country		Semi-Natural		Natural	
	Norm	High	Norm	High	Norm	High	Norm	High
Camping								
Hiking								
Fishing			■					
Hunting								
Swimming								
Boating								
Parks								
	Trail		Road		Ocean		Air	
Scenic Views						■		
	Educational		Botanical					
Nature Study								

According to public hunting data, Hunting Unit B on the island of Maui consists of portions of the Koolau Forest Reserve. The hydrologic unit of Ohia does not lie within a hunting area unit.
Since changes to streamflow and stream configurations have raised concerns regarding their impact to on-shore and near-shore activities, the Commission attempted to identify these various activities in relation to Ohia Stream. A 1981 Maui Resource Atlas, prepared by the State of Hawaii Department of Transportation's Harbors Division, inventoried coral reefs and coastal recreational activities. Looking at available GIS data, the Commission identified opihi picking and lobster fishing to occur at Ohia (Figure 5-1).

Another element of recreation is the unique educational opportunities that streams provide for nature study. One way to approach this is to identify established study sites or nature centers that offer structured learning programs. In lieu of that, the Commission considered available GIS data to identify schools in proximity to Ohia Stream that may utilize the stream as part of its curriculum. Keanae Elementary School, established in 1915, is the only public education facility in the area and is roughly 0.18 mile east of Ohia Stream, and is in fact in closer proximity to Waiokamilo Stream (State of Hawaii, Department of Education, 2008) in a different hydrologic unit. However, Keanae Elementary was closed in 2005, for the time being, due to a lack of students. Local area students must now attend Hana High and Elementary (San Nicolas, 2005).

See Figure 5-1 for the locations of various recreation-related points of interest. It is important to note that the recreational activities are not limited to the ocean as the figure may suggest. The stream and the surrounding areas are also used for recreational purposes (e.g., hiking, swimming).

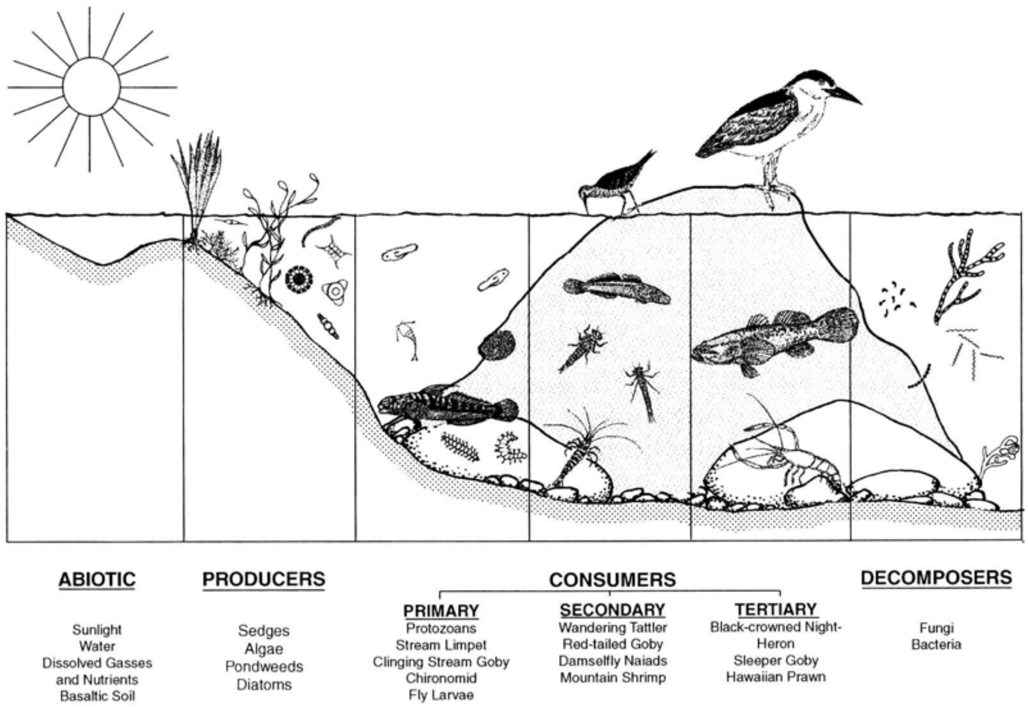
Figure 5-1. Recreational points of interest for Ohia hydrologic unit (Source: State of Hawaii, Office of Planning, 1999, 2002a; 2002c; 2002d; 2004a; USGS, 2001b).



6.0 Maintenance of Ecosystems

An ecosystem can be generally defined as the complex interrelationships of living (biotic) organisms and nonliving (abiotic) environmental components functioning as a particular ecological unit. Depending upon consideration of scale, there may be a number of ecosystem types that occur along a given stream such as estuaries, wetlands, and stream vegetation, according to the State Water Code. Figure 6-1 provides a simplified ecosystem represented in a Hawaiian stream. The entire hydrologic unit, as it relates to hydrologic functions of the stream, could also be considered an ecosystem in a very broad context.

Figure 6-1. Simplified ecosystem illustrated in a Hawaiian stream. (Source: Ziegler, 2002, illustration by Keith Kruger).



The Hawaiian resource-use concept of ahupuaa is closely related to the Western concepts of ecosystem maintenance. Native Hawaiians generally utilized natural resources within the limits of their ahupuaa; therefore, it was important to manage and conserve the resources within their living unit. Likewise, watershed resources must be properly managed and conserved to sustain the health of the stream and the instream uses that are dependent upon it.

The riparian resources of Ohia Stream were not classified by the HSA (National Park Service, Hawaii Cooperative Park Service Unit, 1990). The HSA ranked the streams according to a scoring system using six of the seven variables presented in Table 6-1. Detrimental organisms were not considered in the final ranking; however, their presence and abundance are considerable ecosystem variables.

Table 6-1. Hawaii Stream Assessment indicators of riparian resources for Ohia Stream.

Category	Value
Listed threatened and endangered species: These species are generally dependent upon undisturbed habitat. Their presence is, therefore an indication of the integrity of the native vegetation. The presence of these species along a stream course was considered to be a positive attribute; with the more types of threatened and endangered species associated with a stream the higher the value of the resource. Only federally listed threatened or endangered forest or water birds that have been extensively documented within the last 15 years were included.	None
Recovery habitat: Recovery habitat consists of those areas identified by the USFWS and DLNR as essential habitat for the recovery of threatened and endangered species. Streams that have recovery habitat anywhere along their length were included.	None
Other rare organisms and communities: Many species that are candidates for endangered or threatened status have not been processed through all of the requirements of the Endangered Species Act. Also a number of plant communities associated with streams have become extremely rare. These rare organisms and communities were considered to be as indicative of natural Hawaiian biological processes as are listed threatened and endangered species.	None
Protected areas: The riparian resources of streams that pass through natural area reserves, refuges and other protected areas are accorded special protection from degradation. Protected areas were so designated because of features other than their riparian resources. The presence of these areas along a stream, however, indicates that native processes are promoted and alien influences controlled.	None
Wetlands: Wetlands are important riparian resources. They provide habitat for many species and are often important nursery areas. Because they are often extensive areas of flat land generally with deep soil, many have been drained and converted to agricultural or urban uses. Those that remain are, therefore, invaluable as well as being indicators of lack of disturbance.	None
Native forest: The proportion of a stream course flowing through native forest provides an indication of the potential "naturalness" of the quality of a stream's watershed; the greater the percentage of a stream flowing through native forest most of which is protected in forest reserves the more significant the resource. Only the length of the main course of a stream (to the nearest 10 percent) that passes through native forest was recorded.	0%
Detrimental organisms: Some animals and plants have a negative influence on streams. Wild animals (e.g., pigs, goats, deer) destroy vegetation, open forests, accelerate soil erosion, and contaminate the water with fecal material. Weedy plants can dramatically alter the nature of a stream generally by impeding water flow. Three species, California grass, hau, and red mangrove, are considered to have the greatest influence. The presence of any of these animals or plants along a stream course was considered a potentially negative factor, while the degree of detriment is dependent on the number of species present.	1 (Pigs)

For the purpose of this section, management areas are those locales that have been identified by federal, state, county, or private entities as having natural or cultural resources of particular value. The result of various government programs and privately-funded initiatives has been a wide assortment of management areas with often common goals. Such designated areas include forest reserves, private preserves, natural area reserves, wildlife sanctuaries, national parks, historic landmarks, and so on. In Ohia, about 2 percent of the unit lies within the Pauwalu Point Wildlife Sanctuary (Table 6-2).

Table 6-2. Management areas located within Ohia hydrologic unit. (Source: State of Hawaii, Division of Forestry and Wildlife, 2008a; State of Hawaii, Office of Planning, 2007b).

Management Area	Managed by	Area (mi^2)	Percent of Unit
Pauwalu Point Wildlife Sanctuary	State Division of Forestry and Wildlife	< 0.01	1.8
The Pauwalu Point Wildlife Sanctuary, managed by DLNR's Division of Forestry and Wildlife, encompasses nearly 11 acres (0.02 sq. mi.) and includes Pauwalu Point and the offshore islets of Mokuhala, Mokumana, and Manahoa (Rock). This sanctuary has been identified by the USFWS as an area for waterbird recovery.			

In addition to the individual management areas outlined above, Watershed Partnerships are another valuable component of ecosystem maintenance. Watershed Partnerships are voluntary alliances between public and private landowners who are committed to responsible management, protection, and enhancement of their forested watershed lands. There are currently nine partnerships established statewide, three of which are on Maui. Table 6-3 provides a summary of the partnership area, partners, and management goals of the East Maui Watershed Partnership.

Table 6-3. Watershed partnerships associated with Ohia hydrologic unit. (Source: State of Hawaii, Division of Forestry and Wildlife, 2008b; East Maui Watershed Partnership, 1993).

Management Area	Year Established	Total Area (mi^2)	Area (mi^2)	Percent of Unit
East Maui Watershed Partnership	1991	186.73	0.10	35.2
The East Maui Watershed Partnership (EMWP) is comprised of the County of Maui, State Department of Land and Natural Resources, East Maui Irrigation Co. Ltd., Haleakala National Park, Haleakala Ranch Company, Keola Hana Maui, Inc. (Hana Ranch Company), and The Nature Conservancy. The management priorities of the EMWP include: 1) Watershed resource monitoring; 2) Animal control; 3) Weed control; 4) Management infrastructure; and 5) Public education and awareness programs. The EMWP has conducted various projects including the construction of over seven miles of fence construction and on-going fence maintenance, the survey and removal of invasive plant species, eradication of animal species through an expanded hunting program, implementation of runoff and stream protection measures, water quality monitoring, and extensive public education and outreach campaigns.				

In 1974, the U.S. Fish and Wildlife Service (USFWS) initiated a National Wetlands Inventory that was considerably broader in scope than an earlier 1954 inventory that had focused solely on valuable waterfowl habitat. The inventory for Hawaii was completed in 1978 and utilized a hierarchical structure in the classification of various lands. The USFWS defines wetlands as "lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water" (Cowardin et al., 1979). There are no palustrine wetlands in the Ohia hydrologic unit. The entire unit has a low concentration of threatened and endangered plant species (Figure 6-2).

A current working paper is being developed by the University of Hawaii's Economic Research Organization (UHERO), entitled *Environmental Valuation and the Hawaiian Economy*, which discusses the use of existing measures of economic performance and alternative statistical devices to provide an economic valuation of threatened environmental resources. The paper focuses on the Koolau, Oahu watershed and illustrates three categories of positive natural capital (forest resources, shoreline resources, and water resources) against a fourth category (alien species) that degrades natural capital. In the case of the Oahu Koolau forests, a benchmark level of degradation is first defined for comparison against the current value of the Oahu Koolau system. The Oahu Koolau case study considers a hypothetical major disturbance caused by a substantial increased population of pigs with a major forest conversion from native trees to the non-indigenous Miconia (*Miconia calvescens*), along with the continued "creep" of urban areas into the upper watershed (Kaiser, B. et al., n.d.).

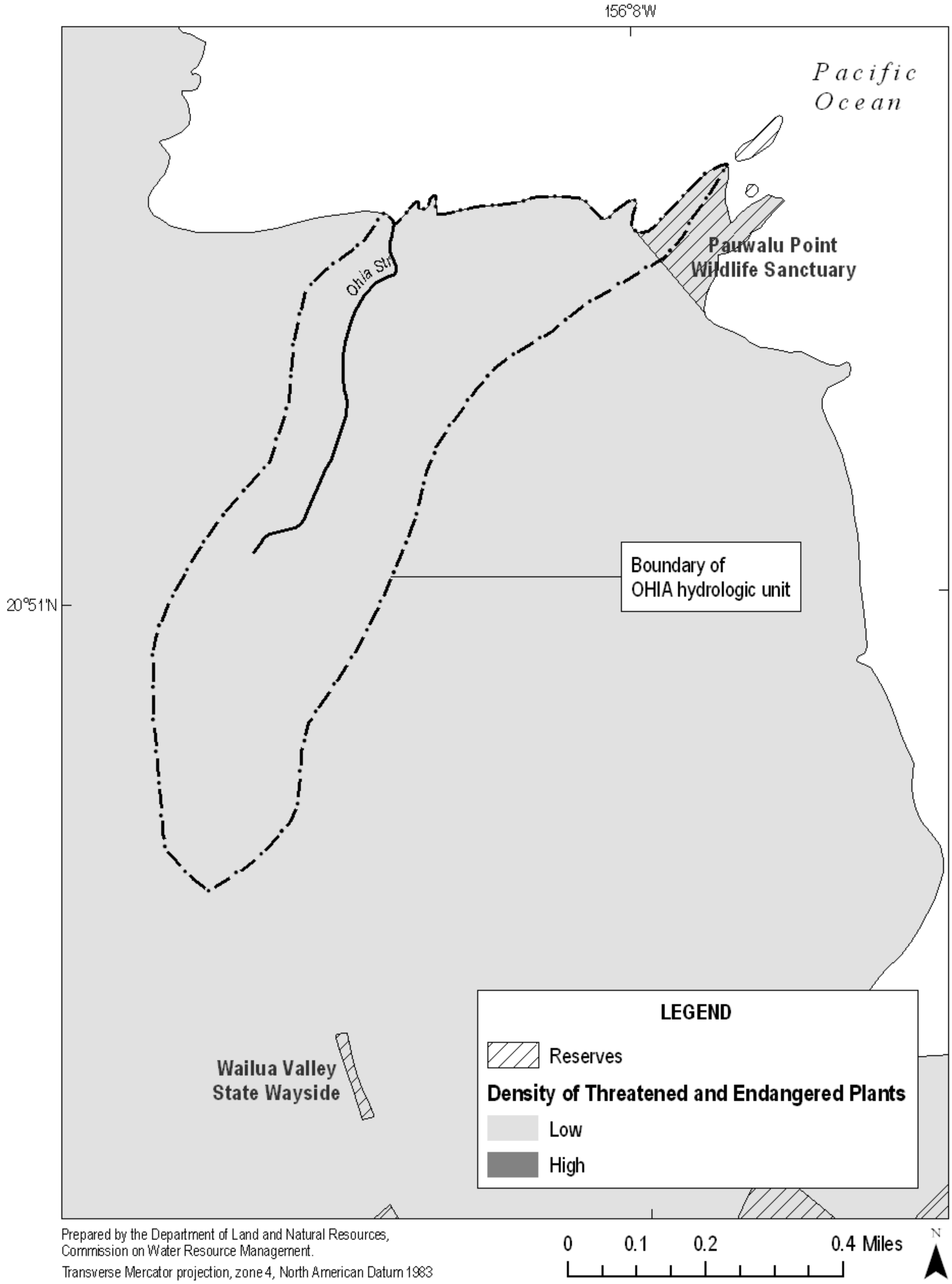
Recognizing that in the United States, the incorporation of environmental and natural resource considerations into economic measures is still very limited, the paper provides the estimated Net Present Value (NPV) for "Koolau [Oahu] Forest Amenities." These values are presented in Table 6-4.

Table 6-4. Estimated Net Present Value (NPV) for Koolau (Oahu) Forest Amenities (Source: Kaiser, B. et al., n.d.).

Amenity	Estimated Net Present Value (NPV)	Important limitations
Ground water quantity	$4.57 to $8.52 billion NPV	Optimal extraction assumed.
Water quality	$83.7 to $394 million NPV	Using averted dredging cost estimates.
In-stream uses	$82.4 to $242.4 million NPV	Contingent valuation estimate for a single small fish species.
Species habitat	$487 to $1,434 million NPV	Contingent valuation estimate for a single small bird species.
Biodiversity	$660,000 to $5.5 million NPV	Average cost of listing 11 species in Koolaus.
Subsistence	$34.7 to $131 million NPV	Based on replacement value of pigs hunted.
Hunting	$62.8 to $237 million NPV	Based on fraction of hunting expenditures in state. Does not include damages from pigs to the other amenities.
Aesthetic values	$1.04 to $3.07 million NPV	Contingent valuation; Households value open space for aesthetic reasons.
Commercial harvests	$600,000 to $2.4 million NPV	Based on small sustainable extraction of koa.
Ecotourism	$1.0 to $2.98 billion NPV	Based on fraction of direct revenues to ecotourism activities.
Climate control	$82.2 million	Based on replacement costs of contribution of all tropical forests to carbon sequestration.
Estimated value of joint services:	**$7.444 to $14.032 billion**	

Following upon the results of the Oahu Koolau case study, the paper provides a brief comparison with the east Maui forests, noting the particular importance of the east Maui watershed as the single largest source of surface water in the state, home to some of the most intact and extensive native forests left in Hawaii, along with having the State's largest concentration of endangered forest birds. In both cases, the Oahu Koolaus and east Maui, the most valuable aspects of the forested areas are believed to be ecotourism, aesthetic pleasure, species habitat, water quality, and water quantity. Both regions are roughly the same size; however, the east Maui forests may have greater value due to greater species diversity and native habitat, and the County of Maui's dependence upon surface water as a drinking water source (water quality) (Kaiser, B. et al., n.d.).

Figure 6-2. Reserves and wetlands for the Ohia hydrologic unit (Source: State of Hawaii, Office of Planning, 2003; 2007b; USGS, 2001b).



7.0 Aesthetic Values

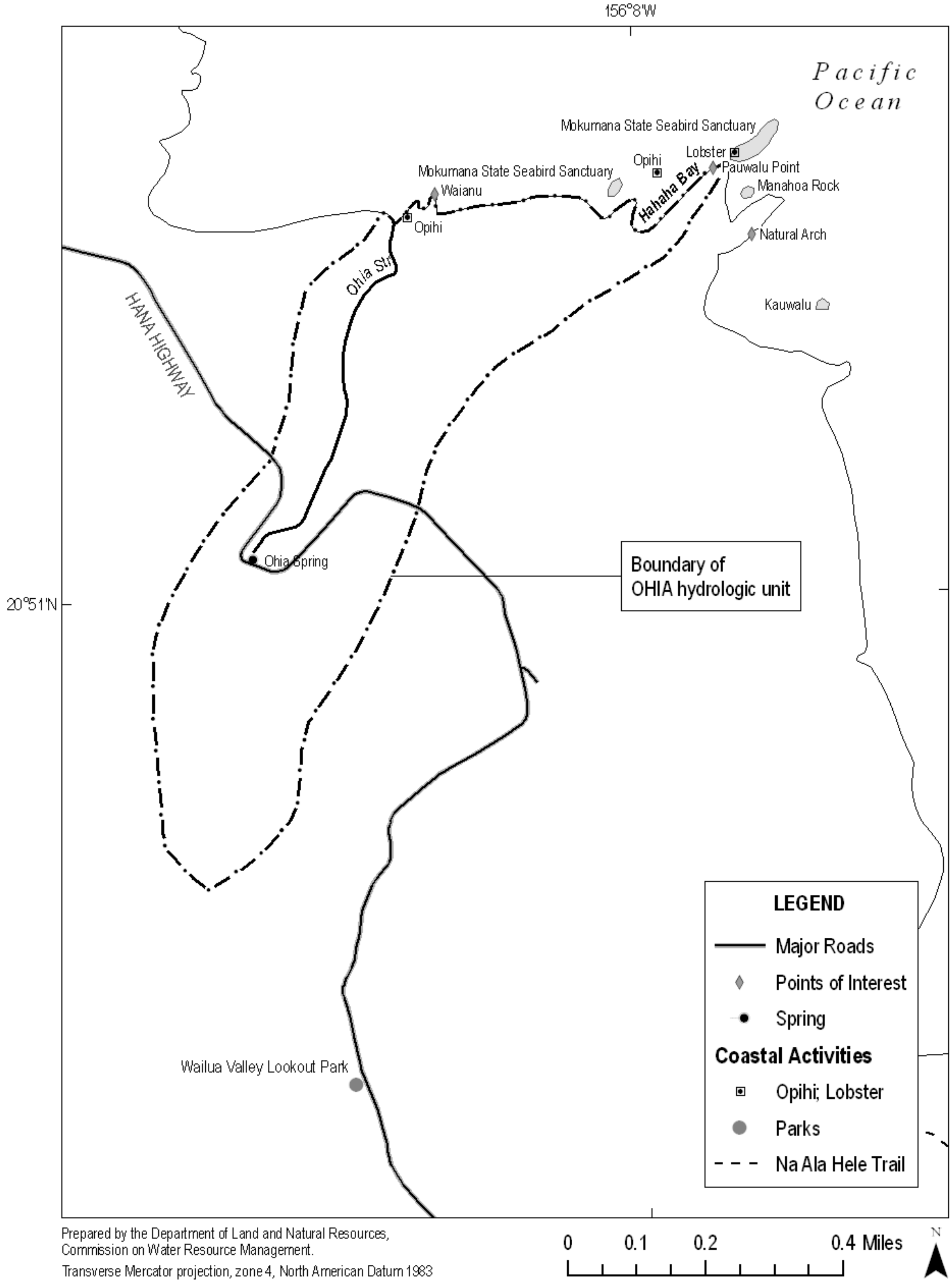
Aesthetics is a multi-sensory experience related to an individual's perception of beauty. Since aesthetics by definition is a subjective observation, a stream's aesthetic value cannot be determined quantitatively (Wilson Okamoto & Associates, Inc., 1983). However, there are certain elements, either within or surrounding a stream, which appeal to an observer's visual and auditory senses, such as waterfalls and cascading plunge pools. Several assumptions were made in identifying the elements that give Ohia Stream a particular aesthetic quality.

Ohia Stream is only 0.6 miles in length that is fed by Ohia Spring near Hana Highway. The stream is surrounded by mainly alien forests with scattered native Ohia forests and Uluhe shrub lands. The hydrologic unit of Ohia does not lie within any forest reserve or preserve. The east end of the hydrologic unit is Pauwlau Point, which offers great views of the Hahaha Bay, and two islets of the Mokumana State Seabird Sanctuary (Figure 7-1).

In a 2007 Hawaii State Parks Survey, released by the Hawaii Tourism Authority (OmniTrak Group Inc., 2007), scenic views accounted for 21 percent of the park visits statewide, though that was a decrease from 25 percent in a 2003 survey. Other aesthetic-related motivations include viewing famous landmarks (9 percent), hiking trails and walks (7 percent), guided tour stops (6 percent), and viewing of flora and fauna (2 percent). On the island of Maui, visitors' preference to visit state parks for scenic views (26 percent) was second only to uses for outings with family and friends (29 percent). In comparison, residents primarily used state parks for ocean/water activities (30 percent), followed by outings with friends and family (28 percent), and then scenic views (9 percent). Overall, Maui residents were very satisfied with scenic views giving a score of 9.7 (on a scale of 1 to 10, with 10 being outstanding), with out-of-state visitors giving a score of 9.3. The scenic Hana Highway route to Hana town is a popular tourist attraction (PR-2009-18, 85.0), in which visitors take photos of waterfalls and the valley where the stream crosses Hana Highway.

While a limited number of studies analyze the value of a free flowing stream, a stream that has mauka to maki flow could have direct economic benefits to the State and to the public. According to a Maui resident (PR-2009-18, 85.0), several Maui eco-tour companies are willing to pay the state $5 for each person that is allowed to enter and view one of the streams in west Maui that has mauka to makai flow. The State would potentially collect $60,000 a year for 12,000 participants.

Figure 7-1. Aesthetic points of interest for the Ohia hydrologic unit (Source: USGS, 1996; 2001b).



8.0 Navigation

The State Water Code, Chapter 174C, HRS, includes navigation as one of nine identified instream uses; however, it fails to further define navigation. Navigational water use is largely defined as water utilized for commercial, and sometimes recreational, transportation. In the continental United States, this includes water used to lift a vessel in a lock or to maintain a navigable channel level. Under the provisions of the Clean Water Act, navigable waters also include wetlands (State of Nevada, Department of Conservation and Natural Resources, Division of Water Resources, n.d.).

Hawaii streams are generally too short and steep to support navigable uses. If recreational boating (primarily kayaks and small boats) is included under the definition of navigation, then there are only a handful of streams statewide that actually support recreational boating and even fewer that support commercial boating operations. Kauai's Wailua River is the only fresh water waterway where large boat commercial operations exist, and no streams are believed to serve as a means for the commercial transportation of goods.

The hydrologic unit of Ohia is not known to support any instream uses of navigation.

9.0 Instream Hydropower Generation

The generation of hydropower is typically accomplished through instream dams and power generators; however, the relatively short lengths and flashy nature of Hawaii's streams often require water to be diverted to offstream power generators. In these "run-of-river" (i.e., utilizes water flow without dams or reservoirs) designs, water is diverted through a series of ditches, pipes, and penstocks to the powerplant, and then returned to the stream. Some designs call for the powerplant to be situated such that the drop of water level (head) exiting the plant can be sent to fields for crop irrigation.

Considering the definition of instream hydropower generation, there are no known true instream hydropower systems located on Ohia Stream, nor has the potential for hydropower generation been identified in previous reports (W.A. Hirai & Associates, Inc., 1981).

10.0 Maintenance of Water Quality

The maintenance of water quality is important due to its direct impact upon the maintenance of other instream uses such as fish and wildlife habitat, outdoor recreation, ecosystems, aesthetics, and traditional and customary Hawaiian rights. There are several factors that affect a stream's water quality, including physical, chemical, and biological attributes. The State of Hawaii Department of Health (DOH) is responsible for water quality management duties statewide. The DOH Environmental Health Administration oversees the collection, assessment, and reporting of numerous water quality parameters in three high-priority categories:

- Possible presence of water-borne human pathogens;
- Long-term physical, chemical and biological components of inland, coastal, and oceanic waters; and
- Watershed use-attainment assessments, identification of sources of contamination, allocation of those contributing sources, and implementation of pollution control actions.

The Environmental Health Administration is also responsible for regulating discharges into State waters, through permits and enforcement actions. Examples include federal National Pollutant Discharge Elimination System (NPDES) permits for storm water, and discharge of treated effluent from wastewater treatment plants into the ocean or injection wells.

Sediment and temperature are among the primary physical constituents of water quality evaluations. They are directly impacted by the amount of water in a stream. The reduction of streamflow often results in increased water temperatures, whereas higher flows can aid in quickly diluting stream contamination events. According to a book published by the Instream Flow Council, "[w]ater temperature is one of the most important environmental factors in flowing water, affecting all forms of aquatic life (Amear et al, 2004)." While this statement is true for continental rivers, fish in Hawaii are similar, but their main requirement is flowing water. Surface water temperatures may fluctuate in response to seasonal and diurnal variations, but only a few degrees Celsius in natural streams, mainly because streams in Hawaii are so short. However, temperatures in streams with concrete-lined channels, and dewatered streams, may fluctuate widely due to the vertical solar contact. Surface water temperatures may also fluctuate widely due to water column depth, channel substrate, presence of riparian vegetation, and ground water influx. Surface water also differs considerably from ground water, generally exhibiting lower concentrations of total dissolved solids, chlorides, and other major ions, along with higher concentrations of suspended solids, turbidity, microorganisms, and organic forms of nutrients (Lau and Mink, 2006). Findings of a 2004 USGS National Water Quality Assessment (NAWQA) Program report identified land use, storm-related runoff, and ground water inflow as major contributors of surface water contaminants (Anthony, S.S. et al., 2004).

Water body types can be freshwater, marine, or brackish. They can be further delineated as inland fresh waters, estuaries, embayments, open coastal waters, and oceanic waters (HAR 11-54-5 to 11-54-6). Each water body type has its own numeric criteria for State of Hawaii Water Quality Standards (WQS).

Fresh waters are classified for regulatory purposes, according to the adjacent land's conservation zoning. There are two classes for the inland fresh waters. Class 1 inland waters are protected to "remain in their natural state as nearly as possible with an absolute minimum of pollution from any human-caused source." These waters are used for a number of purposes including domestic water supply, protection of native breeding stock, and baseline references from which human-caused changes can be measured.

Class 2 inland waters are protected for uses such as recreational purposes, support of aquatic life, and agricultural water supplies.

Class 1 waters are further separated into Classes 1a and 1b. Class 1a waters are protected for the following uses: scientific and educational purposes, protection of native breeding stock, baseline references from which human-caused changes can be measured, compatible recreation, aesthetic enjoyment, and other non-degrading uses which are compatible with the protection of the ecosystems associated with waters of this class. Streams that run through natural reserves, preserves, sanctuaries, refuges, national and state parks, and state or federal fish and wildlife refuges are Class 1a. Streams adjacent to the most environmentally sensitive conservation subzone, "protective" are Class 1b, and are protected for the same uses as Class 1a waters, with the addition of domestic water supplies, food processing, and the support and propagation of aquatic life (HAR 11-54-3). These classifications are used for regulatory purposes, restricting what is permitted on the land around receiving waters. For example, public access to Class 1b waters may be restricted to protect drinking water supplies.

Land use affects water quality because direct runoff (rainfall that flows overland into the stream) can transport sediment and its chemical contaminants into the stream. According to the U.S. Environmental Protection Agency (EPA), "[a] TMDL or Total Maximum Daily Load is a calculation of the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards, and an allocation of that amount to the pollutant's sources. Water quality standards are set by States, Territories, and Tribes. They identify the uses for each waterbody, for example, drinking water supply, contact recreation (swimming), and aquatic life support (fishing as well as ecological health), and the scientific criteria required to support those uses. A TMDL is the sum of the allowable loads of a single pollutant from all contributing point and nonpoint sources. The calculation must include a margin of safety to ensure that the waterbody can be used for the purposes the State has designated. The calculation must also account for seasonal variation in water quality. The Clean Water Act, section 303, establishes the water quality standards and TMDL programs (EPA, 2008)."

The DOH, Environmental Health Administration maintains the State of Hawaii Water Quality Standards (WQS), a requirement under the Federal Clean Water Act (CWA) regulated by the EPA. The CWA aims to keep waters safe for plants and animals to live and people to wade, swim, and fish. Water Quality Standards are the measures that states use to ensure protection of the physical, chemical, and biological health of their waters. "A water quality standard defines the water quality goals of a water body, or portion thereof, by designating the use or uses to be made of the water and by setting criteria necessary to protect the uses (CWA §131.2)." Each state specifies its own water uses to be achieved and protected ("designated uses"), but CWA §131.10 specifically protects "existing uses", which it defines as "…those uses actually attained in the water body on or after November 28, 1975, whether or not they are included in the water quality standards (CWA §131.3)."[12] Although the State WQS do not specify any designated uses in terms of traditional and customary Hawaiian rights, the "protection of native breeding stock," "aesthetic enjoyment," and "compatible recreation" are among the designated uses of Class 1 inland

[12] Existing uses as defined in the CWA should not be confused with existing uses as defined in the State Water Code, although there is some overlap and linkage between the two. Under the Water Code, if there are serious threats to or disputes over water resources, the Commission may designate a "water management area." Water quality impairments, including threats to CWA existing uses, are factors that the Commission may consider in its designation decisions. Once such a management area is designated, people who are already diverting water at the time of designation may apply for water use permits for their "existing uses." The Commission then must weigh if the existing use is "reasonable and beneficial." The Water Code defines "reasonable-beneficial use" as "the use of water in such a quantity as is necessary for economic and efficient utilization, for a purpose, and in a manner which is both reasonable and consistent with the state and county land use plans and the public interest." The relationships between a Commission existing use and a CWA existing use can help determine the appropriateness of the use and its consistency with the public interest.

waters, and “recreational purposes, the support and propagation of aquatic life, and agricultural and industrial water supplies” are among the designated uses of Class 2 inland waters. This means that uses tied to the exercise of traditional and customary Hawaiian rights that are protected by the State Constitution and the State Water Code (Section 12.0, Protection of Traditional and Customary Hawaiian Rights), including but not limited to gathering, recreation, healing, and religious practices are also protected under the CWA and the WQS as designated and/or existing uses. Therefore, the Commission’s interim IFS recommendation may impact the attainment of designated and existing uses, water quality criteria, and the DOH antidegradation policy, which together define the WQS and are part of the joint Commission and DOH obligation to assure sufficient water quality for instream and noninstream uses.

State of Hawaii WQS define: 1) the classification system for State surface waters, which assigns different protected uses to different water classes; 2) the specific numeric or narrative water quality criteria needed to protect that use; and 3) a general antidegradation policy, which maintains and protects water quality for the uses defined for a class. Quantitative and qualitative data are utilized. Numeric water quality criteria have specific concentrations (levels of pollutants) that must be attained based on water body type, e.g. fresh water stream. Qualitative standards are general narrative statements that are applicable to all State waters, such as “all waters shall be free of substances attributable to domestic, industrial, or other controllable sources of pollutants (State of Hawaii, Department of Health, 2004).” Conventional pollutants include nutrients and sediments. Toxic pollutants include pesticides and heavy metals. Indicator bacteria are utilized to assess bacterial levels. Biological assessments of aquatic communities are also included in the data collected.

Once data are gathered and evaluated for quality and deemed to be representative of the waterbody segment, a decision is made as to whether the appropriate designated uses are being attained. This set of decisions are then tabulated into a report to the EPA that integrates two CWA sections; (§) 305(b) and §303(d). This Integrated Report is federally required every even-numbered year. CWA §305(b) requires states to describe the overall water quality statewide. They must also describe the extent to which water quality provides for the protection and propagation of a balanced population of shellfish, fish, and wildlife and allows recreational activities in and on the water. Additionally, they determine whether the designated uses of a water body segment are being attained, and if not, what are the potential causes and sources of pollution. The CWA §303(d) requires states to submit a list of Water-Quality Limited Segments, which are waters that do not meet state water quality standards and those waters’ associated uses. States must also provide a priority ranking of waters listed for implementation of pollution controls, which are prioritized based on the severity of pollution and the uses of the waters. In sum, the §303(d) list leads to action.

The sources for the 2006 Integrated Report are Hawaii’s 2004 §303(d) list, plus readily-available data collected from any State water bodies over the preceding 6 years (State of Hawaii, Department of Health, 2007). Per §303(d), impaired waters are listed after review of “‘all existing and readily available water quality-related data and information’ from a broad set of data sources” (State of Hawaii, Department of Health, 2004, p.57). However, available data are not comprehensive of all the streams in the State. According to the Hawaii Administrative Rules Title 11 Chapter 54 (HAR 11-54) all State waters are subject to monitoring; however, in the most recent list published (from the 2006 list that was published in 2007), only 74 streams statewide had sufficient data for evaluation of whether exceedence of WQS occurred. Ohia Stream is a newly listed stream on the 2006 List of Impaired Waters in Hawaii, Clean Water Act §303(d). Data indicated that turbidity, total nitrogen, total phosphorus, nitrite and nitrate nitrogen exist as visual listing from 2001 to 2004. Trash was recorded as one of the other pollutants in the stream. According to the available data, Ohia Stream is listed as category 5 as having one or more designated use non-attainments or water quality impairment. It is also a low priority stream for initiating TMDL development.

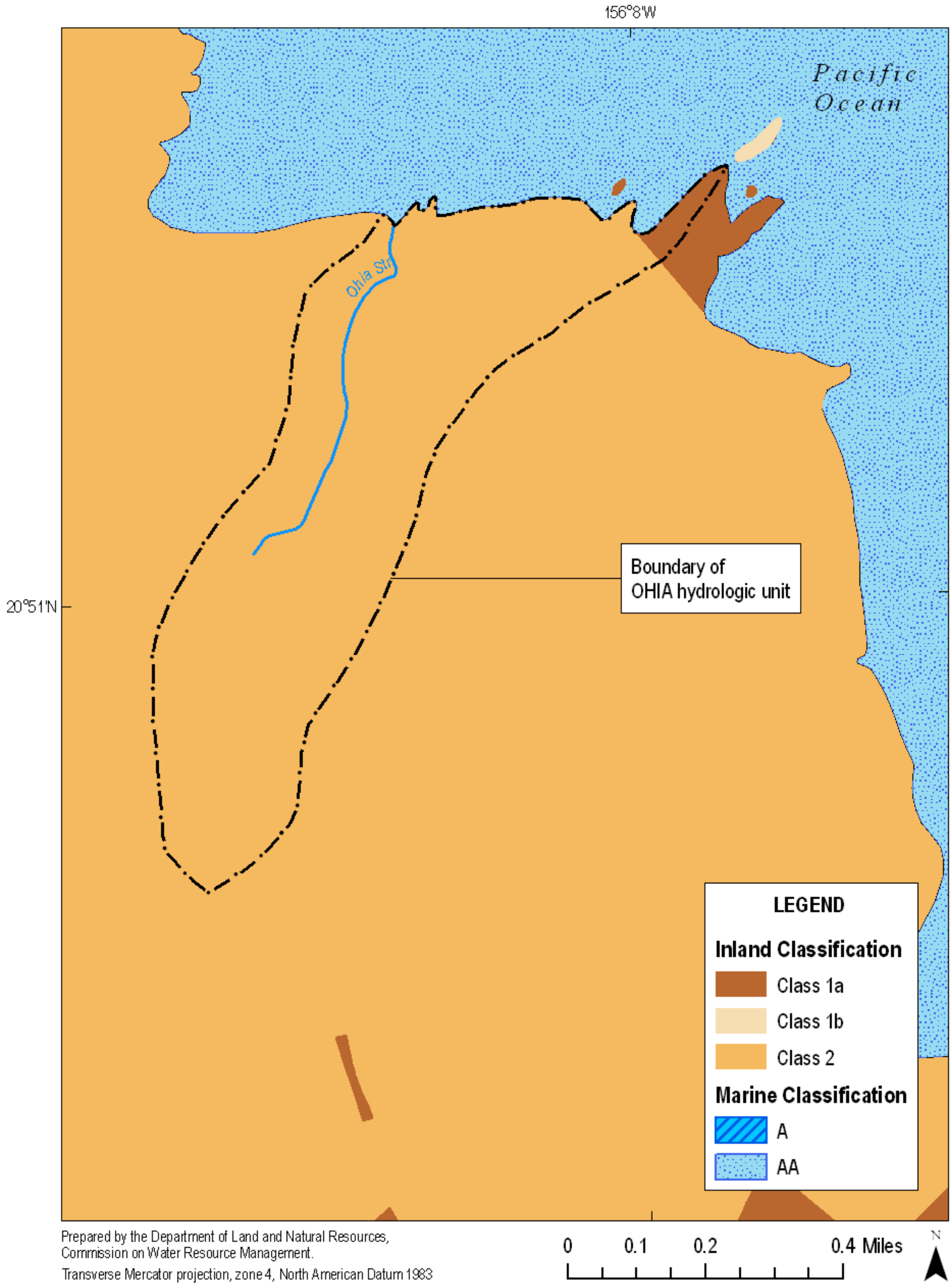
The 2006 Integrated Report indicates that the current WQS require the use of *Enterococci* as the indicator bacteria for evaluating public health risks in the waters of the State; however, no new data were available for this parameter in inland waters. As mentioned in Section 5.0, Outdoor Recreational Activities, DOH maintains WQS for inland recreational waters based on the geo-mean statistic of *Enterococci*: 33 colony-forming units per 100 mL of water or a single-sample maximum of 89 colonies per 100 mL. This is for full-body contact (swimming, jumping off cliffs into waterfall pools, etc.). If *Enterococci* count exceeds those values, the water body is considered to be impaired. DOH Clean Water Branch efforts have been focused on coastal areas (State of Hawaii, Department of Health, 2006, Chapter II, p.20). The marine recreational zone, which extends from the shoreline seaward to 1,000 feet from shore, requires an *Enterococci* geo-mean of less than 7 colony-forming units per 100 mL of water to protect human health (HAR 11-54-8).

The 2006 Integrated Report also states: "Public health concerns may be underreported. *Leptospirosis* is not included as a specific water quality standard parameter. However, all fresh waters within the state are considered potential sources of *Leptospirosis* infection by the epidemiology section of the Hawaii State Department of Health. No direct tests have been approved or utilized to ascertain the extent of the public health threat through water sampling. Epidemiologic evidence has linked several illness outbreaks to contact with fresh water, leading authorities to issue blanket advisories for all fresh waters of the state (State of Hawaii, Department of Health, 2006, Chapter II, p.3)."

Ohia Stream is classified as Class 2 inland waters in which the stream is protected for uses such as recreational purposes, support of aquatic life, and agricultural water supplies. It should be noted that the conservation subzone map utilized for this interpretation is general and elevations are not exact. It should also be noted that there is no direct relationship between elevation and attainment of water quality standards.

Marine water body types are delineated by depth and coastal topography. Open coastal waters are classified for protection purposes from the shoreline at mean sea level laterally to where the depth reaches 100 fathoms (600 feet). Marine water classifications are based on marine conservation areas. The objective of Class AA waters is that they "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." Class A waters are protected for recreational purposes and aesthetic enjoyment; and protection of fish, shellfish, and wildlife. Discharge into these waters is permitted under regulation. The marine waters at the mouth of the Ohia hydrologic unit are Class AA waters. Figure 10-1 shows the Ohia hydrologic unit, including inland and marine (coastal) water classifications.

Figure 10-1. Water quality standards for the Ohia hydrologic unit. (Source: State of Hawaii, Office of Planning, 2002e; 2008). The classifications are general in nature and should be used in conjunction with Hawaii Administrative Rules, Chapter 11-54, Water Quality Standards.



11.0 Conveyance of Irrigation and Domestic Water Supplies

Under the State Water Code, the conveyance of irrigation and domestic water supplies to downstream points of diversion is included as one of nine listed instream uses. The thought of the stream as a conveyance mechanism for noninstream purposes almost seems contrary to the concept of instream flow standards. However, the inclusion of this instream use is intended to ensure the availability of water to all those who may have a legally protected right to the water flowing in a stream. Of particular importance in this section is the diversion of surface water for domestic purposes. In its August 2000 decision on the Waiahole Ditch Combined Contested Case Hearing, the Hawaii Supreme Court identified domestic water use of the general public, particularly drinking water, as one of, ultimately, four trust purposes.

Neither the State nor the County keeps a comprehensive database of households whose domestic water supply is not part of a municipal system (i.e. who use stream and / or catchment water). The County of Maui Department of Water Supply (DWS) does not have data for water users who are not on the county system and may be using catchment or surface water for domestic use (Ellen Kraftsow, personal communication, June 23, 2008). The State of Hawaii Department of Health Safe Drinking Water Branch administers Federal and State safe drinking water regulations to public water systems in the State of Hawaii to assure that the water served by these systems meets State and Federal standards. Any system which services 25 or more people for a minimum of 60 days per year or has at least 15 service connections is subject to these standards and regulations. Once a system is regulated by the Safe Drinking Water Branch, the water must undergo an approved filtration and disinfection process when it has been removed from the stream. It would also be subject to regulatory monitoring. The DOH Safe Drinking Water Branch does not currently regulate any public water systems in the Waikamoi hydrologic unit.

The Commission's records for the hydrologic unit of Ohia indicate that there is only one registered diversion. The registrant (File reference: HOKOANA BK) diverts water for the purpose of irrigating 2.09 acres of taro, along with domestic and landscaping uses for a house on the property.

More information on the diversion for the Ohia hydrologic unit may be found in Table 13-1 of Section 13.0, Noninstream Uses.

12.0 Protection of Traditional and Customary Hawaiian Rights

The maintenance of instream flows is important to the protection of traditional and customary Hawaiian rights, as they relate to the maintenance of stream resources (e.g., hihiwai, opae, oopu) for gathering, recreation, and the cultivation of taro. Article XII, Section 7 of the State Constitution addresses traditional and customary rights: "The State reaffirms and shall protect all rights, customarily and traditionally exercised for subsistence, cultural and religious purposes and possessed by ahupuaʻa tenants who are descendants of native Hawaiians who inhabited the Hawaiian Islands prior to 1778, subject to the right of the State to regulate such rights." Case notes listed in this section indicate, "Native Hawaiian rights protected by this section may extend beyond the ahupuaʻa in which a native Hawaiian resides where such rights have been customarily and traditionally exercised in this manner. 73 H.578, 837 P.2d 1247."

It is difficult to fully represent in words the depth of the cultural aspects of streamflow, including traditions handed down through the generations regarding gathering, ceremonial and religious rites, and the ties to water that are pronounced in Hawaiian legend and lore. "There is a great traditional significance of water in Hawaiian beliefs and cultural practices…The flow of water from mountain to sea is integral to the health of the land. A healthy land makes for healthy people, and healthy people have the ability to sustain themselves (Kumu Pono Associates, 2001b, p.II:8)."

Taro cultivation is addressed in this section of the report as well as the next section, 13.0 Noninstream Uses. This is because instream flow standards take into account both social and scientific information. For sociological and cultural purposes, taro cultivation can be considered an instream use as part of the "protection of traditional and customary Hawaiian rights," that is specifically listed as an instream use in the Water Code. Taro cultivation can also be considered a noninstream use since it removes water from a stream (even if water from taro loi is later returned to the stream). It could be argued that for scientific analysis, taro cultivation is an instream use since taro loi provide habitat for stream biota, but because the water is physically taken out of the stream, it is also a noninstream use. Another way to look at the approach of indentifying taro cultivation as both instream and noninstream uses is that when the Commission addresses taro cultivation as an instream use, it is generally in the context of traditional and customary Hawaiian rights; whereas when the Commission addresses taro cultivation as a noninstream use, it is approaching the issue from the aspects of agriculture and water use.

In ancient Hawaii, the islands (*moku*) were subdivided into political subdivisions, or ahupuaa, for the purposes of taxation. The term ahupuaa in fact comes from the altar (*ahu*) that marked the seaward boundary of each subdivision upon which a wooden head of a pig (*puaa*) was placed at the time of the *Makahiki* festival when harvest offerings were collected for the rain god and his earthly representative (Handy et al., 1972). Each ahupuaa had fixed boundaries that were usually delineated by natural features of the land, such as mountain ridges, and typically ran like a wedge from the mountains to the ocean thus providing its inhabitants with access to all the natural resources necessary for sustenance. The beach, with its fishing rights, were referred to as *ipu kai* (meat bowl), while the upland areas for cultivation were called *umeke ai* (poi container hung in a net) (Handy et al., 1972). As noted earlier in Section 6.0, Maintenance of Ecosystems, Western concepts of ecosystem maintenance and watersheds are similar to the Hawaiian concept of ahupuaa, and so the Commission's surface water hydrologic units often coincide with or overlap ahupuaa boundaries. The hydrologic unit of Ohia is within the ahupuaa of Keanae as shown in Figure 12-2.

An appurtenant water right is a legally recognized right to a specific amount of surface freshwater – usually from a stream – on the specific property that has that right. This right traces back to the use of water on a given parcel of land at the time of its original conversion into fee simple lands: When the land allotted during the 1848 Mahele was confirmed to the awardee by the Land Commission and/or when the Royal Patent was issued based on such award, the conveyance of the parcel of land carried with it the appurtenant right to water if water was being used on that land at or shortly before the time of the Mahele (State of Hawaii, Commission on Water Resource Management, 2007).

An appurtenant right is different from a riparian right, but they are not mutually exclusive. Riparian rights are held by owners of land adjacent to a stream. They and other riparian landowners have the right to reasonable use of the stream's waters on those lands. Unlike riparian lands, the lands to which appurtenant rights attach are not necessarily adjacent to the freshwater source (i.e., the water may be carried to the lands via auwai or ditches), but some pieces of land could have both appurtenant and riparian rights.

Appurtenant rights are provided for under the State Water Code, HRS §174C-101, Sections (c) and (d), as follows:

- Section (c). Traditional and customary rights of ahupuaa tenants who are descendants of native Hawaiians who inhabited the Hawaiian Islands prior to 1778 shall not be abridged or denied by this chapter. Such traditional and customary rights shall include, but not be limited to, the cultivation or propagation of taro on one's own kuleana and the gathering of hihiwai, opae, oopu, limu, thatch, ti leaf, aho cord, and medicinal plants for subsistence, cultural, and religious purposes.

- Section (d). The appurtenant water rights of kuleana and taro lands, along with those traditional and customary rights assured by this section, shall not be diminished or extinguished by a failure to apply for or to receive a permit under this chapter.

The exercise of an appurtenant water right is still subject to the water use permit requirements of the Water Code, but there is no deadline to exercise that right without losing it, as is the case for correlative and riparian rights, which must have been exercised before designation of a water management area.

In August 2000, the Hawaii Supreme Court issued its decision in the Waiahole Ditch Combined Contested Case Hearing, upholding the exercise of Native Hawaiian and traditional and customary rights as a public trust purpose. These rights are described in the Commission's 2008 Water Resource Protection Plan – *Public Review Draft* as follows:

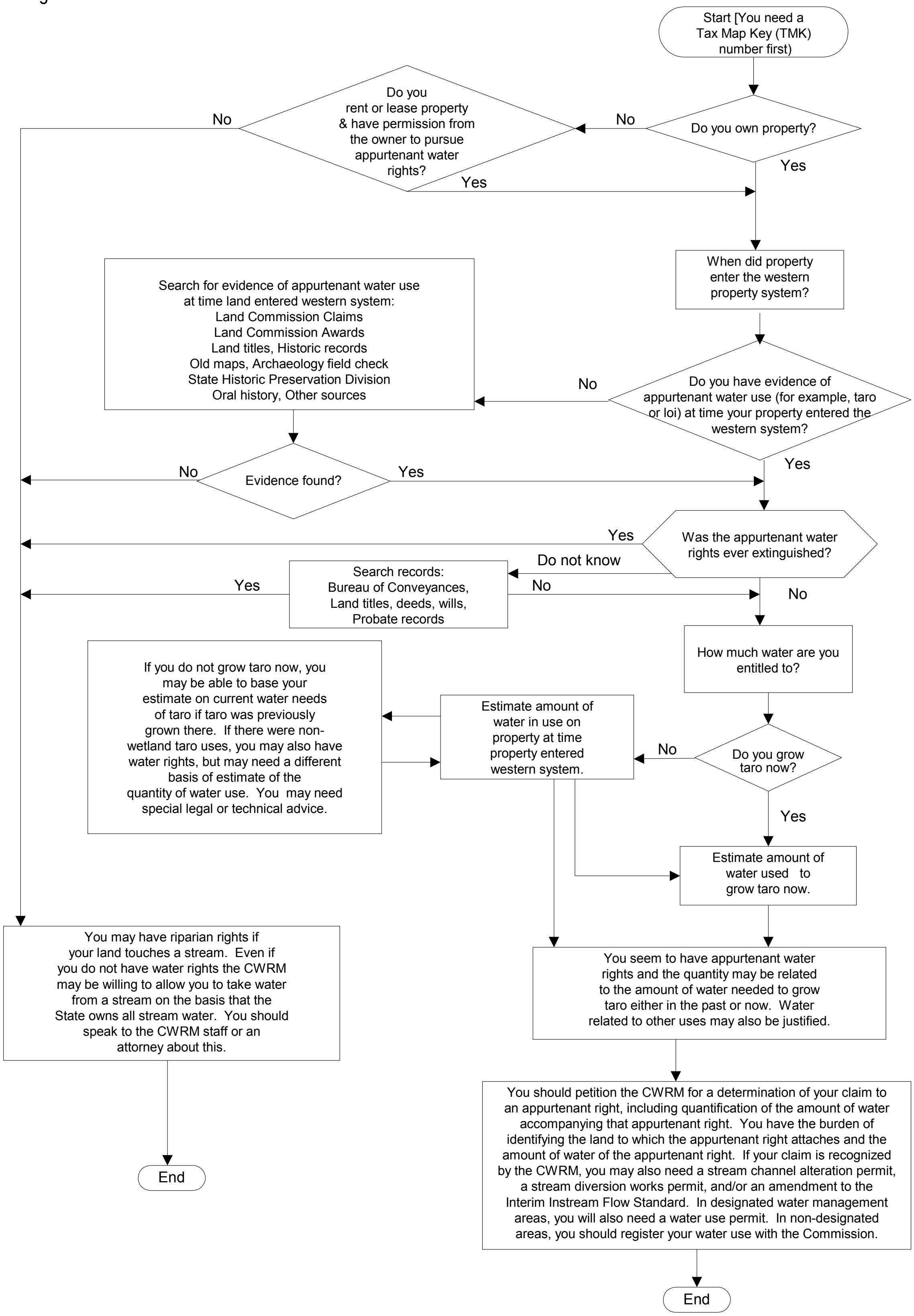
> Appurtenant water rights are rights to the use of water utilized by parcels of land at the time of their original conversion into fee simple lands i.e., when land allotted by the 1848 Mahele was confirmed to the awardee by the Land Commission and/or when the Royal Patent was issued based on such award, the conveyance of the parcel of land carried with it the appurtenant right to water.[13] The amount of water under an appurtenant right is the amount that was being used at the time of the Land Commission award and is established by cultivation methods that approximate the methods utilized at the time of the Mahele, for example, growing wetland taro.[14] Once established, future uses are not limited to the cultivation of traditional products approximating those utilized at the time of the Mahele[15], as long as those uses are reasonable, and if in a water management area, meets the State Water Code's test of reasonable and beneficial use ("the use of water in such a quantity as is necessary for economic and efficient utilization, for a purpose, and in a manner which is both reasonable and consistent with the State and county land use plans and

[13] 54 Haw. 174, at 188; 504 .2d 1330, at 1339.
[14] 65 Haw. 531, at 554; 656 P.2d 57, at 72.
[15] *Peck v Bailey*, 8 Haw. 658, at 665 (1867).

the public interest"). As mentioned earlier, appurtenant rights are preserved under the State Water Code, so even in designated water management areas, an unexercised appurtenant right is not extinguished and must be issued a water use permit when applied for, as long as the water use permit requirements are met [Figure 12-1].

The Hawaii Legislative Session of 2002 clarified that the Commission is empowered to "determine appurtenant rights, including quantification of the amount of water entitled to by that right," (HRS §174C-5(15)). In those cases where a Commission decision may affect an appurtenant right, it is the claimant's duty to assert the appurtenant right and to gather the information required by the Commission to rule on the claim. The Commission is currently in the process of developing a procedural manual to aid in the understanding and assembling of information to substantiate an appurtenant rights claim.

Figure 12-1. Generalized process for determining appurtenant water rights. This process is generalized and may not fully explain all possible situations. It does not apply to Hawaiian Homes Lands. If you are Native Hawaiian you may have other water rights.



The Commission conducted a cursory assessment of tax map key parcels to identify their associated Land Commission Awards, in an attempt to identify the potential for future appurtenant rights claims within the hydrologic unit of Ohia. In addition to the original reference documents, a 2001 inventory conducted by Kumu Pono Associates, under contract by East Maui Irrigation Company, serves as a valuable reference of historical accounts of the lands of Hamakua Poko, Hamakua Loa and Koolau, Maui Hikina (east Maui). Table 12-1 presents the results of the Commission's assessment.

Table 12-1. Tax map key parcels with associated Land Commission Awards for the Ohia hydrologic unit.

[LCA is Land Commission Award; Gr. is Grant; and G.L. is Government Lease.]

TMK	Landowner	LCA	Grants/Leases	Notes
(2)1-1-007:003	East Maui Irrigation /Etal	none	Gr. 1911	
(2)1-1-007:007	East Maui Irrigation /Etal	none	Gr. 2098	
(2)1-1-007:009	East Maui Irrigation /Etal	3472-B:1	none	
(2)1-1-007:010	East Maui Irrigation /Etal	none	none	Includes Deed referece.
(2)1-1-007:011	East Maui Irrigation /Etal	4848:1	none	
(2)1-1-007:012	East Maui Irrigation /Etal	none	none	Includes Deed reference.
(2)1-1-007:013	Canby, Marjorie /Etal	none	Gr. 1525	
(2)1-1-007:014	State of Hawaii	none	none	Includes Rev. Pmt. 1572.
(2)1-1-007:015	Kaahanui, James H /Etal	none	Gr. 2665	
(2)1-1-007:016	State of Hawaii	none	none	Includes Rev. Pmt. 1572 (por.).
(2)1-1-007:017	East Maui Irrigation /Etal	none	Gr. 2092:1	
(2)1-1-007:018	Hueu, James Keolaokalani III	none	Gr. 1526	
(2)1-1-007:019	Akiu, Daniel (Dec'd) /Etal	none	Gr. 2091:1	
(2)1-1-007:020	Ng, John Philip Ioane /Etal	none	Gr. 2091:2	
(2)1-1-008:010	East Maui Irrigation /Etal	none	Gr. 1899	
(2)1-1-008:020	State of Hawaii /Etal	none	none	Includes Exec. Order 621

In accordance with the State Water Code and the Supreme Court's decision in the Waiahole Ditch Combined Contested Case Hearing, the Commission is focused on the assertion and exercise of appurtenant rights as it largely relates to the cultivation of taro. Wetland kalo or taro (*Colocasia esculenta* (L.) Schott) is an integral part of Hawaiian culture and agricultural tradition. The preferred method of wetland taro cultivation, where terrain and access to water permitted, was the construction of loi (flooded terraces) and loi complexes. These terraces traditionally received stream water via carefully engineered open channels called auwai. The auwai carried water, sometimes great distances, from the stream to the loi via gravity flow. In a system of multiple loi, water may either be fed to individual loi through separate little ditches if possible, or in the case of steeper slopes, water would overflow and drain from one loi to the next. Outflow from the loi may eventually be returned to the stream.

The loi also served other needs including the farming of subsidiary crops such as banana, sugar cane, and ti plants that were planted on its banks, and the raising of fish such as oopu, awa, and aholehole within the waters of the loi itself. At least 85 varieties of taro were collected in 1931, each of which varied in color, locale, and growing conditions. The water needs of taro under wet conditions depend upon: 1) climate; 2) location and season (weather); 3) evaporation rate; 4) soil type; 5) ground water hydrology; 5) water temperature; and 6) agronomic conditions (crop stage; planting density and arrangement; taro variety; soil amendment and fertilization regime; loi drainage scheme; irrigation system management; and weed, pest, and disease prevalence and management).

Among its comments during the preparation of previous IFSARs for east Maui, Native Hawaiian Legal Corporation (NHLC) submitted testimony from 2001 relating to taro cultivation and gathering practices in east Maui streams. The pre-printed forms were completed by several east Maui residents. The information relating to taro cultivation is presented in Table 12-2 (See PR-2008-07). No testimony specifically identifies the hydrologic unit of Ohia.

Table 12-2. Summary of the 2001 testimonies submitted by NHLC related to taro cultivation.

Declarant (CPRC Reference)	Stream Adjacent To Property	Stream Adjacent To Property Where Kalo Is Grown	Stream Source For Auwai Adjacent To Property	Stream Source For Auwai Adjacent To Property Where Kalo Is Grown	Streams Where Kalo Would Be Grown If Water Were Available
Charles L. Barclay (CPRC 29.2-3)	Wailuanui	Lakini	Lakini	Kualani, Waiokamilo (Kamilo)	Makapipi
	<u>Problem Statement (Kalo):</u> "No constant water flow. Also because of lack of water flow at Lakini we are unable to open all of our patches at Wailua-Nui."				
Awapuhi Carmichael (CPRC 29.2-55)					
Daniel Carmichael (CPRC 29.2-33)					
Puanani Holokai (CPRC 29.2-17)	(lease) Piinaau & Palahulu	(lease) Piinaau & Palahulu	(lease) Piinaau & Palahulu	(lease) Piinaau & Palahulu	
Cindy Ku'uipo Ka'auamo (CPRC 29.2-21)	Waiokamilo			Waiokamilo, Kulani, Wailuanui, Palauhulu, Piinaau	
Darlene Kaauamo (CPRC 29.2-19)	Waiokamilo			Waiokamilo, Kulani, Wailuanui, Palauhulu, Piinaau	
Frances Kaauamo (CPRC 29.2-45)			Waikani		
Hannah K. Kaauamo (CPRC 29.2-27)	Ka'amilo (Wai O'Ka Milo)	La'Kine, Wai O'Ka Milo, Kulani	Wai'Lua'Nui, Wai'O'Kamilo	La'Kine, Wai'Lua'Nui, Kulani, Wai Kani, Wai O'Ka Milo,	Wai'Lua'Nui
	<u>Problem Statement (Kalo):</u> "There is not enough water flowing through the streams, - That is one of the reason why we have a lot diseases destroying our taro - We have to depend on the rain to get more water flow - In the above streams but some of the stream have no life (note enough flow)."				
Leolani R. Kaauamo (CPRC 29.2-41)	Ka'a Hiio (?)	Laikaine-moii (?, illegible)	Wailuanui, Waiokamoii	Wailuanui, Waiokamoii, Lakai, Waiokani	Wailuanui
	<u>Problem Statement (Kalo):</u> "Water was constructed by the State of HI but insufficient water to feed way water has diminished since not enough water to fill 8" of pipe on a continuous flow."				
Mary Kaauamo (CPRC 29.2-43)			Wailuanui and Waiokamilo	Wailuanui and Waiokamilo	

Table 12-2. Continued. Summary of the 2001 testimonies submitted by NHLC related to taro cultivation.

Declarant (CPRC Reference)	Stream Adjacent To Property	Stream Adjacent To Property Where Kalo Is Grown	Stream Source For Auwai Adjacent To Property	Stream Source For Auwai Adjacent To Property Where Kalo Is Grown	Streams Where Kalo Would Be Grown If Water Were Available
Samuel E. Kaauamo (CPRC 29.2-25)	Lakini, Kaamilo	Lakini, Kaamilo	Lakini, Kaamilo	Lakini, Kaamilo	Lakin, Kamilo
Solomon Kaauamo Jr. (CPRC 29.2-29)	Kaamilo (Waiokamilo)	Lakini, Kulani, Waiokamilo, Wailuanui	Wailuanui, Waiokamilo	Wailuanui, Waiokamilo, Lakini, Kulani	Wailuanui
	<u>Problem Statement (Kalo):</u> "Water way was constructed by the State of HI, but insufficient water to feed water way. Water has diminished since. Not enough water to fill 8" of pipe, on a continuous flow."				
Gladys Kanoa (CPRC 29.2-31)	Waiokamilo, Piinaau, Palauhulu, Kulani	Waiokamilo, Piinaau, Palauhulu, Kulani	Waiokamilo, Piinaau, Palauhulu, Kulani	Lakini, Makilo, Waiokamilo, Palauhulu, Kualani	
Jerome Kekiwi, Jr. (CPRC 29.2-49)	Lakini, Kulani, Kamilo	Wai O Kamilo, Lakini, Kulani	Wai O Kamilo, Lakini, Kulani		Waikau, Wailua
	<u>Problem Statement (Kalo):</u> "The water is unable to reach the land because there is no access or irrigation to go to the kalo patch."				
Puaala Kekiwi (CPRC 29.2-47)			(lease) Kulani, Waiokamilo	Kulani, Waiokamilo	
Chauncey K. Kimokeo (CPRC 29.2-5)			Palahulu	Keanae Flume	
Ihe Kimokeo (CPRC 29.2-11)			Palahulu	Keanae Flume	
Lincoln A. Kimokeo (CPRC 29.2-9)			Palahulu	Palahulu	Kolea to Makapipi
	<u>Problem Statement (Kalo):</u> "Because of low water pressure water is unable to reach loi furthest from flume catchments and production is minimal and could be of higher quality. This prevents all kalo farmers & residents of this ahupua'a from utilizing all of the resources in this ahupua'a and making higher productivity depending on the streams."				
Pualani Kimokeo (CPRC 29.2-7)			Palahulu	Palahulu	Any property next to me
	<u>Problem Statement (Kalo):</u> "We need constant flowing water at all times. Patches next to the flume catch is more likely to have a better growth than the patches at the end cause the water pressure gets smaller and warmer."				
Willie K. Kimokeo (CPRC 29.2-13)	Palahulu	Keanae Flume	Keanae Flume	Keanae Flume	
Norman D. Martin Jr. (CPRC 29.2-15)	Waikane, Kulani, Waiokamilo	Waikane, Kulani, Waiokamilo	Waikane, Kulani, Waiokamilo	Waikane, Kulani, Waiokamilo	Waikane
	<u>Problem Statement (Kalo):</u> "Lack of water."				

Table 12-2. Continued. Summary of the 2001 testimonies submitted by NHLC related to taro cultivation.

Declarant (CPRC Reference)	Stream Adjacent To Property	Stream Adjacent To Property Where Kalo Is Grown	Stream Source For Auwai Adjacent To Property	Stream Source For Auwai Adjacent To Property Where Kalo Is Grown	Streams Where Kalo Would Be Grown If Water Were Available
B. Tau-a M. Pahukoa (CPRC 29.2-51)	Waiakamilo (sic), Piinaua (sic)	Palauhulu, Waiakamilo & Piinaua But [illegible] water from flume that comes from Palauhulu also.	Waiakamilo, Palauhulu, Piinaua & also Waipio	Waiokamilo & Piinaau	Waipio
	<u>Problem Statement (Kalo):</u> "There is lack of water to even push (?) the stream."				
Benjamin Smith Sr. (CPRC 29.2-37)	Wailua Nui		Wailua Nui, Ka Milo		
	<u>Problem Statement (Kalo):</u> "We subsist on whatever water that is not diverted. Since 1985 our streams are dry. We need more water that we are accustomed to before Hawaii became a state."				
Lucille L. Smith (CPRC 29.2-39)	Wailua Nui		Wailua Nui, Kamilo		
Edward Wendt (CPRC 29.2-53)	Lakini and Waiokamilo, Kulani	Lakini and Waiokamilo, Kulani	Lakini, Kulani, Waiokamilo	Lakini, Kulani, Waiokamilo	

In 2002, the State Office of Hawaiian Affairs cosponsored a "No Ka Lo'i Conference", in the hopes of bringing together taro farmers from around the state to share knowledge on the cultivation of taro. An outcome of the conference was an acknowledgement that farmers needed to better understand the water requirements of their taro crops to ensure and protect their water resource interests. The result of this effort was a 2007 USGS wetland kalo water use study, prepared in cooperation with the State Office of Hawaiian Affairs, which specifically examined flow and water temperature data in a total of 10 cultivation areas on four islands in Hawaii. Two of the loi (flooded terrace) complexes are located in east Maui (Wailua and Keanae).

The study reiterated the importance of water temperature in preventing root rot. Typically, the water in the taro loi is warmer than water in the stream because of solar heating. Consequently, a taro loi needs continuous flow of water to maintain the water temperature at an optimum level. Multiple studies cited in Gingerich, et al., 2007, suggest that water temperature should not exceed 77ºF (25ºC). Low water temperatures slow taro growth, while high temperatures may result in root rot (Penn, 1997). When the flow of water in the stream is low, possibly as a result of diversions or losing reaches, the warmer water in the taro loi is not replaced with the cooler water from the stream at a quick enough rate to maintain a constant water temperature. As a result, the temperature of the water in the taro loi rises, triggering root rot.

The USGS 2007 study noted that "although irrigation flows for kalo cultivation have been measured with varying degrees of scientific accuracy, there is disagreement regarding the amount of water used and needed for successful kalo cultivation, with water temperature recognized as a critical factor. Most studies have focused on the amount of water consumed rather than the amount needed to flow through the irrigation system for successful kalo cultivation (Gingerich, et al., 2007)." As a result, the study was designed to measure the throughflow of water in commercially viable loi complexes, rather than measuring the consumption of water during taro growth.

Because water requirements for taro vary with the stage of maturity of the plants, all the cultivation areas selected for the study were at approximately the same stage (i.e. near harvesting, when continuous flooding is required). Temperature measurements were made every 15 minutes for approximately 2 months. Flow measurements were collected at the beginning and the end of that period. Data were collected during the dry season (June – October), when water requirements for cooling kalo are higher. Surface water temperatures generally begin to rise in April and remain elevated through September, due to increased solar heating. Water inflow temperature was measured in 17 loi complexes, and only three had inflow temperatures rising above 27ºC (the threshold temperature above which wetland kalo is more susceptible to fungi and associated rotting diseases).

The average and median inflows from all 10 cultivation areas studied are listed in Table 12-3. The study indicated that the "values are consistent with previously reported inflow and are significantly higher than values generally estimated for consumption during kalo cultivation." It should also be noted that farmers were interviewed during field visits; most "believed that their supply of irrigation water was insufficient for proper kalo cultivation."

Table 12-3. Summary of water use calculated from loi and loi complexes by island, State of Hawaii (Source: Gingerich et al., 2007, Table 10).

[gad = gallons per acre per day; na = not available]

Island	Complex				Loi			
	Number	Average water use (gad)	Average windward water use (gad)	Average leeward water use (gad)	Number	Average water use (gad)	Average windward water use (gad)	Average leeward water use (gad)
Kauai	6	120,000	97,000	260,000	2	220,000	220,000	na
Oahu	5	310,000	380,000	44,000	4	400,000	460,000	210,000
Maui	6	230,000	230,000	na	na	na	na	na
Hawaii	2	710,000	710,000	na	na	na	na	na
Average of all measurements		260,000	270,000	150,000		350,000	370,000	210,000
Median of all measurements		150,000	150,000	150,000		270,000	320,000	210,000

The windward Maui areas chosen for the study were Waihee, Wailua, and Keanae. Wailua and Keanae each have numerous individual loi and loi complexes. Three of the Wailua area complexes were available for study: 1) Lakini complex, supplied through an auwai with water diverted from Hamau Stream, which in turn receives diverted water from Waiokamilo Stream; 2) Wailua complex, supplied through an auwai with water diverted from Waiokamilo Stream; and 3) Waikani complex, supplied through an auwai with water diverted from Wailuanui Stream. The loi in Keanae were treated as a single complex supplied by the Keanae Flume, which diverts water from Palauhulu Stream.

The study results are presented below in Table 12-4 (discharge measurements) and Table 12-5 (water-temperature statistics).

Table 12-4. Summary of discharge measurements and areas for selected loi complexes, Island of Maui (Source: Gingerich et al., 2007, Table 6).

[mgd = million gallons per day; gad = gallons per acre per day; na = not applicable; average water use is determined by summing the averages of each complex or loi and dividing by the number of complexes or loi.]

Area	Complex						
	Station	Irrigation area (acre)	Date	Measurement time	Discharge (mgd)	Water use (gad)	Remarks
Waihee	Ma08A-CI	2.3	7/29/2006	1501	0.34	150,000	total flow for upper and lower complexes
			9/22/2006	1158	0.30	130,000	total flow for upper and lower complexes
	Ma08B-CIR	na	7/29/2006	1500	0.025		
	Ma08B-CIL	na			0.06		
		0.76		na	0.085	110,000	combined right and left complex inflows
	Ma08B-CIR	na	9/22/2006	1150	0.058		
	Ma08B-CIL	na		1055	0.067		
		0.76		na	0.13	160,000	combined right and left complex inflows
Wailua (Lakini)	Ma09-CIR	na	7/30/2006	1004	0.26		
	Ma09-CIL	na		947	0.30		
		0.74		na	0.56	750,000	combined right and left complex inflows
	Ma09-CIR	na	9/21/2006	1015	0.16		
	Ma09-CIL	na		1049	0.06		
	Ma09-CIM	na		1206	0.19		
		0.74		na	0.41	550,000	combined right, left, and middle complex inflows
Wailua	Ma10-CI	3.32	7/30/2006	1136	0.59	180,000	
			9/21/2006	845	0.46	140,000	
Wailua (Waikani)	Ma11-CI	2.80	7/30/2006	1236	0.54	190,000	
			9/21/2006	1608	0.26	93,000	
Keanae	Ma12-CI	10.53	7/31/2006	836	1.90	180,000	former USGS streamflow-gaging station
			9/21/2006	1415	1.60	150,000	
number		6.00				6	
minimum		0.74				93,000	
maximum		10.53				750,000	
average		3.41				230,000	

Table 12-5. Water-temperature statistics based on measurements collected at 15-minute intervals for loi complexes on the Island of Maui (Source: Gingerich et al., 2007, Table 7).

[ºC = degrees Celsius; na = not applicable]

Geographic designation	Area	Station	Period of record	Temperature (ºC) Mean	Range	Mean daily range	Temperature measurements greater that 27ºC (percent)
Windward	Waihee	Ma08A-CI	7/29/2006 - 9/22/2006	21.6	19.9 - 24.0	2.0	0.0
		Ma08B-CIL	7/29/2006 - 9/22/2006	24.9	20.3 - 34.0	7.6	25.4
		Ma08B-CO	7/29/2006 - 9/22/2006	25.5	20.0 - 35.5	5.7	27.0
Windward	Wailua (Lakini)	Ma09-CIT	7/30/2006 - 9/21/2006	20.7	18.5 - 23.4	2.3	0.0
		Ma09-CO	7/30/2006 - 9/21/2006	23.2	18.4 - 31.7	7.4	16.9
Windward	Wailua	Ma10-CI	7/30/2006 - 9/21/2006	22.5	20.5 - 25.9	1.9	0.0
Windward	Wailua (Waikani)	Ma11-CI	7/30/2006 - 9/21/2006	22.2	21.0 - 24.0	0.7	0.0
		Ma11-CO	7/30/2006 - 9/21/2006	26.1	22.1 - 31.8	3.3	29.1
Windward	Keanae	Ma12-CI	7/31/2006 - 9/21/2006	20.0	19.0 - 21.9	1.0	0.0
		Ma12-CO	equipment malfunction	na	na	na	na

The Commission's records for the hydrologic unit of Ohia indicate that there is only one registered diversion. The registrant (File reference: HOKOANA BK) declared water use for irrigation of 2.09 acres of taro. This source, along with two others on Waiokamilo and Palauhulu Streams, are also used for irrigation of roughly 3 acres of taro and 10 acres of other uses including watercress, ti plants, and flowers, domestic purposes, and landscaping on the property. More information on the registered diversions may be found in Table 13-1 of Section 13.0, Noninstream Uses.

Commission staff held a Public Fact Gathering Meeting on April 10, 2008 in Haiku, Maui to gather comments on previous IFSARs for east Maui. Written comments were also accepted over a 3-month period. A great deal of the oral and written testimony addressed traditional and customary rights, including taro cultivation and gathering practices. Dozens of east Maui residents testified that insufficient water in the streams to cultivate as much taro as desired; and that often the water that does flow is too warm, resulting in root rot.

Further, testimony indicated that there is insufficient native fauna for gathering, and the water is also not sufficient for recreation. Testimony before the Board of Land and Natural Resources from May 2001 was also provided, with six long-time east Maui residents all stating that the streamflow in east Maui has diminished within their lifetimes (See PR-2008-07, 29.3-1 through 29.3-12). Some of the same six residents also provided oral testimony on April 10, 2008 and/or in writing. They, and others, state that the reduction in streamflow has impacted their ability to survive off the land and to perpetuate the Hawaiian culture (See PR-2008-07).

As noted earlier, NHLC submitted comments during the preparation of previous IFSARs for east Maui. The testimony from 2001 consisted of a pre-printed form in which people identified information pertaining to taro cultivation and gathering practices in east Maui streams. The information from these forms, as it relates to gathering, is presented in Table 12-6 (See PR-2008-07, 29.2-1 through 29.2-56). Though Ohia was not specifically identified, the hydrologic unit of Ohia falls within the area (Kolea/Honomanu to Makapipi/Kuhiwa) where many declarants claim gathering is practiced or would be practiced if water were available.

Table 12-6. Summary of the 2001 testimonies submitted by NHLC related to gathering practices.

Declarant (CPRC Reference)	What Is Gathered By The Family	Streams Where Gathering Is Practiced	What Would Be Gathered If Water Were Available	Streams Where Gathering Would Be Practiced If Water Were Available
Charles L. Barclay (CPRC 29.2-3)	opae, hihiwai, o'opu	Honomanu to Makapipi	opae, hihiwai, o'opu	Honomanu, Waiokamilo
	<u>Problem Statement (Gathering):</u> "Not enough free-flowing water to maintain the kalo, opae, hihiwai & o'opu."			
Awapuhi Carmichael (CPRC 29.2-55)	opae, hi hi wais, oopu	from Honomanu to Makapipi	opai (?)	Palauhulu, West Wailuaiki
	<u>Problem Statement (Gathering):</u> "As a child we had all the water we needed to gather & grow healthy taro. When Hawaii became a state, our ahupua'a is left with little or no water to grow healthy taro and gather. Our fishing areas are depleted. We need the water for this native (Kanaka maoli) ahupuaa whose people have existed here since time immemorial."			
Daniel Carmichael (CPRC 29.2-33)	opaes, hihiwais, oopu, and a variety of fishes in the ocean	Hanawi - Palauhulu, Piinaau Haepuaena - Wailuanui Stream - Waioka Milo aka Kamilo - Kapa'akea - Waiohue, Kapiliula, Wailuaiki East and West, Makapipi	a variety of species	all streams between Kolea & Kuahiwi
	<u>Problem Statement (Gathering):</u> "We do not have enough water in all streams from Kolea to Kuahiwi Nahiku for us to gather from mountain to ocean and from boundary in the ahupua'a of Keanae - Wailuanui within the Koolau District."			
Puanani Holokai (CPRC 29.2-17)	hihiwai, opae	Makapipi - Honomanu	opae, hihiwai	Palahulu
	<u>Problem Statement (Gathering):</u> "Can not gather opae in Palahulu stream because no water flow."			

Table 12-6. Continued. Summary of the 2001 testimonies submitted by NHLC related to gathering practices.

Declarant (CPRC Reference)	What Is Gathered By The Family	Streams Where Gathering Is Practiced	What Would Be Gathered If Water Were Available	Streams Where Gathering Would Be Practiced If Water Were Available
Cindy Ku'uipo Ka'auamo (CPRC 29.2-21)	opae, hi'iwai, prawns, o'opu, gold fish, haha	Makapipi to Honomanu	opae, hi'iwai	Wailuanui, Waiokamilo, Kulani, Palauhulu, Piinaau, Honomanu
	Problem Statement (Gathering): "Water is a source of life to land and man. It is not for man to possess, but simply for man to use. However, the right to use water depends entirely upon the use of it. The people of Keanae-Wailuanui Ahupua'a have respected the rights of water use for many generations. Our ancestors have taught us that water is of great value. Without it there is no life. "The decrease of water flow affects all life in, around and on this land. It prevents spawning of 'opae & 'o'opu, disrupting the natural process of reproduction resulting in decrease food supply. In addition, making it harder for people to gather. "Insufficient water flow decreases water temperature causing stagnation, allowing small ponds to become host of bacteria, spreading disease among striving creatures, plant life and even man. "Finally, the interruption of natural water flow affects taro. Diseases, foreign pest, decrease in production, frustration among farmers and a threat to our Hawaiian Culture as well as our way of life. "Like our ancestors, the people of Keanae-Wailuanui Ahupua'a understand the importance of water for all life. Because of this, we have inherited the rights of trusteeship over our natural resources. "Ad a trustee, I ask that you answer this question… Do you value the comfort of man or the life of man?... Think about it and do what is right. Restore our streams… Give life not death!"			
Darlene Kaauamo (CPRC 29.2-19)	opae, hihiwai, haha, prawn, gold fish, prawns	Makapipi to Honomanu	opae, hihiwai, haha, gold fish	Wailuanui, Waiokamilo, Kulani, Palauhulu, Piinaau, Honomanu
	Problem Statement (Gathering): "Insufficient water flow in our streams causes multiple problems. It decreases the production of food supply in our streams, causes an increase of bacteria in the water that remain in our streams causing hazard to the people & life that live in and around that area. Most importantly, it destroys the essence of out lifestyle of a taro farming community by causing damage to our taro."			
Frances Kaauamo (CPRC 29.2-45)				
	Problem Statement (Gathering): "Water flow in streams at times are reduced to 0 which years back the same streams would flow continuously."			
Hannah K. Kaauamo (CPRC 29.2-27)	pohole, leko, polu (?), opai, o'opu, hihiwai, HaHa	Makapipi to Kolea		
Leolani R. Kaauamo (CPRC 29.2-41)	Po-ne (sic), leko, poiup (?), ooipi (?), opoe (opae?), oopu, hihiwai, haha, pula, leko, pohole	Makapip (sic) to Kolea		in most of these streams but not enough water to sustain life
	Problem Statement (Gathering): "Not enough water for oopu to move downstream to spawn. Today there is no oopu."			
Mary Kaauamo (CPRC 29.2-43)			opae, oopu, hihiwai	Wailuanui and Waiokamilo

Table 12-6. Continued. Summary of the 2001 testimonies submitted by NHLC related to gathering practices.

Declarant (CPRC Reference)	What Is Gathered By The Family	Streams Where Gathering Is Practiced	What Would Be Gathered If Water Were Available	Streams Where Gathering Would Be Practiced If Water Were Available
Samuel E. Kaauamo (CPRC 29.2-25)	pupu, kalo, paholi [possibly means pohole?], haha, luau	Kuhiwa - Kolea		Kuhiwai Kolea
	Problem Statement (Gathering): "EMI is taking too much water."			
Solomon Kaauamo Jr. (CPRC 29.2-29)	opae, oopu, hihiwai, pulu, leko, pohole	Makapipi to Kolea		in most of these streams but not enough water to sustain life
	Problem Statement (Gathering): "Not enough water for oopu to move downstream to spawn. Today there is no oopu."			
Gladys Kanoa (CPRC 29.2-31)	hihiwai, opae, oopu, prawns, ahole, mullet	Honomanu to Makapipi	hihiwai, opae, oopu, prawns	Honomanu to Makapipi
	Problem Statement (Gathering): "Most years we have losses to our taro crops due to drought. Water temperatures cannot be maintained cold enough to keep taro healthy. Taro farmers shouldn't have to compete for use of limited water."			
Jerome Kekiwi, Jr. (CPRC 29.2-49)	opae, hihiwai, oopu	from Honomanu to Makapipi	opae, hihiwai, oopu	Kolea, Honomanu
	Problem Statement (Gathering): "When the rain stops, the water flow in Wailua streams drop to almost nothing. It is hard to grow kalo with no water in the patches."			
Puaala Kekiwi (CPRC 29.2-47)	opae, hihiwai, oopu	from Makapipi to Honomanu	opae	Palahulu in Keanae
	Problem Statement (Gathering): "Getting water to a few of our patches when my neighbor doesn't let any water down."			
Chauncey K. Kimokeo (CPRC 29.2-5)	opae, hihiwai, o'opu, ferns, plants	from Kolea to Makapipi		
Ihe Kimokeo (CPRC 29.2-11)	oopu, hihiwai, opae, pig hunting, prons (sic)	Kolea to Makapipi		
Lincoln A. Kimokeo (CPRC 29.2-9)	opae, hihiwai, prawns, Hawaiian herbs, ferns shoots, ti leaves, flowers, plants to make leis	all streams (Kolea to Makapipi)	Everything of use	Kolea to Makapipi
	Problem Statement (Gathering): "Regular water flow once sustained the right environment for great populations of fish and other stream life, today disturbed water flow prevents stream life to increase population."			
Pualani Kimokeo (CPRC 29.2-7)	opae, hihiwai, o'opu, Hawaiian herbs, ferns shoots, ti leaves, flowers, lei making ferns	all streams of the Koolau	Everything	All (along the Koolau Valley)
	Problem Statement (Gathering): "Our kalo growth would be massive if the water was left alone. We would not have all these sickness in our loi. Worked the loi all my life and never did see all the problems on our kalo & water till the years of late 1960 through now."			

Table 12-6. Continued. Summary of the 2001 testimonies submitted by NHLC related to gathering practices.

Declarant (CPRC Reference)	What Is Gathered By The Family	Streams Where Gathering Is Practiced	What Would Be Gathered If Water Were Available	Streams Where Gathering Would Be Practiced If Water Were Available
Willie K. Kimokeo (CPRC 29.2-13)	oopu, hihiwai, opae, water cress, mountain kalo, haha	Kolea to Makapipi	oopu, hihiwai, opae, water cress	Kolea to Makapipi
	<u>Problem Statement (Gathering):</u> "Lack of water."			
Norman D. Martin Jr. (CPRC 29.2-15)	oopu, hihiwai, opai, everything	Kolea to Makapipi	oopu, opai, hihiwai	Kolea to Makapipi
	<u>Problem Statement (Gathering):</u> "Lack of water."			
B. Tau-a M. Pahukoa (CPRC 29.2-51)	opae, hihiwai	from Kolea to Makapipi		from Makapipi to Kolea & Waipio, Honomanu, Wailuaiki & Waialohe which is the muluwai of Palauhulu & Piinaau
	<u>Problem Statement (Gathering):</u> "The problem is not all of the water in the streams meet the sea."			
Benjamin Smith Sr. (CPRC 29.2-37)	opai, hihiwai, oopu	Hanawi, Kapaula, Kopiliula, Kapa'akea, East and West Wailua Iki , Honomanu, Makapipi	opai, hihiwai, oopu	all streams between Kolea & Kuahiwa
Lucille L. Smith (CPRC 29.2-39)	opai, hihiwai & oopu	Hanawi, Makapipi, Kopiliula, Kapa'akea, East and West Wailua Iki , Kapahula, Waiohue, Honomanu	opai, hihiwai, oopu	streams between Kolea & Kuahiwa
Edward Wendt (CPRC 29.2-53)	opae, hihiwai, oopu		opai, hihiwai, oopu	Waiokamilo - Wailua Stream
	<u>Problem Statement (Gathering):</u> "Cause not enough free flowing to enhance aquatic life and to assist in good taro growth."			

Historical uses of Ohia Stream can also provide some insight into the protection of traditional and customary Hawaiian rights. Without delving into the extensive archive of literature (refer to Kumu Pono Associates, 2001a), Handy et al., in *Native Planters of Old Hawaii* (1972), provide a limited regional description as follows:

> The northeast coast of East Maui has precipitous shores eroded by the waves which the trade winds sweep against its cliffs, islets, and inlets. Here the flank of Haleakala is steep, and as the trade winds blow up across their forested slopes they are cooled and release their moisture, making this the wettest coastal region in all the islands.
>
> There are several small streams between Ke'anae and Wailuanui. They flow in deep small gorges, and the terrain is very rough, but there were a few small *lo'i* developments.
>
> There are said to have been two springs of fresh water, which were opened by Kane and Kanaloa in their travels on Maui. From these springs, in a valley named 'Ohi'a, comes the water that

> irrigates the *lo'i* in Wailua, so says the legend (*Ka Nupepa Ku'oko'a*, October 4, 1923). The Wailuanui Stream gushes down in a beautiful cascade in its gorge just before flowing into the *lo'i* area. This cascade is called Wai-o-Kane (Water of Kane).
>
> Throughout wet Ko'olau, the wild taro growing along the streams and in the pockets high on the canyonlike walls of the gulches bespeaks former planting of stream taro along the watercourses, on the side of the gulches, and in the forest above. The same is true of the wild taros seen here and there in the present forest above the road and in protected spots on what was formerly low forest land, now used as pasture.

Martha Beckwith's *Hawaiian Mythology* (1940) emphasizes the cultural importance of spring water in the following excerpt:

> LEGENDS OF KANE AND KANALOA AS WATER FINDERS
>
> Kane and Kanaloa go into the precipitous mountains back of Keanae on Maui and lack water. They discuss whether it can be obtained at this height. "Oiana (Let it be seen)!" says Kanaloa; so Kane thrusts in his staff made of heavy, close-grained kauila wood (Alphitonia excelsa) and water gushes forth...Two holes are pointed out just below the road across Ohia gulch beyond Keanae on Maui where Kane dug his spear first into one hole and then into the other with the words, "This is for you, that for me." The water gushing from these apertures is called "the water of Kane and Kanaloa."

The HSA classified the cultural resources of Ohia Stream as "substantial." Data were collected in three general areas of: 1) archaeological; 2) historical; and 3) modern practices. Archaeological data were originally compiled by the State Historic Preservation Division and are only current to 1990, the date of the HSA (Table 12-7).

Table 12-7. Cultural resource elements evaluated as part of the Hawaii Stream Assessment for Ohia Stream.

Category	Value
Survey coverage: The extent of archaeological survey coverage was analyzed and recorded as complete, partial, very limited, and none. Few valleys are completely surveyed. Many have little or no survey coverage.	Very limited
Predictability: The ability to predict what historic sites might be in unsurveyed areas was scored as high, medium, or low predictability or unable to predict. A high score was assigned if archaeologists were able to predict likely site patterns in a valley given historic documents, extensive archaeological surveys in nearby or similar valleys, and/or partial survey coverage. A low score was assigned if archaeologists were unable to predict site patterns in a valley because of a lack of historical or archaeological information. A medium score was assigned to all other cases.	Low
Number of Sites: The actual number of historic sites known in each valley is straightforward yet very time consuming to count. Instead, archaeologists used survey information to estimate the number of sites in each valley. These figures, adequate for this broad-based assessment, are only rough estimates.	1

Valley significance as a Whole District: The overall evaluation of each valley's significance was made considering each valley a district. The significance criteria of the National and Hawaii Registers of Historic Places was used. Criterion A applies if the district is significant in addressing broad patterns of prehistory or early history. Criterion B applies if the district is associated with important people (rulers) or deities. Criterion C applies if the district contains excellent examples of site types. Criterion D applies if the district is significant for information contained in its sites. Finally, Criterion E applies if the district is culturally significant for traditionally known places or events or for sites such as burials, religious structures, trails, and other culturally noteworthy sites.	A, D, E
Site Density: The density patterns of historic sites make up a variable extremely important to planners. Three ranks were assigned: low for very few sites due either to normal site patterning or extensive land alteration, moderate for scattered clusters of sites, and high for continuous sites. Valleys with moderate or high density patterns are generally considered moderate or high sensitivity areas.	Low

Table 12-7. Continued. Cultural resource elements evaluated as part of the Hawaii Stream Assessment for Ohia Stream.

Category	Value
Site Specific Significance: The site specific significance variable was developed for valleys that had low densities of sites (very few sites) due either to normal site patterning or to extensive land alteration. An example of the first type might be a valley with housing sites on the side but too narrow for taro or housing sites on the valley floor. The second type might be a valley in which there had been sugar cane cultivation but a large heiau was left. The site specific significance of these valleys was categorized as either: 1) sites significant solely for information content which can undergo archaeological data recovery; or 2) sites significant for multiple criteria and merit preservation consideration. Those categorized as meriting preservation consideration would likely include large heiau, burial sites, and excellent examples of site types.	Sites significant for preservation
Overall Sensitivity: The overall sensitivity of a valley was ranked very high, high, moderate, low, or unknown. Very high sensitivity areas have moderate or high densities of sites with little or no land alteration. They are extremely important archaeological and/or cultural areas. High sensitivity areas have moderate or high densities of sites with little or no land alteration. Moderate sensitivity areas have very few sites with the sites meriting preservation consideration due to multiple criteria or moderate densities of sites with moderate land alteration. Low sensitivity areas have very few sites due to normal site patterning or due to extensive land alteration. The sites present are significant solely for their informational content, which enable mitigation through data recovery. Those valleys where no surveying had been undertaken and the ability to predict what might be found was low were ranked unknown.	Moderate
Historic Resources: Several types of sites were considered by inclusion in this section, particularly bridges, sugar mills and irrigation systems. Those that are listed on the State or National register were inventoried, but none of them assessed.	None
Taro Cultivation: Streams and stream water have been and continue to be an integral part of the Hawaiian lifestyle. The committee identified a number of factors important to current Hawaiian practices. These include current taro cultivation, the potential for taro cultivation, appurtenant rights, subsistence gathering areas, and stream-related mythology. The committee felt that a complete assessment of the cultural resources of Hawaii's streams should include these items but, due to limits of information, only the current cultivation of taro was included.	Up to 10 acres of taro

Fishponds are another integral part of traditional Hawaiian culture, which speaks volumes of Native Hawaiian skill and knowledge of aquaculture, which has also seen a resurgence of interest in recent years. Fishponds are found throughout the Hawaiian Islands and were either man-made or natural enclosures of water used for the raising and harvesting of fish and other aquatic organisms. Kikuchi (1973) identified six main types of fishponds, two of which are associated with streams (*loko wai*, *loko ia kalo*) and one type is associated with fresh water springs (*kaheka* or *hapunapuna*).

- Type III – *Loko Wai*: An inland fresh water fishpond which is usually either a natural lake or swamp, which can contain ditches connected to a river, stream, or the sea, and which can contain sluice grates. Although most frequently occurring inland, *loko wai* are also located along the coast near the outlet of a stream.
- Type IV – *Loko Ia Kalo*: A fishpond utilizing irrigated taro plots. *Loko ia kalo* are located inland along streams and on the coast in deltas and marshes.
- Type VI – *Kaheka* and *Hapunapuna*: A natural pool or holding pond. The majority, if not all of these types of ponds, are anchialine ponds with naturally occurring shrimp and mollusks.

According to a 1990 Hawaii Coastal Zone Management Program *Hawaiian Fishpond Study for the Islands of Hawaii, Maui, Lanai, and Kauai*, there are no fishponds present in the Ohia hydrologic unit (DHM, Inc., 1990).

Another component in the assessment of traditional and customary Hawaiian rights is the presence of Department of Hawaiian Home Lands (DHHL) parcels within the surface water hydrologic unit. The mission of DHHL is to effectively manage the Hawaiian Home Lands trust and to develop and deliver land to native Hawaiians (PBR Hawaii, 2004). In September 2004, DHHL published the Maui Island Plan which served to examine infrastructure needs, provide development cost estimates, and identify priority areas for homestead development. Of the more than 31,000 acres of DHHL land on the island of Maui, no parcels occur within the Ohia hydrologic unit (Figure 12-3).

Figure 12-2. Traditional ahupuaa boundaries in the vicinity of Ohia hydrologic unit. This hydrologic unit lies within the ahupuaa of Keanae (Source: State of Hawaii, Office of Planning, 2007a; USGS, 2001b).

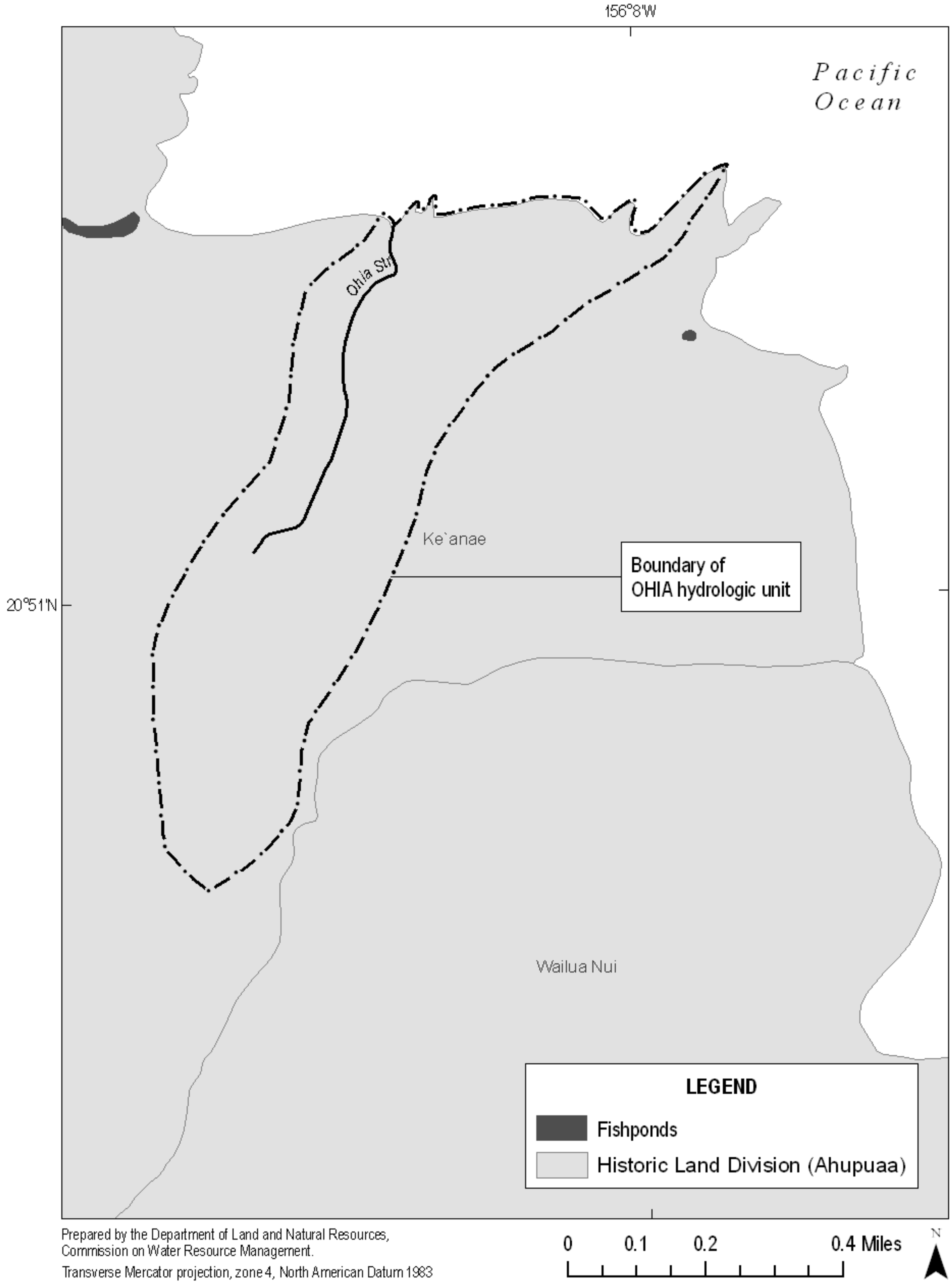
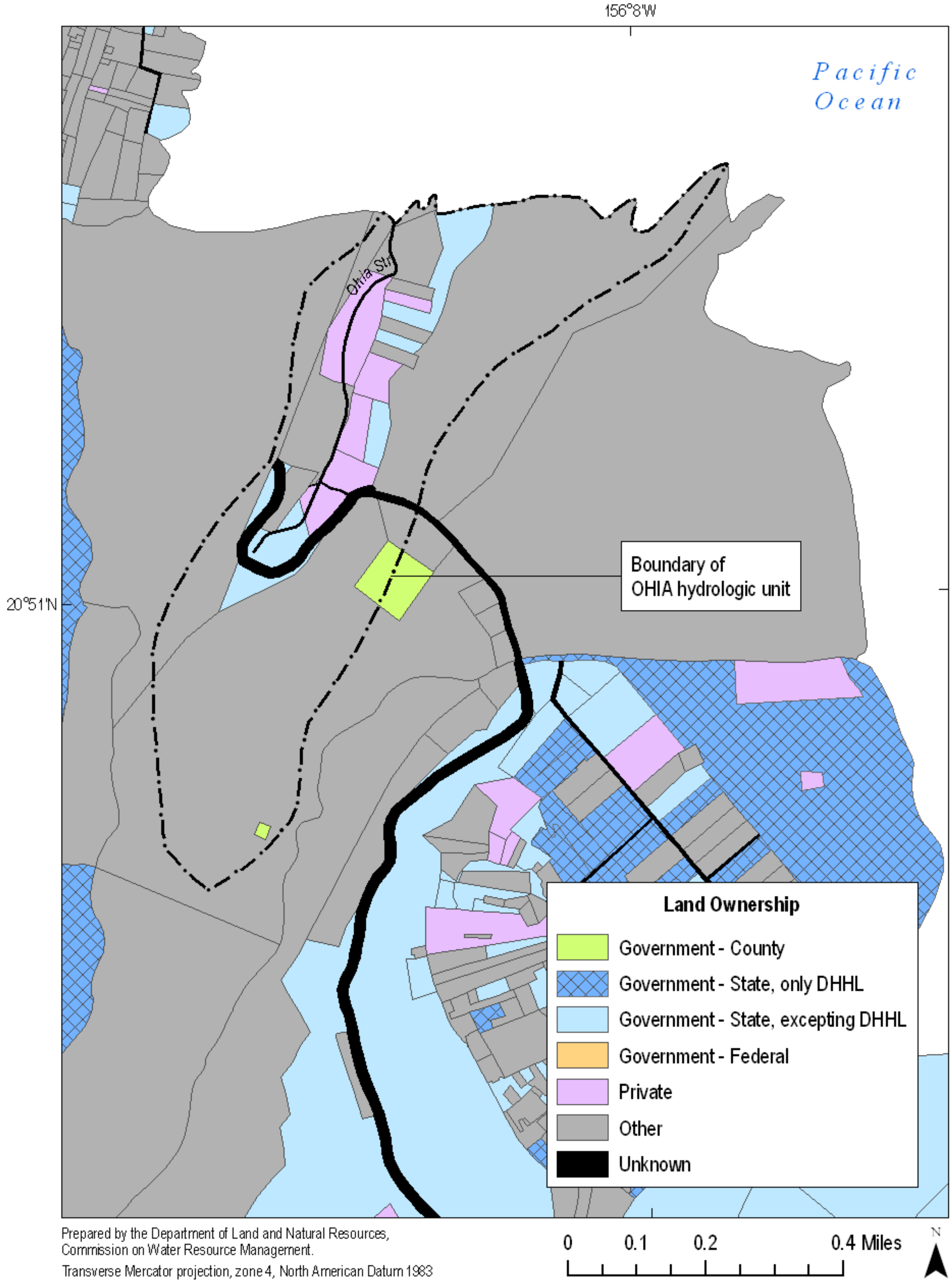


Figure 12-3. Land ownership in Ohia hydrologic unit (Source: County of Maui, 2006; USGS, 2001b).



13.0 Noninstream Uses

Under the State Water Code, noninstream uses are defined as "water that is diverted or removed from its stream channel…and includes the use of stream water outside of the channel for domestic, agricultural, and industrial purposes." Article XI, Section 3 of the State Constitution states: "The State shall conserve and protect agricultural lands, promote diversified agriculture, increase agricultural self-sufficiency and assure the availability of agriculturally sustainable lands." Water is crucial to agriculture and agricultural sustainability. Article XI, Section 3 also states, "Lands identified by the State as important agricultural lands needed to fulfill the purposes above shall not be reclassified by the State or rezoned by its political subdivisions without meeting the standards and criteria established by the legislature and approved by a two-thirds vote of the body responsible for the reclassification or rezoning action. [Add Const Con 1978 and election Nov 7, 1978]." It is the availability of water that allows for the designation of Important Agricultural Lands.

In most cases, water is diverted from the stream channel via a physical diversion structure. Diversions take many forms, from small PVC pipes in the stream that remove relatively small amounts of water, to earthen auwai (ditches), hand-built rock walls, and concrete dams that remove relatively larger amounts of water from the stream. Water is most often used away from the stream and it is not returned; however, as in the case of taro fields and hydroelectric plants, water may be returned to the stream at a point downstream of its use. While the return of water to the stream would generally be considered a positive value, this introduces the need to consider water quality variables such as increased temperature, nutrients, and dissolved oxygen, which may impact other instream uses. Additionally, discharge of water from a ditch system into a stream may introduce invasive species.

In addition to the amount of water currently or potentially being diverted offstream, the Commission must also consider the diversion structure and the type of use, all of which impact instream uses. The wide range of diversion structures, as noted above, is what makes regulation of surface water particularly difficult, since one standard method cannot be depended upon for monitoring and measuring flow. The ease of diverting streamflow, whether by gravity-flow PVC pipe, pump, or a dug channel, also plays a role in the convenience of diverting surface water and the abundance of illegal, non-permitted diversions.

13.1 Stream Diversions

Upon the enactment of the State Water Code and subsequent adoption of the Hawaii Administrative Rules, the Commission required the registration of all existing stream diversions statewide. The Commission categorized the diversions and filed registrations according to the registrant's last name or company name. While it is recognized that the ownership and/or lease of many of the properties with diversions has changed since then, the file reference (i.e., FILEREF) remains the name of the original registrant file (Table 13-1). Locations are depicted in Figure 13-3.

East Maui Irrigation Company (EMI) does not operate any diversions or ditch systems in the hydrologic unit of Ohia. There is only one registered diversion within the hydrologic of Ohia, which declared water use for domestic and irrigation purposes, including the cultivation of taro.

Table 13-1. Registered diversions in the Ohia hydrologic unit.

Event ID	File Reference	Tax Map Key	Diversion Amount (cfs)	Active (Yes/No)	Verified (Yes/No)	Riparian (Yes/No)	Rights Claim (Yes/No)
REG.501.6	HOKOANA BK	1-1-008:010		Yes	No	Yes	Yes
Water is diverted from an unnamed/unmapped spring mauka of Hana Highway via an auwai. Water is used to irrigate 2.09 acres of taro. Registration indicates that this source, along with two others on Waiokamilo and Palauhulu Streams, are used for roughly 3 acres of taro, 10 acres of other uses including watercress, ti plants, and flowers. The diversions also serve domestic and landscaping uses for a house on the property. No photo available.							

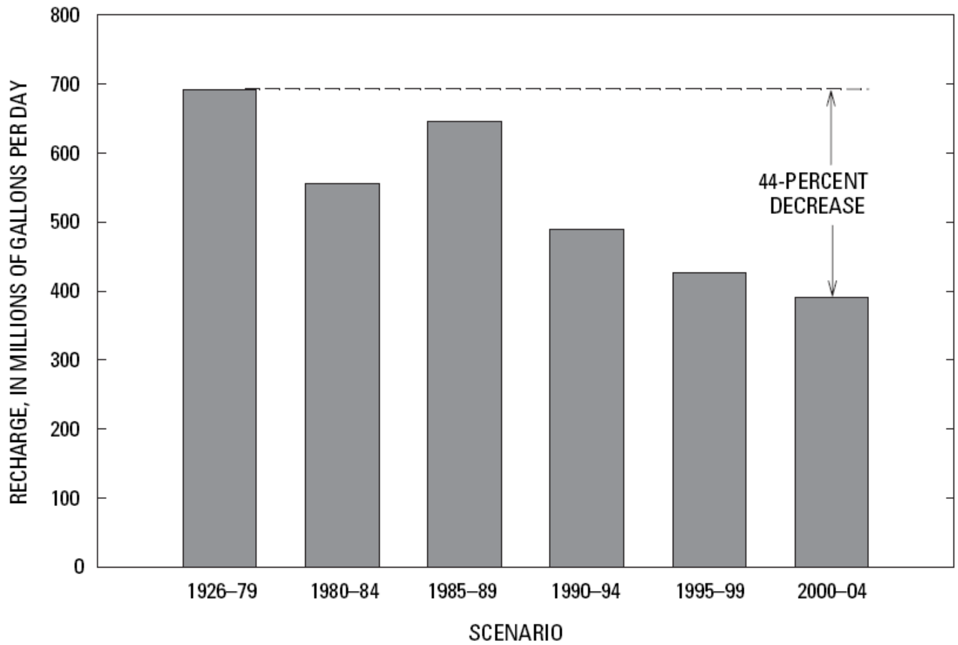
13.2 Ground Water Recharge

Following the establishment of instream flow standards, one of the proposed measures to increase streamflow may be to decrease the amount of water diverted from streams. Such a measure has important implications to ground water recharge because it affects the amount of water available for irrigation. Decreasing the amount of water diverted at the ditches located in east Maui affects the amount of water available for the irrigation of crops in west and central Maui. Since the early 20th century, about 100 billion gallons of water (274 million gallons per day) have been diverted each year from Maui streams for irrigation in west and central Maui. More than half of this diverted water, 59 billion gallons per year (162 million gallons per day), comes from east Maui (Engott and Vana, 2007).

The effects of irrigation water on ground water recharge can be analyzed using the water budget equation[16]. Engott and Vana (2007) at the USGS conducted a study that estimated each of the water budget components for west and central Maui using data from 1926 to 2004. Components of the water budget include rainfall, fog drip, irrigation, runoff, evapotranspiration, and recharge. Results of the study were separated into six historical periods: 1926-79, 1980-84, 1985-89, 1990-94, 1995-99, and 2000-04. From 1979 to 2004, ground water recharge decreased 44 percent from 693 million gallons per day to 391 million gallons per day (Figure 13-1). The low recharge rate in 2004 coincides with the lowest irrigation and rainfall rates that were 46 percent and 11 percent lower than those in 1979, respectively. During this period, agricultural lands decreased 21 percent from 112,657 acres in 1979 to 88,847 acres in 2004. Further analysis revealed that a 20 percent decrease in irrigation rate could result in a 9 percent reduction in recharge. A similar study by Izuka et al. (2005) reported that a 34 percent decrease in irrigation rate constituted a 7 percent reduction in recharge in the Lihue basin in Kauai, Hawaii. Since over half of the irrigation water for central Maui comes from east Maui, a 20 percent decrease in the amount of water diverted from streams in the east can potentially reduce recharge in central Maui by 5 percent.

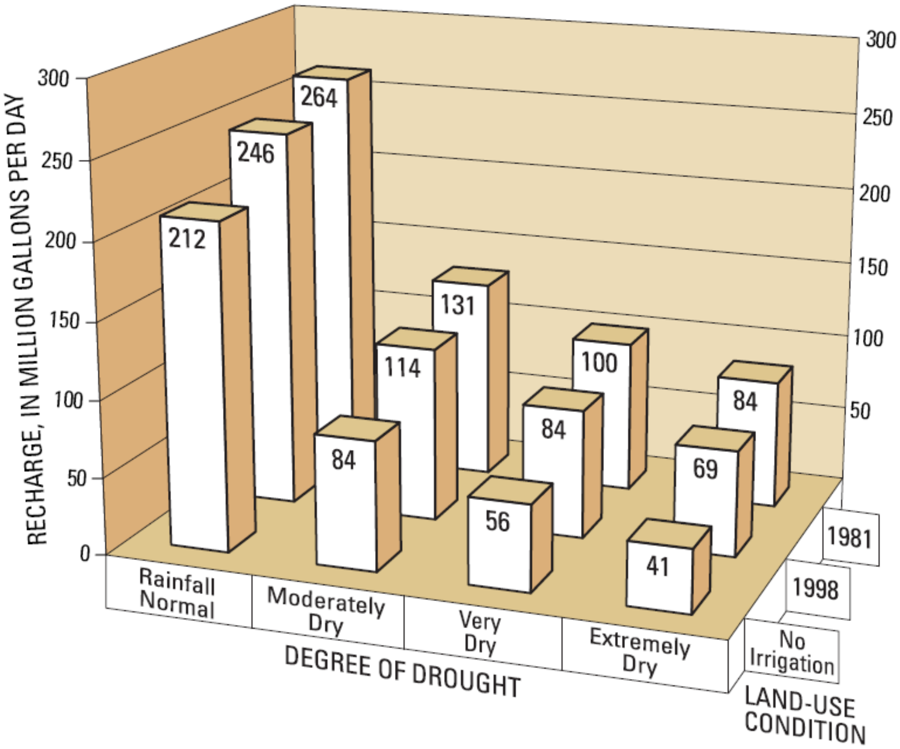
[16] Water-budget is a balance between the amount of water leaving, entering, and being stored in the plant-soil system. The water budget method/equation is often used to estimate ground water recharge.

Figure 13-1. Estimated recharge for six historical periods between 1926 and 2004, central and west Maui, Hawaii (Source: Engott and Vana, 2007).



Droughts, or periods of lower than average rainfall, have been shown to drastically decrease ground water recharge (Figure 13-2). The period of drought that occurred in 1998-2002, during which rainfall was at least 30 percent lower than the average annual rainfall, was estimated to reduce recharge by 27 percent in west and central Maui (Engott and Vana, 2007). For example, on the island of Kauai, the drought conditions reduced recharge in Lihue basin by 34 to 37 percent (Izuka et al., 2005). Even though droughts can have exacerbating effects on ground water recharge, these effects are transient and are usually mitigated by periods of higher than average rainfall (Engott and Vana, 2007). However, prolonged loss of irrigation water caused by a decrease in the amount of water diverted by irrigation ditches has greater effects on the long-term trends of ground water levels.

Figure 13-2. Summary of estimated recharge, in million gallons per day, for various land-use and rainfall conditions in the Lihue Basin, Kauai, Hawaii (Source: Izuka et. al., 2005).



13.3 Classification of Agricultural Lands

The identification and designation of Important Agricultural Lands (IAL) was approved in 1978 in an effort to promote agricultural viability. Important agricultural lands are those that are capable of producing sustained high agricultural yields for export or local consumption. These lands are identified based on current land use, soil and growing conditions, water availability, other agricultural land classifications, existing County plans, and proximity to supporting infrastructure conducive to agricultural productivity (DOA, 2009a). On June 29, 2009, the State Land Use Commission designated 27,102 acres of A&B agricultural lands at Wailuku and Makawao in the island of Maui as Important Agricultural Lands. More than 22,000 acres of the designated lands are irrigated with water from the EMI System (PR-2009-18, 72.0). This is the first IAL to be designated since the constitutional amendment for IAL was passed 30 years ago (PR-2009-18, 17.0).

The Agricultural Lands of Importance to the State of Hawaii (ALISH) were completed by the State Department of Agriculture (HDOA) in 1977, with the assistance of the Soil Conservation Service (SCS), U.S. Department of Agriculture, and the College of Tropical Agriculture, University of Hawaii. Three classes of agriculturally important lands were established for Hawaii in conjunction with the SCS in an effort to inventory prime agricultural lands nationwide. Hawaii's effort resulted in the classification system of lands as: 1) Prime agricultural land; 2) Unique agricultural land; and 3) Other important agricultural land. Each classification was based on specific criteria such as soil characteristics, slope, flood frequency, and water supply. ALISH was intended to serve as a long-term planning guidance for land use decisions related to important agricultural lands. HDOA is currently in the process of developing agricultural incentives based on classifications of Important Agricultural Lands. Ohia is comprised of about 18 percent "other important agricultural lands", but does not contain any "prime agricultural lands".

From 1978 to 1980, HDOA prepared agricultural land use maps (ALUM) based on data from its Planning and Development Section and from SCS. The maps identified key commodity areas (with subclasses) consisting of: 1) Animal husbandry; 2) Field crops; 3) Orchards; 4) Pineapple; 5) Aquaculture; 6) Sugarcane; and Wetlands (Table 13-2).

Table 13-2. Agricultural land uses and area distributions in the Ohia hydrologic unit.

Density	Area (mi^2)	Percent of Unit
Animal husbandry, grazing	0.13	45.8
Wetlands	0.01	2.5

Though both ALISH and ALUM datasets are considerably outdated, many of the same agricultural assumptions may still hold true. The information is presented here to provide the Commission with present or potential noninstream use information (Figure 13-4).

Figure 13-3. All registered diversions and EMI minor diversions identified in the Ohia hydrologic unit (Source: East Maui Irrigation Company, 1970; State of Hawaii, Commission on Water Resource Management, 2008f; USGS, 2001b).

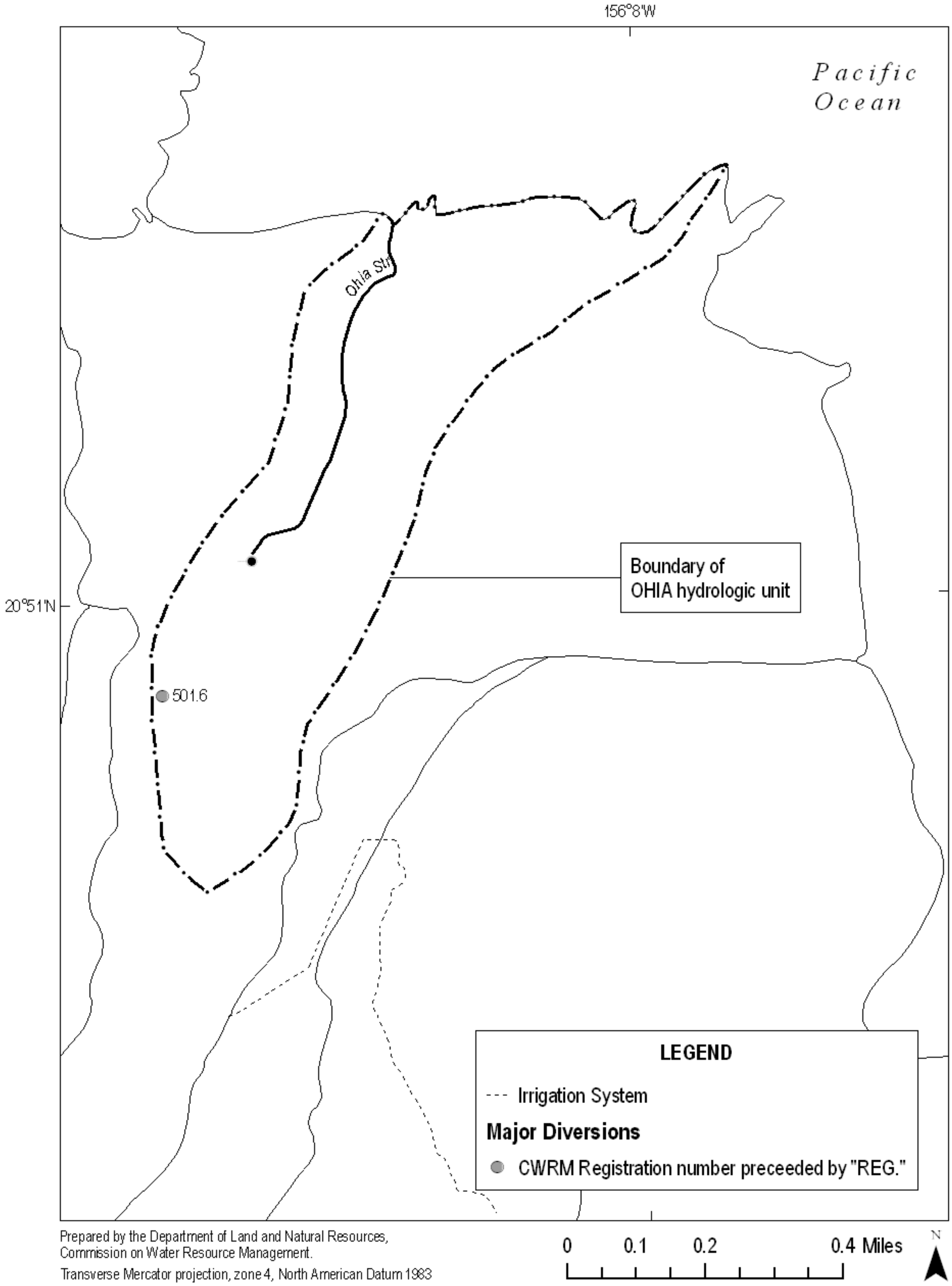
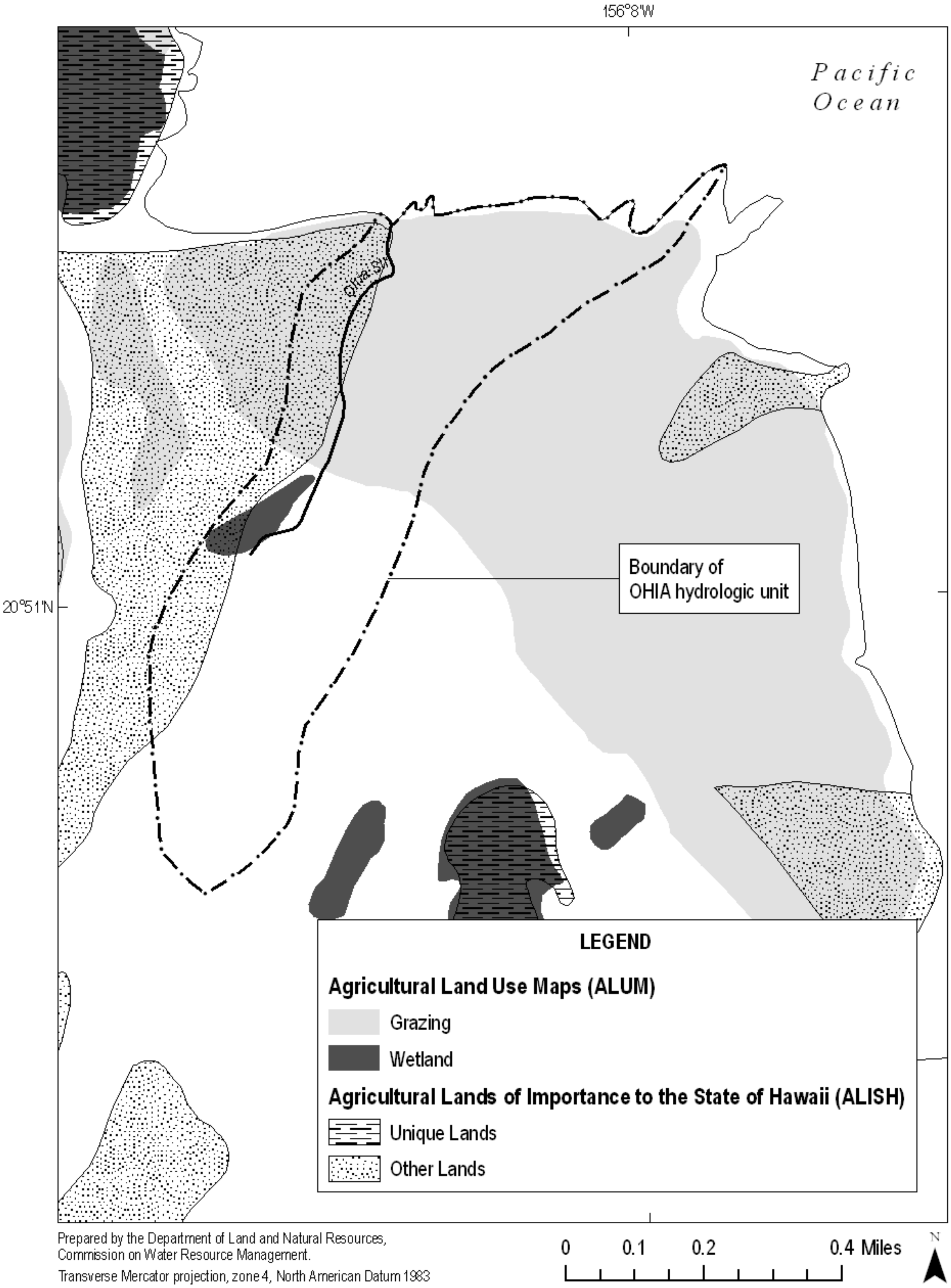


Figure 13-4. Potential agricultural land use for the Ohia hydrologic unit based on the ALISH and ALUM classification systems (Source: State of Hawaii, Office of Planning, 1977; 1980; USGS, 2001b).



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15.0 Appendices

Appendix A Petition to Amend Interim Instream Flow Standards. Waianu Stream, East Maui. *State of Hawaii, Department of Land and Natural Resources, Commission on Water Resource Management.*

Appendix A

State of Hawaii
COMMISSION ON WATER RESOURCE MANAGEMENT
Department of Land and Natural Resources

'01 MAY 24 P3:10

PETITION TO AMEND INTERIM INSTREAM FLOW STANDARDS

WAIANU STREAM, EAST MAUI

Instructions: Please print in ink or type and send completed petition with attachments to the Commission on Water Resource Management, P.O. Box 621, Honolulu, Hawaii 96809. Petition must be accompanied by a non-refundable filing fee of $25.00 payable to the Dept. of Land and Natural Resources. The Commission may not accept incomplete applications. For assistance, call the Regulation Branch at 587-0225.

1. PETITIONER
   Firm/Name Na Moku 'Aupuni o Ko'olau Hui c/o Native Hawaiian Legal Corporation
   Contact Person Alan Murakami, Attorney Ph: 521-2302
   Address 1164 Bishop Street, Honolulu, HI 96813

2. STREAMFLOW DATA NONE
   USGS stream gaging station ______ Period of Record UNAVAILABLE.
   Location/Reach
   (Attach a USGS map, scale 1"=2000', and a property tax map showing diversion location referenced to established property boundaries.)

TABLE 1. PERIOD OF RECORD AVERAGE MONTHLY STREAMFLOW WITHIN THE AFFECTED STREAM REACH, IN CFS

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
UNAVAILABLE.												

Annual Median flow in cfs =

TABLE 2. PROPOSED AVERAGE MONTHLY STREAMFLOW DIVERSION FROM AFFECTED STREAM REACH, IN CFS

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
UNDETERMINED; SUFFICIENT FOR TARO FARMING AND/OR GATHERING.												

Annual Median flow in cfs =

TABLE 3. AVERAGE MONTHLY STREAMFLOW IN AFFECTED STREAM REACH AFTER DIVERSION (min release flow), IN CFS

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
NATURAL STREAMFLOW EXCEPT FOR EXERCISE OF APPURTENANT WATER RIGHTS.												

Annual Median flow in cfs =

3. EXISTING INSTREAM AND OFFSTREAM WATER USES FOR ENTIRE STREAM REACH

TMK	OWNER	USE
RESEARCH IN PROGRESS.		

(If more space is necessary, attach an extended list following above format)

4. ANTICIPATED IMPACTS ON STREAM AND BASIS FOR SUCH IMPACTS:

RESTORATION OF INSTREAM NATURAL HABITAT AND BIOTA, AND BENEFICIAL APPURTENANT AND GATHERING USES.

(Attach supporting documentation, plans, letters, etc.)

NATIVE HAWAIIAN LEGAL CORPORATION

May 24, 2001
Date

Signature

Alan Murakami Petitioner
Attorney for Na Moku 'Aupuni o Ko'olau Hui

For Official Use
Date Received ______
Date Accepted ______