Instream Flow Standard Assessment Report

Island of Maui
Hydrologic Unit 6014
Honokohau

November 2019 **PR-2019-03**

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

COVER
Satallite image of Honokohau hydrologic unit with the Honokohau Stream flowing into the Pacific Ocean, West Maui [Google Earth, 2008].

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

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)
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
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
HDOA	State Department of Agriculture (State of Hawaii)
HI-GAP	Hawaii Gap Analysis Program
HOT	hotel
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
KAA	Kekaha Agriculture Association
KIUC	Kauai Island Utility Cooperative
KLM	Kaanapali Land Management Company
LCA	Land Commission Award
LUC	Land Use Commission (State of Hawaii)
MECO	Maui Electric Company
MF	multi-family residential
mgd	million gallons per day
Mgal/d	million gallons per day
mi	mile
MLP	Maui Land & Pineapple
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
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

General Overview

The hydrologic unit of Honokohau is located in West Maui, on the the western flank of Puu Kukui Mountain and the moku of Kaanapali, which forms the western part of the Hawaiian island of Maui (Figure 1-3). It covers an area of 11.46 square miles from 5,780 feet elevation to the sea with a mean basin elevation of 2,200 feet and a mean basin slope of 78 percent (Figures 1-4 and 1-5). Sixty-two percent of the basin has a slope greater than 30 percent. The longest flow path in Honokohau is 11.4 miles in length, traversing in a northernly direction from its headwaters to Honokohau Bay. There is one main stem of the Honokohau Stream with a number of short tributaries in the upper reaches. Base flow supports mauka to makai flow 100 percent of the time if water was not diverted. The basin has a mean annual precipitation of 168 inches. Seepage-run measurements indicate spatially continuous flow downstream of the Honokohau Ditch intake, although some reaches are losing and some gaining flow. Base flow is supported by high elevation ground water discharge in the upper reaches, contributing as much as 3.4 million gallons per day (mgd). The highest elevation sections of the hydrologic unit are made up of conservation land owned by Maui Land and Pineapple (MLP). The City of Lahaina with a total population of 11,704 people, is a census designated place that includes Kaanapali and Kapalua beach resorts and Honokohau Valley residents (U.S. Census Bureau Office of Planning 2011). The lower altitudes are dominated by alien trees, while the upper regions support native ohia-dominated forests. Throughout the middle and lower reaches along the stream, taro was extensively cultivated before plantations started removing water from the stream. Today, only 3.5 of the over 50 acres of loi remain. The state highway provides the primary access through Honokohau, with a secondary road continuing up the valley and a number of former agricultural roads providing limited access to some areas of the hydrologic unit (Figure 1-6). The Honokohau Ditch was jointly funded by MLP and Pioneer Mill Company (PMC), bringing water diverted from from Honokohau and Honolua watersheds into drier lands to support pineapple and sugarcane agriculture. Since the closure of Pioneer Mill in 2000 and Maui Pineapple Company in 2009, water has been diverted by the ditch to support non-potable needs of the Kapalua Resort area (landscape irrigation, golf course irrigation) and the Mahinahina Water Treatment Facility of the Maui Department of Water Supply. The stream supports habitat for native aquatic biota and damselflies (*Magalerion sp.*). There is substantial recreational and aesthetic value in the lower reaches. Some families rely on Honokohau Stream for domestic needs.

Current Instream Flow Standard

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

> <u>Interim instream flow standard for Maui</u>. The Interim Instream Flow Standard for all streams on 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 December 31, 1988. Streamflow was not measured on that date; therefore, the current interim IFS is not a quantifiable value.

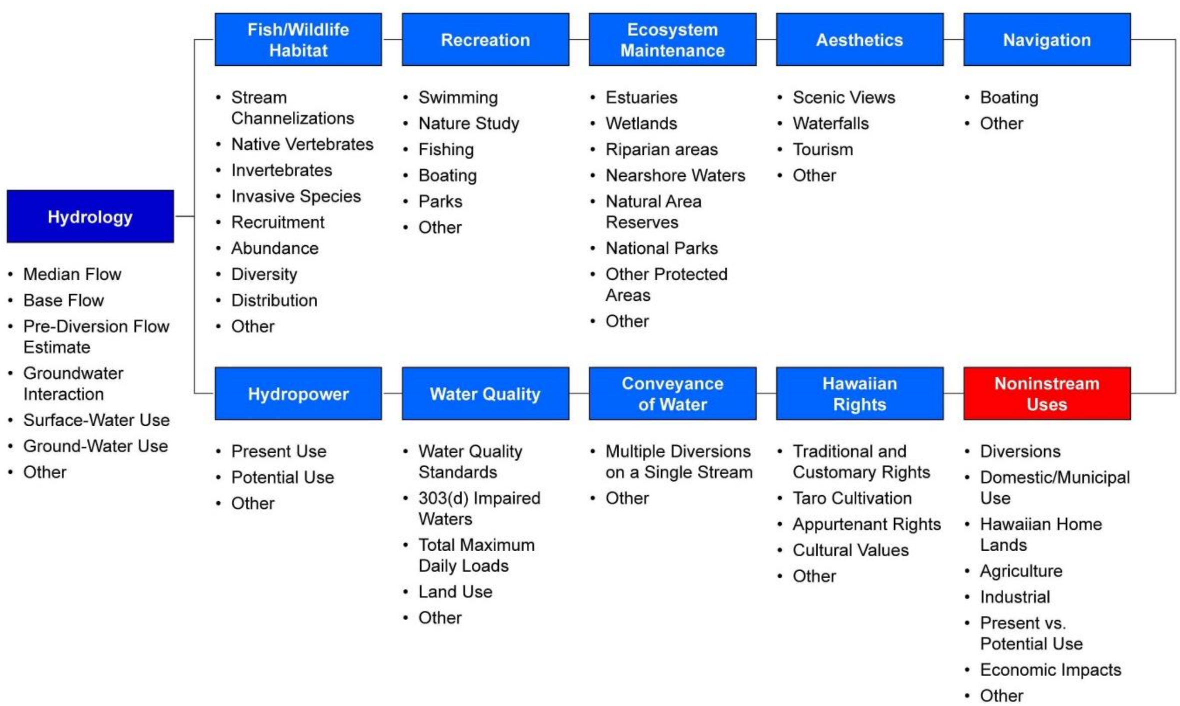
Instream Flow Standards

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 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.

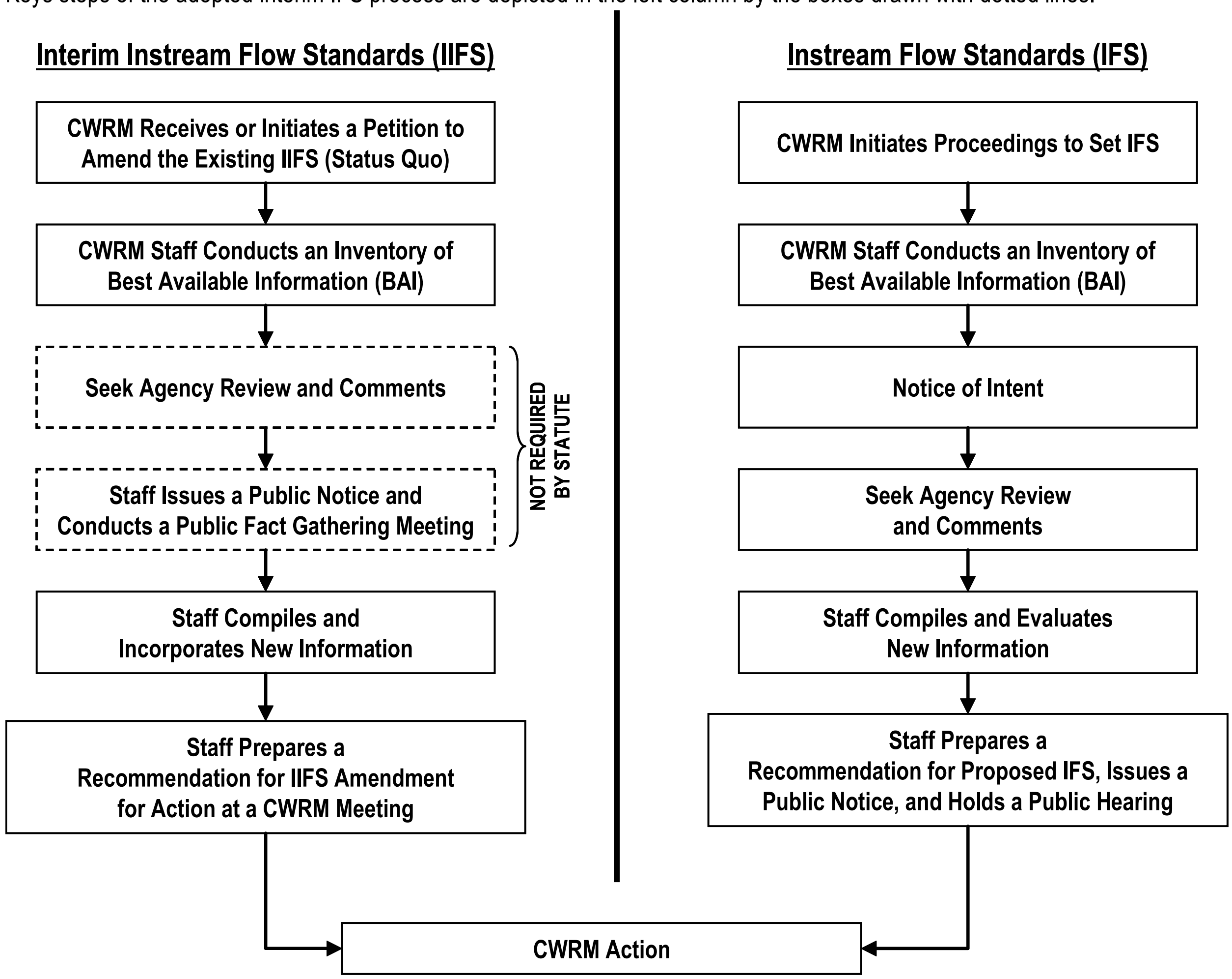


Interim Instream Flow Standard Process

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. Keys steps of the adopted interim IFS process are depicted in the left column by the boxes drawn with dotted lines.



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. Section 13.0 describes public trust uses of water not covered in other sections. Noninstream uses are summarized in Section 14.0. Maps are provided at the end of each section to help illustrate information presented within the section's text or tables. Finally, Section 15.0 provides a comprehensive listing of cited references and is intended to offer readers the opportunity to review IFSAR references in further detail.

An important component of the IFSAR and the interim IFS process is the Compilation of Public Review Comments (CPRC). The CPRC serves as a supporting document containing the oral and written comments that are submitted as part of the initial public review process. Comments referred to within the IFSAR will identify both the section and page number where the original comment can be located in the CPRC. For example, a reference to "8.0-3" indicates the third page of comments in Section 8.0 of the CPRC.

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.

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.

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. Quickbird satellite imagery of the Honokohau hydrologic unit and streams in West Maui, Hawaii. (Source: State of Hawaii, Planning Department, 2004; State of Hawaii, Commission on Water Resource Management, 2015c; State of Hawaii, Division of Aquatic Resources, 2005)

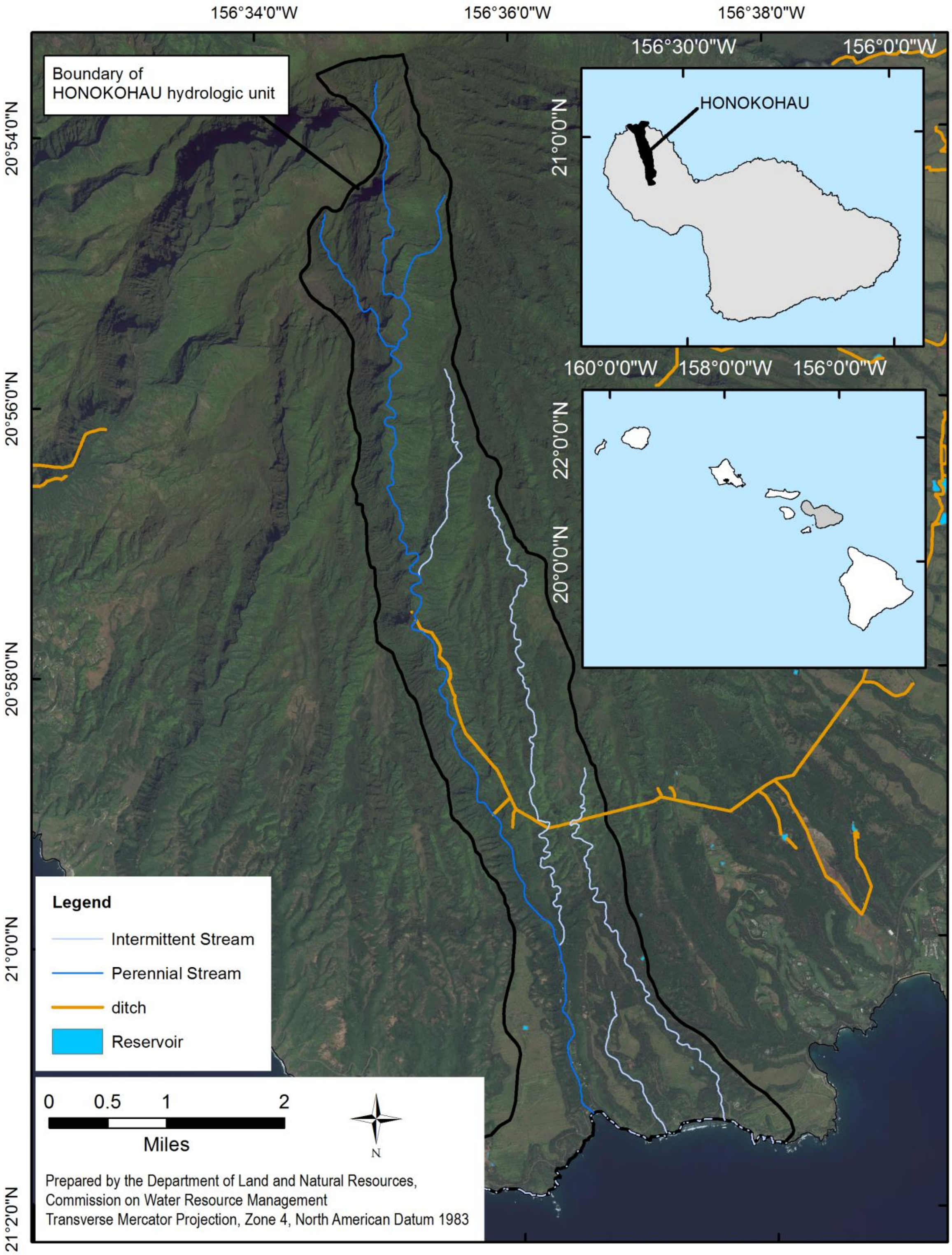


Figure 1-4. Elevation range of the Honokohau hydrologic unit. (Source: State of Hawaii, Office of Planning, 2004e; U.S. Geological Survey, 2001)

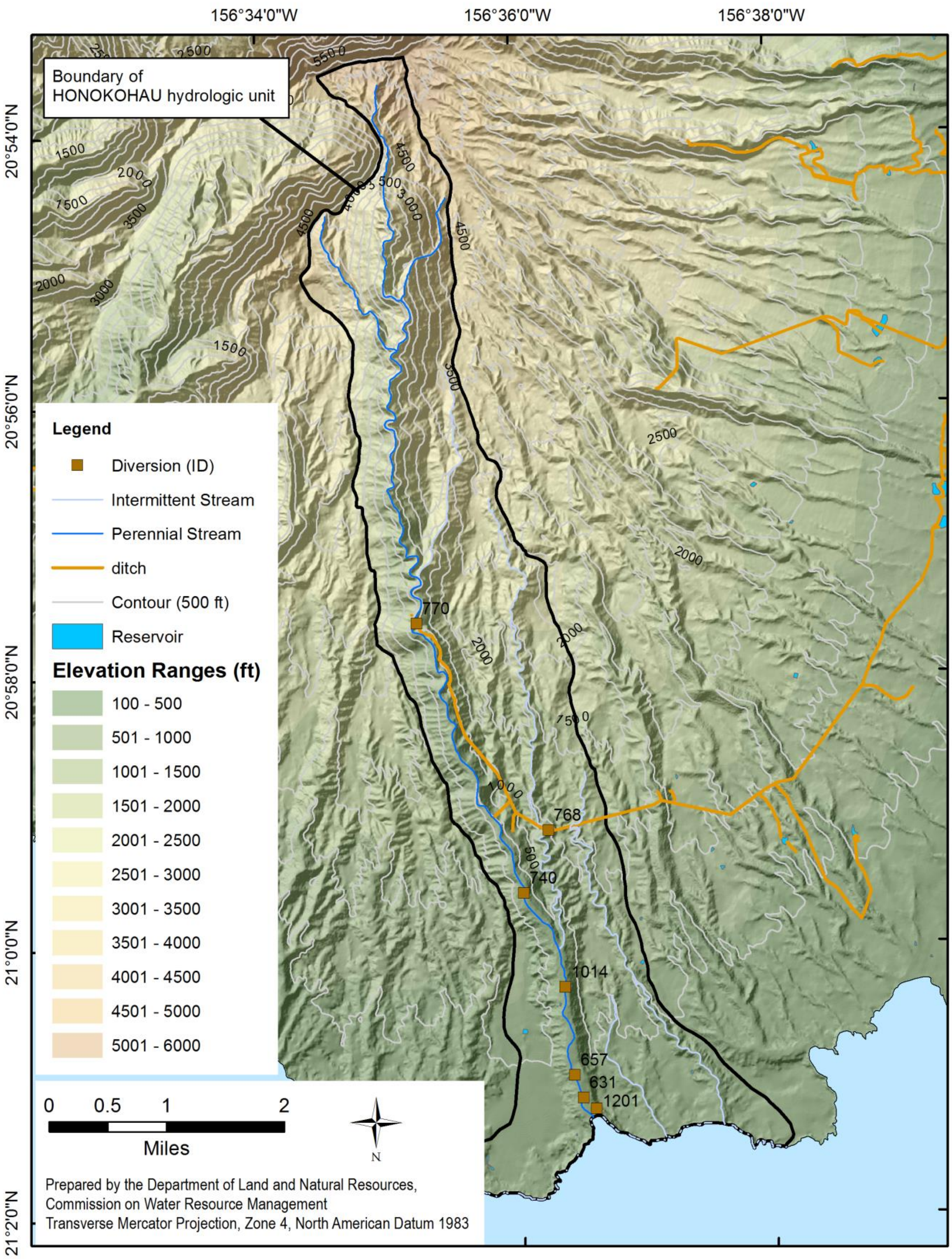


Figure 1-5. USGS topographic map of Honokohau hydrologic unit. (Source: U.S. Geological Survey, 1996)

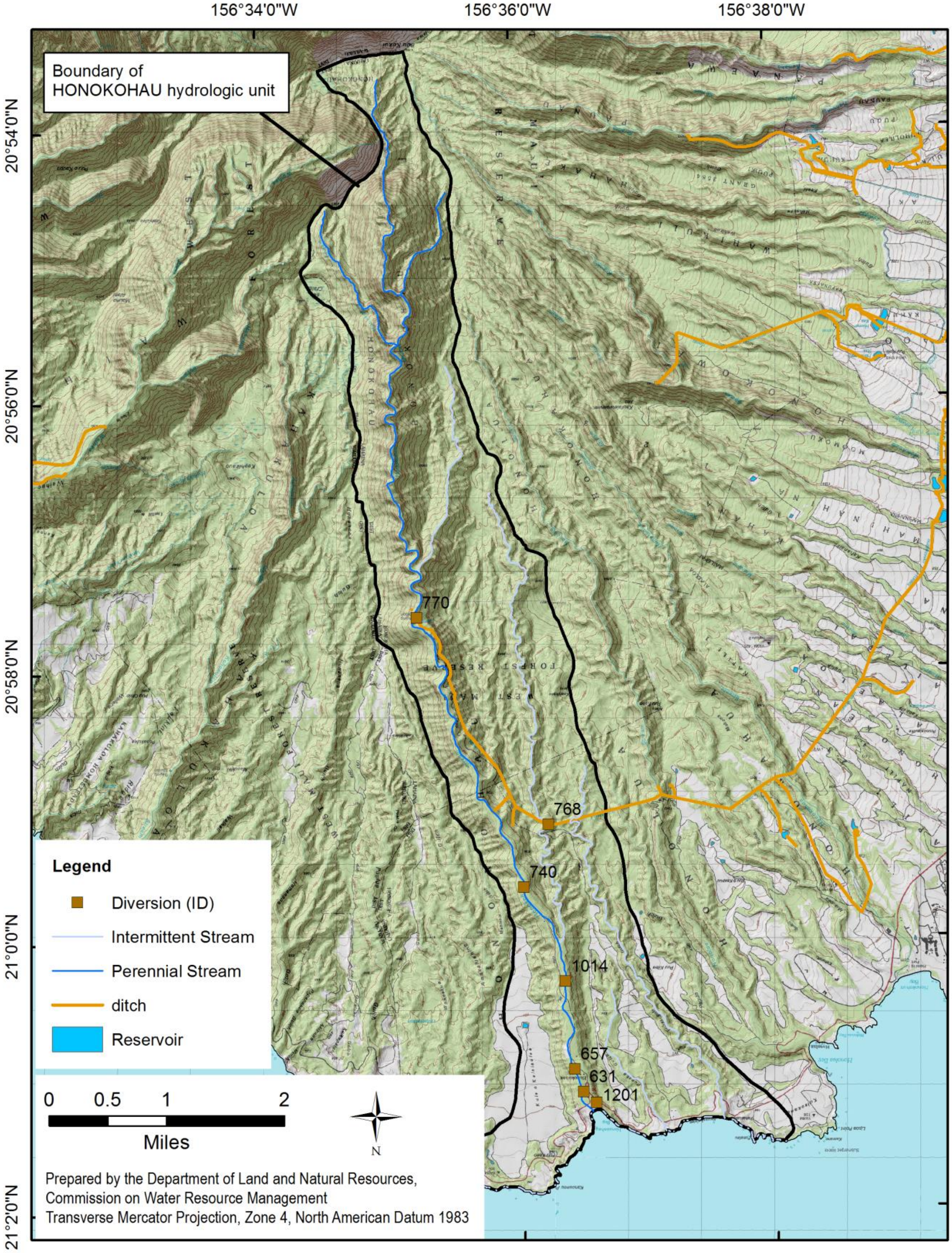
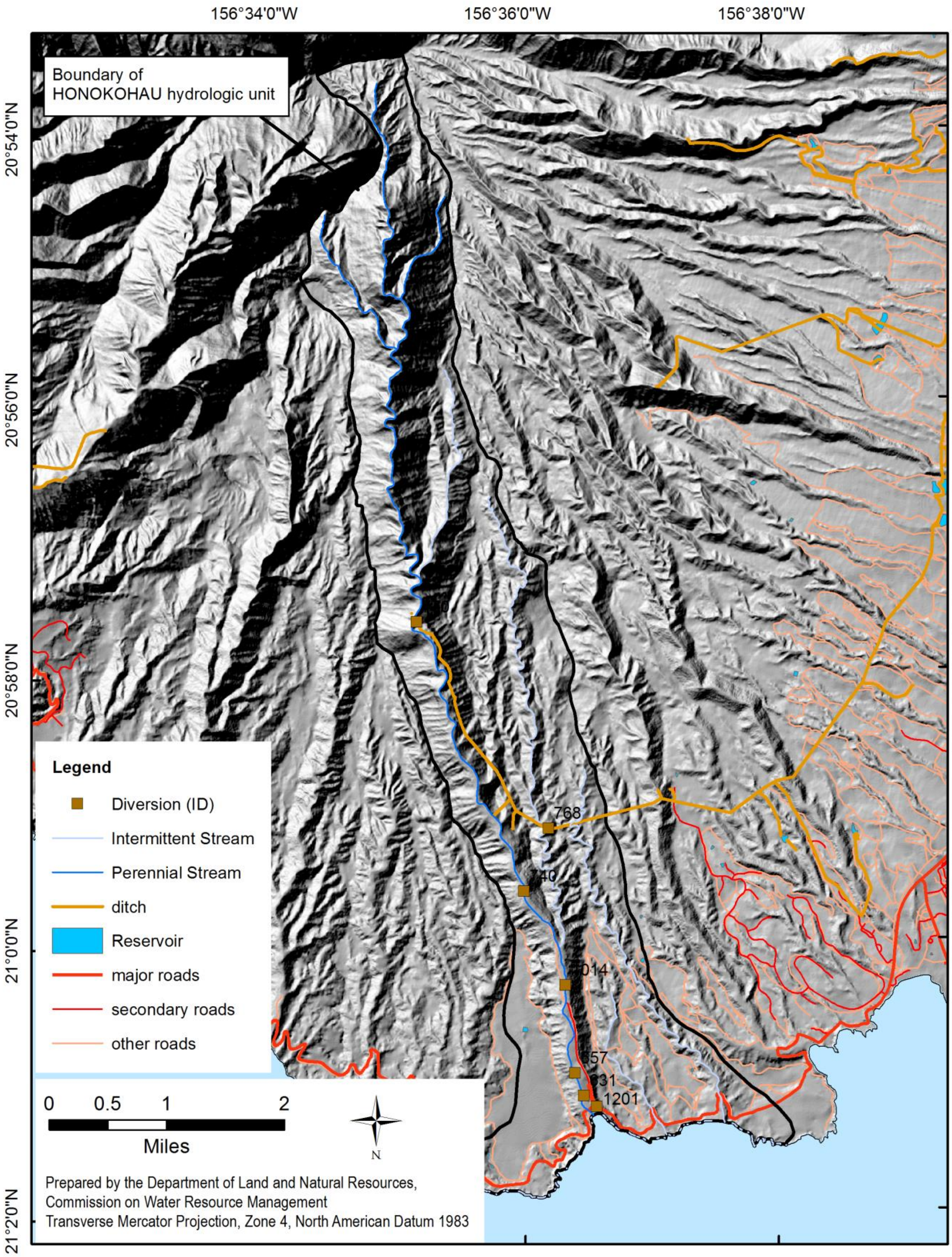


Figure 1-6. Major and minor roads for the Honokohau hydrologic unit. (Source: State of Hawaii, Office of Planning 2015)



2.0 Unit Characteristics

Geology

Honokohau is on the western flanks of Puu Kukui, the West Maui volcano. There were three separate volcanic phases in West Maui (Stearns and Macdonald 1942). The first phase, called the Wailuku Volcanic Series, makes up about 97% of the volume of the volcano, and consists of thin pahoehoe and aa flows of tholeiitic olivine basalt with minor plagioclase basalt as thick as 1700 meters (Table 2-1). The summit of this shield building phase eventually collapsed to form a caldera about 3.2 km across, with horizontal post-caldera lava flows. The Honolua Volcanic Series, the second phase, is dominated by alkali rocks that formed an incomplete cap to the volcano ranging from single flows less than 10 m thick to several flows as thick as 230 m on the northeastern slopes (Macdonald and Abbott 1970). Occasionally viscuous trachytic magma formed domes with steeply sloping flow planes, especially in the Kahoma and Launiupoko areas. Many dike and vent formations were produced in the Honolua Series although due to the lack of well-developed rift zones, their distribution is somewhat irregular. The Honolua Series finished about 500 kya, followed by a brief third phase of activity which included four small eruptions occurring on the southwestern slope forming the Lahaina Volcanic Series. These lava flows were all silica undersaturated basanitoids or basanites. The rapid erioson and valley incision of West Maui has produced broad alluvial fans with unconsolidated dunes of lithified to semi-lithified calcareous sand on the western slopes. The generalized geology of the Honokohau hydrologic unit is depicted in Figure 2-2.

Table 2-1 Area and percentage of surface geologic features for Honokohau hydrologic unit. (Source: Sherrod et al, 2007)

Name	Rock Type	Area (mi^2)	Percent (%)
Wailuku Volcanics	Tholeiitic basalt; pahoehoe lava flows	8.306	72.5
Honolua Volcanics	Hawaiite and trachyte composition; lava and bulbous dome of massive lava; aa flows	2.849	24.9
Alluvium	Sand and Gravel	0.309	2.7

Soils

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; group D soils have the lowest. In the Honokohau hydrologic unit, upland soils are dominated by rough mountainous land with rough broken and stony land. By contrast, mid elevations are dominated by rough broken land and some honolua series. Alaeloa and stony alluvial land make up the lowest elevations of the unit (Table 2-2). Most of the unit consists of soils in Group B (43.96%), silty loam or loam with moderate infiltration rates, with Group D (27.5%) soils consisting of clay loam, silty clay loam, or clay, with high runoff potential. Group A and C soils occupy the lower elevations. The less sloping tops of ridges and interfluves (regions of higher land between valleys in the same hydrologic unit) are poorly drained but still support moderate infiltration (Figure 2-3). The numerous gulches and mountainsides have slopes of 40 to 70 percent, leading to high rates of slopewash. Runoff is rapid in these soils and geologic erosion is active. The soils of rough broken land are not uniform. The clay is moderately permeable with slow to medium runoff and a slight to moderate erosion hazard (U.S. Department of Agriculture, National Resource Conservation Service, 1986).

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

Soil Series Unit	Hydrologic Soil Group	Area (mi^2)	Percent (%)
Alaeloa	C	0.881	7.7%
Beaches	C	0.01	0.1%
Honolua	B	0.313	2.7%
Hydrandepts-Tropaquods	A	0.534	4.7%
Koele-rocky complex	B	0.349	3.0%
Rock land	C	0.058	0.5%
Rough broken land	D	1.438	12.5%
Rough mountainous land	B	7.681	67.0%
Stony alluvial land	A	0.149	1.3%
Tropaquepts	A	0.046	0.4%

Rainfall

The West Maui Mountains are the driving force affecting the distribution of rainfall in Honokohau with rainfall affected by both the orographic[1] effect and the rain shadow 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 moist air cools, water condenses and the air mass releases precipitation. As a result, frequent and heavy rainfall is observed at the windward mountain slopes. 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). The fog drip zone occurs below the elevation where cloud height is restricted by the temperature inversion, where temperature increases with elevation (Sholl et al., 2002). Fog drip is a result of cloud-water droplets impacting vegetation (Scholl et al., 2002) and can contribute significantly to ground water recharge. Above the inversion zone, the air is dry and the sky is frequently clear (absence of clouds) with high solar radiation, creating an arid atmosphere with little rainfall.

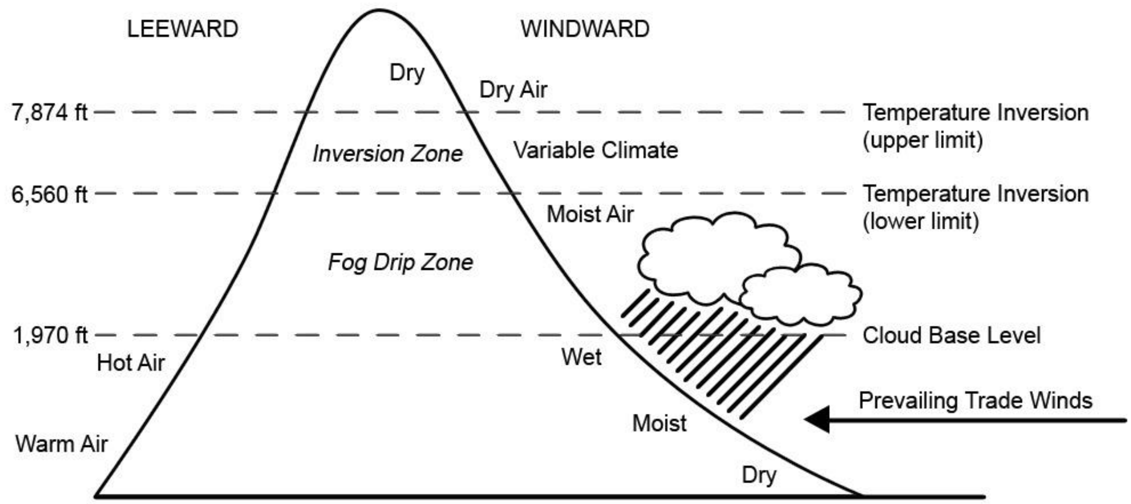
A majority of the mountains in Hawaii peak in the fog drip zone, where cloud-water is intercepted by vegetation. In such cases, air passes over the mountains, warming and drying while descending on the leeward mountain slopes. Precipitation on Puu Kukui is influenced by its position relative to the trade winds. The highest position lies in the cloudy layer below the trade wind inversion resulting in peak rainfall for the region. Mean annual rainfall on Puu Kukui measured by the USGS (station 380.0) and Maui Land & Pineapple since 1928 is about 362 inches. The fog drip zone on the windward side of islands 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). The steep gradient around the island forces moisture-laden air to rapidly rise in elevation (over 3,000 feet) in a short distance, resulting in a rapid release of rainfall in one location. Finally, the relatively round, conical shape of the West Maui Mountains exposes all sides of the peak to wind and moisture.

The Honokohau hydrologic unit is situated on north flank of the West Maui Mountains and as such receives much orographic rainfall do to it's orientation relative to the primary trade wind direction (east-northeast). Wind will blow rainfall over the interfluve from east/northeast facing hydrologic units, contributes to higher rainfall in the upper elevations as does the high rate of fog drip which contributes to the water budget at upper elevations (Figure 2-4). The high spatial variability in rainfall is evident by the

[1] 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.

large variation in mean annual rainfall across the hydrologic unit. For the whole hydrologic unit, mean annual rainfall averages inches. Above 2000 ft, rainfall is highest during the months of December and April, where the mean monthly rainfall varies from 9.4 to 16.2 inches, although there is a fairly good distribution of rainfall across all months (Table 2-3).

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



Fog drip has only been monitored in a few select locations on windward slopes and there is no monitoring on the West Maui mountains. 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, 1991); 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). This method was used to determine the contribution of fog drip in the Honokohau hydrologic unit, which is calculated by multiplying the ratios with the monthly rainfall values in the fog drip zone based on Giambelluca et al (2013). Calculations show that approximately 41 percent of Honokohau lies in the fog drip zone based on elevations greater than 2000 feet. The total contribution from fog drip to the water budget based on percent of fog drig from monthly rainfall is about 35 percent (46.5 inches out of 136.2 inches) of the upper (>2000 ft) watershed, assuming the same ratios apply here (Table 2-3).

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 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. In Honokohau, average annual solar radiation ranged from 179.3 to 243.2 W/m^2 per day, with a watershed wide average of 217.5 W/m^2 per day (Figure 2-5). It is greatest at the coast and decreases toward the uplands, where cloud cover is more of an influence (Giambelluca et al., 2014).

Table 2-3. Fog drip to rainfall ratios for the windward slopes of Mauna Loa on the island of Hawaii and approximate contributions to the Honokohau Hydrologic Unit based on an elevation range of 2000-5780 feet and equivalent ratios.

Month	Ratio (%)	Mean Rainfall (in)	Contribution (in)
January	13	17.1	2.22
February	13	12.3	1.60
March	13	20.6	2.68
April	27	17.2	4.64
May	27	13.6	3.67
June	27	12.9	3.48
July	67	17.3	11.59
August	67	13.3	8.91
September	67	12.7	8.51
October	40	13.2	5.28
November	40	16.1	6.44
December	27	16.8	4.54

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 lost to the atmosphere. 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[2], rainfall, humidity, wind speed, surface temperature, and sensible heat advection[3]. 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). 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[4] and the cloud layer (Figure 2-6). 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 on the landscape (Nullet, 1987).

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

Shade (1999, Fig. 9) estimated pan evaporation rates of 30 inches per year below 2,000 feet elevation to 90 inches per year near the coast. Within the cloud layer, evaporation rates are particularly low due to the low radiation and high humidity caused by fog drip. Pan evaporation rates dropped 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 summit causes increased evaporation, with pan evaporation rates of about 50 to 70 inches per year (Shade, 1999, Fig. 9). For example, 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. Potential annual evapotranspiration in the Honokohau hydrologic unit (Figure 2-6) averages 115.7 inches per year and ranges from 39.1 to 214.9 inches per year (Giambelluca et al. 2014).

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 2014, the LUC designated 75 percent of the land in Honokohau as conservation and 25 percent as agriculture (State of Hawaii, Office of Planning, 2015d). The conservation district is located in the upper part of the hydrologic unit, whereas the agricultural district lies in the lowest part of the hydrologic unit (Figure 2-7).

The 1996 West Maui Community Plan identified a number of urban centers for expanded development, with the intension of:

1. Allocating adequate open spaces for public recreational activities, especially within urbanized areas and along the shoreline.
2. Slow the rate of growth and stabilize the economy
3. Protect natural resources and environmental stewardship
4. Exert control on the rate and distribution of development within the region
5. Encourage infill to protect agricultural and mauka open spaces

The goals and objectives within each urban center were numerous, but largely focused on providing affordable housing and job opportunities for residents with policy recommendations to preserve open spaces, limit environmental degradation, and balance rural and urban needs. The Maui County Department of Planning is currently (2019) undergoing a revision of each of the county region's community plan, using in-person and online workshops to draft an updated plan. In this update as well as the draft update to the Maui County Water Use and Development Plan (2019), the Kaanapali Region is expected to undergo expanded urbanization, particularly in the Honokowai watershed. This includes housing and commercial development in the Leali‘i neighborhood as well as expanded luxury home development. Around the West Maui airport, additional residential housing is planned. However, Honokohau is not expected to experience much change in land use.

Land Cover

Land cover for the hydrologic unit of Honokohau is represented by two separate 30-meter Landsat satellite datasets. One of the datasets, developed by the Coastal Change Analysis Program (C-CAP), provides a general overview of the land cover types in Honokohau, e.g., forest, grassland, shrub land, with minor developed areas, cultivated areas, and bare land (Table 2-4, Figure 2-8). 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 2-9).

Based on the two land cover classification systems, the land cover of Honokohau consists mainly of scrub and forested areas. Almost half of the hydrologic unit is made up of alien forest, grassland or shrubland. There is some native dry cliff vegetation, shrubland and sparse ohia spread throughout the upper slopes. A mixture of alien and ohia forests and uluhe shrub lands can be found at intermediate slopes. Alien grasslands and cultivated cropland cover a majority of the lower altitudes near the coast with urban or industrial developments.

Table 2-4. C-CAP land cover classes and area distribution in Honokohau hydrologic unit. (Source: National Oceanographic and Atmospheric Agency, 2015)

Land Cover	Description	Area (mi^2)	Percent of Unit
Evergreen Forest	Areas where more than 67% of the trees remain green throughout the year	7.87	68.7%
Scrub/Shrub	Areas dominated by woody vegetation less than 6 meters in height	1.80	15.7%
Cultivated Crops	Areas intensely managed for the production of annual crops	0.71	6.2%
Palustrine Forested Wetland	Includes tidal and nontidal wetlands dominated by woody vegetation more than 5 meters in height, and all such wetlands that occur in tidal areas in which salinity is below 0.5%	0.36	3.2%
Palustrine Scrub/Shrub Wetland	Includes tidal and nontidal wetlands dominated by woody vegetation less than 5 meters in height, and all such wetlands that occur in tidal areas in which salinity is below 0.5%	0.23	2.0%
Developed, Low Intensity	Constructed surface with substantial amounts of vegetated surface	0.21	1.9%
Grassland/Herbaceous	Natural and managed herbaceous cover	0.15	1.3%
Palustrine Emergent Wetland	Includes tidal and nontidal wetlands dominated by persistent emergent vascular plants, mosses or lichens	0.05	0.4%
Bare Land	Bare soil, gravel, or other earthen material with little or no vegetation	0.05	0.4%
Open Water		0.01	0.1%
Developed, Medium Intensity	Areas with a mixture of constructed materials and substantial amounts of vegetation	0.00	0.0%
Developed, Open Space	Areas mostly managed grasses or low-lying vegetation planted for recreation, erosion control, or aesthetic purposes	0.00	0.0%

The land cover maps (Figures 2-8, 2-9) provide a general representation of the land cover types in Honokohau. 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, particularly with reference to the cultivation of commercial crops. At small scales, community members have reported lands cultivated with tropical flowers, dryland (and some wetland) taro, sweet potato, banana, and papaya, long beans, and eggplant primarily in the lower-middle portions of the hydrologic unit. Along the coast, a number of typical native and alien species have been reported. Some of those native species include ulei, naupaka kahakai, akia, lauwe, and hala.

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

Land Cover	Area (mi^2)	Percent of Unit
Open Ohia Forest	3.314	28.92%
Alien Forest	2.650	23.13%
Closed Ohia Forest	1.356	11.83%
Cultivated Cropland	1.312	11.45%
Ohia Forest	0.653	5.70%
Native Shrubland / Sparse Ohia (native shrubs)	0.487	4.25%
Native Wet Cliff Vegetation	0.480	4.19%
Alien Shrubland	0.391	3.41%
Alien Grassland	0.258	2.25%
Uluhe Shrubland	0.240	2.10%
Bog Vegetation	0.225	1.97%
Very Sparse Vegetation to Unvegetated	0.058	0.51%
Developed, Low Intensity	0.016	0.14%
Undefined	0.013	0.11%
Open Water	0.003	0.03%
Uncharacterized Open-Sparse Vegetation	0.002	0.02%

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 a given magnitude flood occuring 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 all the 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 the entire stream channel. 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.

Peak floods in Honokohau have not been monitored directly, but can be modeled using basin characteristics within the USGS Streamstats GIS-based program (Rea and Skinner, 2012). The 2-, 5-, 10-, 50-, and 100-year flood magnitudes in Honokohau at Hoonoapiilani Highway are estimated as 3820, 5880, 7390, 11,100, and 12,800 cfs. 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 identified most of the Honokohau hydrologic unit as flood-risk zone X, outside of the the 1% annual chance of flood. Almost none of the lands in Honokohau are designated flood zone A except for a region immediately adjacent to the stream channel in the lower reaches, with less than a 1% chance of flooding annually in most areas due to the size of the incised gulch which has developed over geologic time. There is a small region along the lower reach in Honokohau where the flood risk is considered zone A or zone AE, with the potential for shallow flooding of 1-3 feet annually and a region in zone VE, with the potential for inundation by the flood with a 1% annual chance with additional hazards due to storm induced velocity wave action (Figure 2-10).

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 or surface water due to reduced stream flow. 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 recent past 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). The most recent drought occurred in 2000-2002, affecting all islands, especially the southeastern end of the State.

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 and Hana regions have the greatest risk to drought impact on Maui because of its dependence on surface water sources, limited rainfall, or relatively high drought frequency and high population density. The growing population in the already densely populated area further stresses the water supply. While Honokohau stream may experience lower than normal flows during extended periods of low rainfall (hydrological drought), the Honokohau watershed is not considered vulnerable to drought in the agricultural sector. As Honokohau is one of the northernmost watersheds in the Lahaina District, there may be a small wildfire risk due to drought, but there is less risk of drought to the general population. However, Honokohau Stream is relied upon by the Maui DWS as a source for drinking water supply, which may be impacted by extreme low flows.

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 the Honokohau hydrologic unit. (Source: Sherrod et al., 2007)

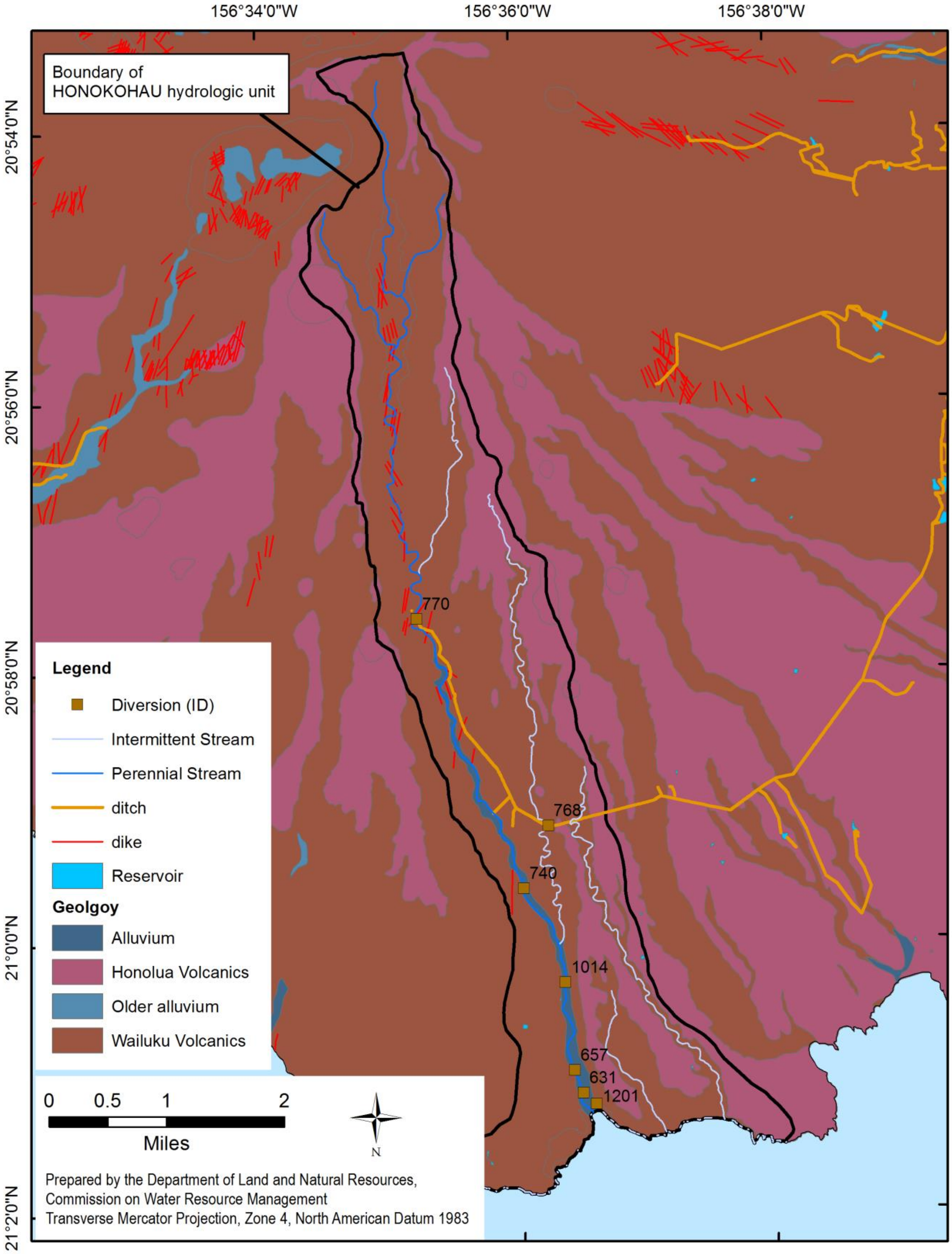


Figure 2-3. Soil classification of the Honokohau hydrologic unit. (Source: State of Hawaii, Office of Planning, 2015m)

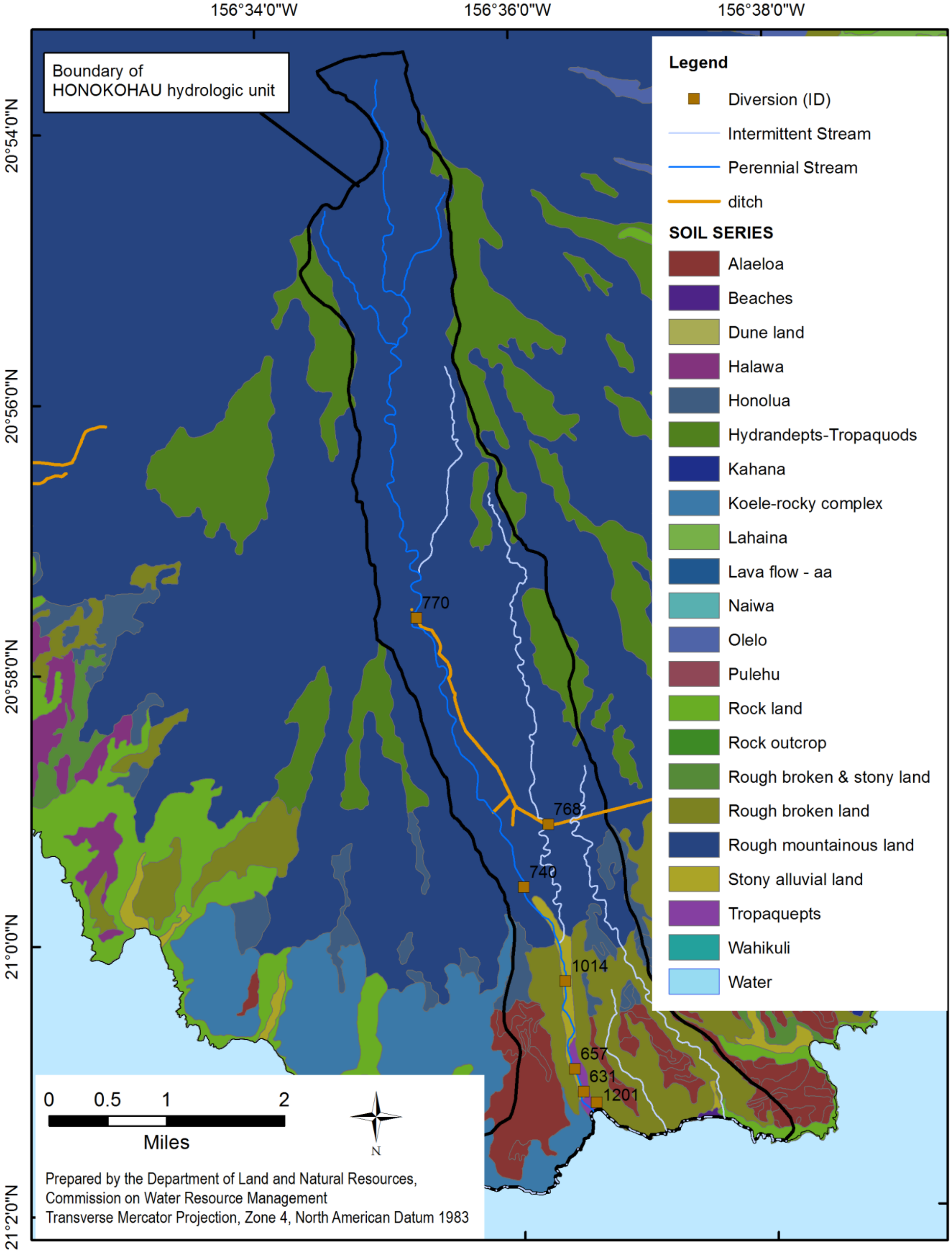


Figure 2-4. Mean annual rainfall of the Honokohau hydrologic unit. (Source: Giambelluca et al., 2013)

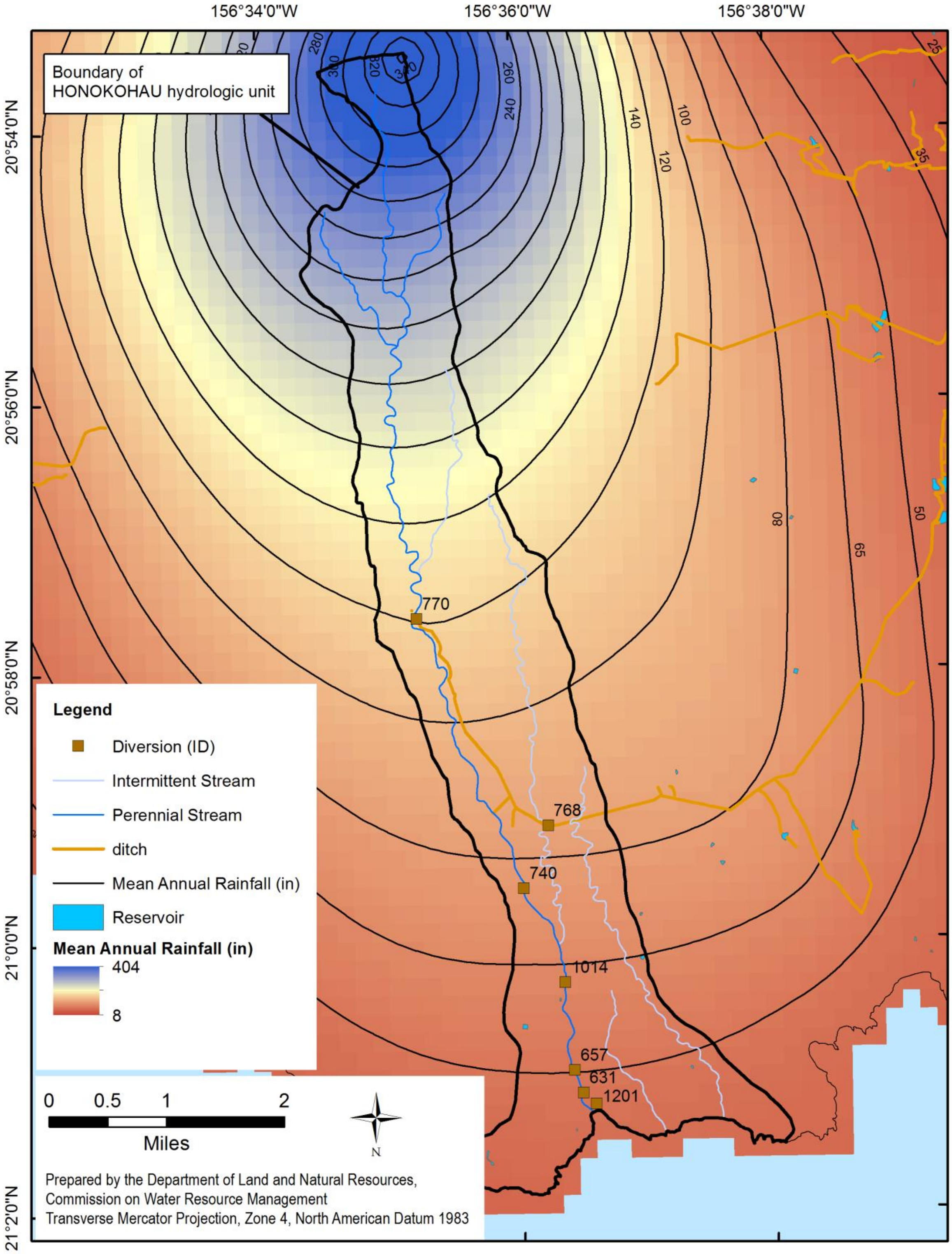


Figure 2-5. Mean annual solar radiation of the Honokohau hydrologic unit. (Source: State of Hawaii, Office of Planning, 2015c)

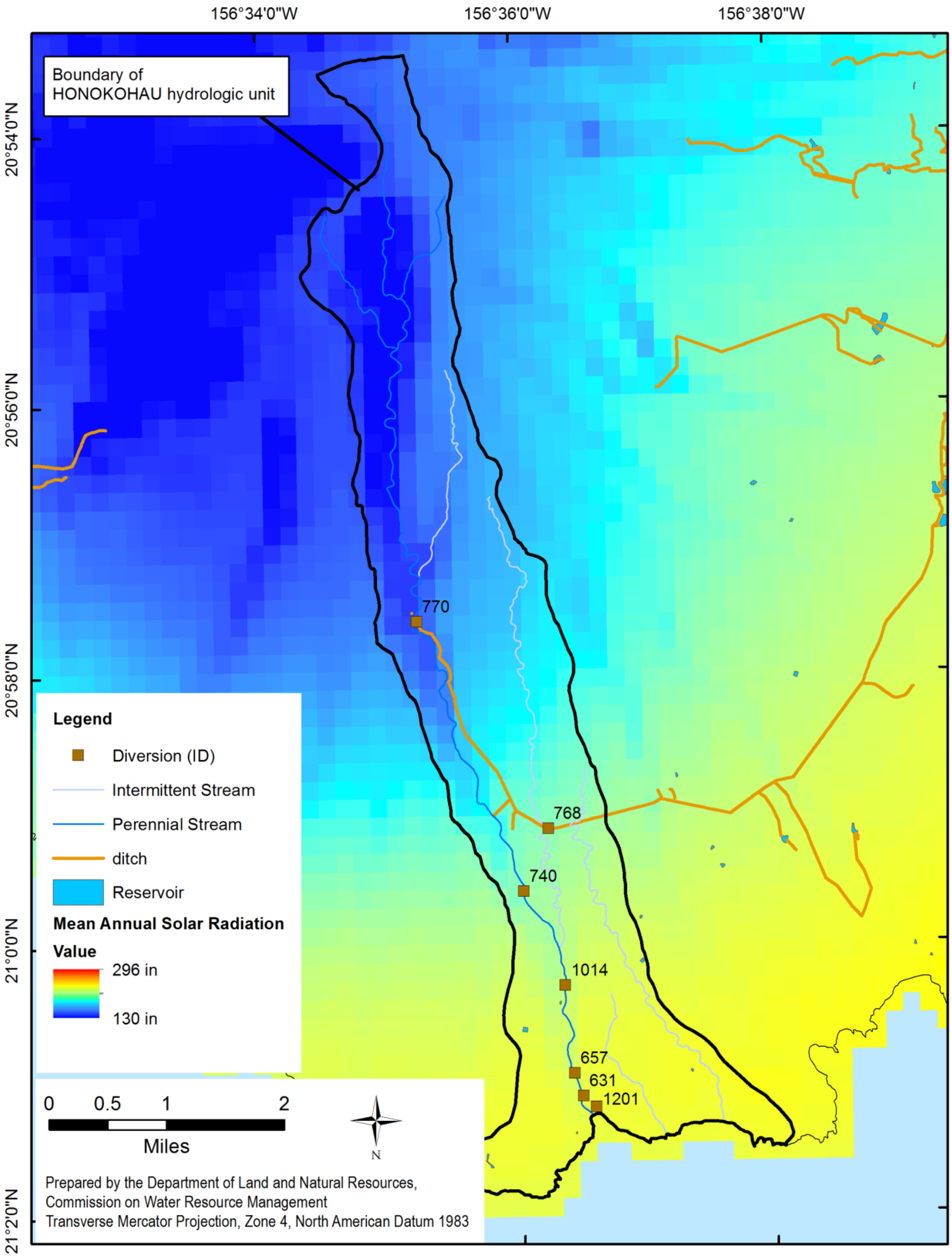


Figure 2-6. Mean annual potential evapotranspiration (Penman-Monteith method) for the Honokohau hydrologic unit. (Source: Giambelluca et al., 2014)

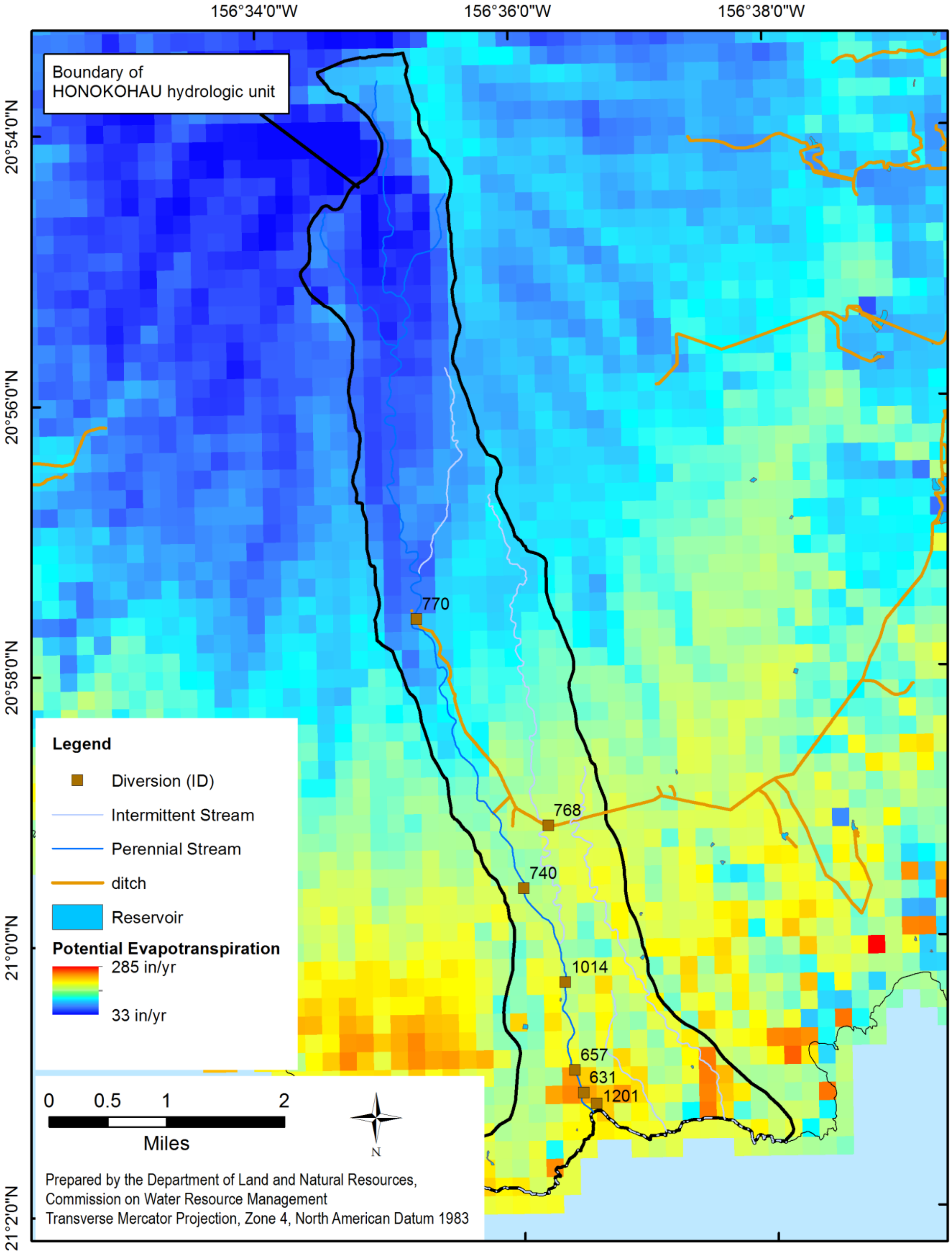


Figure 2-7. State land use district boundaries of the Honokohau hydrologic unit (Source: State of Hawaii, Office of Planning, 2015d).

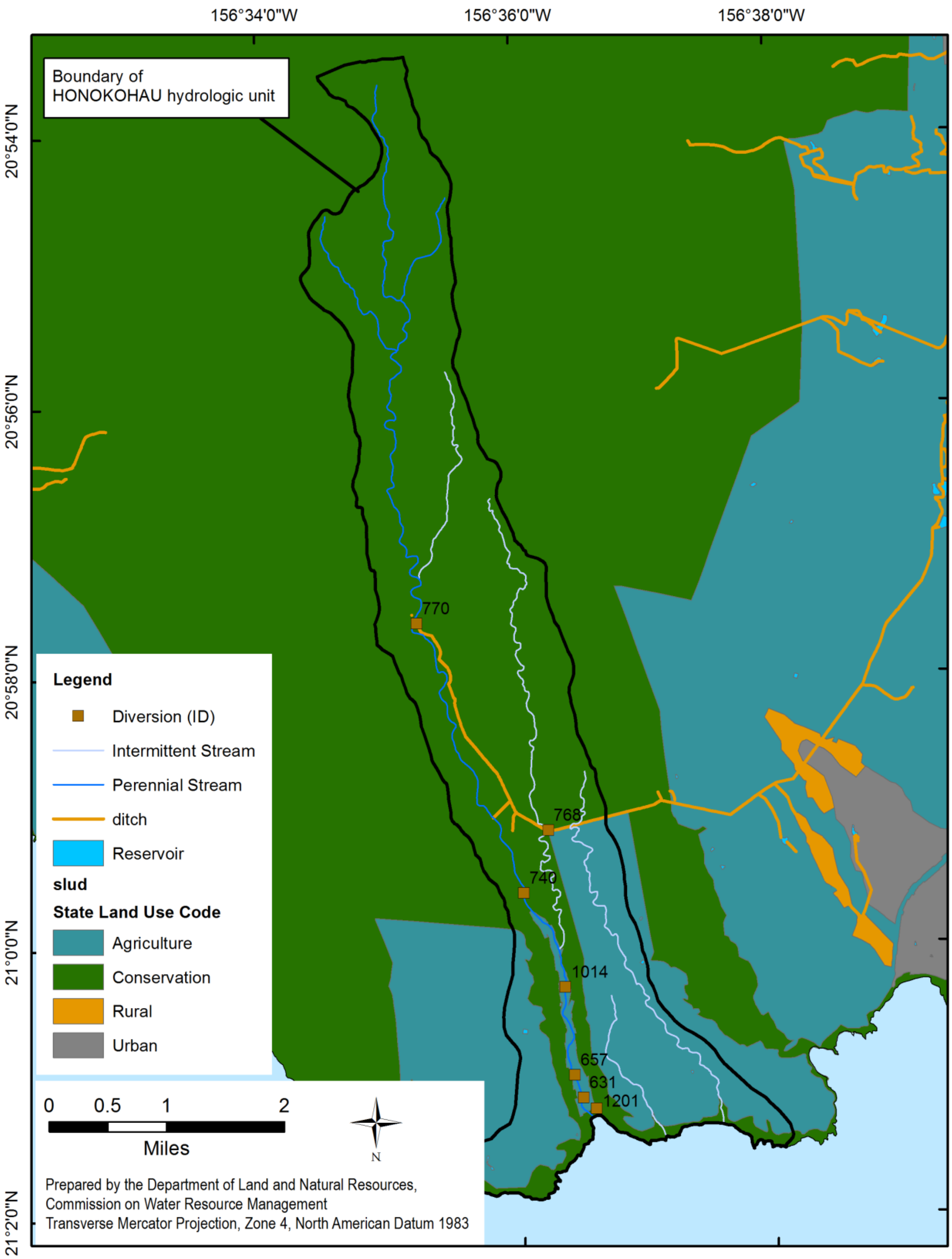


Figure 2-8. C-CAP land cover of the Honokohau hydrologic unit. (Source: State of Hawaii, Office of Planning, 2015k).

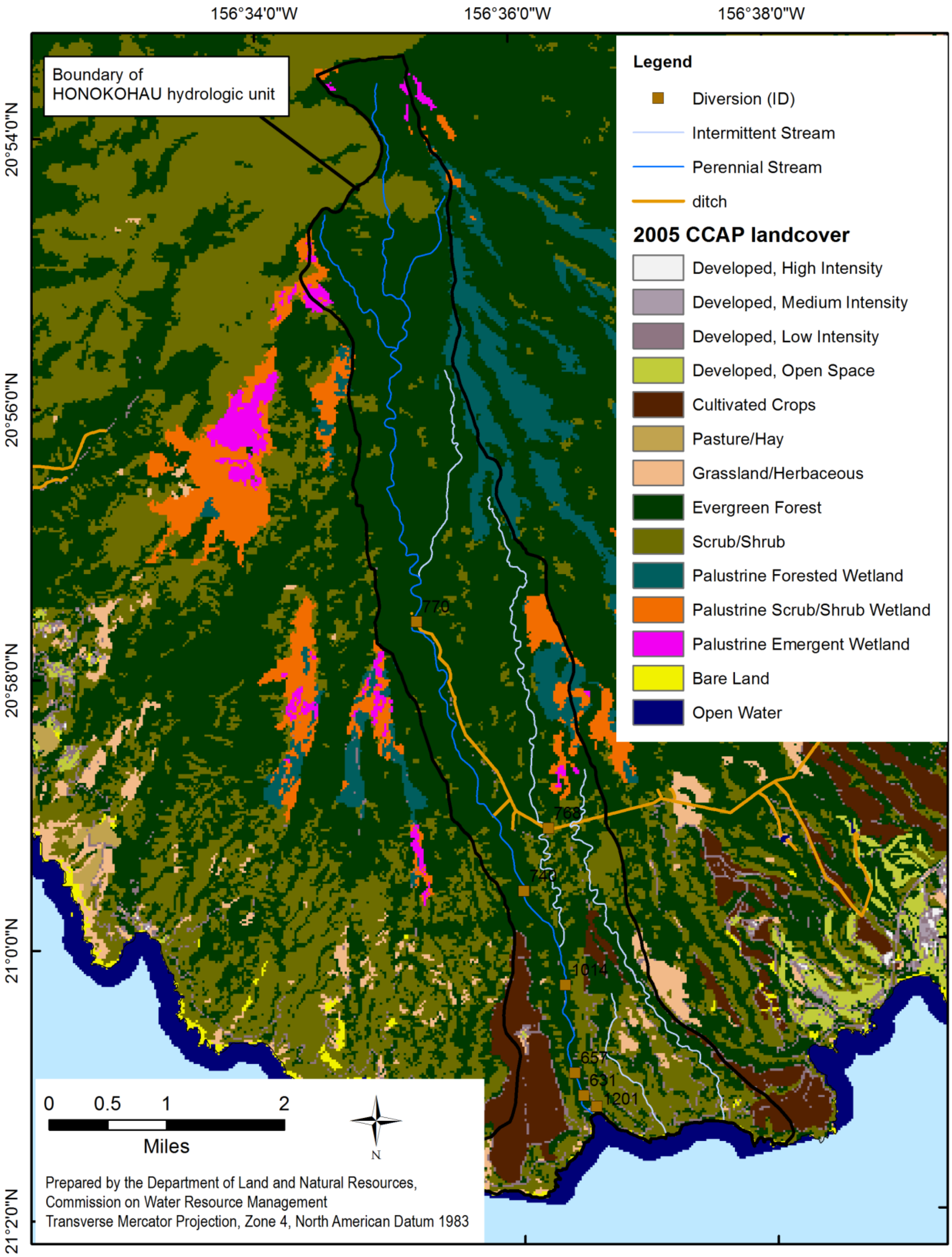


Figure 2-9. Hawaii GAP land cover classes of the Honokohau hydrologic unit (Source: State of Hawaii, Office of Planning, 2015f).

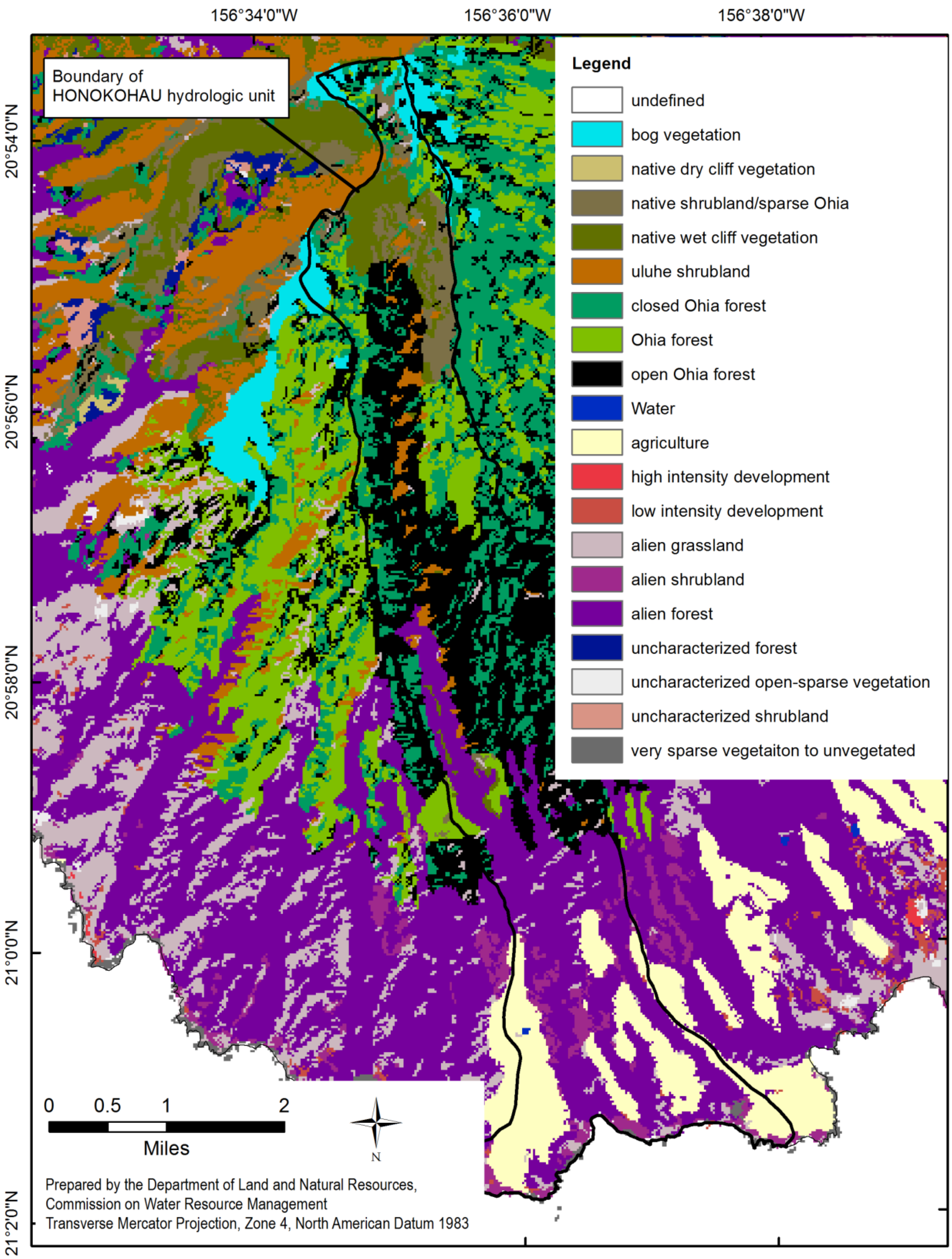
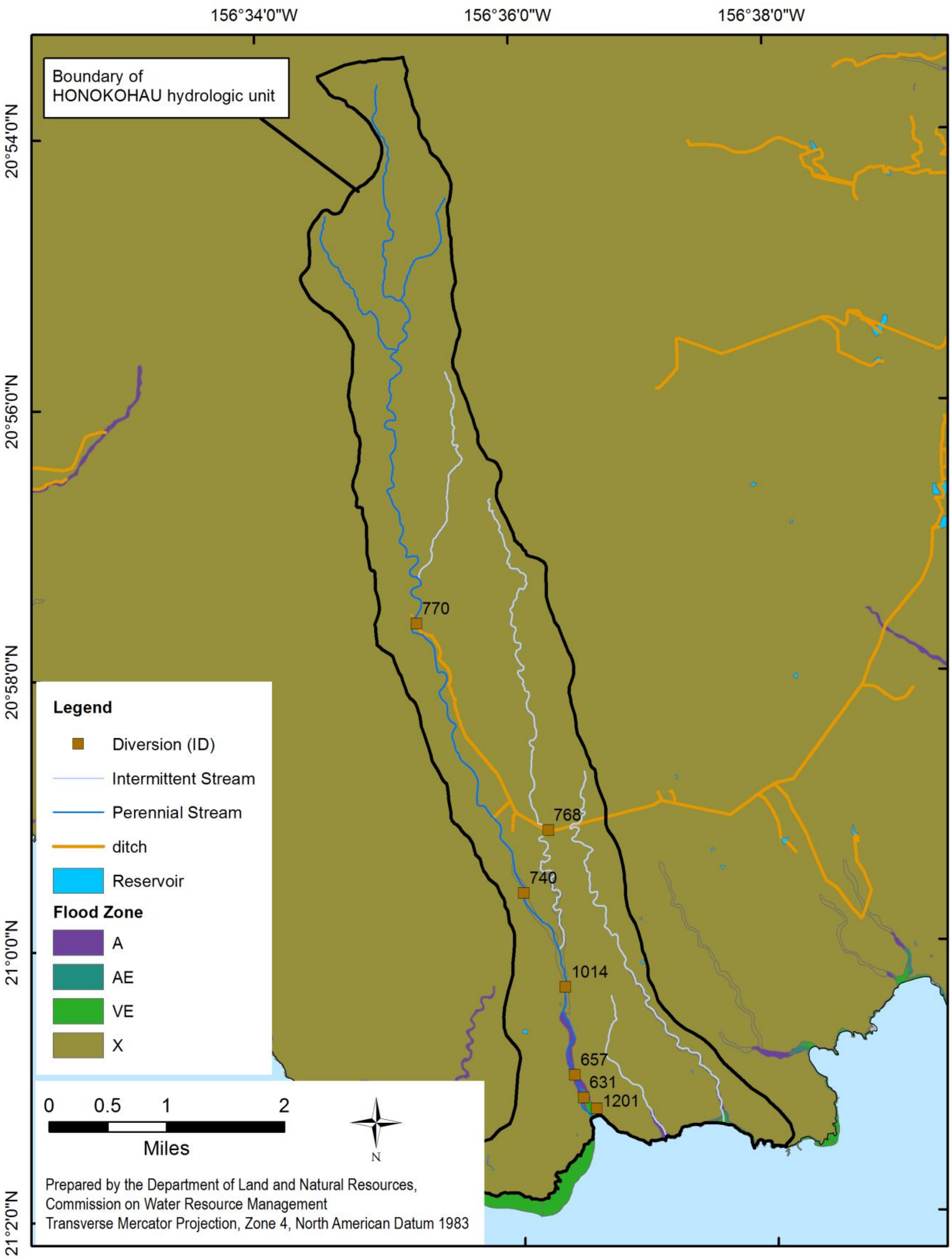


Figure 2-10. FEMA flood zone regions in the Honokohau hydrologic unit (Source: Federal Emergency Management Agency, 2014).



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 Honokohau Stream.

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 the different components of the hydrologic cycle, as well as man-made structures such as diversions and other stream channel alterations (e.g. channelizations and dams).

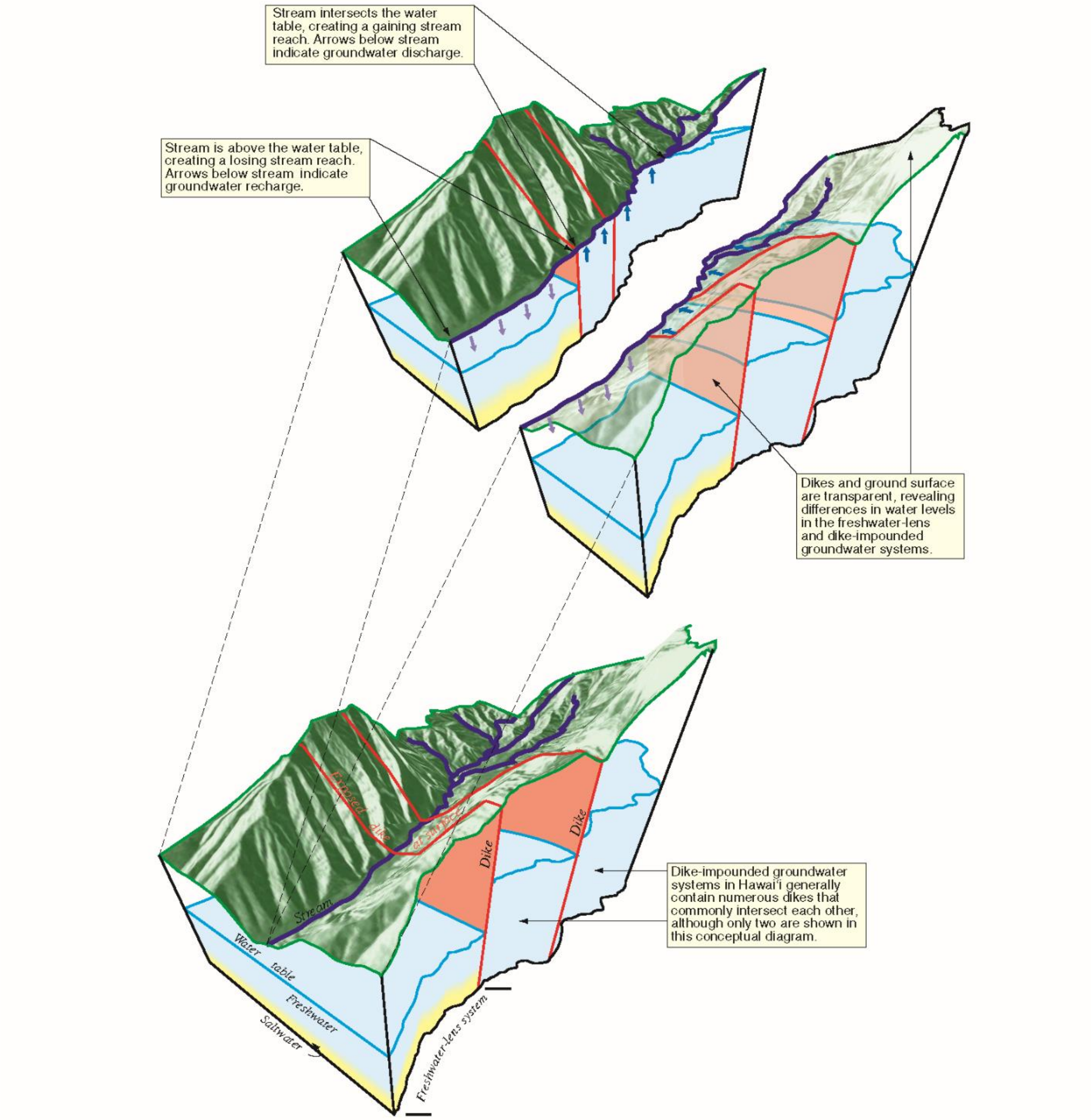
Streams in Hawaii can either gain or lose water at different locations depending on the geohydrologic conditions. A stream gains water when the ground water table is above the streambed. When the water table is below the streambed, the stream can lose water. Where the streambed is lined with concrete or other low-permeability or impermeable material, interaction between surface water and ground water is unlikely. 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 through erosion, exposing a high-level water table and resulting in ground water discharges that contribute directly to streamflow.

The USGS has maintained two stream and ditch gaging stations over time, although only the stream gage is currently active (Figure 3-8). Station 16620000 currently monitors natural flow in Honokohau Stream, located above the Honokohau ditch diversion (diversion 770) and development tunnels 21 and 22. This station is one of the longest continuous record gaging stations in the State of Hawaii. A former USGS station monitored flow in Honokohau Ditch (station 16621000) just below the intake from 1907 to 1913. Historic data from these stations are available in Table 3-1.

Table 3-1. Selected flow duration discharge exceedance values for the period of record in the Honokohau hydrologic unit, Maui, Hawaii. (Source: USGS 2003) [Flows are in cubic feet per second (million gallons per day]

USGS ID	USGS station	Period of Record	Discharge (Q) for a selected percentage ($_{xx}$) discharge was equaled or exceeded				
			Q_{50}	Q_{60}	Q_{70}	Q_{80}	Q_{90}
16620000	Honokohau Stream	1913-2000	24 (15.5)	21 (13.6)	18 (11.6)	16 (10.3)	13 (8.4)
16621000	Honokohau Ditch blw Honokohau Intake	1907-1913	35 (22.6)	31 (20.0)	28 (18.1)	25 (16.2)	22 (14.2)

Figure 3-1. Conceptual diagram illustrating surface water-ground water interactions in West Maui. (Source: Oki et al., 2010).



Ground Water

Ground water is an important component of streamflow as it constitutes the base flow[5] of Hawaiian streams. When ground water is withdrawn from a well, the water level in the surrounding area is lowered. 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 decrease in stream habitats for native species and a reduction in the

[5] 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).

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. Vertically extensive fresh water-lens system can extend several hundreds or even thousands of feet below mean sea level. By contrast, 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 Honokohau is in the Honokohau aquifer system as part of the Lahaina Aquifer Sector. A general overview of the ground water occurrence, movement, and interactions with surface water in this area is described in Oki et al. (2010) and illustrated in Figure 3-1. Ground water is found in dike-impounded structures of Honolua and Wailuku Volcanics as well as in the fresh water-lens system making up the basal aquifer. Withdrawal from wells at or below sea level should not affect the high-elevation water table because the thick unsaturated zone will prevent any significant changes in the vertical flow gradient. However, during certain hydrologic conditions, there may be surface water-ground water interactions, especially in gaining reaches. The Honokohau hydrologic unit has many dike structures to support ground water contributions to surface flow at high elevation and there are areas of spring flow into the stream in the middle reaches. However, there are also losing reaches in which surface flow is lost to ground water.

Wells in the Honokohau Hydrologic Unit

The Lahaina aquifer sector includes many aquifer systems: Honokohau, Honolua, Honokowai, Launiupoko, Olowalu, and Ukumehame. The sustainable yield, 12-month moving average and 10-year average pumping rate for each system is provided in Table 3-2. Historic records put some perspective on the current pumping rates from the Lahaina aquifer sector (Figure 3-2). Ground water withdrawals steadily increased with the expansion of plantation agriculture and urbanization. From 1918-1929, an average of 33 mgd was withdrawn from the aquifer, while from 1930-1979, withdrawals averaged 44 mgd, primarily from the Honokowai and Launiupoko aquifer systems (Gingerich and Engott, 2012). With the closure of pineapple and sugar cane plantation operations, ground water withdrawals declined to about 21 mgd from 1980 to 2000, and eventually down to 4 mgd by 2008. However, the 2018 12-month moving average for the Lahaina aquifer sector was 6.23 mgd, demonstrating an increased demand by tourism and a growing resident population (State of Hawaii, Commission on Water Resource Management 2018b).

The location of wells in the hydrologic unit in relation to the aquifer sectors in Lahaina are depicted in Figure 3-2. As depicted, the Honokohau surface water hydrologic unit almost totally encompasses the Honokohau groundwater aquifer system. Therefore, there are few drilled wells actually in the Honokohau watershed and there is zero pumpage, which is well below the aquifer sector's current sustainable yield of 7 mgd (State of Hawaii, Commission on Water Resource Management, 2015d). Two development tunnels (tunnel 21 and tunnel 22) exist above diversion 770 which accesses high-elevation dike-impounded ground water. This water contributes to stream flow and is used to meet off-stream non-potable and municipal needs in the Lahaina and Kaanapali areas. Detailed information for each well is specified in Table 3-3. Total monthly pumpage from the Lahaina Aquifer Sector for Maui County Department of Water Supply and Hawaii Water Service are provided in Figure 3-3. Total reported monthly pumpage from the Honokohau aquifer system is provided in Figure 3-4. Currenlty, there is one active well for domestic use (drilled in 2009) but the pumpage is not being reported.

A majority of the reported ground water use from the nearby Honolua aquifer system is for municipal use and irrigation of landscaping. Many of the wells have been discontinued due to the reduced demand for water from agriculture.

Table 3-2. Current sustainable yields for aquifer systems in the Lahaina Aquifer Sector in West Maui, current (2018) 12-month moving average (MAV) pumping, and 10-year average pumping (million gallons per day, mgd).

Sector	Sustainable Yield (mgd)	12-month MAV (mgd)	10-year average (mgd)
Ukumehame	2.0	0.037	0.031
Olowalu	2.0	0.093	0.068
Launiupoko	7.0	0.727	0.664
Honokōwai	6.0	3.380	3.249
Honolua	8.0	1.993	2.410
Honokōhau	9.0	0.000	0.000

Ground water Pumping and Salinity Levels

Of growing concern is the impact of increased ground water pumpage on ground water salinity. As pumpage draws down the less dense freshwater lense, brachish ground water from the transition zone will mix, increasing the salinity (and thus chloride content) of the freshwater lense. Freshwater is water with a chloride content of less that 250 parts per million (ppm), or 1.3% of the chloride content of seawater. Hydrologists with the USGS and CWRM monitor the elevation of the freshwater lense, the transition zone to brachish water, and the elevation of sea water in deep monitoring wells across the state. In West Maui, the Mahinahina Deep Monitoring Well has been an important tool for monitoring ground water conditions across the Lahaina aquifer sector for many years (Figure 3-5). In areas of the aquifer that have a thin freshwater lense, the impact of over pumping of ground water on salinity levels can be immediately apparent (Figure 3-6). Thus, even if current pumpage does not reach the aquifer's sustainable yield, pumpage can negatively impact the future use of the aquifer.

Table 3-3. Information of wells located in Honokohau hydrologic unit (top) and the Honokohau aquifer (bottom) (Source: State of Hawaii, Commission on Water Resource Management, 2015d). [Negative elevation values indicate feet below mean sea level; positive elevation values indicate feet above mean sea level. Pump rate measured in gallons per minute (gpm); -- indicates value is unknown; DWS = Department of Water Supply; ABD = abandoned; OBS = observation]

Well number	Well Name	Well Owner	Year drilled	Ground elevation (feet)	Well depth (feet)	Pump elevation (feet)	Pump depth (feet)	Pump rate (mgd)	Average 2018 (mgd)
0136-001	GCP Maui LLC	McCarty, J	2009	--	40	--	32	0.012	--
0137-001	Rennie Deprue	Shim, Henry	1970	100	140	--	--	--	--
5735-001	Tunnel 21	Maui Land & Pine	--	880	--	--	--	--	0.65
5735-002	Tunnel 22	Maui Land & Pine	--	900	--	--	--	--	2.52

Figure 3-2. Well locations and numbers in and nearby the Honokohau hydrologic unit, in the Honokohau aquifer system, Maui. (Source: State of Hawaii, Commission on Water Resource Management, 2018b).

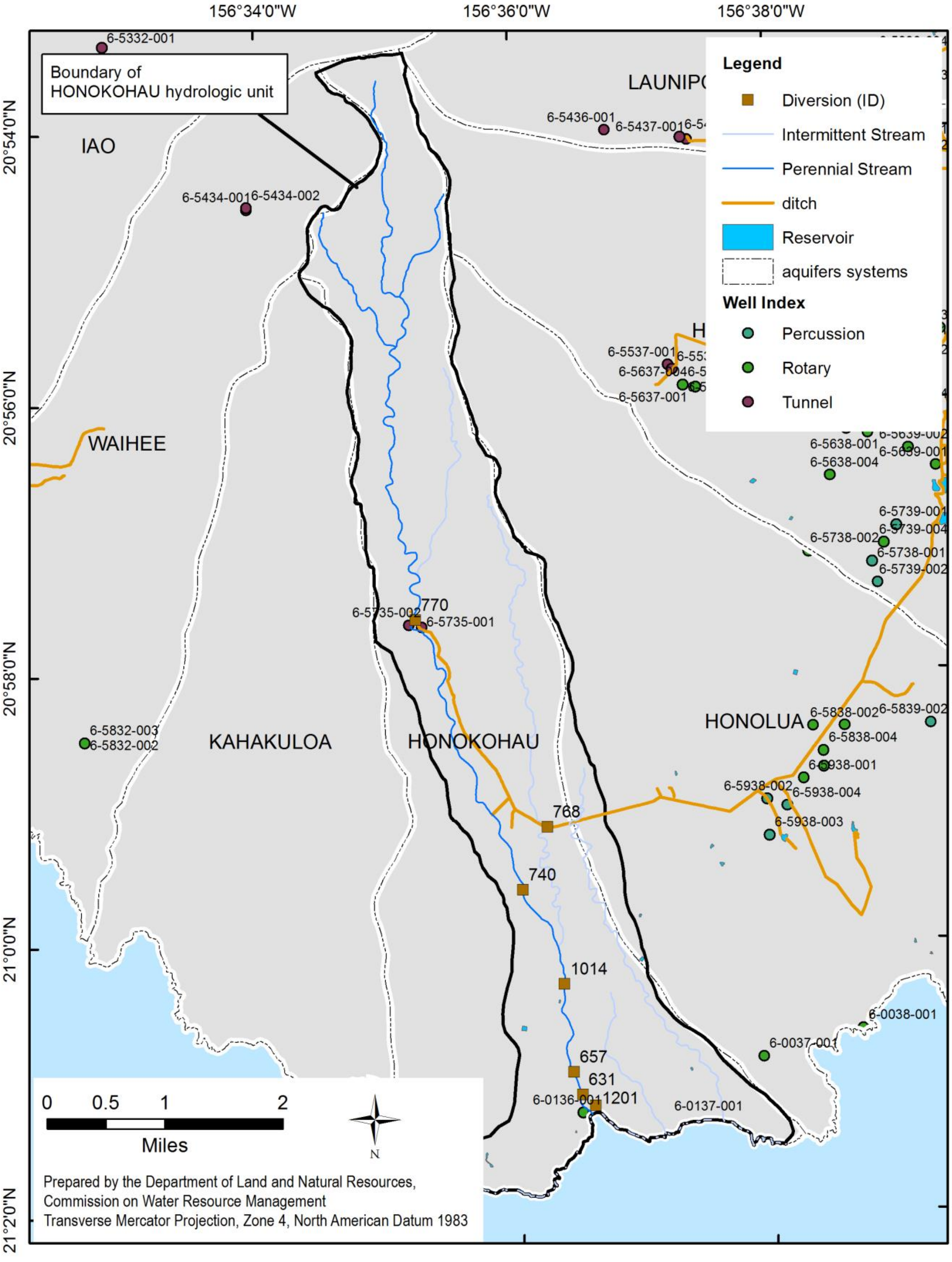


Figure 3-3. Monthly reported pumpage, 12-month moving average (12-MAV) and sustainable yield for the Honokohau Aquifer system. (Source: Source: State of Hawaii, Commission on Water Resource Management, 2018b).

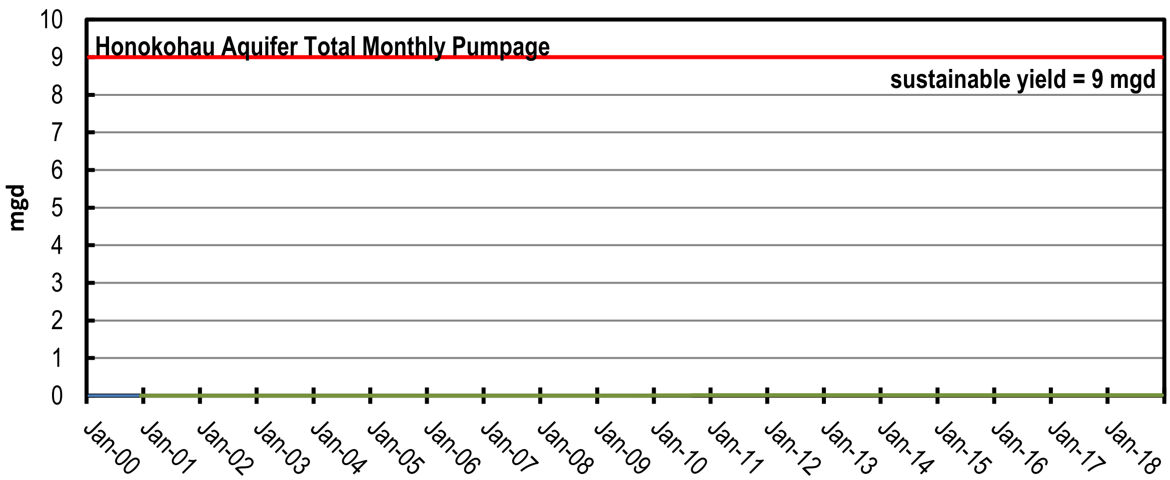
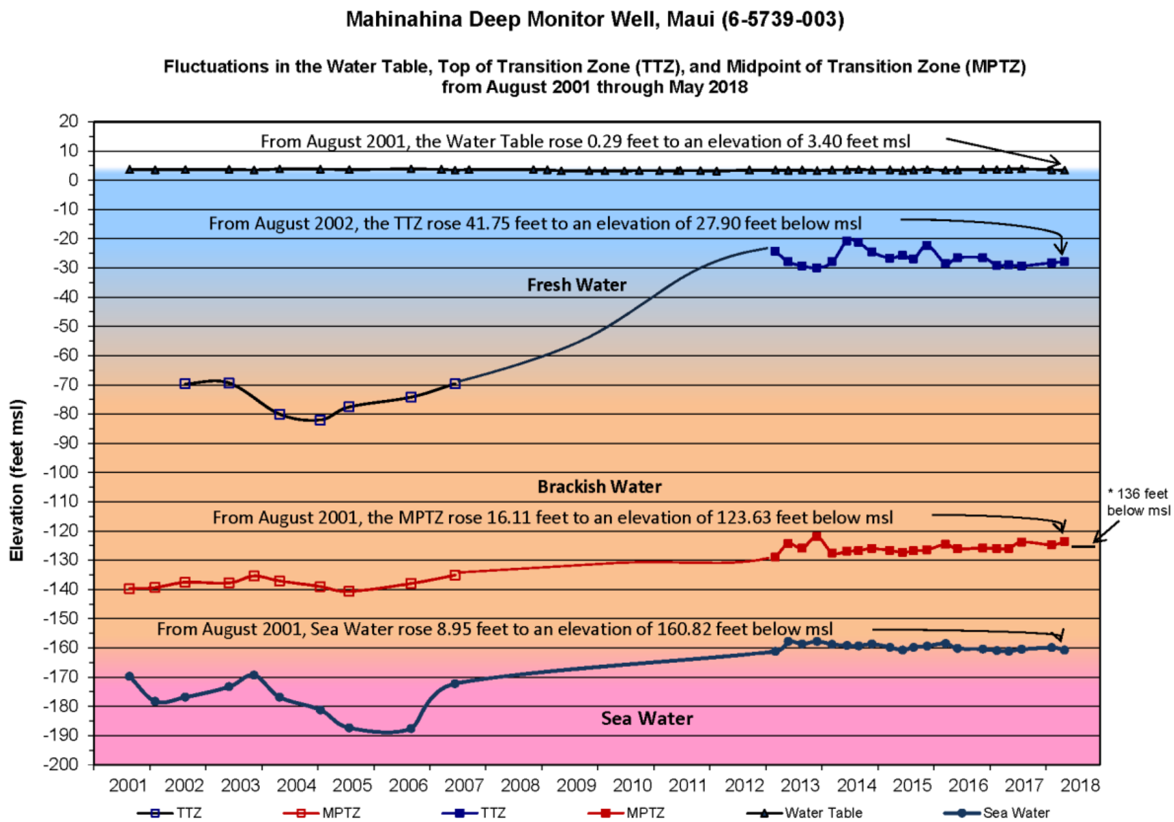


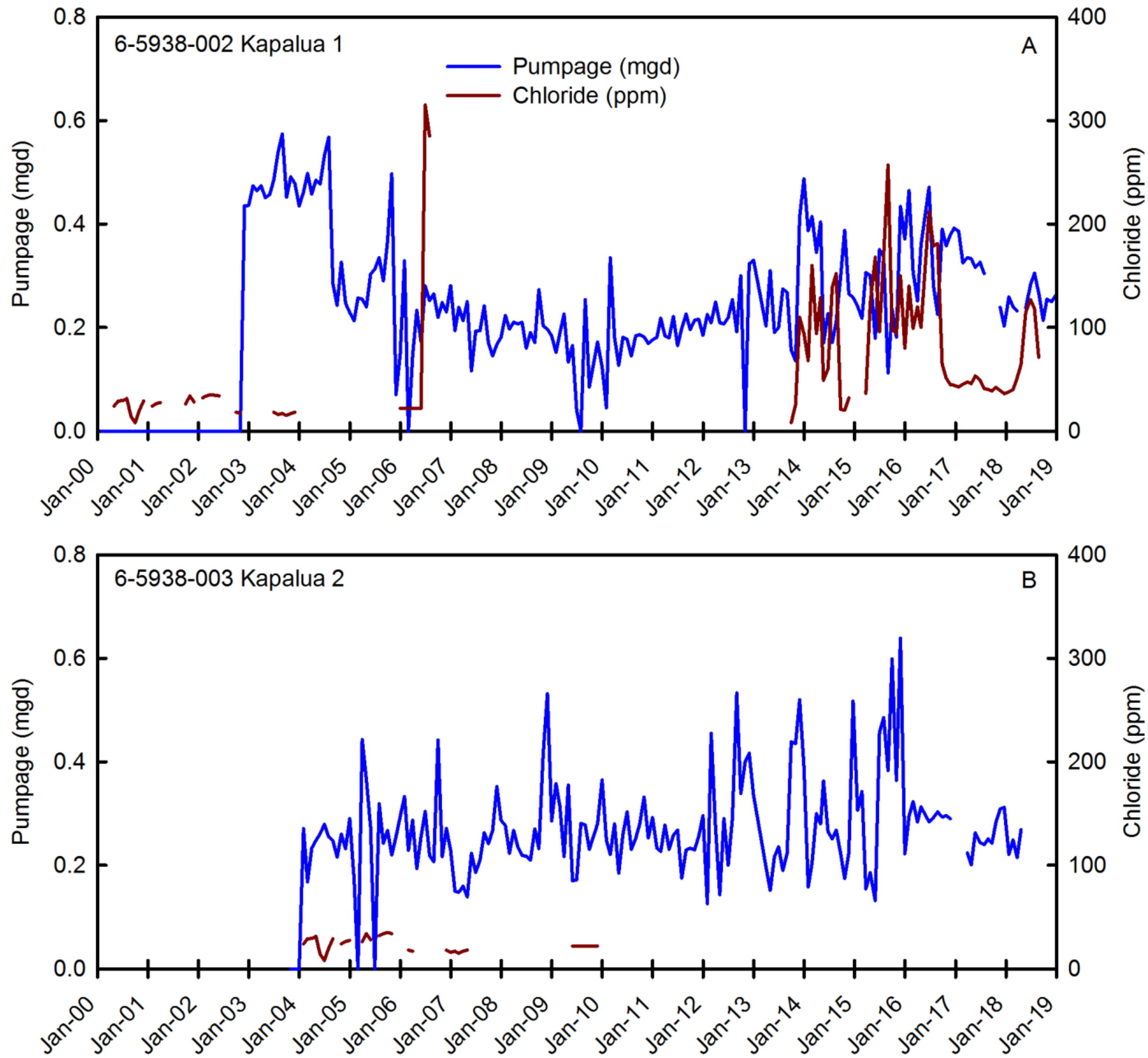
Figure 3-4. Elevation to freshwater lense, brackish water transition and sea water in the Mahinahina Deep Monitoring Well, Maui. (Source: State of Hawaii, Commission on Water Resource Management, 2018a).



Notes: : (1) TTZ = 1,000 µS/cm (~ 220 mg/L Cl⁻); MPTZ = 25,000 µS/cm (~ 8,500 mg/L Cl⁻) (2) Fresh Water < 220 mg/L Cl¯, Brackish Water 220 mg/L CL¯ to 16,999 mg/L Cl¯, Sea Water >= 17,000 mg/L Cl¯; (3) OS 421/425 = Ocean Sensors CTD (absolute conductivity); (4) RBR 12895 = RBR Global CTD (Specific Conductivity); (5) msl = mean sea level. Conditions inside the well prevented successful CTD deployment from 2006 through 2012, CTD profiling of this well was resumed 3-13-2013.

* Since the year 2001, the MPTZ rose 16.11 feet, to an elevation of 123.63 feet below mean sea level, where it is near the calculated Ghyben-Herzberg equilibrium elevation of 136 feet below msl, relative to the Water Table, measured at 3.40 feet above msl.

Figure 3-5. Monthly ground water pumpage and chloride concentration from Kapalua Water Company wells in Honolua hydrologic unit. (Source: State of Hawaii, Commission on Water Resource Management, 2018b).



Streamflow Characteristics

Natural streamflow conditions were only monitored continuously in Honokohau from 1913-present day at USGS station #16620000. Based on these data, USGS developed low-flow characteristics for the current climate period (1984-2013) as provided in Table 3-4. Differences in discharges between historic and current periods are due to differences in climate from differing years of record.

Table 3-4. Selected natural-flow duration discharge exceedance values for various climate periods based on the continuous-record gaging stations for Honokohau stream at USGS 1662000. (Source: USGS 2003; USGS 2016) [Flows are in cubic feet per second (million gallons per day]

		Discharge (Q) for a selected percentage ($_{xx}$) discharge was equaled or exceeded				
	Period of Record	Q_{50}	Q_{60}	Q_{70}	Q_{80}	Q_{90}
total flow at 1662000	1984-2013	21 (13.6)	19 (12.3)	16 (10.3)	14 (9.05)	12 (7.76)
total flow at 1662000	1913-2000	24 (15.5)	21 (13.6)	18 (11.6)	16 (10.3)	13 (8.4)
base flow at 1662000	1913-2000	18 (11.6)	17 (11.0)	15 (9.7)	14 (9.05)	12 (7.76)
total flow at Aotaki Weir	1913-2000	30 (19.4)	26 (16.8)	23 (14.9)	20 (12.9)	17 (11.0)

In the USGS report on low-flow characteristics for the Honokohau Stream (USGS, 2003), the mean, median, and minimum discharges for selected locations at the Honokohau Intake.

Table 3-5. Mean, median, and minimum daily discharges for selected locations in the vicinity of the Honokohau Ditch diversion (Aotaki Weir) at 825 ft elevation for water years 1913-2000. (Source: USGS 2003) [Flows are in cubic feet per second (million gallons per day]

Site Location	mean	median	minimum
USGS 16620000	39.1 (25.3)	24 (15.5)	8.4 (5.4)
Development Tunnels T-21 and T-22	5.6 (3.6)	5.2 (3.4)	2.5 (1.6)
Upstream of diversion dam	44.6 (28.8)	30 (19.4)	11 (7.1)
Honokohau Ditch just below the intake	38.3 (24.8)	29 (18.7)	11 (7.1)

Honokohau stream is gaining in the uppermost reaches of the watershed, but has discontinuous flow (some gaining, some losing) below the Honokohau Ditch to the ocean (Figure 3-8). There are two development tunnels (tunnel 21 and tunnel 22) which contribute a variable flow of water to the stream (USGS, 2003). USGS estimated the combined mean flow from these tunnels from 1913-2000 was 5.6 cfs (3.62 mgd) and the median flow of 5.2 cfs (3.36 mgd). Based on these estimates, the mean and median surface flow at diversion 770 is 44.6 cfs (28.8 mgd) and 30.0 cfs (19.39 mgd). Using seepage runs, USGS estimated seepage loss between different locations three different times from 1995 to 1999. There is an estimated 1.4 mgd gain in spring flow between diversion 770 at 825 ft and McDonald's Dam at 340 ft and a small losing reach below the 340 ft elevation, with the stream losing up to 2.0 cfs (1.3 mgd).

USGS estimated the consequences of particular ditch flow releases at taro gate for flow at Chun's Dam on Honokohau Stream, given the various seepage gains and loses between these locations. Various statistics from those estimates are presented in Table 3-6.

In response to numerous complaints and to prepare for the monitoring of a future interim IFS, CWRM staff installed a real-time continuous monitoring station on Honokohau Stream at McDonald's Dam (6-149). Staff then began taking point measurements of stream flow (Table 3-7). From December 2018 to July 2019, the mean flow at this station was 29.9 mgd, and the median flow was 20.1 mgd (Figure 3-6).

Table 3-6. Estimated magnitude flow duration values at Chun's Dam for given releases at taro gate assuming no release of water at Aotaki Weir on Honokohau Stream. (Source: USGS 2003)
[Flows are in cubic feet per second (million gallons per day]

Taro Gate Release	Q_{90}	Q_{70}	Q_{50}
0.0 (0.0)	0.97 (0.63)	2.1 (1.4)	4.5 (2.9)
0.5 (0.32)	1.2 (0.78)	2.4 (1.6)	5.0 (3.2)
1.0 (0.64)	1.5 (0.97)	3.0 (1.9)	5.5 (3.6)
1.5 (0.97)	1.8 (1.2)	3.2 (2.1)	6.0 (3.9)
2.0 (1.29)	2.1 (1.4)	3.5 (2.3)	6.5 (4.2)
3.0 (1.94)	2.6 (1.7)	4.3 (2.8)	7.5 (4.9)

On June 11, staff conducted a seepage run, measuring various points of flow in Honokohau. Flow measured at USGS 16620000 was 15.8 cfs (10.2 mgd), the combined flows of T-21 and T-22 were 4.9 cfs (3.2 mgd), flow in Honokohau Ditch at Adit 6 was 16.1 (10.4 mgd), and flow at McDonald's Dam was 19.8 cfs (12.8 mgd).

Table 3-7. Discharge measurements at gage 6-149 on Honokohau Stream at McDonald's Dam. (Source: CWRM) [Flows are in cubic feet per second (million gallons per day]

date	time	Stage (ft)	Discharge
11/27/2018	8:23	1.25	17.7 (11.4)
12/12/2018	10:45	3.60	171 (110.5)
1/18/2019	13:55	1.37	20.3 (13.1)
2/11/2019	16:37	1.89	31.8 (20.6)
6/11/2019	16:36	1.49	19.8 (12.8)
7/22/2019	17:32	1.45	18.5 (11.9)

For many years, MLP released a targe of 1.0 mgd from taro gate back into the stream to support community and ecosystem needs downstream of diversion 770. However, from 1995 to 2001, of the 10 flow measurements, only once did they meet 1.0 mgd target (USGS, 2003). Reduced streamflow has an impact on downstream water temperatures, an important water quality parameter for taro farmers. However, spring flow supporting ground water gains in the stream below diversion 770 also influence water temperature.

Figure 3-6. Mean daily flow in Honokohau Stream at McDonald's Dam (CWRM gage 6-149)

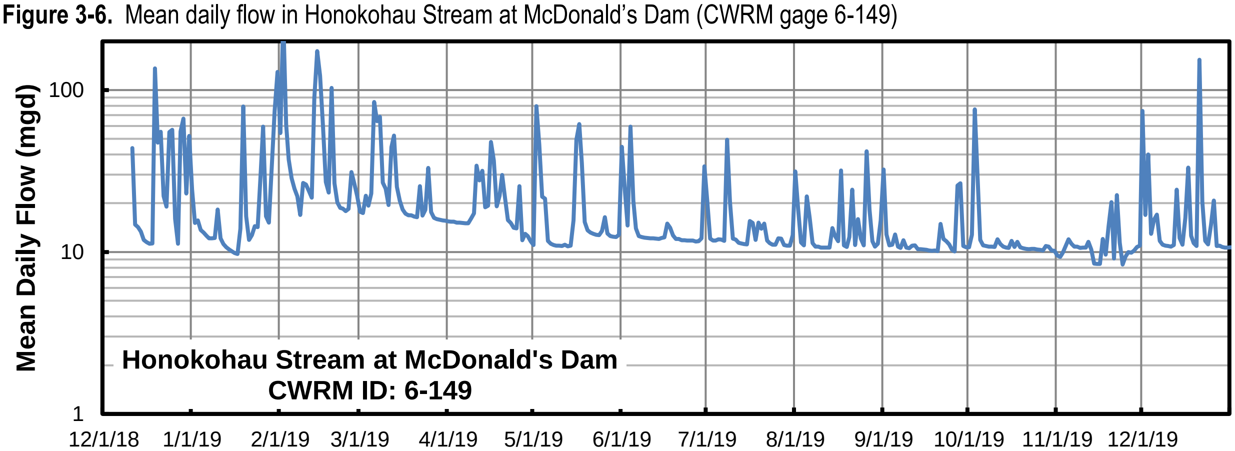


Figure 3-7. Ditches, diversions and gaging stations of the Honokohau hydrologic unit (Source: State of Hawaii, Commission on Water Resource Management, 2015a).

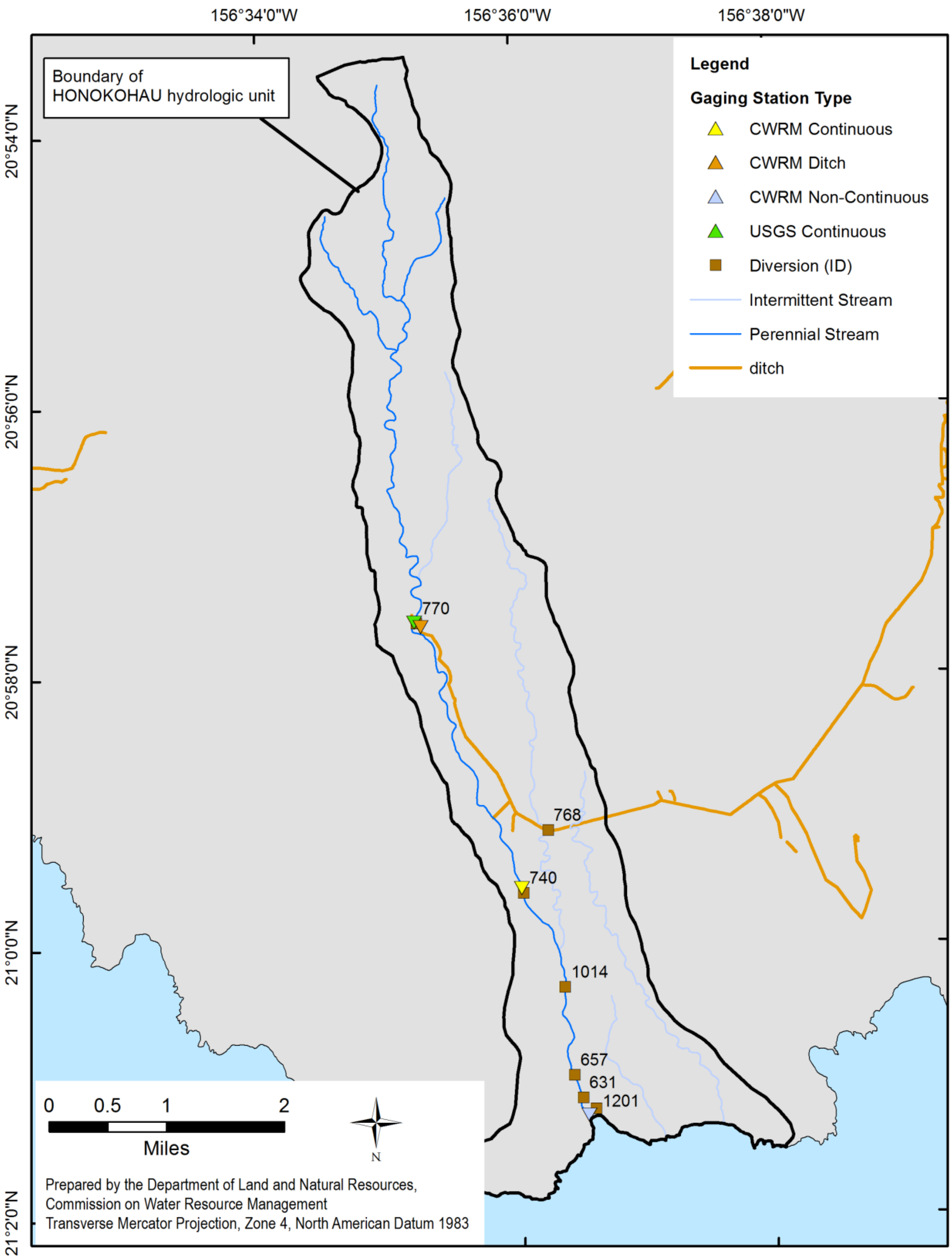
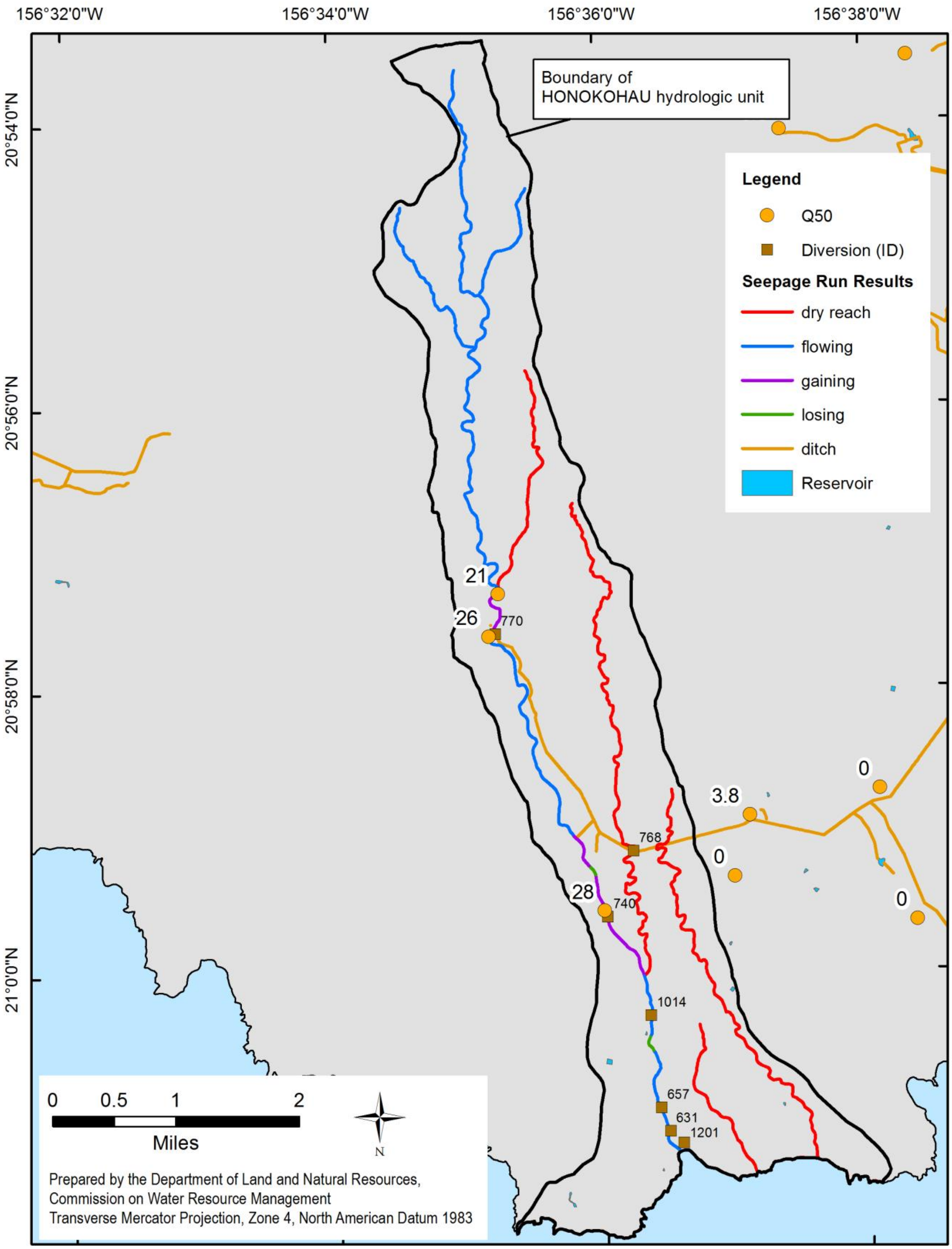


Figure 3-8. Seepage run results and estimated natural median flow in the Honokohau hydrologic unit (Source: State of Hawaii, Commission on Water Resource Management, 2015a; Cheng, 2014).



Long-term trends in flow

The climate has profound influences on the hydrologic cycle and in the Hawaiian Islands, shifting climate patterns have resulted in an overall decline in rainfall and streamflow. Rainfall trends are driven by large-scale oceanic and atmospheric global circulation patterns including large-scale modes of natural variability such as the El Nino Southern Oscillation and the Pacific Decadal Oscillation, as well as more localized temperature, moisture, and wind patterns (Frazier and Giambelluca, 2017; Frazier et al, 2018). Using monthly rainfall maps, Frazier and Giambelluca (2017) identified regions that have experienced significant ($p<0.05$) long-term decline in annual, dry season, and wet season rainfall from 1920 to 2012 and from 1983 to 2012. In West Maui, there is a substantial area that has experienced a significant decline in annual and dry season rainfall (Figure 3-10).

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. Figure 3-11 illustrates the results of the study for 7 long-term gaging stations around the islands. According to the analyses, low flows generally decreased from 1913 to 2002, which is consistent with the long-term downward trends in rainfall observed throughout the islands during that period. Monthly mean base flows decreased from the early 1940s to 2002, which is consistent with the measured downward trend of low flows from 1913 to 2002. This long-term downward trend in base flow may imply a reduction of ground water contribution to streams. At a nearby gaging station on Honokohau Stream, which has been active almost continuously from 1917 to present day, trends in mean annual flow provide some context for the long-term decline in rainfall (Figure 3-9). Changing streamflow characteristics could pose a negative effect on the availability of drinking water for human consumption and habitat for native stream fauna (Oki, 2004).

Figure 3-9. Mean annual flow (cubic feet per second, cfs) at USGS station 16620000 on Honokohau Stream, Maui. Line represents linear regression trend over the period of record.

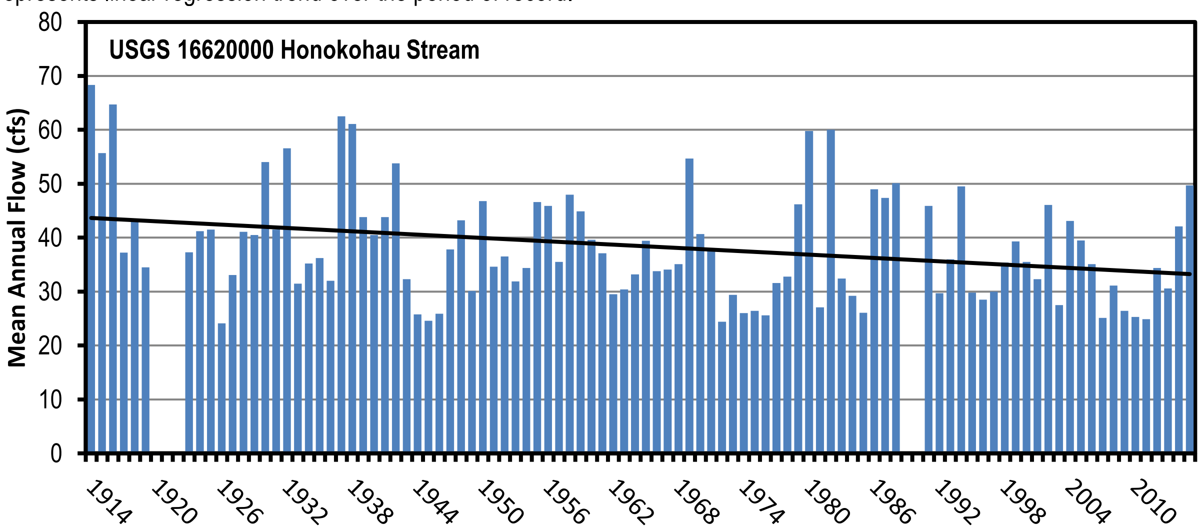


Figure 3-10. Annual, wet season (Nov-Apr) and dry season (May-Oct) rainfall trends for the 1920-2012 (A) and 1983-2012 (B) periods, Maui. Hashed line areas represent significant trend over the period.
(with permission from Frazier and Giambelluca, 2017)

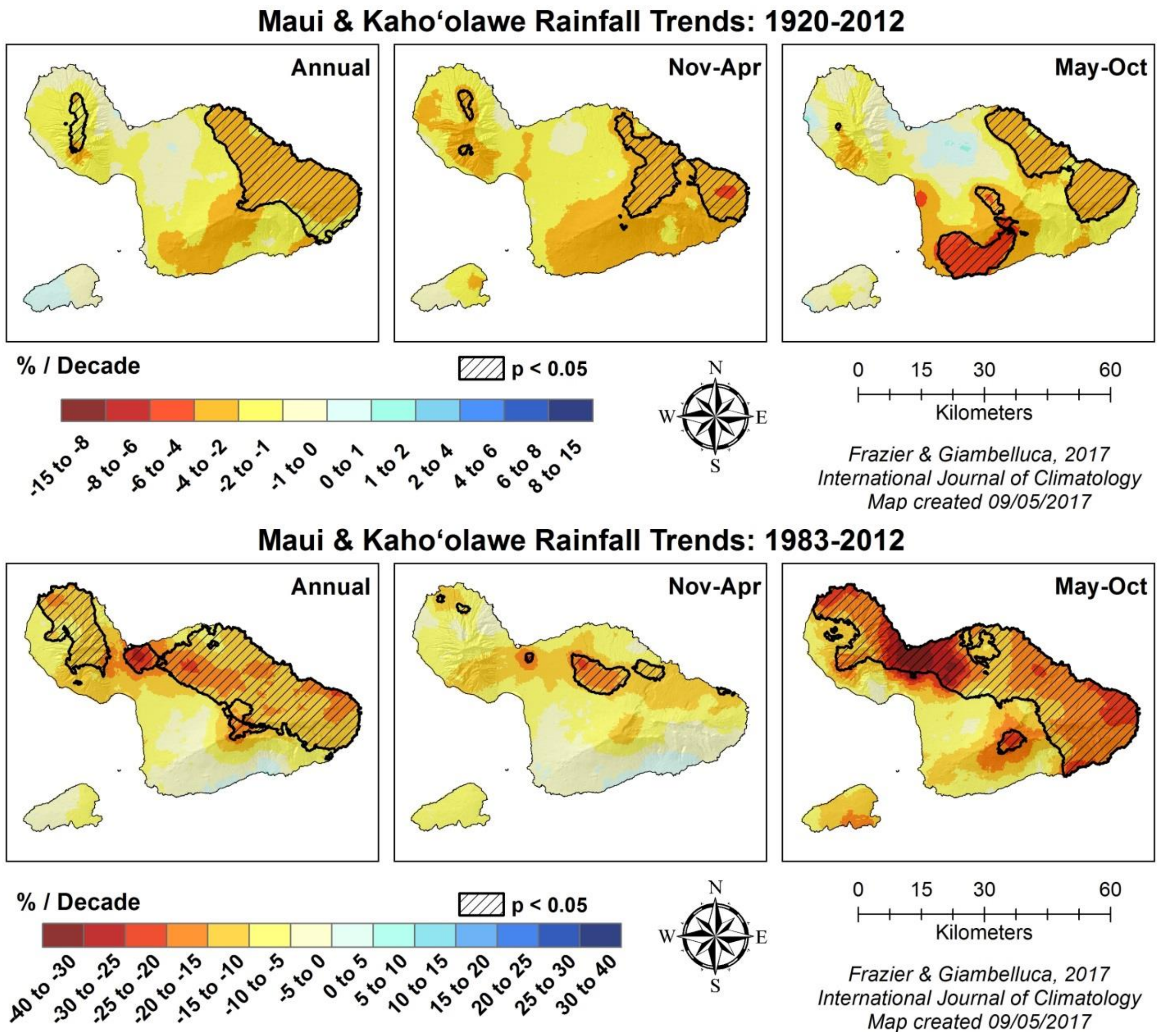
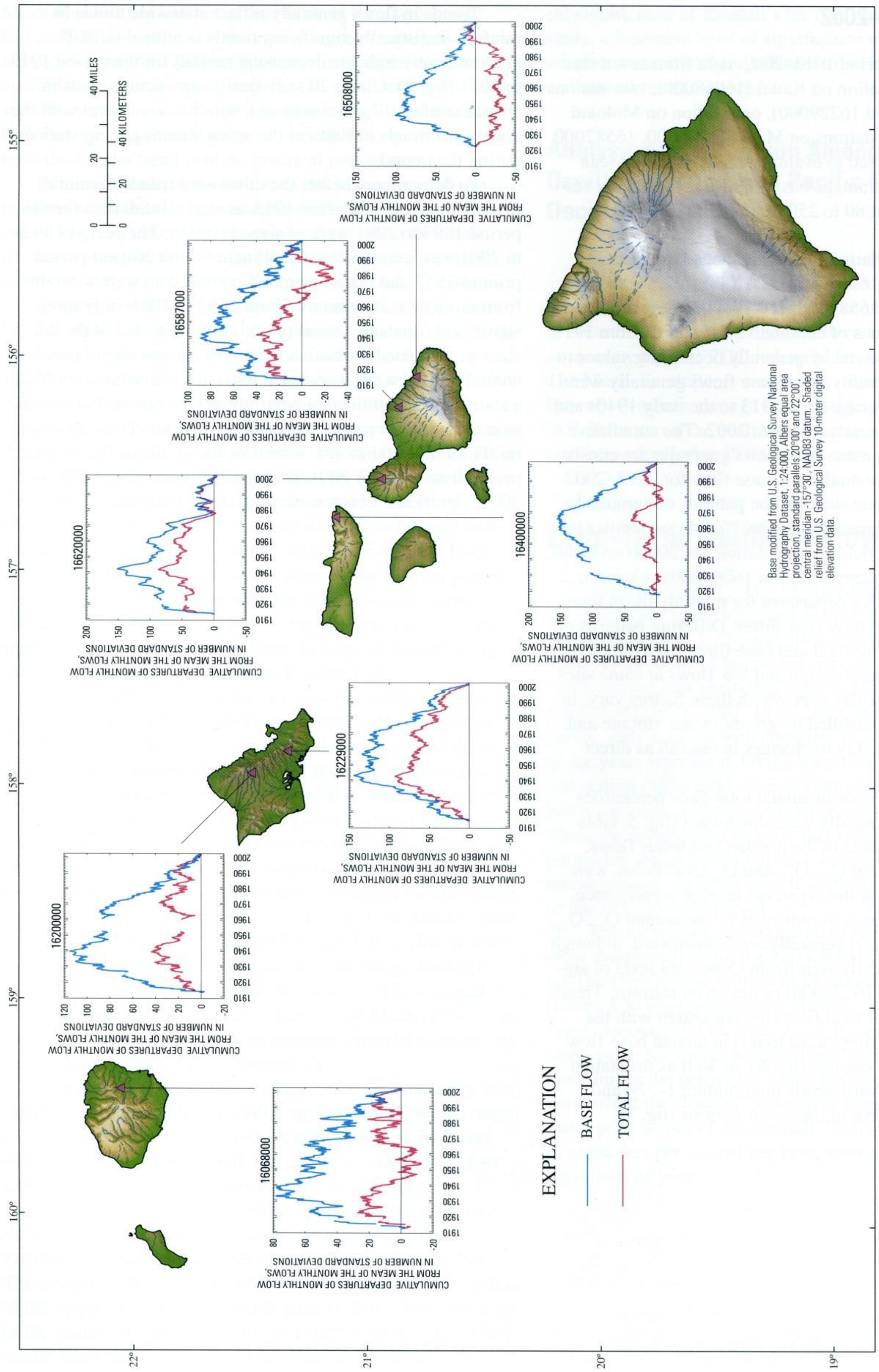


Figure 3-11. Cumulative departures of monthly mean flow from the mean of the monthly flows, Hawaii. This data is based on complete water years from 1913 through 2002. (Oki, 2004, Figure 4)



4.0 Maintenance of Fish and Wildlife Habitat

When people in Hawaii consider the protection of instream flows for the maintenance of fish habitat, their thoughts generally focus on just a handful of native species including five native fishes (four gobies and one eleotrid), two snails, one shrimp, and one prawn. Table 4-1 below identifies commonly mentioned native stream animals of Hawaii.

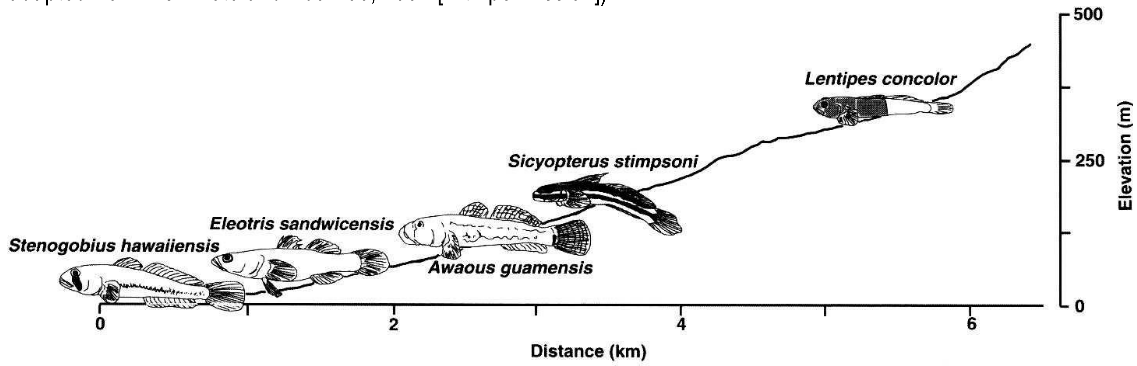
Table 4-1. List of commonly mentioned native stream organisms. (Source: State of Hawaii, Division of Aquatic Resources, 1993)

Scientific Name	Hawaiian Name	Type
Awaous stamineus	‘O‘opu nakea	Goby
Lentipes concolor	‘O‘opu hi‘ukole (alamo‘o)	Goby
Sicyopterus stimpsoni	‘O‘opu nopili	Goby
Stenogobius hawaiiensis	‘O‘opu naniha	Goby
Eleotris sandwicensis	‘O‘opu akupa (okuhe)	Eleotrid
Atyoida bisulcata	‘Opae kala‘ole	Shrimp
Macrobrachium grandimanus	‘Opae ‘oeha‘a	Prawn
Neritina granosa	Hihiwai	Snail
Neritina vespertina	Hapawai	Snail

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 freshwater 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 lower stream reaches. *Stenogobius hawaiiensis* has fused pelvic fins, but lacks the musculature necessary for climbing (Nishimoto and Kuamoo, 1997). *Awaous stamineus* and *Sicyopterus stimpsoni* are able to ascend moderately high waterfalls (less than ~20 meters) (Fitzsimons and Nishimoto, 1990), 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.

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. The biological aspects of Hawaii’s streams have an extensive history, and there is a wealth of knowledge, which continues to grow and improve.

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])



Hawaii Stream Assessment

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 field work 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). Based on the stream rankings, the HSA offered six different approaches to identifying candidate streams for protection: streams with outstanding resources (aquatic, riparian, cultural or recreational), streams with diverse or "blue ribbon" resources, streams with high quality natural resources, streams within aquatic resource districts, free flowing streams, or streams within the National Wild and Scenic Rivers database.

Due to the broad scope of the HSA 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 throughout this report. The HSA recommended that the Honokohau hydrologic unit streams be listed as an outstanding candidate for protection based on its riparian, aquatic, cultural and recreational resources. At the time of the assessment, all of the four group one native species had been observed in Honokohau Stream. Additionally, five group two native species (*Atyoida bisulcata*, *Eleotrsi sandwicensis*, *Kuhlia sandvincensis*, *Macrobrachium grandimanus*, *Stenogobius hawaiiensis*) had been observed in the stream (Figures 4-2 to 4-7).

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 easy 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 interim IFS recommendations. A copy of the updated inventory report for Honokohau Stream is in Appendix A. The following is a brief summary of findings:

- **Point Quadrat Survey.** In Honokohau Stream, two stream surveys were conducted in 1961. Point quadrat surveys were then conducted in 2003 and 2004. Although the post larval recruitment of native fish was not surveyed, diversions that fully dewater streams restrict the passage of larval and limit upstream movement of adult stream animals. Streamflow restoration would likely benefit recruitment and survival of native species in the lower, middle and upper reaches. Recent (2019) biota surveys above and below the diversion 770 indicate healthy populations of *A. guamensis*, *L. concolor*, and *S. stimpsoni*.

- **Insect Survey.** Honokohau Stream met the DAR qualification for native insect diversity (>19 spp) and native macrofauna diversity (>5 spp.) giving it a high score for native species. Some native damselflies are currently proposed for listing as Endangered under the federal Endangered Species Act.

- **Watershed and Biological Rating.** The Honokohau watershed has the highest watershed rating for Maui and the state for land cover and stewardship due to the high percentage of conservation land. The lack of estuarine and shallow marine areas associated with Honokohau ranks it low for shall waters. Honokohau Stream has a low rating for stream size, a medium rating for wetness, and an above average reach diversity resulting in a high total watershed rating for Maui and statewide. The stream ranks high for number and diversity of native species found and ranks high for a lack of introduced species, resulting in a high all species and total biological rating for Maui and the state. These scores combined gave Honokohau Stream the highest overall watershed rating.

A team of scientists led by CWRM and DAR staff conducted an intensive survey of Honokohau Stream above diversion 770 (at 825 ft elevation) in June 2019 and above McDonald's Dam (at 350 ft elevation) in July 2019. Results of 25 point quadrant samples are provided in Table 4-2.

Table 4-2. Total count and mean density (standard deviation, SD) from point quadrat surveys of Honokohau Stream above diversion 770 at 825 ft elevation (n = 25) and above McDonald's Dam at 350 ft elevation (n = 25) in June and July 2019.

Scientific Name	total count (n)	density (SD) (per m^2)	average size range (in)
At 825 ft elevation			
Sicyopterus stimpsoni	0	0	n/a
Awaous stamineus	1	0.078 (0.386)	> 3 to ≤ 5
Lentipes concolor	12	1.121 (1.975)	> 3 to ≤ 4
Atyoida bisulcata	5	0.812 (4.058)	≤ ¼
At 350 ft elevation			
Sicyopterus stimpsoni	1	0.088 (0.440)	>5
Awaous stamineus	5	0.686 (1.432)	> 3 to ≤ 5
Lentipes concolor	3	0.354 (1.002)	> 1 to ≤ 2
Atyoida bisulcata	0	0	n/a

Figure 4-2. Presence and absence of *Awaous stamineus* in point-quadrat surveys of Honokohau Stream conducted by DAR in 1961, 2003, and 2004. (Source: Division of Aquatic Resources Database, accessed 2018)

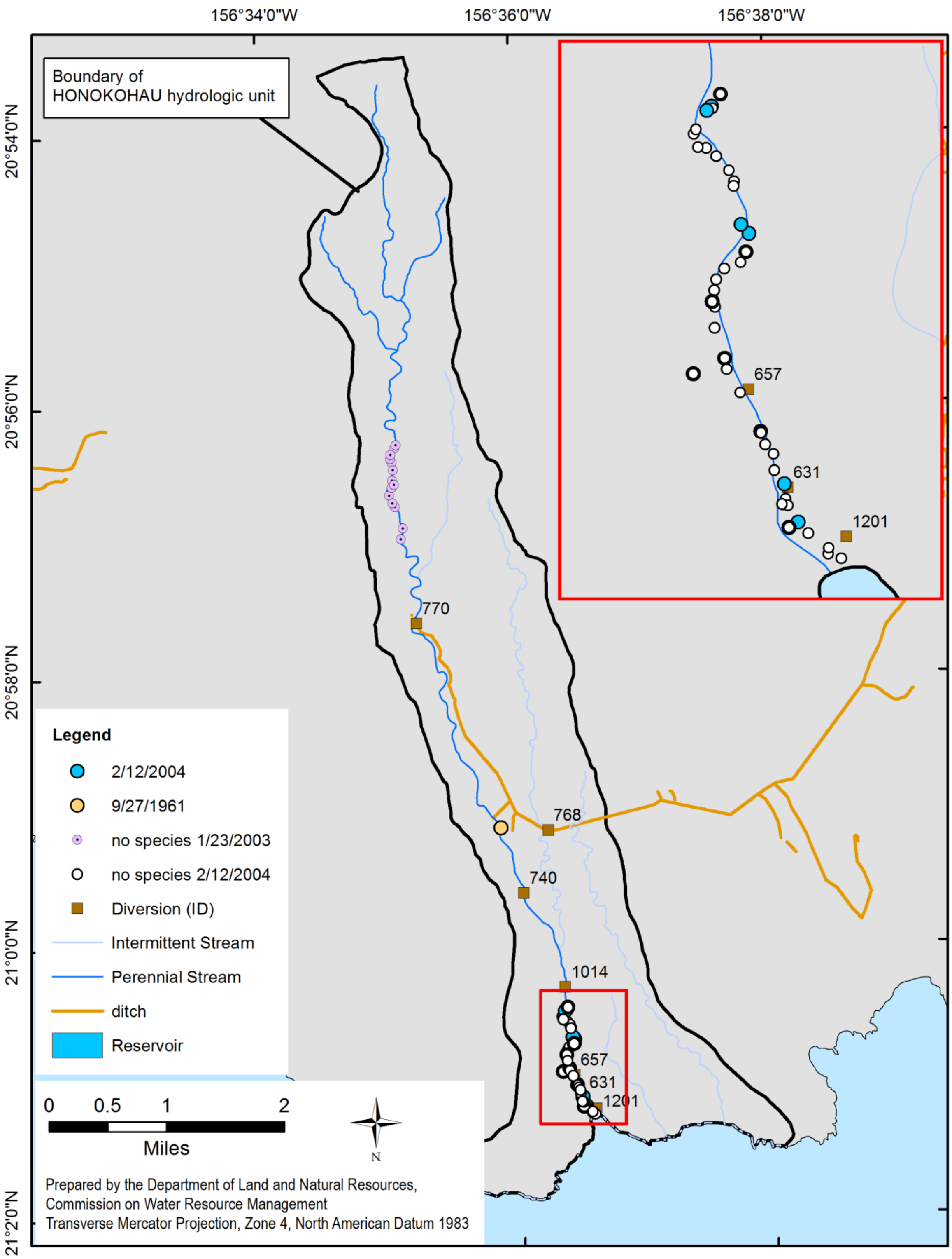


Figure 4-3. Presence and absence of *Lentipes concolor* in point-quadrat surveys of Honokohau Stream conducted by DAR in 1961, 2003, and 2004. (Source: Division of Aquatic Resources Database, accessed 2018)

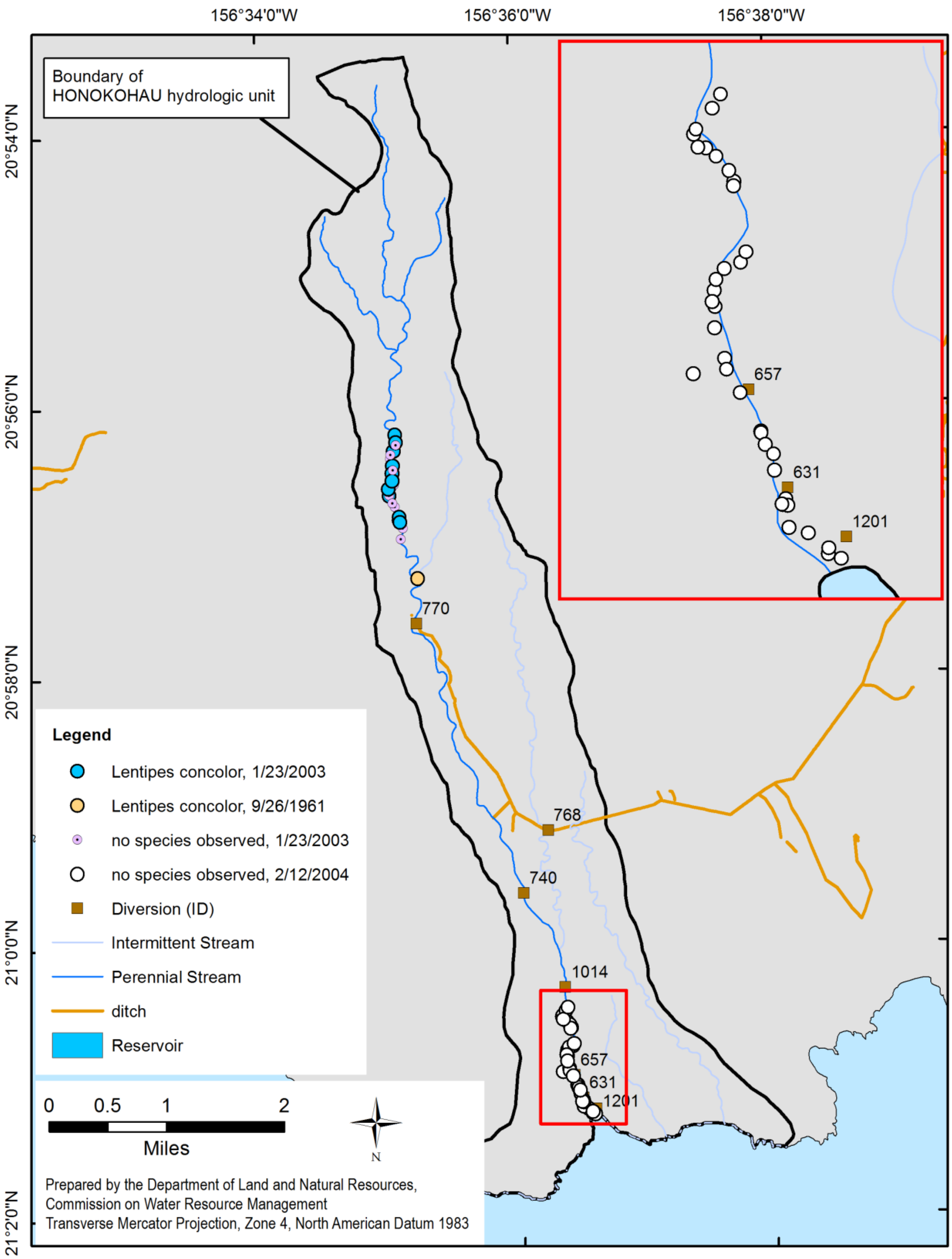


Figure 4-4. Presence and absence of *Sicyopterus stimpsoni* in point-quadrat surveys of Honokohau Stream conducted by DAR in 1961, 2003, and 2004. (Source: Division of Aquatic Resources Database, accessed 2018)

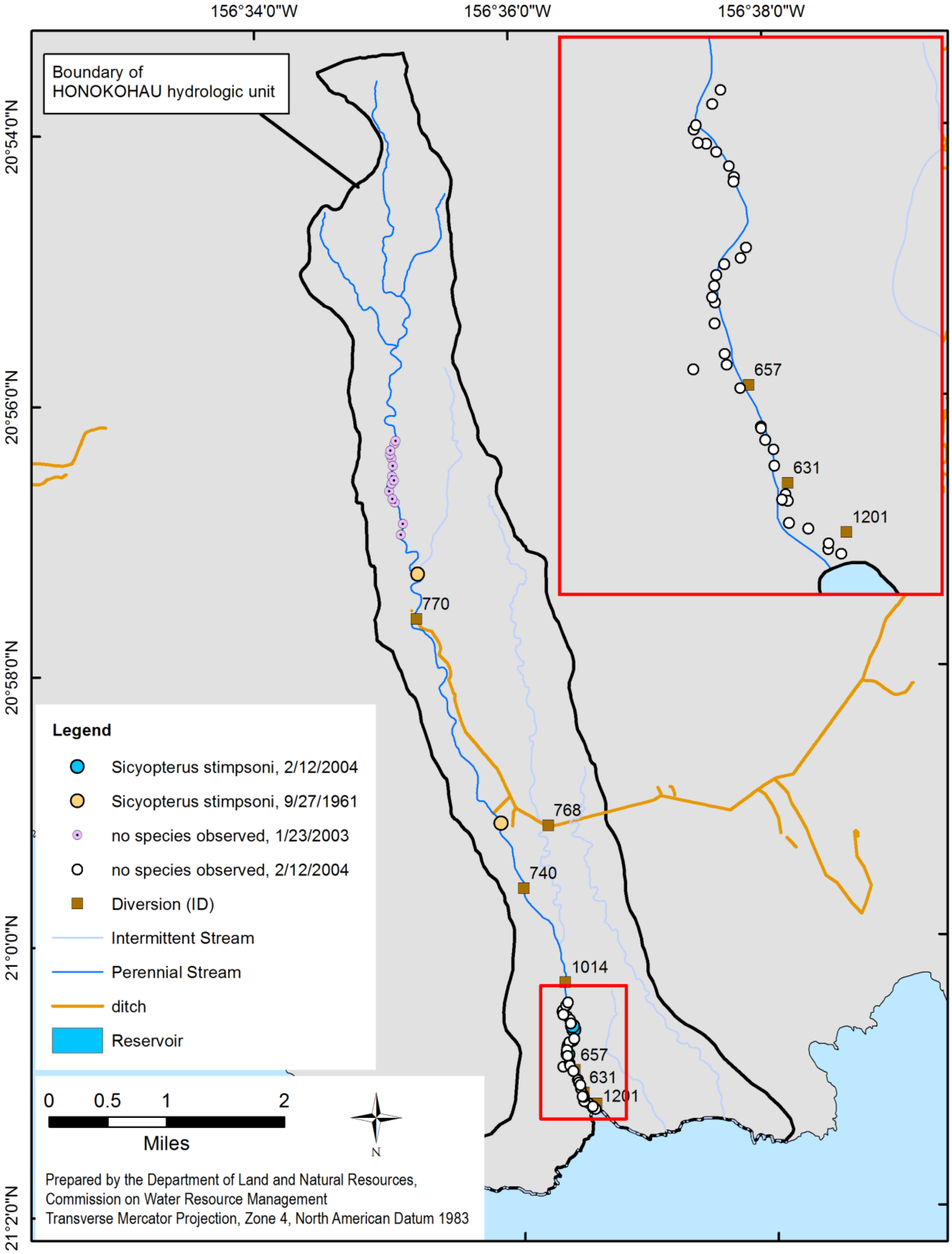


Figure 4-5. Presence and absence of *Atyoida bisulcata* in point-quadrat surveys of Honokohau Stream conducted by DAR in 1961, 2003, and 2004. (Source: Division of Aquatic Resources Database, accessed 2018)

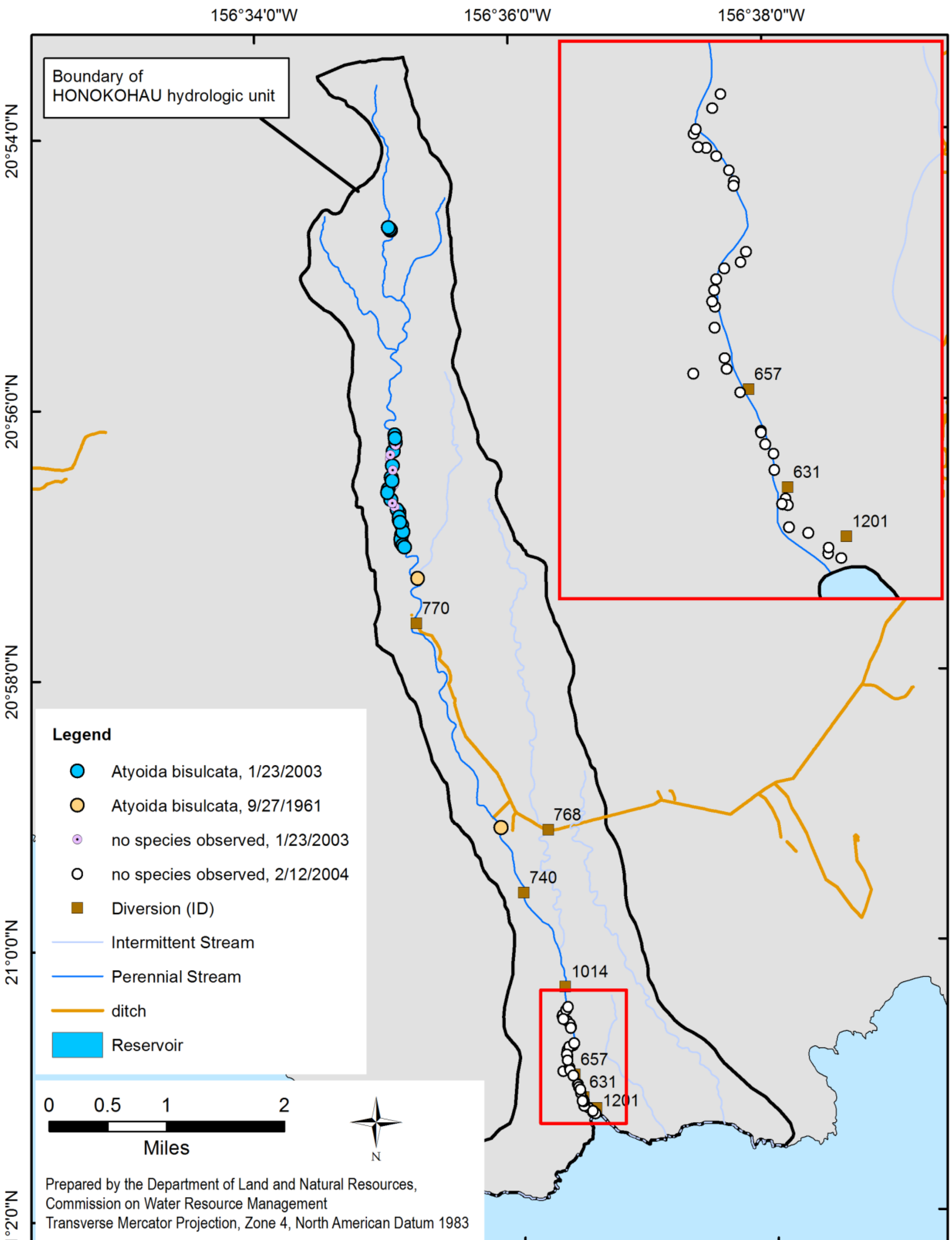


Figure 4-6. Presence and absence of *Atyoida bisulcata* in point-quadrat surveys of Honokohau Stream conducted by DAR in 1961, 2003, and 2004. (Source: Division of Aquatic Resources Database, accessed 2018)

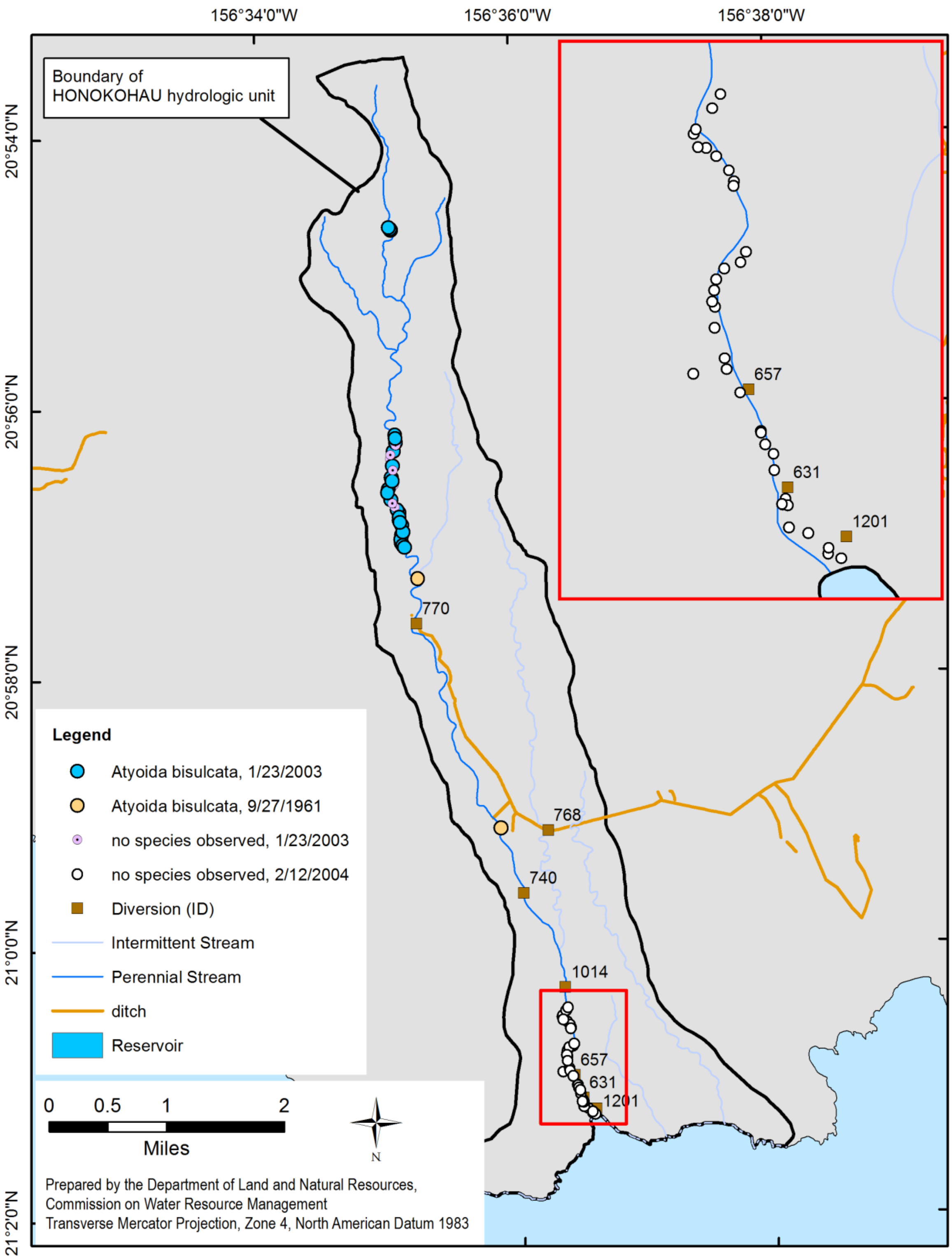
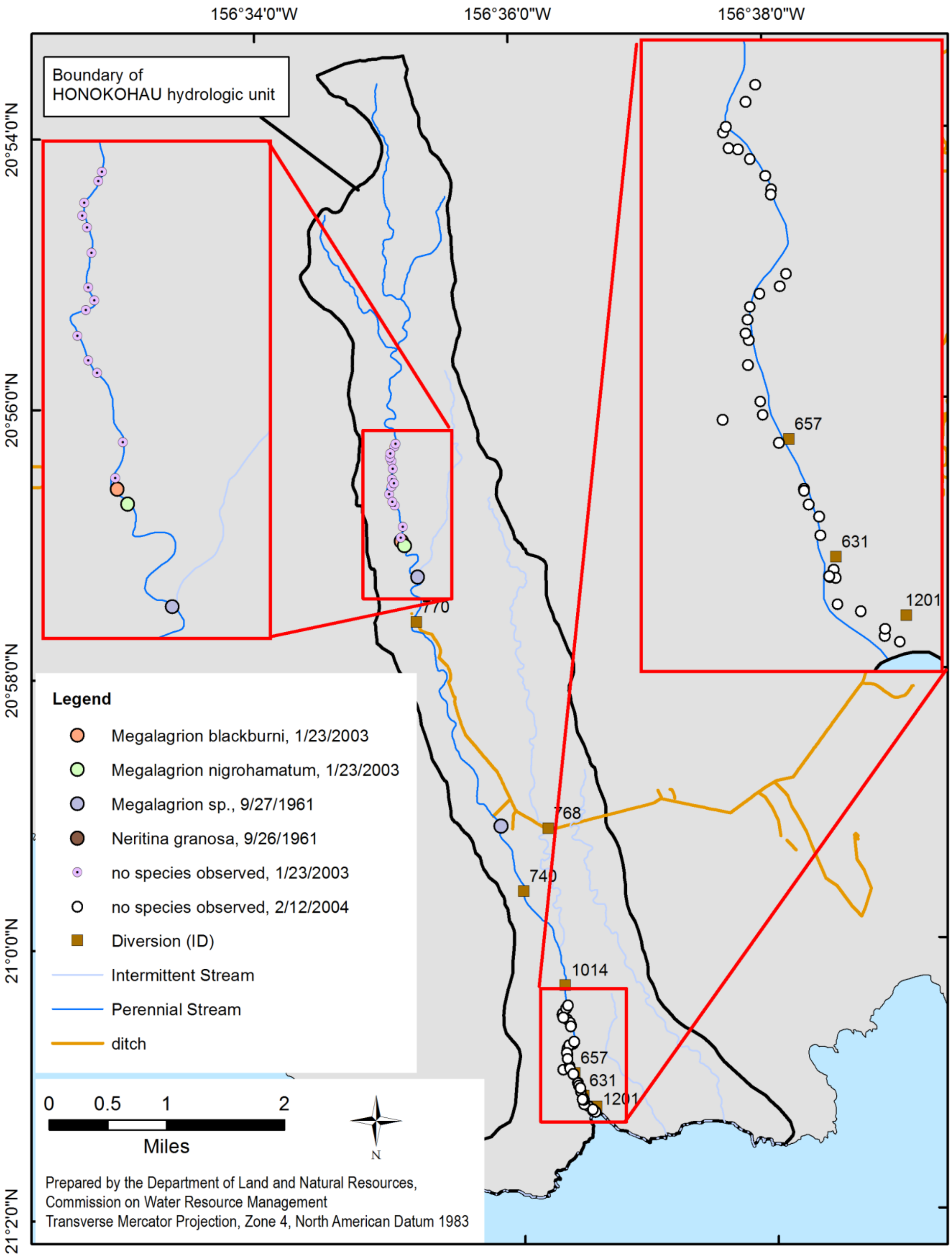


Figure 4-7. Presence and absence of *Magalagrion sp.* and *Neritina* granosa in point-quadrat surveys of Honokohau Stream conducted by DAR in 1961, 2003, and 2004. (Source: Division of Aquatic Resources Database, accessed 2018)



5.0 Outdoor Recreational Activities

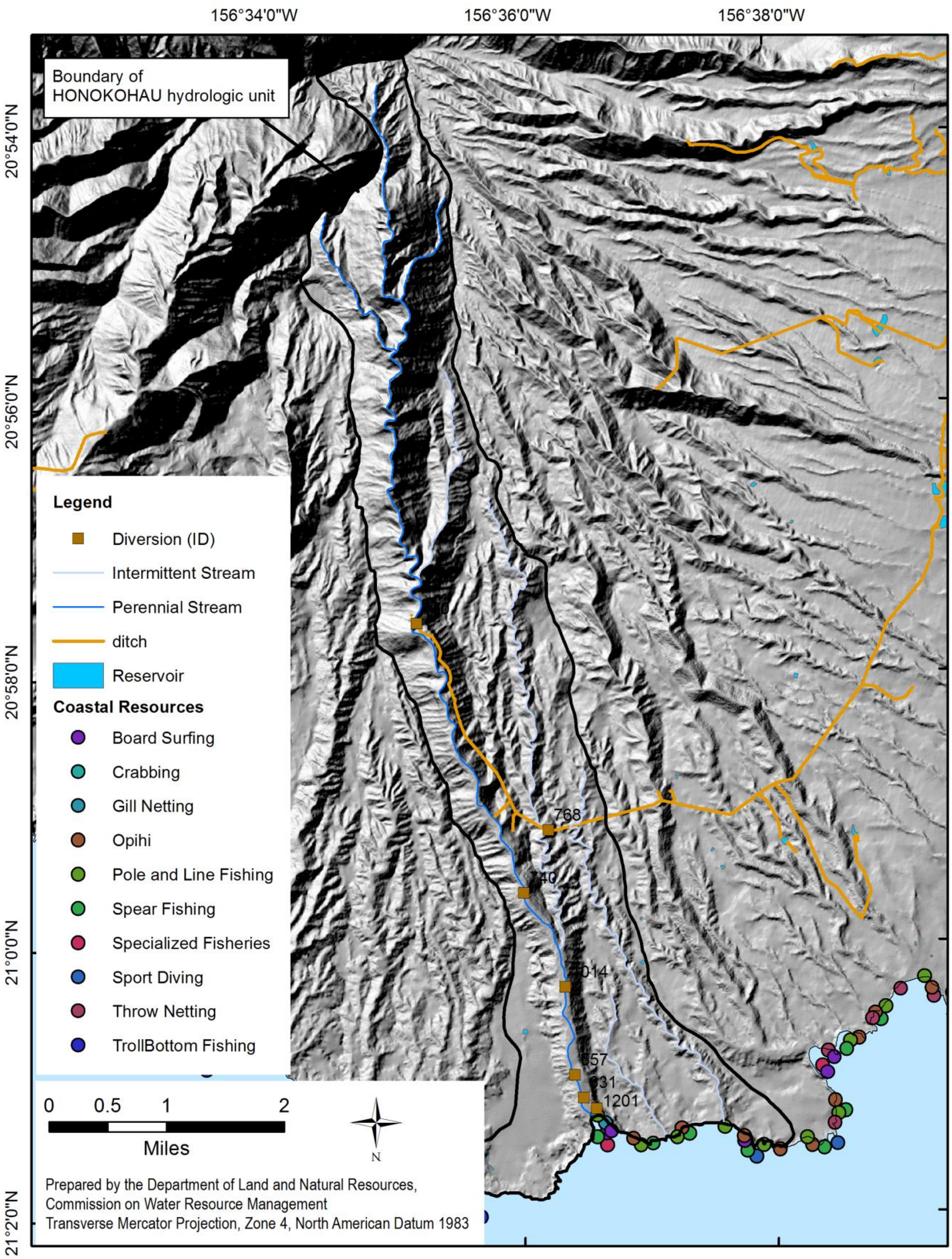
Water-related recreation is an integral part of life in Hawaii. Though beaches may attract more users, the value of maintaining streamflow is important to sustaining recreational opportunities for residents and tourists alike. Streams are often utilized for water-based activities, such as boating, fishing, 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 Hawaii Stream Assessment identified hiking and scenic views as stream recreational opportunities in the Honokohau hydrologic unit and the regional committee classified the stream as "limited" (National Park Service, Hawaii Cooperative Park Service Unit, 1990). There are many near-shore opportunites, but little to no opportunities along the stream.

Mammal hunting is permitted in Unit A on the island of Maui in the state-owned portions of the West Maui Forest Reserve. However, none of the Honokohau hydrologic unit is in designated as hunting area (Figure 5-1).

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 Honokohau 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, some of the activities the Commission identified that were known to occur or observed at or near Honokohau include: pole and line fishing, bait fishing, gill netting, torch fishing, sport diving and throw netting, surfing, standup paddle boarding, seaweed and shell collecting (Figure 5-1).

Figure 5-1. Public hunting areas for game mammals and locations for other recreational activies in the Honokohau hydrologic unit. (Source: State of Hawaii, Office of Planning, 2002b)

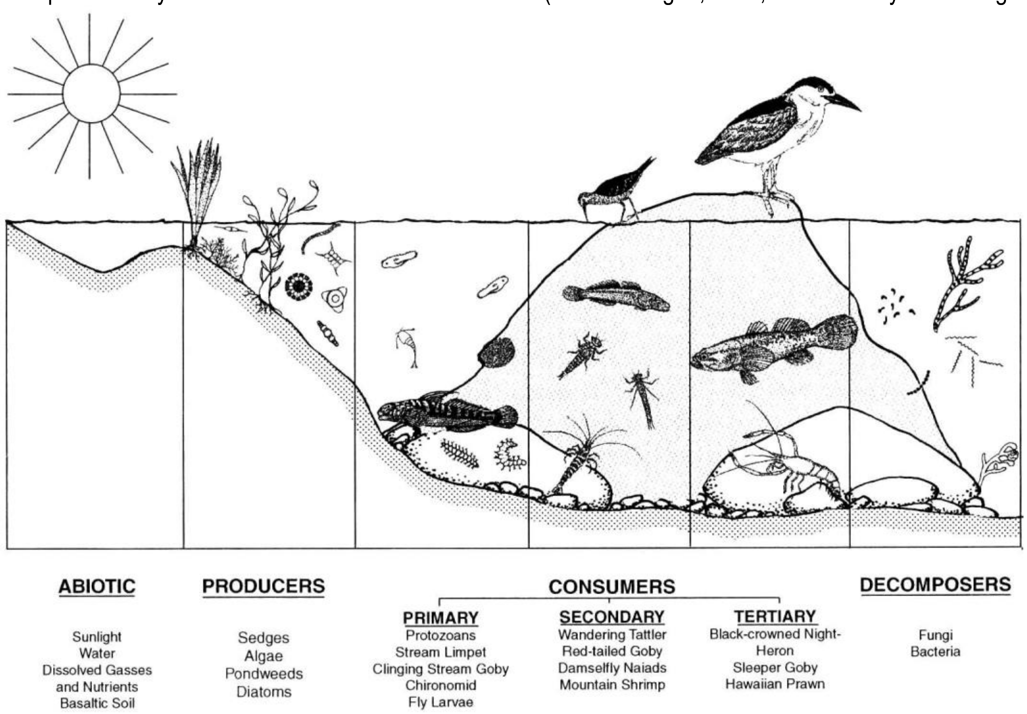


6.0 Maintenance of Ecosystems

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.

The HSA determined that Honokohau Stream did not deserve to be a candidate stream for protection based on its Diversity of Resources scoring (does not have an outstanding rating in three categories) or its Blue Ribbon Resources scoring. Honokohau does have substantial riparian resources and outstanding aquatic and cultural resources. Detrimental organisms (non-native species that have a negative effect on the ecosystem) were not considered in the final ranking; however their presence and abundance are considerable ecosystem variables. The destruction to both vegetation and soil resources in the Honokohau hydrologic unit by determintal organisms (pigs) is considered a major factor in alterations to the hydrology and water quality of the stream. However, a large portion of the headwaters of Honokohau are protected by fencing and managed by the Puu Kukui Watershed Preserve as part of the West Maui Mountains Watershed Partnership.

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 these resources. 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 Honokohau Stream were classified by the HSA (National Park Service, Hawaii Cooperative Park Service Unit, 1990) and ranked according to a scoring system using six of the seven variables (Table 6-1).

Table 6-1. Hawaii Stream Assessment indicators of riparian resources for Honokohau hydrologic unit. (National Park Service, 1990)

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.	1
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.	Plaustrine Wetland
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.	60%
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.	3 (Hau, California Grass, 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 Honokohau, about 6.5 square miles (57 percent) of the hydrologic unit falls within the Puu Kukui Watershed Preserve (Table 6-2, Figure 6-2).

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 6-2 provides a summary of the partnership area, partners, and management goals of the West Maui Mountains Watershed Partnership.

Table 6-2. Watershed partnerships associated with the Honokohau hydrologic unit. (Source: State of Hawaii, Division of Forestry and Wildlife, 2008b)

Management Area	Year Established	Total Area (mi^2)	Area (mi^2)	Percent of Unit
West Maui Mountains Watershed Partnership	1998	78.125	6.506	56.7%
The West Maui Mountains Watershed Alliance (WMMWA) is comprised of the County of Maui Department of Water Supply, Hawaii State Department of Land and Natural Resources (Division of Forestry and Wildlife, Kaanapali Land Management Corp., Kahoma Land Company L.L.C., Kamehameha Schools, Makila Land Company L.L.C., Maui Land Pineapple Company, Inc., and The Nature Conservancy of Hawaii, and Wailuku Water Company, L.L.C. The management priorities of the WMMWP include: 1) Baseline watershed forest health and threat assessments; 2) Establishment of forest health monitoring transects; 3) Fencing to control movement of feral animals, especially pigs and deer; 4) Staff control to remove pest animals from upper watershed; and 5) Pest plant control, particularly of priority weed species such as *Psidium cattleianum*. As of 2013, 19.44 miles of fencing have been built, of which 4.43 miles are pig and deer fencing (8-foot) and 14.91 miles are pig (4-foot) fencing resulting in 21,084 acres of protected lands.				

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). Nearly 2.8 percent of the Honokohau Hydrologic Unit is classified as wetlands (emergent, freshwater forested or pond), mostly occurring in the headwaters of the hydrologic unit (Table 6-4 and Figure 6-3).

Table 6-3. Wetland classifications for Honokohau hydrologic unit. (Source: State of Hawaii, Office of Planning, 2015n)

System Type	Class	Area (mi^2)	Percent of Unit
Marine	Estuarine and Marine Deepwater	0.006	<0.1%
Palustrine	Freshwater Emergent Wetland	0.047	0.4%
Palustrine	Freshwater Forested/Shrub Wetland	0.259	2.3%

A series of vegetation maps describing upland plant communities was prepared as part of a USFWS survey in 1976 to 1981 to determine the status of native forest birds and their associated habitats. Figure 6-4 identifies critical habitat for plant species near Honokohau, although currently, none fall in the hydrologic unit. There is likely also native and potentially endangered damselfly species (*Megalagrion sp*) in Honokohau headwaters, although their distribution is not well known. Over half of the unit is dominated by native vegetation, while almost 40 percent of the unit is dominated by introduced species.

The density of threatened and endangered plant species is high at elevations above 1,200 feet, resulting in almost a majority of the Honokohau hydrologic unit, roughly 68 percent, covered in a high or very high density of threatened and endangered plant species (Table 6-5, Figure 6-5).

A 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.).

Table 6-4. Distribution of native and alien plant species for Honokohau hydrologic unit. (Source: State of Hawaii, Office of Planning, 2015f)

Canopy Type	Area (mi^2)	Percent of Unit
Very High concentration of threatened and endangered species	0.000	0.00%
High concentration of threatened and endangered species	7.731	67.5%
Medium concentration of threatened and endangered species	1.803	15.8%
Low concentration of threatened and endangered species	0.581	5.07%
Little or no threatened and endangered species	1.347	11.8%

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 6-7.

Following the results of the Oahu Koolau case study, some of the most valuable aspects of the forested areas are believed to be ecotourism, aesthetic pleasure, species habitat, water quality, and water quantity. Certain areas of Honokohau provide critical habitat for native forest birds, endangered plants and invertebrates in Maui.

Table 6-5. 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**	

Figure 6-2. Reserves that include the Honokohau hydrologic unit. (Source: State of Hawaii, Office of Planning, 2007b; 2015n)

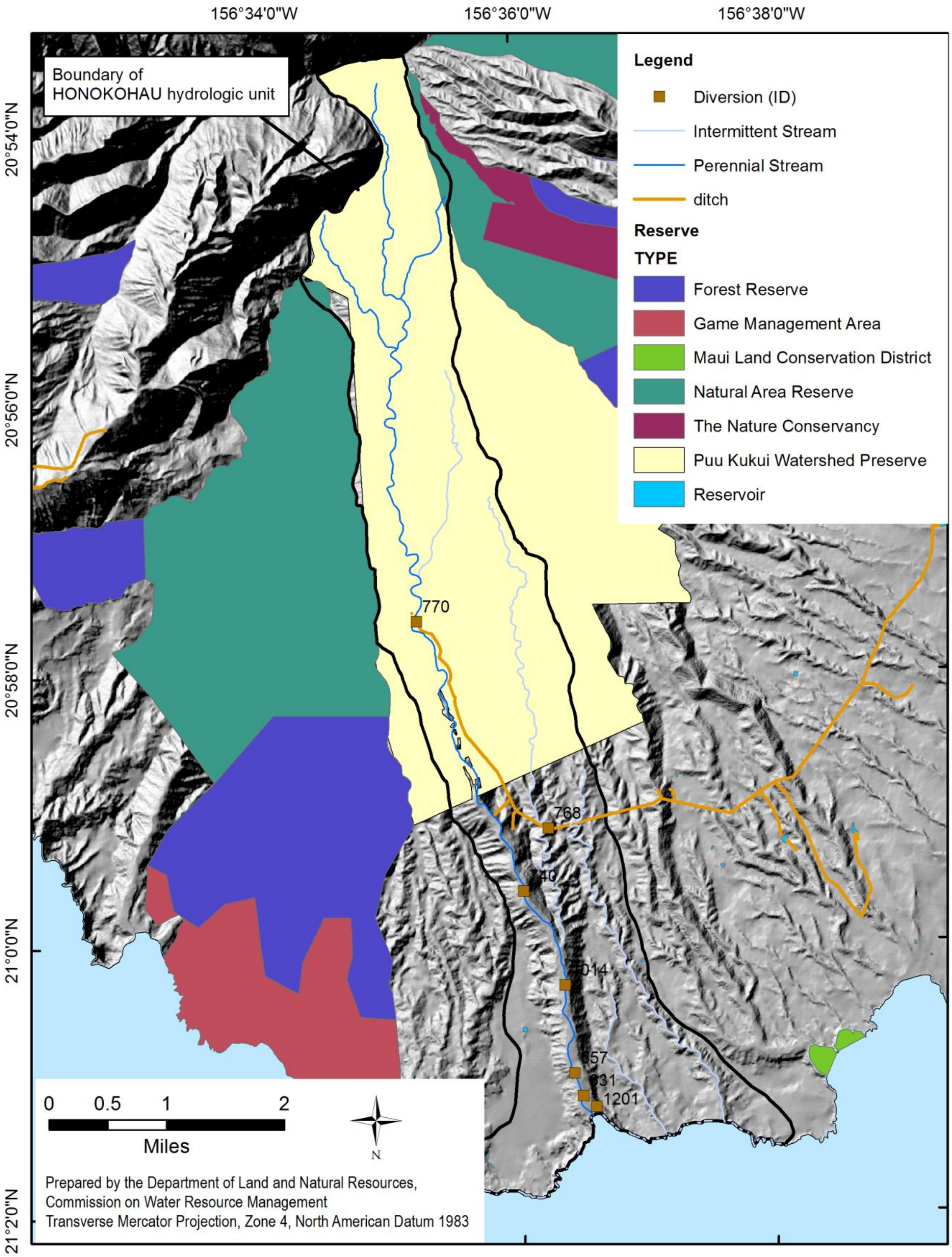


Figure 6-3. Wetlands that include the Honokohau hydrologic unit. (Source: State of Hawaii, Office of Planning, 2007b; 2015n)

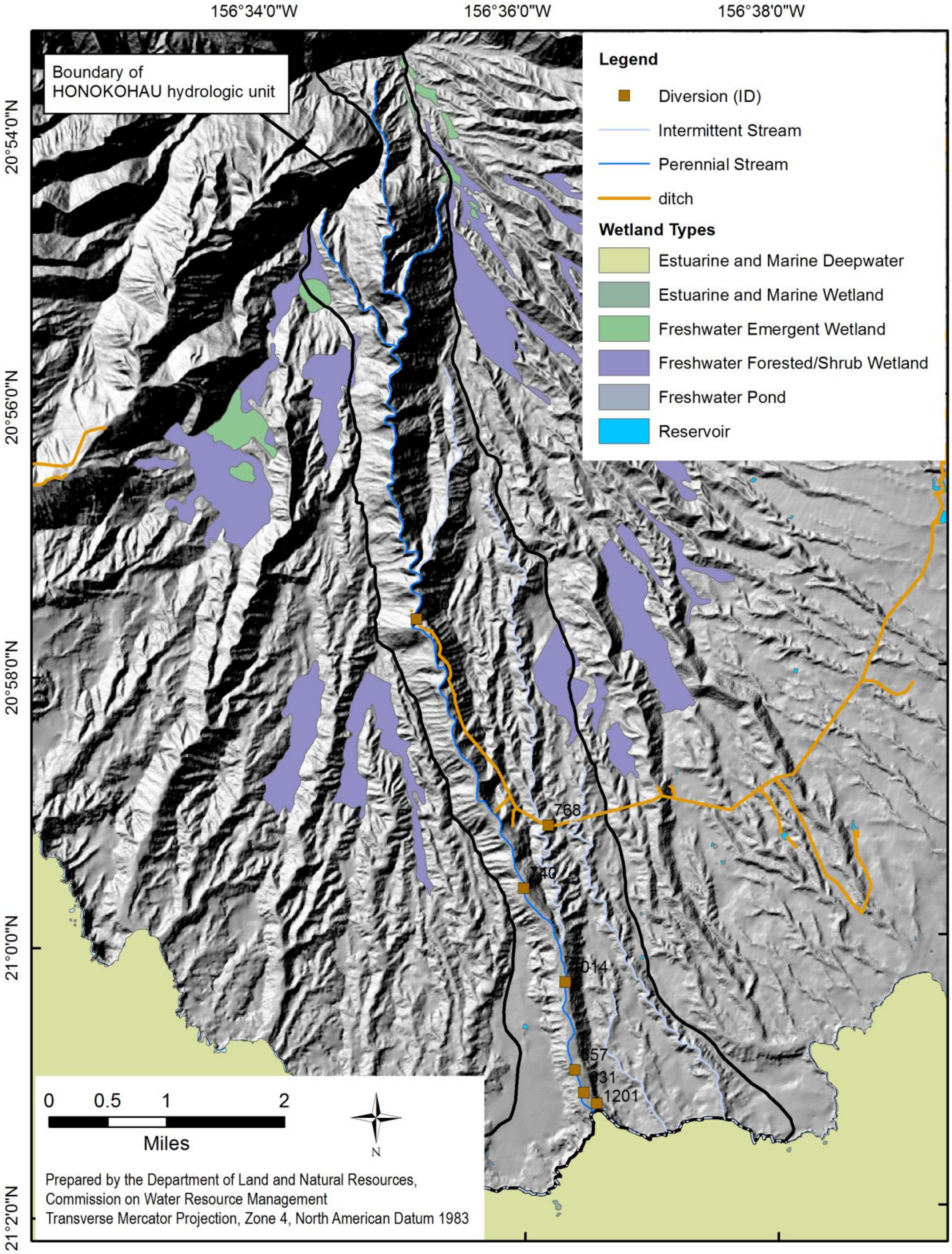


Figure 6-4. Distribution of critical habitat for plant species in the Honokohau hydrologic unit. (Source: State of Hawaii, Office of Planning, 2004b)

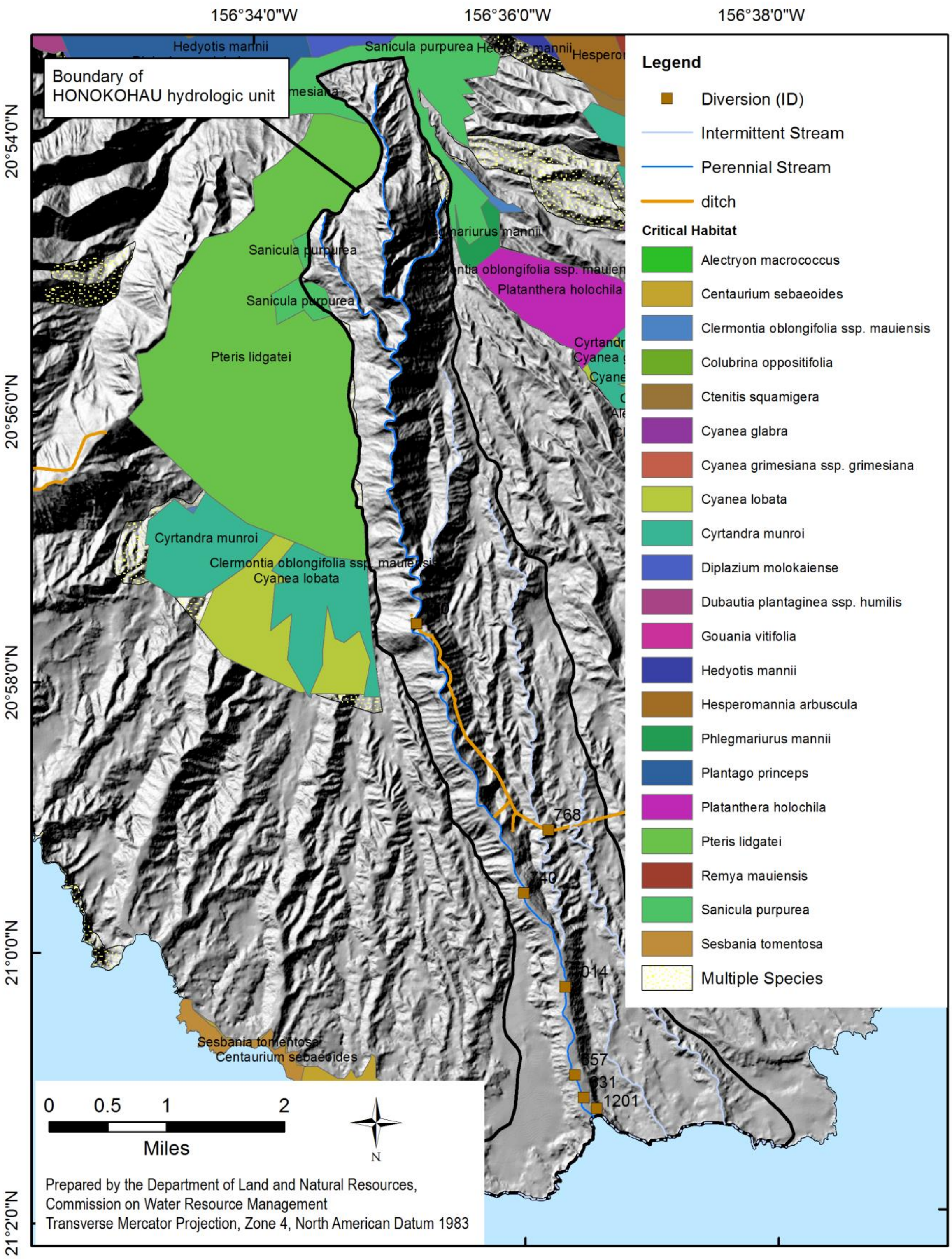
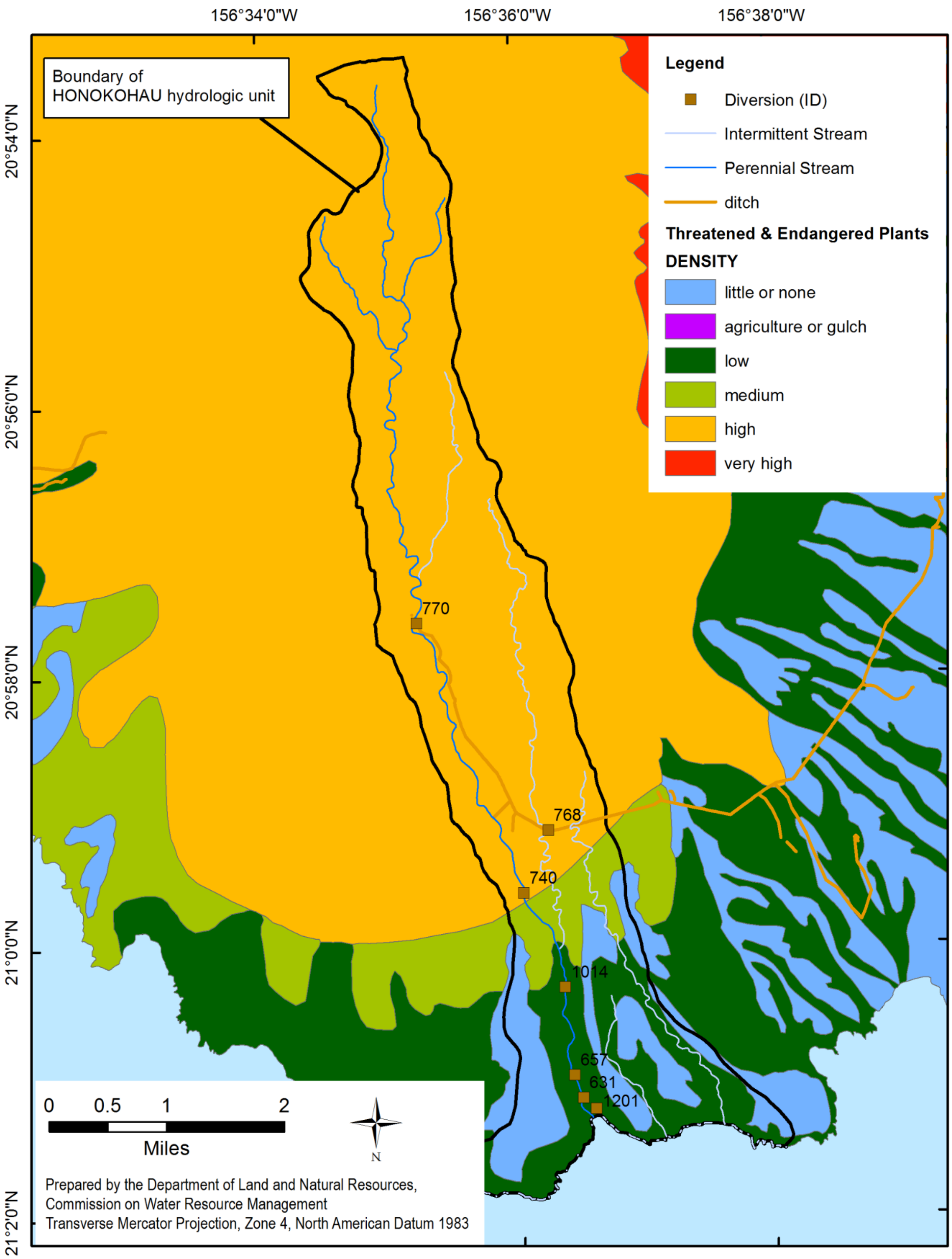


Figure 6-5. Density of threatened and endangered plants in the Honokohau hydrologic unit. (Source: State of Hawaii, Office of Planning, 2015h)



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. Visitors and residents can identify a point that has aesthetic value and continue to return to such a point to gain that value. Such points can potentially be identified, as maped. However, the points identified are not exhaustive and it is beyond the scope of this report to list all potential aesthetic values.

The headwaters of Honokohau Stream originate in the West Maui Mountains, a unique ecological region home to endemic and endangered birds, plants, and insects. However, access to this region is restricted to the general public. Currently, there are few opportunities readily available to the general public to appreciate the aesthetic value of Honokohau Stream except in the lowest reaches which is accessible from the highway to the stream mouth in Honokohau Bay. There is high aesthetic value to the local community, which can be protected with sufficient mauka to makai streamflow.

In a 2007 Hawaii State Parks Survey, released by the Hawaii Tourism Authority (OmniTrak Group Inc., 2007), scenic views accounted for 21 percent of park visits statewide. 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, out-of-state visitors' most common reasons to visit state parks for scenic views (26 percent) was the number one reason for visiting a park above outings with family and friends (25 percent). By contrast, residents primarily used state parks on Maui for outings with family and friends (33 percent) followed by ocean/water activity (23 percent) and then scenic views (11 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.

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 Honokohau does not 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.

For a few decades, a small hydropower plant operated at McDonald's Dam at the 300 ft elevation, receiving water from Honokohau Ditch diverted from the stream by diversion 770. However, this hydropower plant is no longer operational, and there is currently no instream hydropower in the Honokohau hydrologic unit.

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 et al., 2004). Runoff transports large amounts of sediment from bare soil into surface water bodies, with consequences for in-stream and near-shore environments.

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 (USEPA), “[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 (USEPA, 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).”[1] 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

[1] 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 2012 Integrated Report are Hawaii's 2010 §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 2010 list that was published in 2012), only 88 streams statewide had sufficient data for evaluation of whether exceedance of WQS occurred. Honokohau Stream did not appear on the 2012 List of Impaired Waters in Hawaii, Clean Water Act §303(d).

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 2012 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, 2007, Chapter II, p.3)."

Honokohau Stream is classified as Class 1a inland waters from its headwaters to approximately the 700 ft elevation as the surrounding land is in the conservation subzone "protective." 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 Honokohau hydrologic unit are Class A waters.   Figure 10-1 shows the Honokohau hydrologic unit, including inland and marine (coastal) water classifications.

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. Land-based sources of fecal pollution are common in the tropics, where high densities of animals and a warm, moist environment provide ideal conditions for the proliferation of bacteria (Strauch et al., 2014). Data available through the US Environmental Protection Agency's online database (STORET) is available in Figure 10-2. Water quality is especially dependent on streamflow conditions, as runoff transports particulates into the stream channel and higher flows keep particles in suspension for longer periods of time (Strauch, 2017).

Figure 10-1. Water quality standards for the Honokohau hydrologic unit. (Source: State of Hawaii, Office of Planning, 2015e; 2008). The classifications are general in nature and should be used in conjunction with Hawaii Administrative Rules, Chapter 11-54, Water Quality Standards.

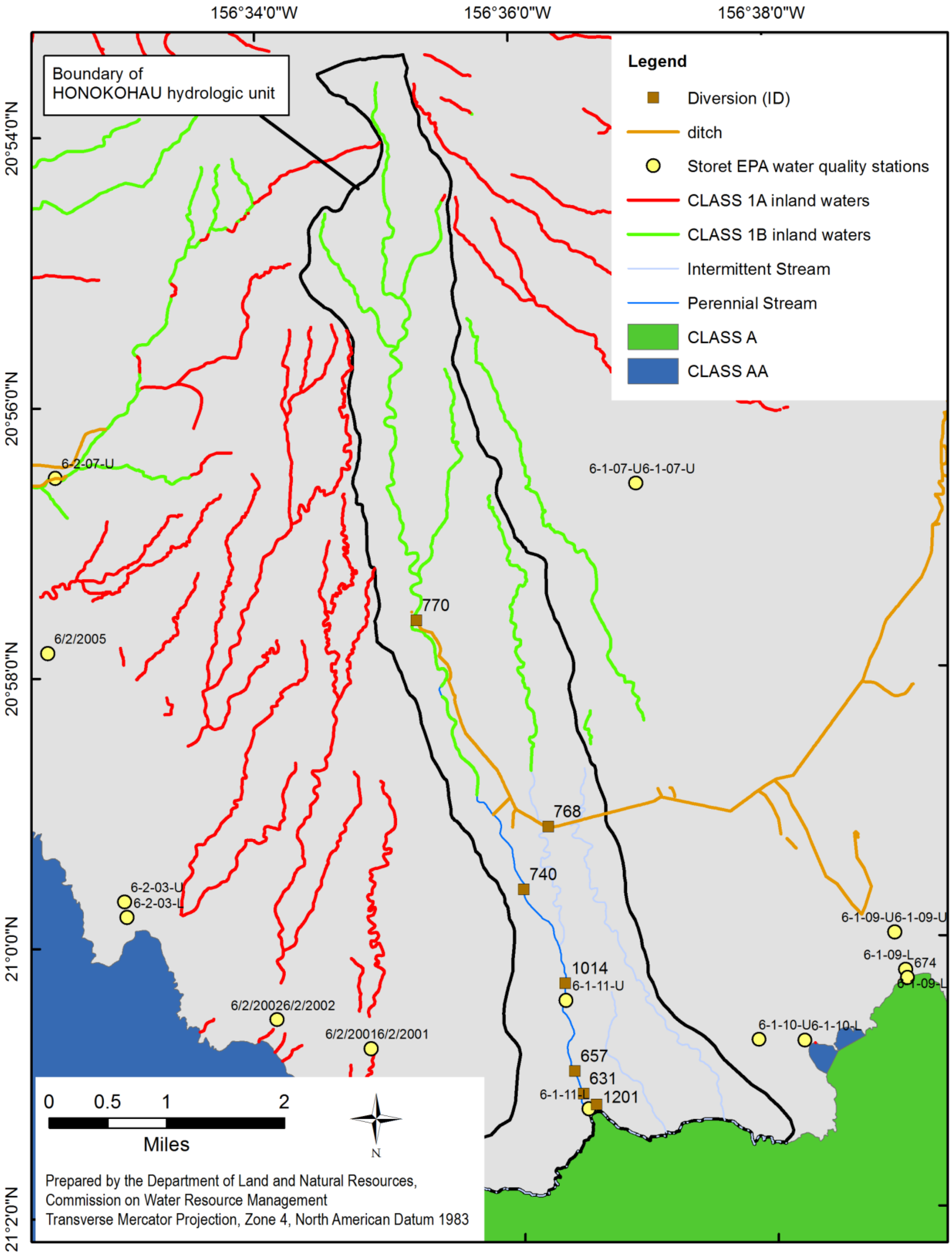
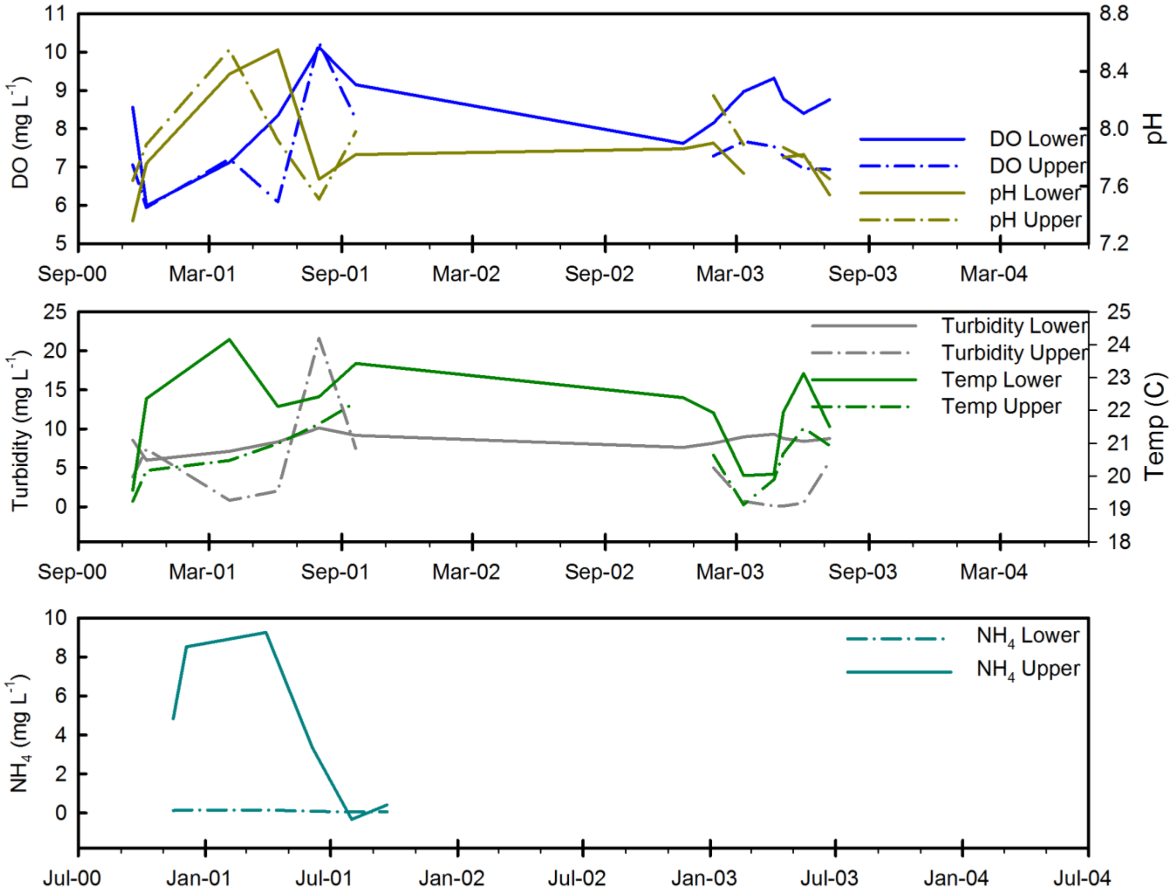


Figure 10-2. Water quality parameters measured at two locations in Honokohau Stream, Maui. (Source: USEPA STORET Database)



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 a 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 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. 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 only water system in the Honokohau hydrologic unit is the distribution system from Maui Department of Water Supply and this does not rely on the stream for the conveyance of water. Some households by use stream water for domestic purposes, and therefore, the stream would be used to conveay water to them.

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 ahupua'a 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 ahupua'a 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 section 14. 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 Honokohau is in the ahupuaa of Honokohau as shown in Figure 12-2. The ahupuaa boundaries are delineated based on the USGS Digital Line Graphs. These boundaries may be different from the information listed on legal documents such as deeds.

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, Section (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 2007 *Water Resource Protection Plan – Public Review Draft*, incorporating a later revision[1] 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.[2] 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.[3] Once established, future uses are not limited to the cultivation of traditional products approximating

[1] Although the final Water Resource Protection Plan had not been printed as of the date of this report, most edits had already been incorporated into the latest version, which the Commission utilized for this report.
[2] 54 Haw. 174, at 188; 504 .2d 1330, at 1339.
[3] 65 Haw. 531, at 554; 656 P.2d 57, at 72.

those utilized at the time of the Mahele[4], 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 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.

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 they largely relate 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).

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 Honokohau. Table 12-1 presents the results of the Commission's assessment. Of particular importance is the presence of terracing and oral testimony that indicates loi kalo existed in the middle reaches of Honokohau, below the current stream diversions (Figure 12-2). The kuleana parcels lining the entire stream channel suggest extensive cultivation of the riparian areas of Honokohau stream all the way to the ocean (Figure 12-3).

[4] *Peck v Bailey*, 8 Haw. 658, at 665 (1867).

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.

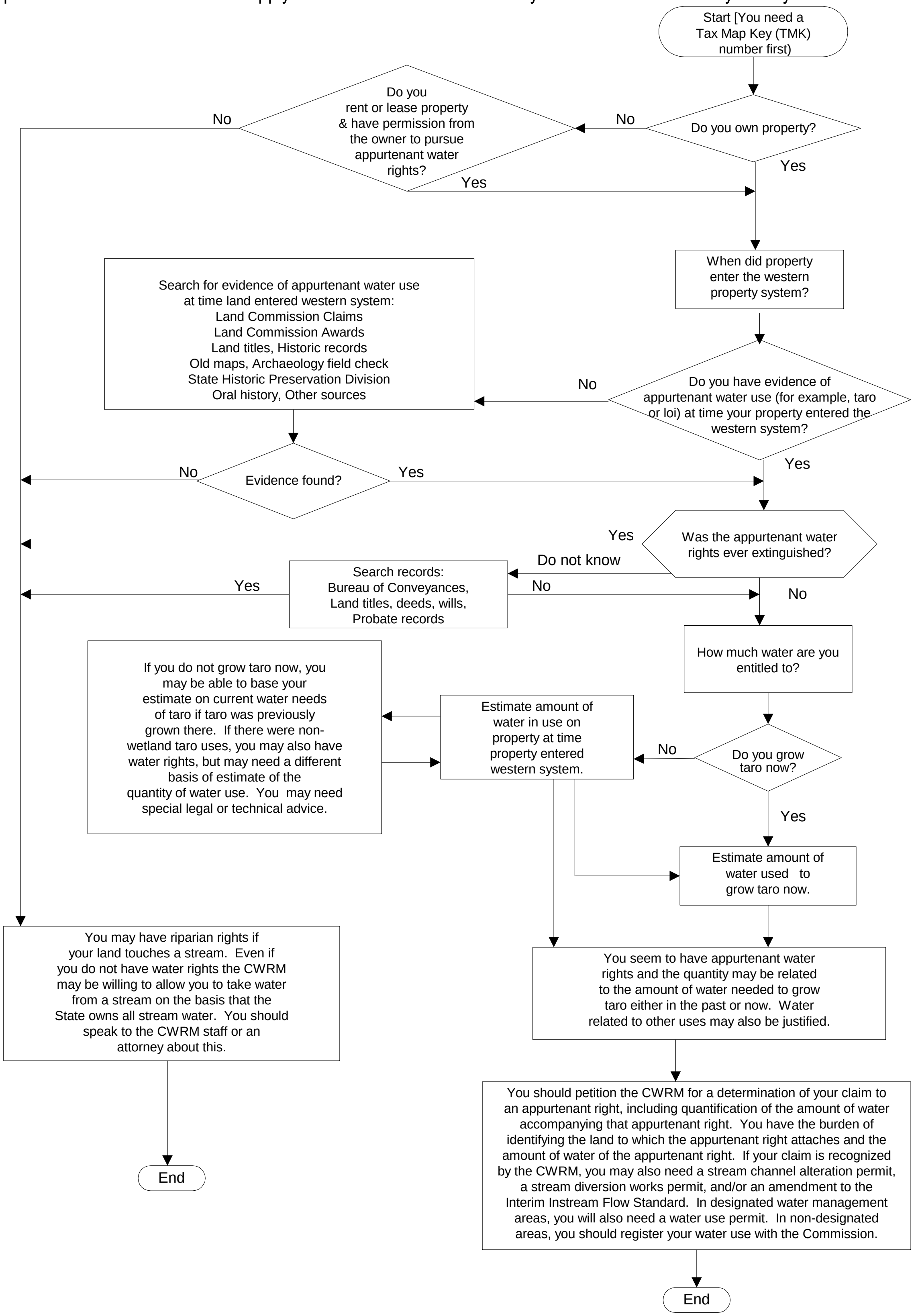


Figure 12-2. Traditional ahupuaa boundaries in the Honokohau hydrologic unit, Maui. (Source: State of Hawaii, Office of Planning, 2015j)

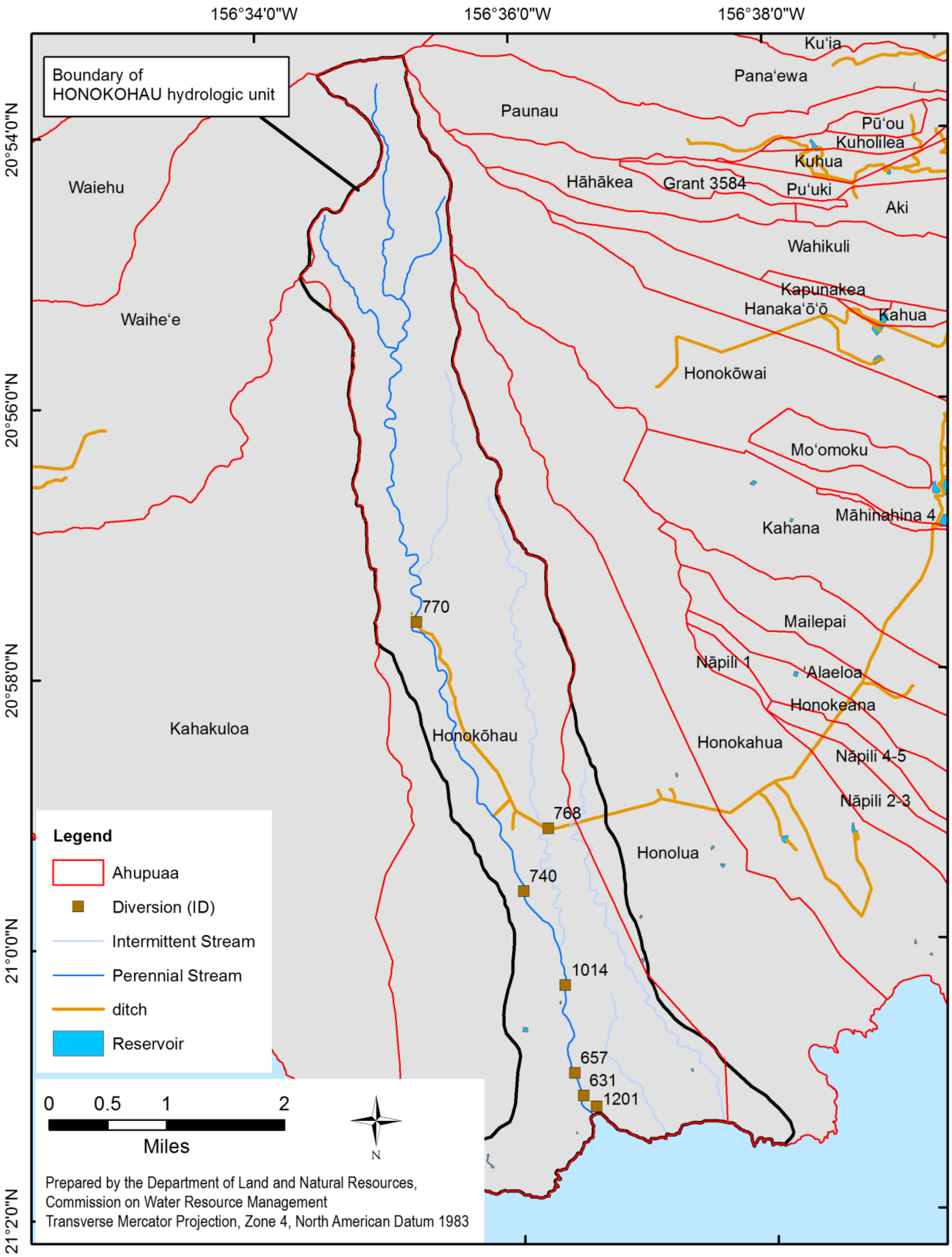


Figure 12-3. Kuleana parcels associated with the Honokohau hydrologic unit, Maui. (Source: County of Maui, 2018)

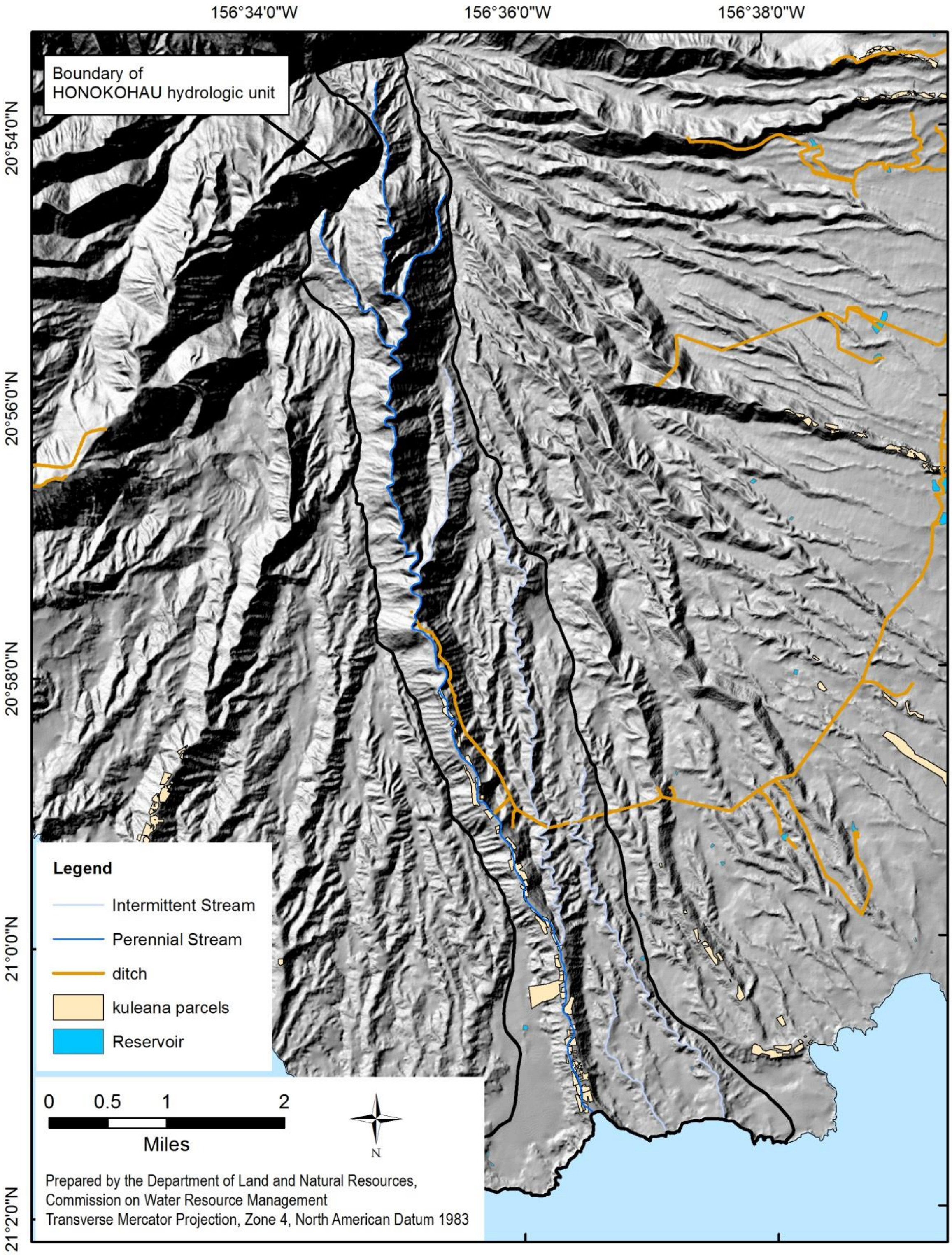


Table 12-1. Tax map key parcels with associated Land Commission Awards for the Honokohau hydrologic unit.
[LCA is Land Commission Award; Gr. is Grant; por. is portion; and G.L. is Government Lease]

Land Award	TMK	Landowner	Claimant
5610:2	241002075	Watanabe, Winston	Kalama
6145 P:2	241002002	Wong, Malia	Napuaihe
4743:1	241002001	Wilson, Kainoa	Makaukau
5768:4	241002008	GCP Maui LLC	Kalalau
6145 P:1	241002009	Sheetz, Deborah	Napuaihe
7714 B:8	241002010	Ferrari, Eugene	Kekuaiwa, Moses
5927:1	241002011	Kaai, Virginia Jean Revoc Trust	Palaualelo
6166:4	241002012	Widemann, Maile S	Paele
5826:2	241002013	Kapaku, Lorraine	Kamaka
5610:1	241002006	Wolf, Grant	Kalama
5776:1	241002076	Ross, Jessica K	Kaahanui
6139:1	241002005	Maui Land & Pineapple	Napeahi
5665:2	241002023	Arlen, Herbert L Trust	Keaweiki
P5	241002005	Maui Land & Pineapple	Poalima
5665:1	241002022	Luika Onehu Estate	Keaweiki
P5	241002025	Maui Land & Pineapple	Poalima
5760	241002024	Kauhaahaa, Henry	Kaolala
7250:1	241002024	Kauhaahaa, Henry	Malule
7250:2	241002024	Kauhaahaa, Henry	Malule
6031:1	241002014	Wong, Malia	Namakaokaia 2
5768:5	241002015	Oue, Mercy	Kalalau
6146	241002017	Chung, Shirley C Trust	Nahuina
5826:1	241002017	Chung, Shirley C Trust	Kamaka
6145 M:1	241002018	Iwashita, Susan T	Helee
7714 B:8	241002019	Maui Land & Pineapple	Poalima
7250:1	241002020	Chung, Shirley C Trust	Kaahupahao
5619:2	241002021	Vogele, Nabil Olinga	Kaahaku
6139:2	241002060	Maui Land & Pineapple	Napeahi
3925 D:3	241002059	Soto, Minne K	Hualii
6139:2	241002060	Maui Land & Pineapple	Napeahi
7250:2	241002030	Maui Land & Pineapple	Kaahupahao
5776:2	241002074	Yoshizawa, Rose Loke	Kaahanui
4698:2	241002027	Chang, Winfield AC	Laelua
5764	241002028	Flemming, Anneliese	Kamakaipooa
4698:1	241002029	Wison, Roxanne	Laelua
6166:1	241002031	Shim, Leona/Ah Puck, Hardy Trust	Paele
4743:2	241002034	Wilson, Kainoa	Makaukau
5211	241002064	Kanekoa, Janelle D A N	Pahia 1
5827	241002066	Kanekoa, Janelle D A N	Kapoi
5129	241002036	Wahinehookae, Joseph	Kimo
5927:2	241002038	Maui Land & Pineapple	Palaualelo
6145 H	241002037	Vogele, Nabil Olinga	Aua
6145 R:2	241002041	Wilson, Kainoa	Mahoe
6166:2	241002039	Wood, William Makia	Paele
6145 E:2	241002040	Masumoto, Patricia H Trust	Lopa
5776:3	241002043	Vogele, Nabil Olinga	Kaahanui
5927:4	241002045	Maui Land & Pineapple	Palaualelo
477 F	241002047	Wilson, Roxanne	Keliipio
6116:5	241002050	Kapahulehua, Russell K	Paele
5610:3	241001051	unknown	Kalama
5768:2	241002052	Wong, Sally	Kalalau
5596	241002054	Keahi Kekuhi Est	Kekuhi
5768:1	241002057	Chung, F C Trust	Kalalau
10366	241002057	Chung, F C Trust	Namakaokaia I

Table 12-1 [continued]

Land Award	TMK	Landowner	Claimant
6145 E:1	241002056	Maui Land & Pineapple	Lopa
5776:5	241002055	Vogele, Nabil Olinga	Kaahanui
6145 G:2	241002058	Watland, A J	Aiwale
6145 C	241003002	Vogele, Nabil Olinga	Pihi
6145 S	241002058	Watland, A J	Kaawe
5768:3	241003003	Shim, Michael H L	Kalalau
7390 S	241003004	Vogele, Nabil Olinga	Hanemo
6145 D	241003005	Guth, Patrick	Leonui
75 B	241001016	Taylor, John	Chockett, Charles
6145 M:2	241003007	Vogele, Nabil Olinga	Helee
6138:1	241003008	Trecker, Barbara	Nohokauai
4744:1	241003009	Maui Land & Pineapple	Mailou
7383 B	241003010	Vogele, Nabil Olinga	Aina
7383	241003012	Pali, Howard	Paniani
6145 U:2	241003013	Willard, John D	Kenui
5619:1	241003015	Wong, Gordon	Kaahaku
7391:2	241003016	Maui Land & Pineapple	Paaoao
4744:3	241003031	Maui Land & Pineapple	Mailou
4704:1	241003019	Vogele, Nabil Olinga	Makapo
5618	241003030	Thrope, Yvonne Ivy K	Kuanoni
7391:3	241003020	Wahinehookae, Margaret	Paaoao
5593	241003032	Napolean, Johnette K	Kapule
1081	241003023	Vogele, Nabil Olinga	Pahiaua 2nd
P5	241003022	Maui Land & Pineapple	Poalima
7391:1	241003024	Maui Land & Pineapple	Paaoao
7392:2	241003025	Wahinehookae, Margaret	Wailiilii
7392:1	241003028	Maui Land & Pineapple	Wailiilii
7389:1	241003029	Vogele, Nabil Olinga	Keuwiwi
7387:2	241004025	Vogele, Nabil Olinga	Kekalo
4704:2	241004001	Vogele, Nabil Olinga	Makapo
7387:1	241004002	Vogele, Nabil Olinga	Kekalo
4704:4	241004003	Vogele, Nabil Olinga	Makapo
6145 I	241004005	Maui Land & Pineapple	Kamakaluku
7381	241004007	Wahinehookae, Margaret	Kaaoao
6604	241004008	Greene, Boe Alan	Lapauli
5921:1	241004009	Vogele, Nabil Olinga	Puohala
4704:3	241004026	Vogele, Nabil Olinga	Makapo
5921:2	241004011	Vogele, Nabil Olinga	Puohala
5619:3	241004011	Vogele, Nabil Olinga	Kaahaku
5927:3	241004012	Maui Land & Pineapple	Palaualelo
7386	241004013	Vogele, Nabil Olinga	I
6145 B	241004015	Vogele, Nabil Olinga	Kalaukaula
6145 N:1	241004019	Maui Land & Pineapple	Napauna
7385:2	241001009	Maui Land & Pineapple	Kalahoouka
7389:2	241001009	Maui Land & Pineapple	Keuwiwi
5920	241004021	Maui Land & Pineapple	Pahiaua 1
7385:3	241004022	Yoshizawa, Rose Loke	Kalahoouka
6145 T:1	241004023	Maui Land & Pineapple	Pakali
6145 T:2	241004024	Maui Land & Pineapple	Pakali
5610:4	241005002	Wilson, Roxanne	Kalama
6031:2	241005003	Maui Land & Pineapple	Namakaokaia 2
4550	241005004	Thrope, Yvonne Ivy K	Kailimelemele
7385:1	241005005	Yoshizawa, Rose Loke	Kalahoouka
6145 G:1	241005006	Vogele, Nabil Olinga	Aiwale

Table 12-1 [continued]

Land Award	TMK	Landowner	Claimant
4550	241005007	Thrope, Yvonne Ivy K	Kailimelemele
5777	241005010	Maui Land & Pineapple	Kupali
7472:1	241005011	Aloy, Napua K K	Kaumauma
7473	241005012	Wilson, Roxanne	Hohia
6145 U:1	241005013	Werner, Rebecca K K	Kenui
5776:4	241005014	Chun Ah Sing Tr	Kaahanui
7474	241005015	Kapahulehua, Russell	Kamokuikai
P5	241005016	Maui Land & Pineapple	Poalima
7472:2	241005015	Kapahulehua, Russell	Kaumauma

Taro Production

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.

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 2007 USGS 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 12-4 below. 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."

The study results are presented in Table 12-5 (discharge measurements) and Table 12-6 (water-temperature statistics).

Table 12-2. Summary of water use calculated from loi and loi complexes by island, and the entire state. (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

Historical uses can also provide some insight into the protection of traditional and customary Hawaiian rights. Handy and Handy in *Native Planters of Old Hawaii* (1972), provide a limited regional description as follows:

> The first four [Honokawai, Kahana, Honokahua, Honolua] all had extensive *lo'i* lands in their valley bottoms, where terraces rose tier on tier in symmetrical stone-faced *lo'i*. On this part of the coast there is no sloping *kula* land seaward of the valleys as there is back of Lahaina and southeastward. Honokohau in particular, which is watered by a large rivulet flowing from far back in the moutains, had the most extensive system of *lo'i* along this coast. In 1931 a greater proportion of *lo'i* were still planted here than anywhere else on this side of Maui, but by 1934 commerical planting and exhaustion of the soil had brought in root-rot, and some of the large *lo'i* were abandoned, and some were planted in rice. [p. 494]

Without delving into the extensive archive of literature (refer to Kumu Pono Associates, 2007a; 2007b), streamflow in the Lahaina District was used extensively for the cultivation of taro and other agricultural crops by Hawaiian communities. Kumu Pono Associates (2007a) provided some context:

> The natural stream alignments were modified and extended in ancient times, with large and small *'auwai* (irrigation channels) constructed to feed thousands of *lo'i kalo* (taro pond fields) in which the primary food crop of the Lahaina region residents was grown…
>
> By the 1850s…To develop the sugar plantations…water began to be diverted from *lo'i kalo* to sugar fields…and by the 1860s…diminishing supplies of water were impacting native residency. Indeed, it was reported that in areas where water once flowed, none could then be found.

Table 12-3. 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]

				Temperature (ºC)			
Geographic designation	Area	Station	Period of record	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

Individual cultural resources of Honokohau hydrologic unit were not classified by the Hawaii Stream Assessment (HSA), but generally classified based on the Historic Preservation Division database. 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). The Honokohau hydrologic unit has archeological evidence addressing broad patterns in prehistory, with culturally significant sites including burials, religious structures, and trails. The terracing and auwai system that supported loi kalo along Honokohau stream are still evident along most of the lower to middle elevation reaches. The location of the *poowai* (traditional diversion from the stream) and *auwai* along the stream channel also provides some support for the distribution of active loi in the valley (Figure 12-4).

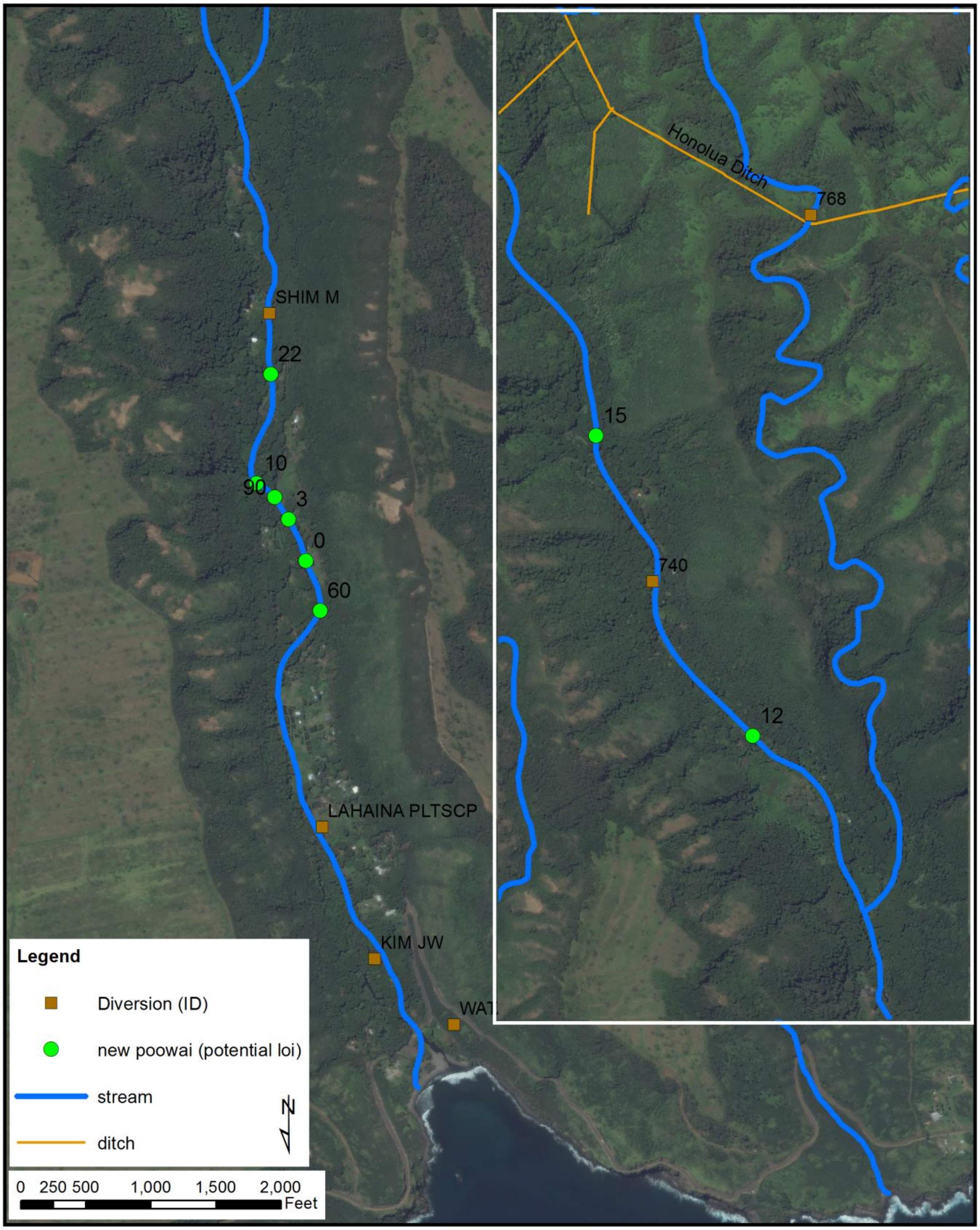
Archaeological Evidence for Hawaiian Agriculture

In the lowest elevations of the Honokohau hydrological unit, there are many identified archaeological sites, with features that include heiau, terracing, platforms, pits, grinding stones, skeletal remains, mounds, middens, and walls consistent with irrigated agricultural complexes and cultural practices (Table 12-4).

Table 12-4. Archaeological sites in the Honokohau hydrologic unit. (Source: Kipuka Database, 2019)

Historic Site #	State Site #	SHPD Library	LCA	Description
00019	50-50-01-00019	M-00055	7714 B:8	Terraced structure; walled structure; supporting structures; potential animal pen

Figure 12-4. Historic poowai locations and number of loi associated with them in the Honokohau hydrologic unit, Maui (Source: CWRM Fieldwork, 2017)



Fishponds

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 ocurring 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 Honokohau hydrologic unit (DHM, Inc., 1990).

Table 12-5. Cultural resource elements evaluated as part of the Hawaii Stream Assessment for Honokohau 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.	High
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 were 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.	ACDE

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.	Scattered clusters of sites
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.	n/a
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.	High
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.	No
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.	Yes

13.0 Public Trust Uses of Water

The State Water Code (Hawaii Revised Statutes 174C-2) states that:

> The state water code shall be liberally interpreted to obtain maximum beneficial use of the waters of the State for purposes such as domestic uses, aquaculture uses, irrigation and other agricultural uses, power development, and commercial and industrial uses. However, adequate provision shall be made for the protection of traditional and customary Hawaiian rights, the protection and procreation of fish and wildlife, the maintenance of proper ecological balance and scenic beauty, and the preservation and enhancement of waters of the State for municipal uses, public recreation, public water supply, agriculture, and navigation.

Article 11, Section 1 of the Hawaii State Constitution maintains that the:

> State and its political subdivisions shall conserve and protect Hawaii's natural beauty and all natural resources, including land, water, air, minerals, and energy sources, and shall promote the development and utilization of these resources in a manner consistent with their conservation and in furtherance of the self-sufficiency of the State. All public natural resources are held in trust by the State for the benefit of the people.

This solidified the Public Trust Doctrine as constitutional law. Further, Article 11, Section 7, states that the "State has an obligation to protect, control, and regulate the use of Hawaii's water resources for the benefit of its people." The Public Trust Doctrine now identifies four priority uses of water as: (1) water for traditional and customary practices, including the growing of taro; (2) reservations of water for Hawaiian Home Land allotments; (3) water for domestic use of the general public; (4) maintenance of waters in its natural state.

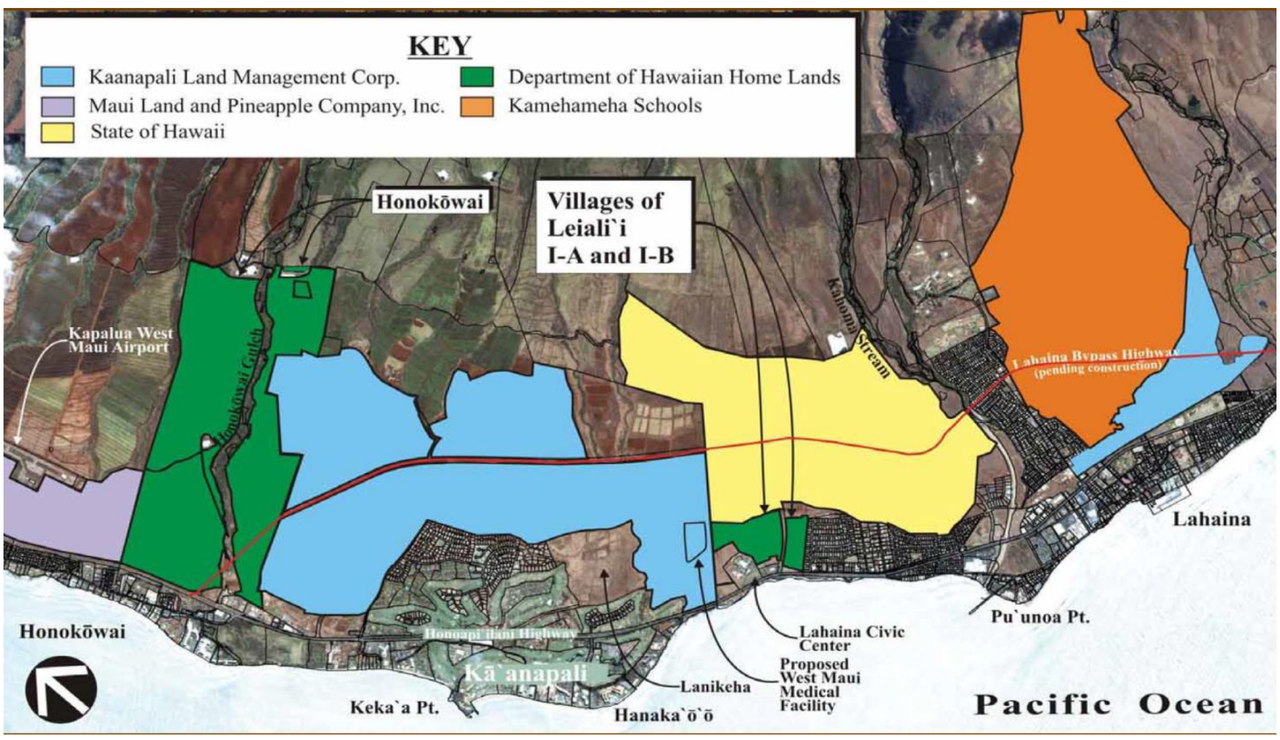
In the Honokohau hydrologic unit, the use of water for traditional and customary practices was covered in Chapter 12 and water in its natural state is covered in Chapters 3-7. The following is an analysis of reservations of water for Hawaiian Home Lands and domestic water use in and nearby Honokohau.

Hawaiian Home Lands

A component in the assessment of water use includes an analysis of the presence of Department of Hawaiian Home Lands (DHHL) parcels within or near 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 June 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, there are 850 acres in West Maui as part of the 2009 DHHL West Maui Regional Plan. DHHL now manages two large tracks of land in West Maui that may be served by nearby water resources. The Leialii tract (1-A and 1-B) encompass approximately 75 acres designated for residential development north of Lahaina. By 2031 the estimated potable water demand by DHHL for the Lahaina Aquifer Sector is 0.770 mgd. DHHL developed a potable water well mauka of the Honokowai tract that will support the Maui Department of Water Supply Lahaina-Napili Water System. The DHHL ground water reservation for Honokowai is 0.770 mgd. Land in Kahoma originally slated for development by the State of Hawaii Housing and Finance Development Corporation (Leialii Village I-A and I-B) was transferred to DHHL in 2004. The first development (Village I-A) was completed and beneficiaries began occupying homes in April 2007. The second development (Village I-B) was expected to begin construction in 2015. DHHL does not own any land in Honokohau. However, water from Honokohau Stream could be diverted by Honokohau Ditch to support non-potable or potable water needs for DHHL.

The Honokowai track consists of 777 acres for housing on former sugar cane and pineapple fields mauka of the Honoapiilani Highway in Kaanapali, south of the West Maui airport (Figure 13-1). This land was designated for mixed development, with residential, community, supplemental agricultural, general agriculture, commercial and industrial uses. This development was planned before the Leialii tract was designated. As such, there is some uncertainty as to the future development plans with the Leialii tract development getting prioritized over the Honokowai tract. The non-potable water demand for Honokowai based on the West Maui Regional Plan is 2.081 mgd (State of Hawaii, Department of Hawaiian Home Lands, 2017), although this was based on a generic agricultural irrigation demand of 3,400 gallons per acre per day (gad). Given the actual soil, evapotranspiration, and rainfall in Honokowai, the CWRM estimates the irrigation demand for most crops as 4,900 gad, resulting in an estimated non-potable demand of 3.8 mgd. Non-potable water demand for irrigation of supplemental agriculture and general agriculture land use may be met with R-1 recycled water available from the Lahaina Wastewater Treatment Facility (WWTF) and/or water from Honokohau Ditch. The Lahaina WWTF is already connected by a 20-inch line to the Maui Land & Pineapple reservoir at the 300 ft elevation and the Lower Field 14 Reservoir at the 750 ft elevation. However, high chloride content precludes direct use of R1 water, requiring it to be blended with another source.

Figure 13-1. Hawaiian Home Lands development parcels and other major land owners, West Maui. (Source: State of Hawaii, Department of Hawaiian Home Lands, 2011)



Domestic Water Supply

Maui County Department of Water Supply (DWS) operates a surface water treatment facility in Kaanapali that utilizes water diverted from Honokohau Valley via Honokohau Ditch. This ditch once serviced pineapple and sugarcane lands throughout the Kapalua, Kaanapali, and Honokowai regions. Surface water is processed at the Mahinahina Surface Water Treatment Facility from Honokohau Ditch for this system. Other Maui DWS wells include the Napili Wells A, B, and C, and Honokohau Well A which are distributed throughout the Maui County Lahaina-Napili system service area and also contribute to the system (Figure 13-2). The Lahaina-Napili water system service area supports much of the single-family connections in the region (Table 13-1).

Table 13-1. Current total and domestic (single family) water use by subdistrict for the Lahaina-Napili service area provided by the Maui County Department of Water Supply. (Source: Maui County, 2018)

subdistrict	Total Use (gpd)	Total Use (mgd)	Single Family Use (gpd)	Single Family % of Total
Lahaina	2,355,746	2.356	435,098	18.5%
Honokowai	2,022,400	2.022	179,658	8.8%
Alaeloa	1,007,878	1.008	417,639	41.4%
Honokohau	2,378	0.002	2,378	100%
Total	5,388,402	5.388	1,034,773	19.2%

Figure 13-2. Water supply service systems for the Lahaina Aquifer Sector, Maui. (Source: Maui County, 2018)

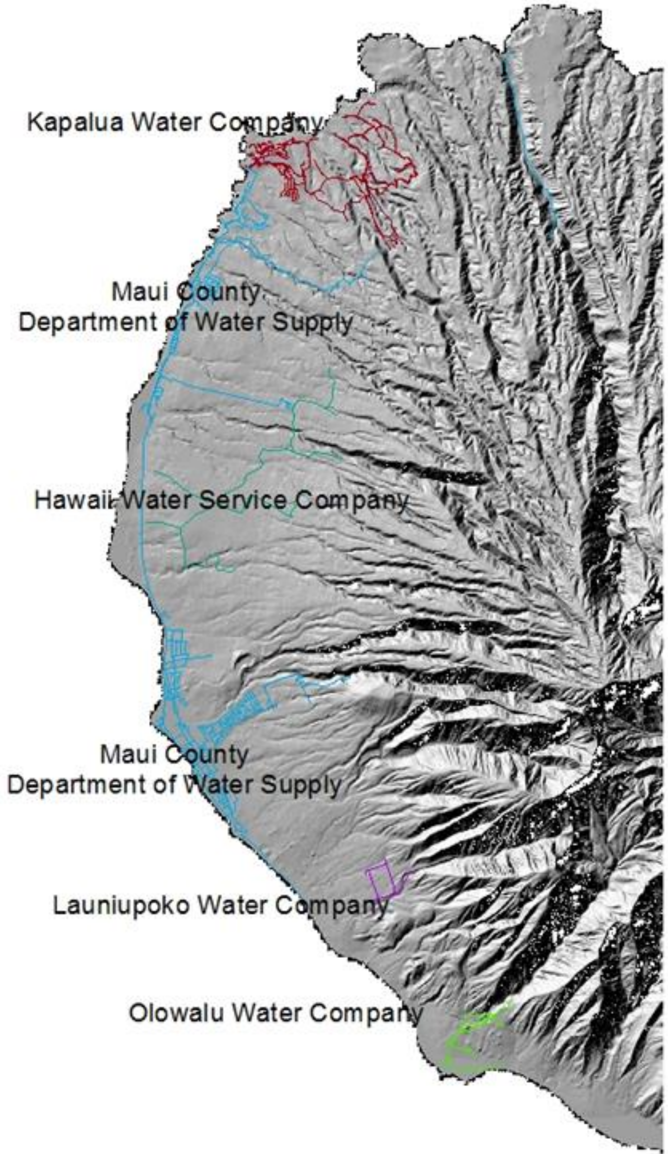
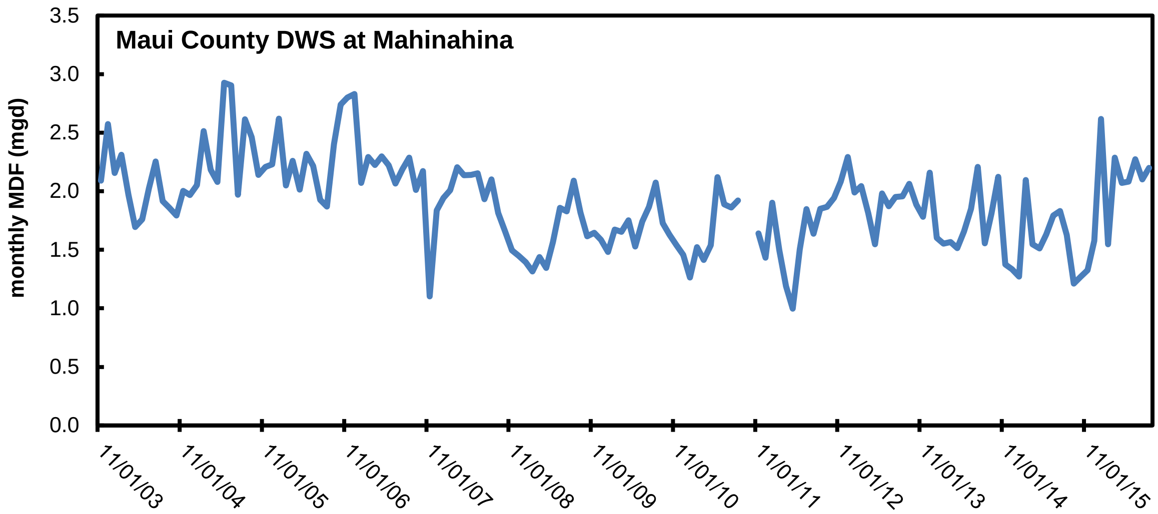


Table 13-2. Maui County DWS Lahaina-Napili water system sources, current (2018) 12-month moving average (MAV), and maximum capacity. [million gallons per day, mgd]

Source	Hydrologic Unit	12-month MAV (mgd)	Maximum Capacity (mgd)	Notes
Lahaina WTF	Kahoma	1.706	2.1	
Māhinahina WTF	Honokōwai	1.744	3.0	
Waipuka 1	Kahoma	0.000	0.324	
Waipuka 2	Kahoma	0.095	0.360	
Kanahā Well 1	Kahoma	0.059	0.360	
Kanahā Well 2	Kahoma	0.044	0.360	
DHHL Honokōwai	Honokōwai	0.000		Developed by DHHL for potable needs on DHHL homesteads

Māhinahina	Honokōwai	---	---	Well drilled in 2011 but deemed unsuccessful; not usable
Kahana	Honolua	---	---	Still in development; no pump, electricity, pipe lines or tanks
Nāpili A	Honolua	0.225	1.000	
Nāpili B	Honolua	0.575	1.008	
Nāpili C	Honolua	0.874	1.430	
Honokahua A	Honolua	0.000	0.710	
Honokahua B	Honolua	0.396	1.008	

Figure 13-3. Mean daily flow at monthly intervals for water used by Maui DWS from Honokohau Ditch at the Mahinahina Water Treatment Facility. (Source: Maui Land & Pineapple)



Kapalua Water Company operates a private potable (wells) and non-potable (surface water) distribution system. The private municipal water system services the domestic and resort needs of the Kapalua area.

Table 13-3. Kapalua Water Company potable water system sources, current (2018) 12-month moving average (MAV), and maximum capacity. [million gallons per day, mgd)

name	source	12-month MAV (mgd)	Maximum Capacity (mgd)	Notes
Kapalua 1	Well	0.257	1.152	
Kapalua 2	Well	0.258	1.152	
Kapalua 3B	Well	0.000	--	Not currently in use

14.0 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. The Hawaii Farm Bureau Federation, Hawaii's largest advocacy organization for general agriculture, states that agriculture is a public trust entity worthy of protection, as demonstrated in its inclusion in the State Constitution. They, on behalf of farmers and ranchers, point to the importance of large-scale agriculture to sustainability and self-sufficiency of our islands, particularly in times of catastrophe when imports are cut off.

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.

Water Leaving the Honokohau Hydrologic Unit in Ditch Systems

Water is most often used away from the stream channel and is not returned; however, as in the case of taro fields, water may be returned to the stream at some point downstream of its use. While the return of surface 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. The Honokohau Ditch was designed to remove water from the Honokohau Stream without returning it to any of the streams in order to supply irrigation water for pineapple and sugarcane land (Figure 14-1). Historic ditch flows varied from 20-60 mgd, however, since 2003, the mean flow in the ditch has been 15.3 mgd (Figure 14-2). Starting in 2005, MLP began releasing approximately 0.3-2.3 mgd through the sluice gate at Aotaki Weir to support aquatic ecosystems.

Figure 14-1. General schematic of the **H**onolua/Honokohau Ditch, diversion, and distribution system as designed by Maui Pineapple Company for irrigation.

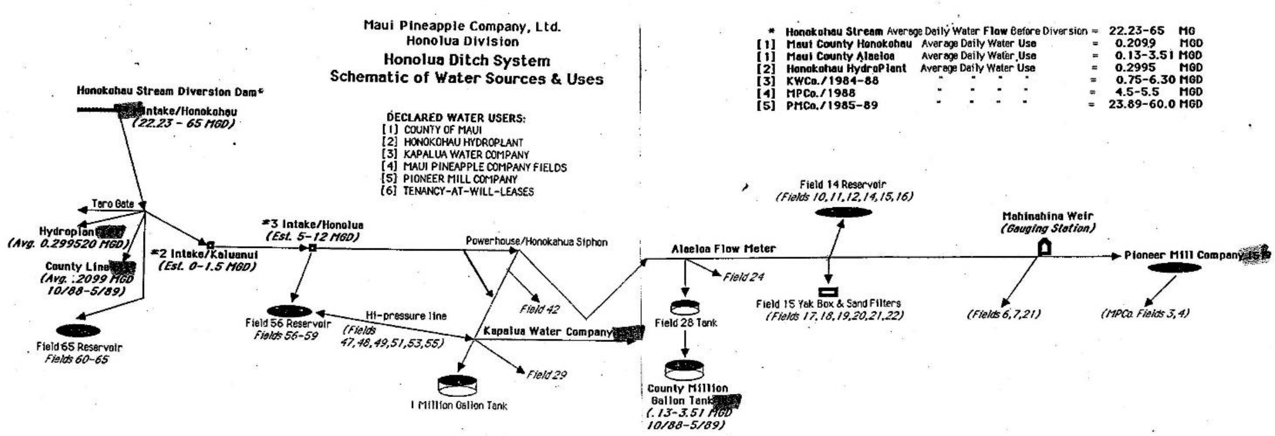
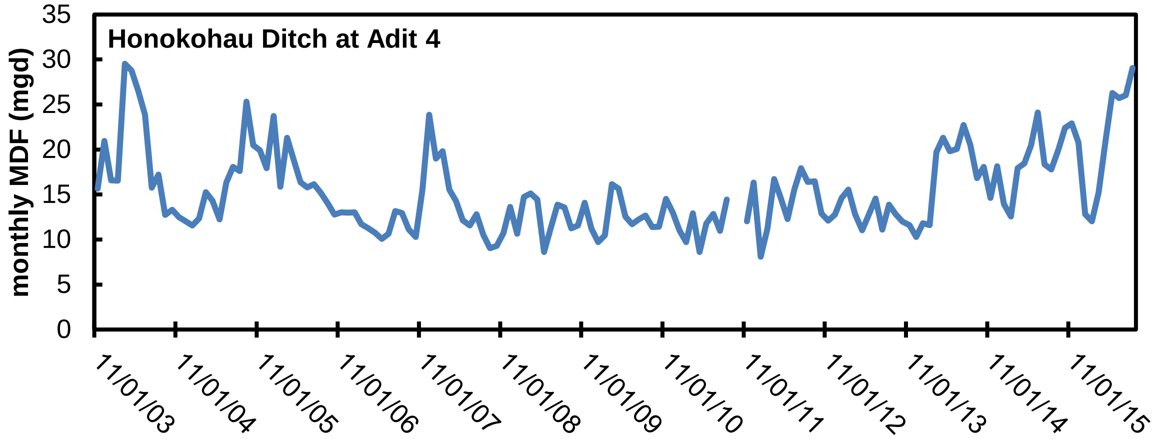
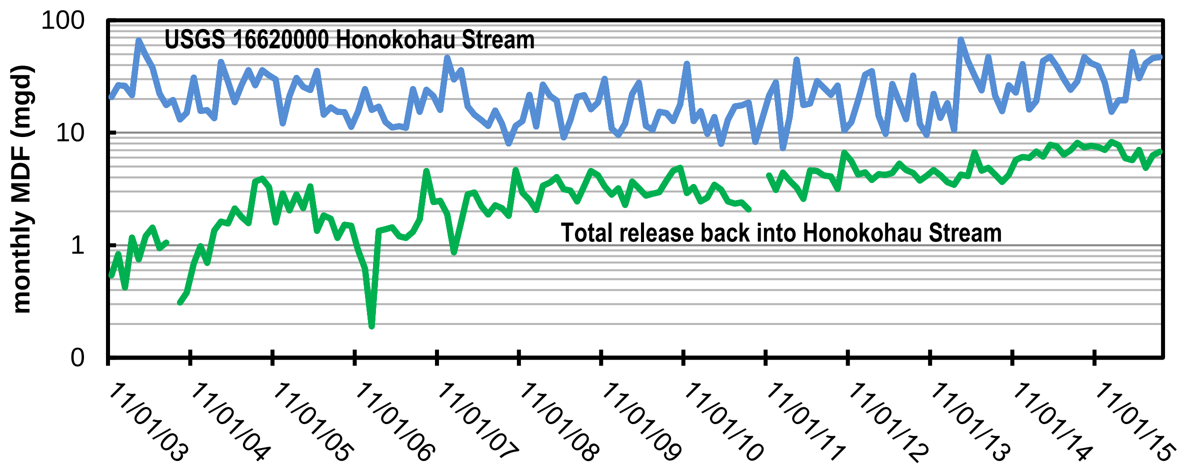


Figure 14-2. Monthly mean daily flow (MDF) diverted from Honokohau Stream. (Source: Maui Land & Pineapple)



Additionally, water has been released at "Taro Gate", a construction adit from the Honokohau Tunnel, back into the stream at the 500 ft elevation. The combined flow releases back into the stream are depicted over time relative to the monthly mean flow of water at USGS 1662000 in Figure 14-3. The monthly mean daily flow returned to the stream since 2003 has been 3.38 mgd.

Figure 14-3. Monthly mean daily flow at USGS 1662000 Honokohau Stream and total release of water from Honokohau Ditch back into Honokohau Stream. (Source: Maui Land & Pineapple)



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 in different ways. 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 it be 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.

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 (FILEREF) remains the name of the original registrant file (Table 14-2) with locations are depicted in Figure 14-4. CWRM staff has monitored stream flow at the mouth (CWRM gage ID 6-156). Historic off-stream water use statistics for water diverted from Honokohau Stream by Honokohau Ditch are provided in Table 14-1 with locations identified in Figure 14-5. Data collected by Commission staff site visits, and information extracted from the original registration files regarding the registered diversions may be found in Table 14-2.

Table 14-1. Selected off-stream water use statistics for water diverted by the Honokohau Ditch. (Source: Maui Land & Pineapple) [KLC = Kapalua Land Company; KWC = Kapalua Water Company]

location	Water Use Gage	Period of record	mean daily flow (mgd)	median flow (mgd)	maximum flow (mgd)	minimum flow (mgd)
Kapalua Golf Course	188	2003-2016	0.94	0.89	2.38	0.00
KLC landcape irrigation	189	2003-2016	0.94	0.94	2.01	0.00
Plantation Estates Meters	146	2003-2016	0.81	0.46	3.35	0.00
KLC diversified agriculture	41	2009-2014	0.30	0.25	1.24	0.01
Troon Golf	40	2009-2014	0.95	0.95	1.61	0.22
Maui Co DWS pre-processing	42	2003-2014	1.68	1.70	2.21	1.00

Since the enactment of HAR Title 13 Chapter 168, stream diversion works permits are required for the construction of new diversions or alteration of existing diversions, with the exception of routine maintenance. These permitted (as opposed to "registered") diversion works are not part of the Commission's verification effort, nor have any diversions been permitted in the Honokohau hydrologic unit.

Current Non-instream Uses of Honokohau Stream Water in Kapalua

The active plantation diversions on Honokōhau and Honolua were originally built to irrigate pineapple and sugarcane for MLP and Pioneer Mill, respectively. In their registration, MLP stated that KLC used 3.3 mgd for the irrigation of 600 acres of golf course (5,500 gallons per acre per day; gad), which, at that time, included three golf courses. Although one golf course was closed, MLP opened a golf academy using some of the available acreage. In the same registration, KWC used 1.0 mgd for the irrigation of 220 acres of resort landscaping (4545 gad).

There is almost no agriculture being practiced in the service area of the Honokohau Ditch. Surface water may be used for small diversified agriculture (essentially domestic use) on small riparian parcels in Honokohau Valley, but only a small amount of water diverted into the Honokohau Ditch is used for agriculture on Maui Land & Pineapple leased lands. Landscape irrigation of luxury homes in the Kapalua region utilizes surface water provided by Kapalua Water Company. Metered use reported by MLP indicates approximately 1.0 mgd is used for resort and luxury home irrigation, approximately, approximately 0.8 mgd is used for golf course and related irrigation, and 0.2 mgd is used for diversified agriculture or other needs (Table 14-3). Non-potable water needs of the Kapalua area are currently met by water diverted only from Honokōhau Stream (Figure 14-6).

Table 14-2 Registered diversions in the Honokohau hydrologic unit, Maui.
[Source of photos are denoted at the end of each description; CWRM, Commission on Water Resource Management;Chevrons ( ) indicate general direction of natural water flow to and out of diversions; Arrows ( ) indicate direction of diverted surface water flow]

Event ID	File Reference	Tax Map Key	Diversion Amount (cfs)	Active (Yes/No)	Verified (Yes/No)	Riparian (Yes/No)	Rights Claim (Yes/No)
REG.770	MAUI LAND&PINE		n/a	Yes	Yes	Yes	No

Photos. a) Diversion 770 from left bank; b) Diversion 770 across channel; c) Intake on diversion 770 from right bank; d) Diversion 770 and intake with sluice from right bank; e) Upstream view of Honokohau Stream from diversion 770 f) New channel east of main channel around diversion 770 post Hurricane Lane.

a)

b)

c)

d)

e)

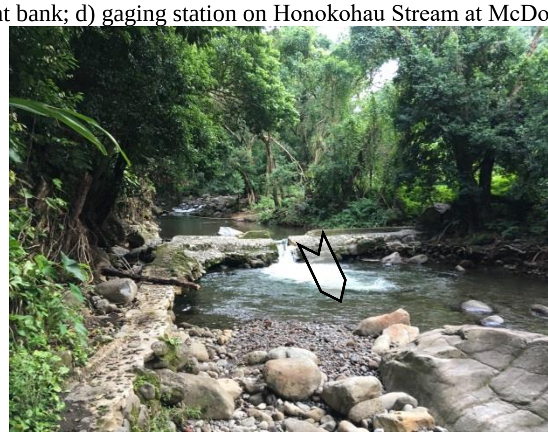
f)


Table 14-2. Continued. Registered diversions in the Honolua hydrologic unit, Maui.

Event ID	File Reference	Tax Map Key	Diversion Amount (cfs)	Active (Yes/No)	Verified (Yes/No)	Riparian (Yes/No)	Rights Claim (Yes/No)
REG.740	MCDONALD J		n/a	No	Yes	Yes	No

Photos. a) Upstream view of diversion 740 from right bank; b) downstream view from diversion 769; c) Diversion 740 from right bank; d) gaging station on Honokohau Stream at McDonald's Dam

a)



b)

c)

d)

Table 14-2. (continued). Registered diversions in the Honokohau hydrologic unit, Maui.

Event ID	File Reference	Tax Map Key	Diversion Amount (cfs)	Active (Yes/No)	Verified (Yes/No)	Riparian (Yes/No)	Rights Claim (Yes/No)
REG.1014	SHIM M		n/a	No	No	Yes	Yes
Water diverted via 2-inch pipe for irrigation of flowers and fruit trees on 1.6 acres of property							
No photos available							
REG.657	LAHAINA PLTSCP	4-1-002:021	n/a	Yes	No	Yes	Yes
Pump from stream via ¾ inch submersible pump to pump up to 3,000 gallons per day in order to irrigate vegetables and nursery on 0.39 acres of land. Stream used for gathering prawns and for recreation. Second property has 0.38 acres and up to 5,000 gallons per day of water demand.							
No photos available							
REG.631	KIM JW	4-1-002:002,14, & 16	n/a	Yes	Yes	Yes	Yes
Pump from stream via 5 HP motor and 2-inch pipe to irrigate 0.5 acres of dryland taro and flowers. Stream used for fishing, gathering and swimming							
No photos available							
REG.1201	WATANABE WT	4-1-002:003 & 75	n/a	Yes	Yes	Yes	No
Pump from stream via 3 HP motor into a 2,500 gallon tank used to irrigation 1.07 acres of fruit trees, vegetables, and landscape							
REG.768	MAUI LAND & PINE	4-1-001:009					
Intake #2 Honokohau Ditch; Kaluanui Stream; Not maintained, silted in							

Table 14-3. Current and future actual and estimated non-potable water use for various entities in the Kapalua-Napili region including golf courses (GC), resorts, luxury homes, Maui County Department of Water Supply (MDWS), and Department of Hawaiian Home Lands (DHHL). (Source: Maui Land and Pineapple, 2019)
[mgd = million gallons per day; gallons per acre per day, gad]

Water Use	2017 actual use (mgd)	2018 actual use (mgd)	2019 estimated use (mgd)	future estimated need (mgd)
Irrigation for Kapalua Resorts, common areas, luxury home landscaping	0.909	0.782	0.988	0.892
Irrigation for Plantation GC, Bay GC, Golf Academy	0.912	0.515	0.817	0.748
Other: Diversified Agriculture, Napili Gardens, Mailepai Cemetery, other homes	0.248	0.110	0.056	0.138
Future Planned Uses: Pulelehua, Wailele Ridge, Mahana Estates, Kapalua Mauka				3.64
MDWS Domestic/Municipal	1.74	1.78	2.50	2.28
DHHL Diversified Agriculture	--	--	--	2.10
Total	3.81	3.19	4.32	9.80

Figure 14-4. All registered diversions (ID) and ditches identified in the Honokohau hydrologic unit, Maui. (Source: State of Hawaii, Office of Planning, 2004d; State of Hawaii, Commission on Water Resource Management, 2015g)

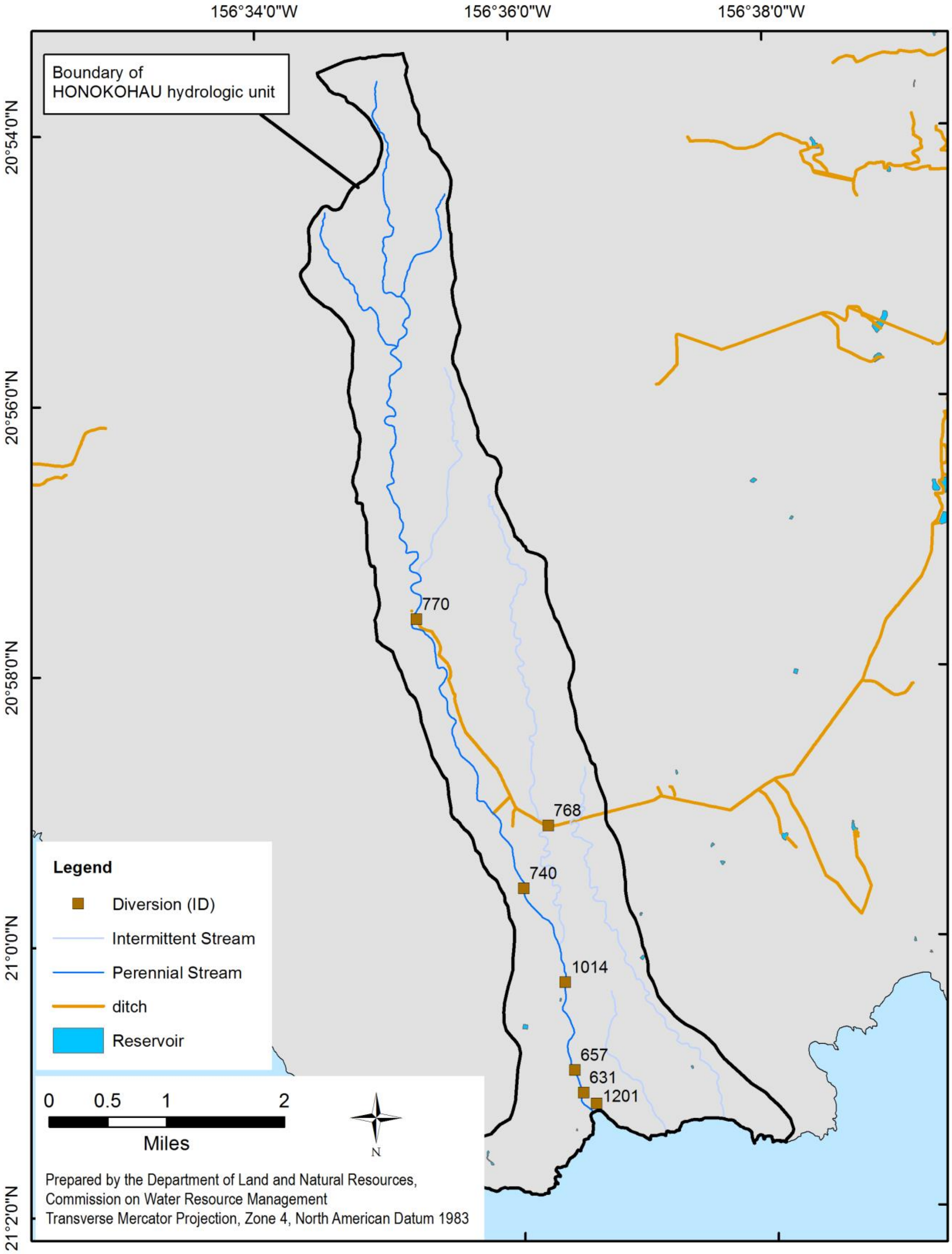
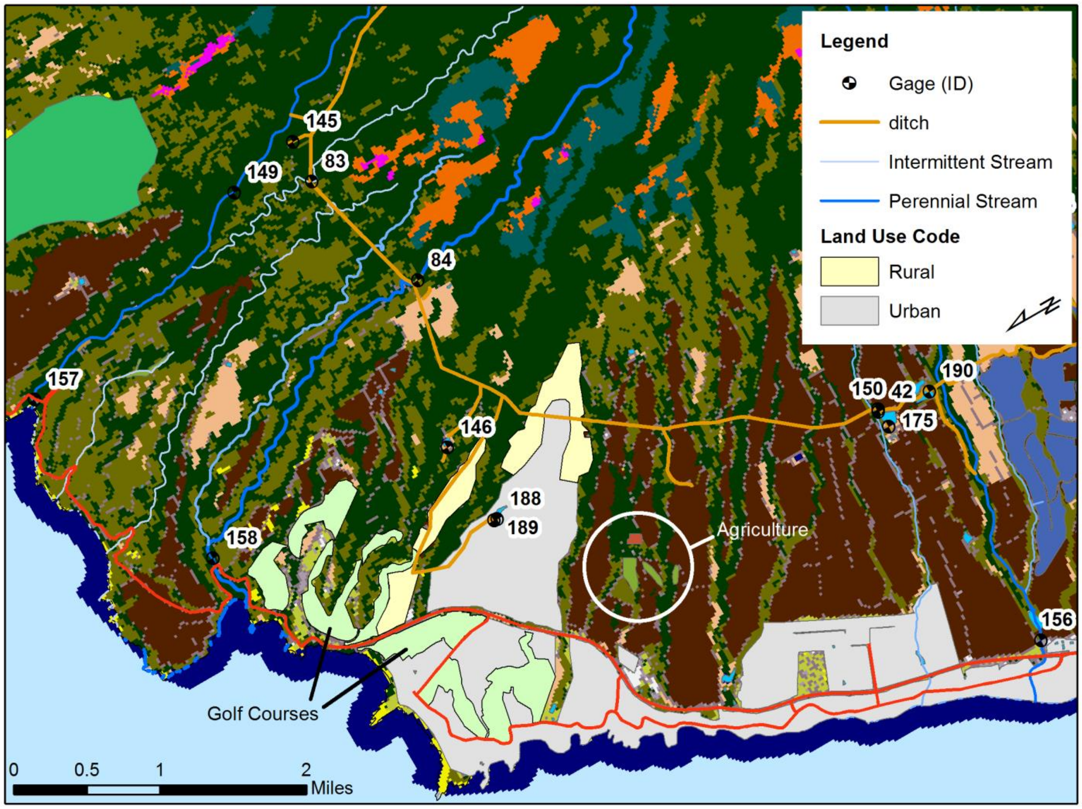


Figure 14-5. Off-stream water use gage locations, golf courses, and current (2015) agriculture utilizing water from Honokohau Ditch. Urban and rural land use zones included for reference. (Source: Office of Planning 2015d, 2015k, 2018o)



Modifications of Ditch Systems and Groundwater Recharge

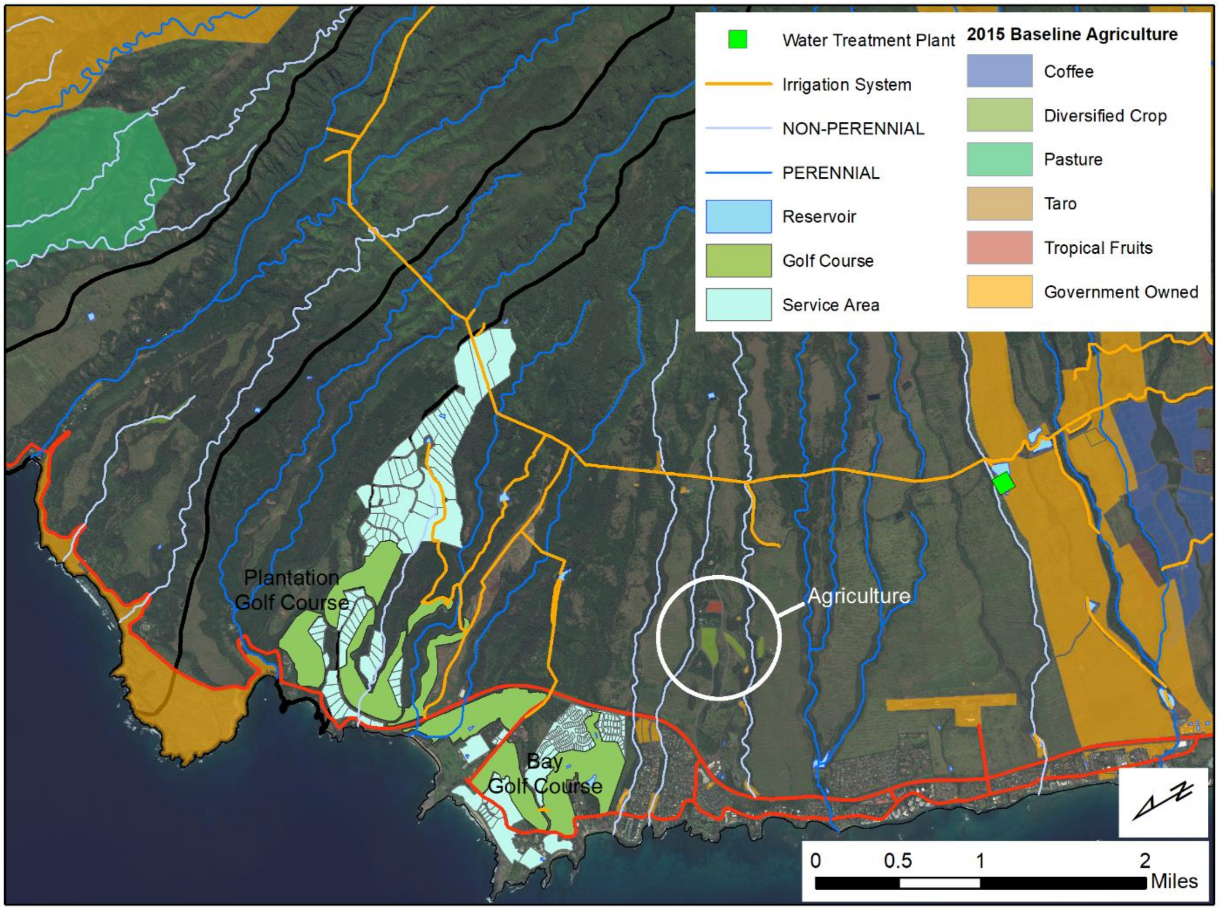
Following the establishment of instream flow standards, one of the proposed measures to increase streamflow may be to decrease the amount of water diverted from streams. Such a measure has important implications to ground water recharge because it affects the amount of water available for irrigation. The effects of irrigation water on ground water recharge can be analyzed using the water budget equation[5]. 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 (Figure 14-7). 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. 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 (Figure 14-8).

Droughts, or periods of lower than average rainfall, have been shown to drastically decrease ground water recharge. The period of drought that occurred in 1998-2002, during which rainfall was at least 30 percent

[5] 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.

lower than the average annual rainfall was estimated to reduce recharge by 27 percent in west and central Maui (Engott and Vana, 2007).

Figure 14-6. Current land use and distribution of non-potable water needs from the Honokōhau Ditch.



Utilization of Important Agricultural Lands

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 (Figure 14-9). 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. As agricultural commodities changed substantially with the closure of large-scale pineapple and sugarcane in the 1980s-2000s, the HDOA funded an updated baseline study of agricultural land use for 2015 (Figure 14-10). HDOA is currently in the process of developing agricultural incentives based on classifications of Important Agricultural Lands. Honokohau is comprised of only 10 percent of designated agricultural land, although all the land is fallow as of 2015. Decreasing the amount of water diverted at the ditches located affects the amount of water available for the irrigation of crops on these important agricultural lands.

Figure 14-7. Estimated recharge for six historical periods between 1926 and 2004, central and west Maui, Hawaii. (Source: Engott and Vana, 2007)

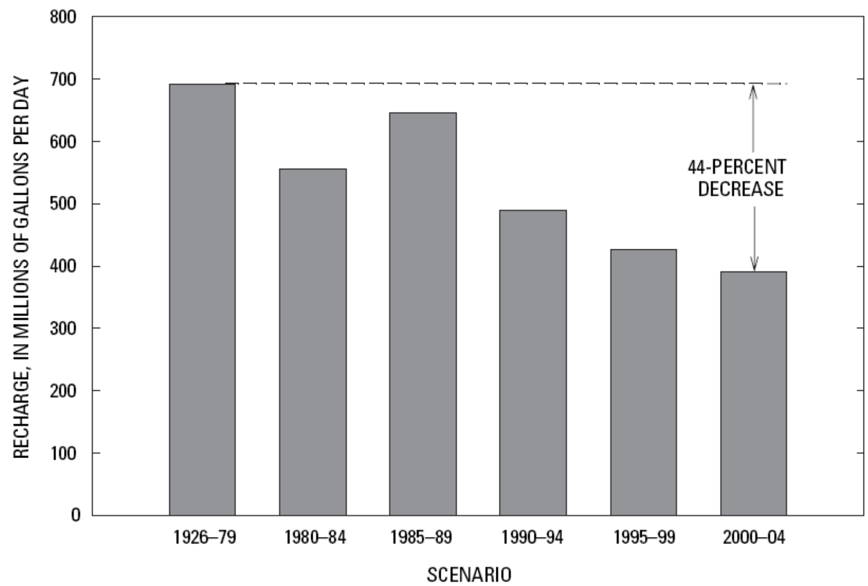


Figure 14-8. Summary of estimated recharge, in million gallons per day, for various land-use and rainfall conditions in the Lihue Basin, Kauai, Hawaii. (Source: Izuka et al., 2005)

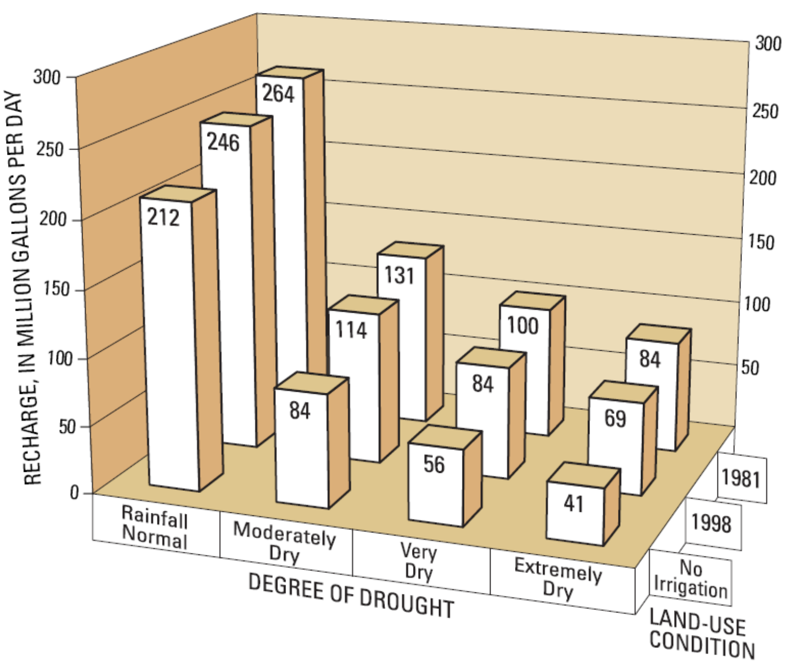


Table 14-4. Agricultural Lands of Importance to the State of Hawaii and area distributions in the Honokohau hydrologic unit, Maui. (Source: State of Hawaii, Office of Planning, 2015g)

Density	Area (mi^2)	Percent of Unit
Prime agricultural land	1.00	8.7%
Other lands	0.22	1.9%

Figure 14-9. Agricultural Lands of Importance to the State of Hawaii (ALISH) for the Honokohau hydrologic unit, Maui. (Source: State of Hawaii, Office of Planning, 2015g)

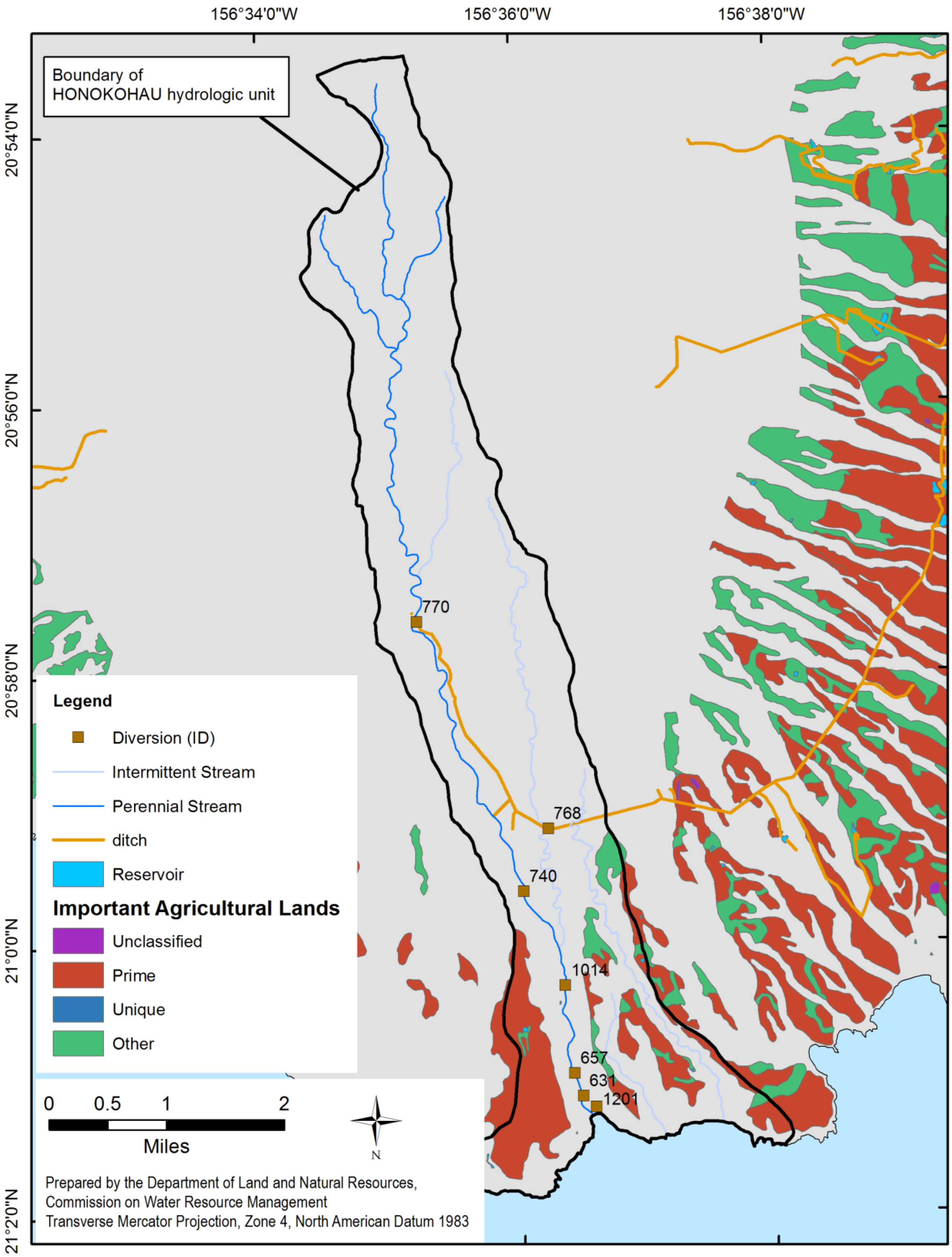
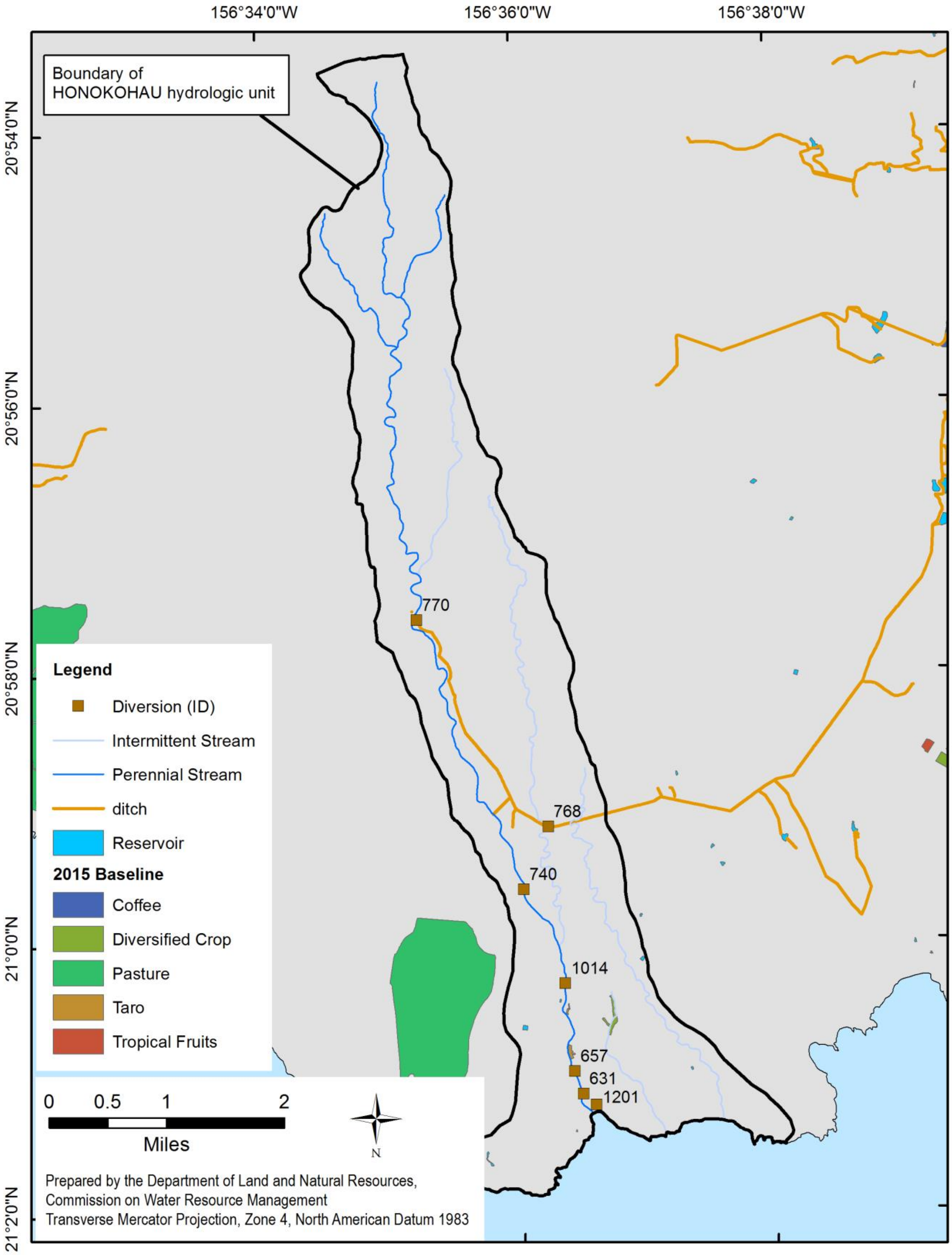


Figure 14-10. 2015 Baseline Agricultural Land Use Map for the Honokohau hydrologic unit. (Source: (Perroy et al. 2016)



Irrigation Needs of the Honokohau Hydrologic Unit

The Commission funded the development of a GIS-based software program the utilizes the state of Irrigation Water Requirement Estimation Decision Support System, IWREDSS (State of Hawaii, Commission on Water Resource Management, 2015b) was developed by the College of Tropical Agriculture and Human Resources, University of Hawaii at Manoa for the State of Hawaii. IWREDSS is an ArcGIS-based numerical simulation model that estimates irrigation requirements (IRR) and water budget components for different crops grown in the Hawaiian environment. The model accounts for different irrigation application systems (e.g., drip, sprinkler, flood), and water application practices (e.g., field capacity versus fixed depth). Model input parameters include rainfall, evaporation, soil water holding capacities, depth of water table, and various crop water management parameters including length of growing season, crop coefficient[6], rooting depth, and crop evapotranspiration.

Calibration and validation of the model was based on the crop water requirement data for different crops from the Hawaii region United States Department of Agriculture (USDA), Natural Resource Conservation Service (NRCS) Handbook 38 (NRCS-USDA, 1996). Relative errors between the net irrigation requirements (NIR) estimated by the model and those estimated by NRCS range from less than 1 percent to a 26 percent overestimate. This difference may be attributed to the general nature of the technique NRCS used in estimating NIR. Results of the regression analysis indicate a good correlation ($R^2 = 0.97$) between the two techniques; however, the NIR calculations by NRCS were consistently 8 percent higher than those of the IWREDSS model. Overall, the model is an appropriate and practical tool that can be used to assess the IRR of crops in Hawaii.

Table 14-5. Mean drip irrigation demand estimates for various crops grown near Honokohau based on IWREDSS scenarios modeled for two soil management techniques and two cover crop options given a 10 ft depth to water table. Irrigation Requirement (IRR) value in gallons per acre per day for the 1 in 5 year drought scenario is provided.

			estimated irrigation demand (gallons/acre/day) for a given drought frequency			
Crops	**row crop management**	**soil management**	**1 in 2 (50%)**	**1 in 5 (20%)**	**1 in 10 (10%)**	**1 in 20 (5%)**
citrus	straight row	Poor	4105	4351	4459	4541
	straight row	Good	4090	4338	4448	4530
	contoured	Poor	4088	4336	4446	4528
	contoured	Good	4083	4330	4439	4521
avocado	straight row	Poor	4814	5218	5400	5538
	straight row	Good	4760	5172	5357	5498
	contoured	Poor	4755	5167	5353	5494
	contoured	Good	4718	5137	5327	5471
coffee	straight row	Poor	4640	5006	5171	5295
	straight row	Good	4588	4963	5132	5260
	contoured	Poor	4580	4958	5128	5257
	contoured	Good	4550	4932	5104	5235

Understanding that water demand is highly site, weather, application, and crop dependent, IWREDSS can still provide a useful approximation of water needs. According to the simulation results, the IRR for

[6] Crop coefficient is an empirically derived dimensionless number that relates potential evapotranspiration to the crop evapotranspiration. The coefficient is crop-specific.

citrus trees is 4000-4500 gallons per acre per day (Table 14-5). The model calculates IRR based on long-term rainfall records available at the weather stations located nearest to the fields. Thus, the estimated IRR represents an average value for given drought scenarios as opposed to average or wet year conditions. However, the estimated IRR for the relative drought year frequencies could be extrapolated to represent the highest demand scenarios. Alternatively, water demand per tree can be used based on the number of trees planted.

Long-term Development in West Maui

The update currently being developed for the West Maui Community Plan analyzes the current and future population, affordable housing shortages, and other development needs for the Lahaina District. In 2017, only 31% of the housing units were owner occupied, with another 35% used as rentals, leaving 34% vacant for transient accommodations (Maui County, 2018b). This is in contrast to statewide in which 50% of all housing units are owner occupied and only 13% are vacant for transient accommodations. A large driver of this issue is the large volume of luxury homes constructed in West Maui, with median 2018 sales prices for Kapalua ($3,000,000), Napili/Kahana/Honokowai ($961,500), Kaanapali ($1,762,250), Lahaina ($835,00), and Olowalu ($1,360,000) largely out of range for the median annual household income of just over $100,000. The majority of West Maui home buyers are mainlanders (62.7%) or foreigners (8.4%), with local residents only accounting for 28.9% of home sales (DBEDT, 2016). A number of affordable (up to 160% of median household income) housing projects are in the works (Table 14-6), which should help with the projected 2040 demand of 13,358 housing units.

Availability of Alternative Resources: Groundwater

While the sustainable yield of the whole Lahaina Aquifer Sector is 34 mgd, increasing access to ground water can be challenging as the underlying geology, interactions with nearby wells, and salinity issues limit the availability of ground water at low elevations. Further, the cost of finding, evaluating, and obtaining necessary approvals can be challenging with no guarentee of success. At higher elevations, pumping rates from the basal aquifer may be greater; however, electrical costs to pump from such an elevation and connectivity costs can limit the suitability of a source. Interconnectivity between public (e.g., Maui County, DHHL) and private (e.g., Kapalua Water Company, Hawaii Water Service) water systems may increase efficiency and resiliency during drought, when surface water sources may be limiting.

Table 14-6. Future affordable housing projects in West Maui. (source: Maui County 2018b) [SF = single family; MF = multi-family]

Project	Developer	Status	units
Kaiaulu at Kaanapali	Aina Pacific, LLC	under construction	33 SF; 100% affordable
Kahoma Residential	West Maui Land	under construction	68 SF; 100% affordable
Kahoma Village	Stanford Carr Development Corp.	under construction	102 MF affordable; 101 SF market rate
Pailolo Place	Aina Pacific, LLC	pending final approval	42 SF; 100% affordable
Puleluhua	Maui Oceanview, LP	under construction	208 MF affordable; 618 MF market rate
Villages of Leialii	HI Housing Finance & Dev. Corp.	planned	200 MF; 100% affordable
Polanui Gardens	Kipa Centennial, LLC	planned	50 SF affordable; 16 Ag lots market rate
Makila Rural—East	Hope Builders, LLC	planned	50 SF affordable; 45 SF market rate
Makila Farms	Makila Kai, LLC	planned	16 SF affordable; 15 Ag lots market rate

Availability of Alternative Resources: Recycled Water

A substantial amount of surface water (~65%) diverted from West Maui streams is used for irrigating landscaping, golf courses, and parks (Maui County, 2018). Reducing the need to irrigate this type of vegetation, by planting alternative species that are more drought tolerant, will reduce demand for scare water supplies. Alternatively, recycled wastewater is available from the County's Lahaina Wastewater Reclamation Facility that serves the West Maui area from Kapalua to Kaanapali (Figure 14-11). The current dry weather treatment capacity is 9.0 mgd, with the resorts currently using the largest portion of recycled water. In 2014, the average production was 4.2 mgd, however, only a portion of the facility's R-1 water was used, with the rest pumped into injection wells. Kapalua Resort and associated golf courses do not currently utilize R-1 water, and there is a lack of distribution infrastructure to make the R-1 water more readily available. Large landowners are more capable of investing in the infrastructure to improve the distribution and use of R-1 water than many small landowners. From Lahaina to Honokohau, there are a few large landowners, including Maui Land & Pineapple, Kaanapali Land Management, and the State of Hawaii Department of Hawaiian Home Lands (Figure 14-12).

Figure 14-11. Existing R1 recycled wastewater infrastructure in West Maui (Source: County of Maui, 2018)

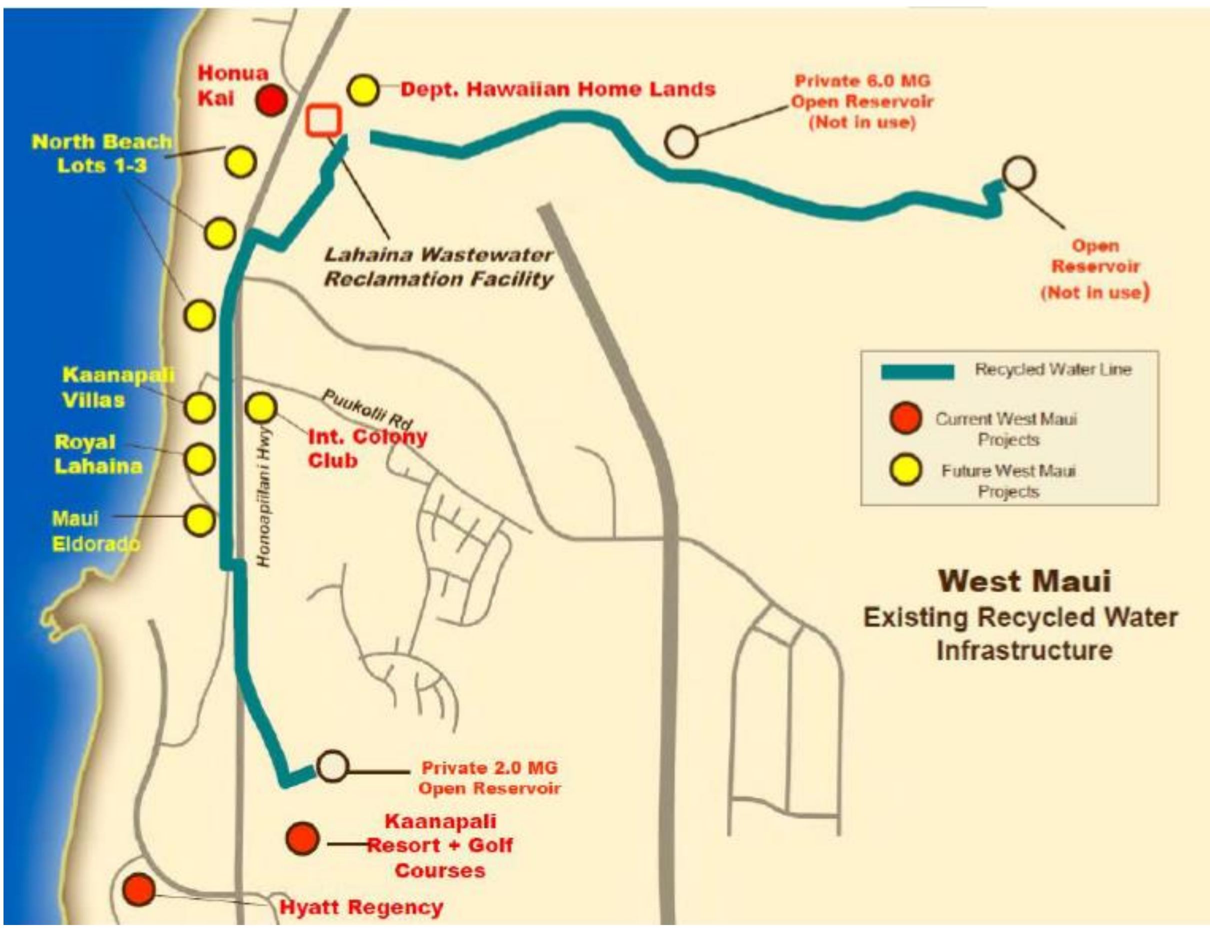
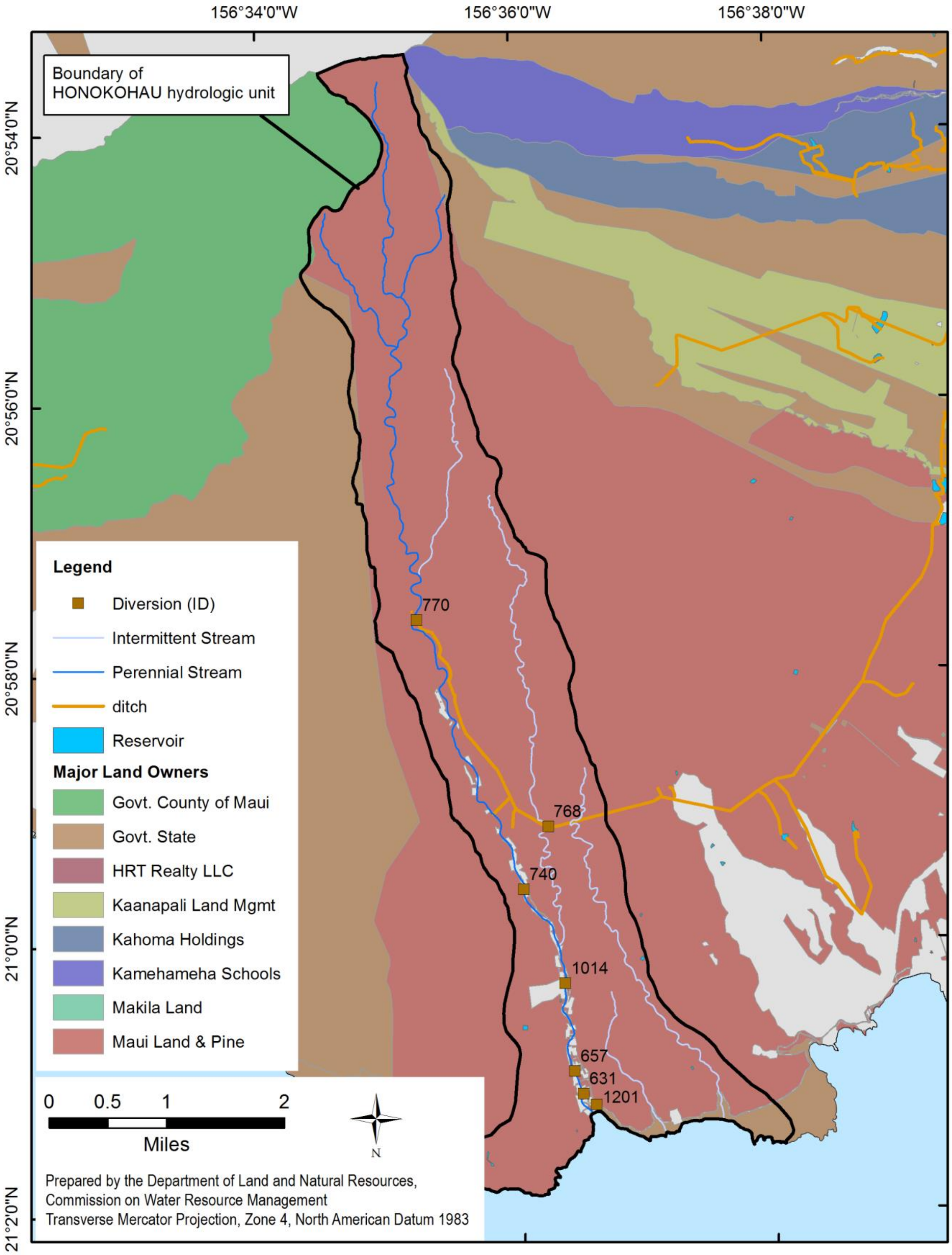


Figure 14-12. Large landowners in the Honokohau hydrologic unit.



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16.0 Appendices

Appendix A Honokohau, Maui, Hawaii. June 2008.
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