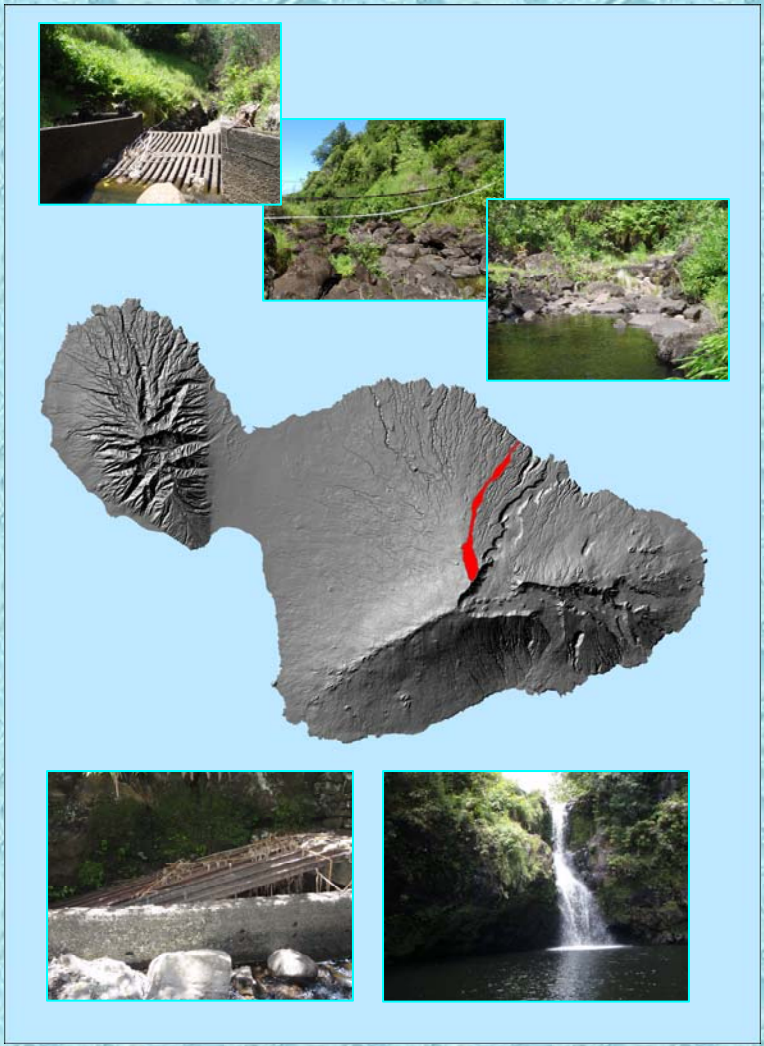
# Report on Waikamoi Stream
# Maui, Hawaii



## August 2009


State of Hawai'i
Department of Land and Natural Resources
**Division of Aquatic Resources**
and
**Bishop Museum**

Funded in part by the Commission on Water Resource Management, DLNR
and

Funded in part by the U.S. Fish & Wildlife Service through its State Wildlife Grant and Wildlife and Sport Fish Restoration Program.

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## August 2009

Prepared for
Commission on Water Resource Management
Department of Land and Natural Resources
State of Hawai‘i

Prepared by
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# Table of Contents

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# Section 1: Introduction

## Overview

On May 24, 2001, the Native Hawaiian Legal Corporation (NHLC) filed a Petition to Amend the Interim Instream Flow Standard (IIFS) for 27 streams in east Maui on behalf of resident taro farmers. Since the acceptance of the petitions in July 2001, the Commission on Water Resource Management (CWRM) has been focused on gathering information for the 27 petitioned streams. Shortly thereafter, NHLC and CWRM staff reached an agreement that efforts would focus on 8 of the 27 petitioned streams: Honopou, Hanehoi, Huelo, Waiokamilo, Kualani, Pi'ina'au, Palauhulu, and Wailua Nui Streams. Currently, the CWRM is collaborating with the State's Division of Aquatic Resources and the U.S. Geological Survey (USGS) for assistance in collecting biological and hydrologic data to determine measurable interim IFS. CWRM has also requested biological data on the remaining 19 petitioned streams which is the main purpose of this report.

This report is an accounting of the aquatic resources that have been observed in Waikamoi, Maui from year 2000 to present. The report was generated to provide information to aid in the instream flow determination for the East Maui Streams at the request of the Commission on Water Resource Management. The focus of this report is the animals that live in the stream and the data collected during surveys of the stream. The report covers four main sections, including:

- Introduction
- Watershed Atlas Report
- DAR Point Quadrat Survey Report
- Photographs of stream taken during stream surveys

The introduction provides the overview for the purpose of this report, a summary of the findings on the stream and its animals, and a discussion of the importance of the findings and how stream conditions influence native species populations. The Watershed Atlas Report provides a description of the watershed and its aquatic resources from Division of Aquatic Resources (DAR) and other published and unpublished surveys as well as a rating of the condition of the stream compared to other streams on Maui as well as statewide. The DAR Point Quadrat Survey Report describes the distribution, habitats, and species observed during the standardized DAR stream surveys. Finally, the photographs provide context to the conditions that the stream surveyors encountered in the stream.

This overview reports on the highlights of these findings and provides a discussion of the importance of the information presented. We hope that this format provides the reader with a simplified, general discussion and understanding of the condition of Waikamoi Stream while also providing substantial evidence to support the conclusions presented.

## Findings for Waikamoi Stream, Maui

Waikamoi is a small (3.9 sq miles), narrow watershed that is steep in the upper sections with little embayment. It is fully zoned for conservation (100%) and the land cover is mostly evergreen forest (85%), scrub (11%), grassland (3%) and bare land (1%). Numerous stream surveys of different types have been completed in Waikamoi stream beginning in 1962 to the present. This watershed rates high in comparison to other watersheds in Maui and statewide, based on data in the DAR aquatic surveys database. It has a total watershed rating of 7 out of 10, a total biological rating of 7 out of 10, and a combined overall rating of 8 out of 10.

Native species observed in the stream include the following categories and species:

Fish - *Awaous guamensis, Eleotris sandwicensis, Kuhlia xenura* and *Sicyopterus stimpsoni*

Crustaceans - *Atyoida bisulcata*

Insect – *Anax junius* , *Anax* sp, *Anax strenuous*, *Limonia grimshawi*, *Limonia jacobus*, *Megalagrion blackburni*, *Megalagrion calliphya*, *Megalagrion* sp., *Procanacae acuminata*, *Procanace confusa, Saldula exulans, Scatella cilipes, Scatella clavipes, Scatella femoralis, Telmatogeton abnormis, Telmatogen* sp., *Telmatogeton torrenticola*

Snails – *Ferrissia sharpi* and *Neritina granosa*

Sponge - *Heteromeyenia baileyi*

Introduced species observed in this stream includes the following categories and species:

Amphibian – *Rana rugosa*

Crustaceans - *Macrobrachium lar*

Insects - *Cheumatopsyche analis,* Chironomid sp., *Cricotopus bicinctus, Dolichopus exsul, Limonia advena, Pantala flavescens*

## Discussion

Waikamoi watershed is narrow and steep with a terminal waterfall at the coastline. Heavy vegetation and re-growth of rose apple (*Syzygium jambos*), stands that died back from ʻōhiʻa rust in the past two years were observed. During July, stream discharge was low and the terminal waterfall was dry. Aerial photographs showed heavy vegetation throughout the watershed and limited areas for helicopter landing zones and stream access. This prevented access to the stream mouth and lower reach of the stream, which prevented estuary or point quadrat surveys to be conducted in those areas.

In December 2008, point quadrat surveys were conducted in the middle reach and lower section of the upper reach of Waikamoi Stream. The stream was accessed by foot from Hāna Highway and through trails above the highway. Surveys were conducted starting from below the Highway to a plunge pool above Hāna Highway. Surveys were also conducted above the diversion intake upstream of the highway. In July 2009, the upper reach was accessed by helicopter, where the upper stream reaches of Waikamoi Stream and a tributary, Alo Stream, were then accessed by foot along East Maui Irrigation (EMI) jeep and foot trails.

Flow measurements were conducted in the middle and upper reaches including Alo Stream tributary. Both streams were diverted in the upper reaches. Flow was measured above the upper Waikamoi Stream intake and immediately above the Alo Stream intake with readings of 2.13 cfs and 1.05 cfs respectively.

Waikamoi Stream had shallower water depths and warmer water temperatures that provided little available stream habitat below the diversions. In contrast, greater flow and lower water temperature above the diversions provided more available stream habitat. Water temperatures varied from 22° C to 18° C from the middle reach to the upper reach respectively.

The native shrimp, **ʻōpae kalaʻole** (*Atyoida bisulcata*), was only observed in the upper reaches. The native goby, **ʻoʻopu ʻalamoʻo** (*Lentipes concolor*) was also observed in upper reaches.

Overall, Waikamoi Stream had reduced instream habitat due to low stream flow. All three diversion structures that were inspected were removing 100% of the flow from the stream at that time. Restoring some stream flow may therefore increase habitat availability to native amphidromous animals, especially *L. concolor* and *A. bisulcata*. Due to the terminal waterfall, other stream species commonly found in the lower reaches would not benefit significantly. Yet, improvements to the diversion structure to increase both upstream and downstream passage would further enhance the overall productivity of Waikamoi Stream.

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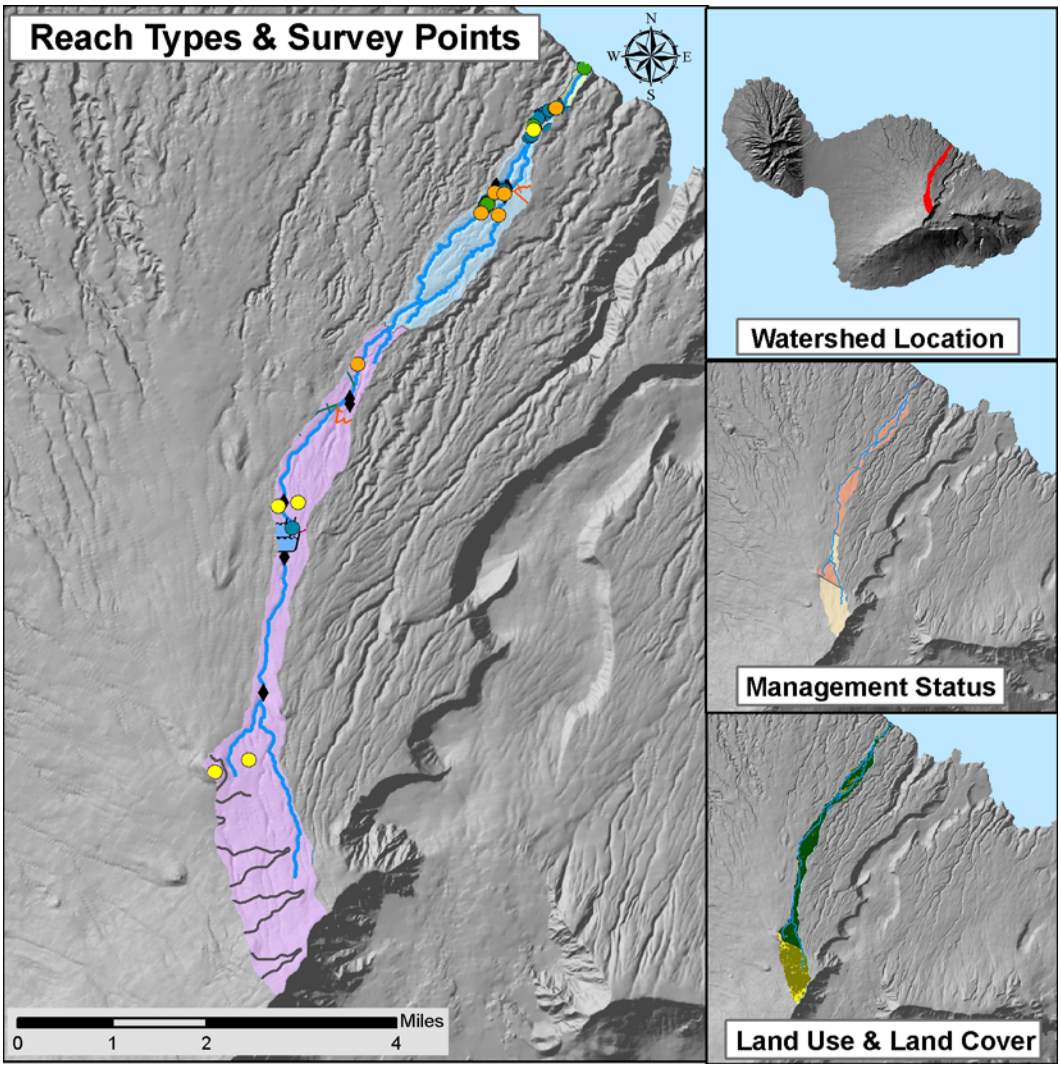
# Section 2: Watershed Atlas

*DAR Watershed Code: 64004*

## Waikamoi, Maui




### WATERSHED FEATURES

Waikamoi watershed occurs on the island of Maui. The Hawaiian meaning of the name is water [of] the moi taro. The area of the watershed is 4.6 square mi (12 square km), with maximum elevation of 9311 ft (2838 m). The watershed's DAR cluster code is 2, meaning that the watershed is small, steep in the upper watershed, and with little embayment. The percent of the watershed in the different land use districts is as follows: 2% agricultural, 98% conservation, 0% rural, and 0% urban.

**Land Stewardship: Percentage of the land in the watershed managed or controlled by the corresponding agency or entity. Note that this is not necessarily ownership.**

| Military | Federal | State | OHA | County | Nature Conservancy | Other Private |
|---|---|---|---|---|---|---|
| 0.0 | 32.6 | 57.9 | 0.0 | 0.0 | 7.8 | 1.8 |

**Land Management Status: Percentage of the watershed in the categories of biodiversity protection and management created by the Hawaii GAP program.**

| Permanent Biodiversity Protection | Managed for Multiple Uses | Protected but Unmanaged | Unprotected |
|---|---|---|---|
| 40.3 | 57.9 | 0.0 | 1.8 |

**Land Use: Areas of the various categories of land use. These data are based on NOAA C-CAP remote sensing project.**

| | Percent | Square mi | Square km |
|---|---|---|---|
| High Intensity Developed | 0.0 | 0.00 | 0.00 |
| Low Intensity Developed | 0.0 | 0.00 | 0.00 |
| Cultivated | 0.0 | 0.00 | 0.00 |
| Grassland | 5.3 | 0.24 | 0.63 |
| Scrub/Shrub | 31.8 | 1.48 | 3.83 |
| Evergreen Forest | 59.8 | 2.77 | 7.18 |
| Palustrine Forested | 0.0 | 0.00 | 0.00 |
| Palustrine Scrub/Shrub | 0.0 | 0.00 | 0.00 |
| Palustrine Emergent | 0.0 | 0.00 | 0.00 |
| Estuarine Forested | 0.0 | 0.00 | 0.00 |
| Bare Land | 2.9 | 0.14 | 0.35 |
| Unconsolidated Shoreline | 0.0 | 0.00 | 0.00 |
| Water | 0.2 | 0.01 | 0.02 |
| Unclassified | 0.0 | 0.00 | 0.00 |

## STREAM FEATURES

Waikamoi is a perennial stream. Total stream length is 14.8 mi (23.9 km). The terminal stream order is 2.

**Reach Type Percentages: The percentage of the stream's channel length in each of the reach type categories.**

| Estuary | Lower | Middle | Upper | Headwaters |
|---|---|---|---|---|
| 0.0 | 0.0 | 5.4 | 40.4 | 54.1 |

The following stream(s) occur in the watershed:

Alo Waikamoi

## BIOTIC SAMPLING EFFORT

Biotic samples were gathered in the following year(s):

1929 1962 1968 1980 1988 1991 1994
2003 2008 2009

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

| Survey type | Estuary | Lower | Middle | Upper | Headwaters |
|---|---|---|---|---|---|
| Damselfly Surveys | 0 | 0 | 0 | 1 | 5 |
| DAR Point Quadrat | 0 | 0 | 8 | 13 | 0 |
| DAR Report | 0 | 0 | 0 | 0 | 1 |
| HDFG | 0 | 0 | 1 | 4 | 1 |
| Published Report | 0 | 0 | 2 | 2 | 0 |

## BIOTA INFORMATION

**Species List**

**Native Species**

| | |
|---|---|
| **Crustaceans** | *Atyoida bisulcata* |
| **Fish** | *Lentipes concolor* |

**Native Species**

| | |
|---|---|
| **Insects** | *Anax junius* |
| | *Anax* sp. |
| | *Megalagrion calliphya* |
| | *Megalagrion hawaiiense* |
| | *Megalagrion* sp. |
| | *Telmatogeton* sp. |

**Introduced Species**

| | |
|---|---|
| **Crustaceans** | *Macrobrachium lar* |
| | *Procambarus clarkii* |
| **Fish** | *Poecilia reticulata* |
| | Poeciliid sp. |
| | *Xiphophorus helleri* |
| | *Xiphophorus* sp. |

**Introduced Species**

| | |
|---|---|
| **Insects** | Chironomid sp. |
| **Snails** | Lymnaeid sp. |
| | Physid sp. |

**Species Size Data: Species size (inches) observed in DAR Point Quadrat Surveys.**

| Scientific Name | Status | Minimum Size | Maximum Size | Average Size |
|---|---|---|---|---|
| *Atyoida bisulcata* | Endemic | 1.25 | 2 | 1.7 |
| *Macrobrachium lar* | Introduced | 1.5 | 5.5 | 3.6 |
| *Lentipes concolor* | Endemic | 4 | 5 | 4.5 |
| *Poecilia reticulata* | Introduced | 0.5 | 2 | 1.0 |
| *Xiphophorus helleri* | Introduced | 0.75 | 4 | 1.5 |
| Physid sp. | Introduced | 0.2 | 0.2 | 0.2 |

**Average Density: The densities (#/square yard) for species observed in DAR Point Quadrat Surveys averaged over all sample dates in each reach type.**

| Scientific Name | Status | Estuary | Lower | Middle | Upper | Headwaters |
|---|---|---|---|---|---|---|
| *Atyoida bisulcata* | Endemic | | | | 5.09 | |
| *Lentipes concolor* | Endemic | | | | 0.2 | |
| *Macrobrachium lar* | Introduced | | | 1.65 | 0.81 | |
| Physid sp. | Introduced | | | | 1.43 | |
| *Poecilia reticulata* | Introduced | | | 3.63 | | |
| *Xiphophorus helleri* | Introduced | | | 7.58 | | |

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

| Scientific Name | Status | Estuary | Lower | Middle | Upper | Headwaters |
|---|---|---|---|---|---|---|
| *Atyoida bisulcata* | Endemic | | | P | P | P |
| *Lentipes concolor* | Endemic | | | | P | |
| *Megalagrion calliphya* | Endemic | | | | | P |
| *Megalagrion hawaiiense* | Endemic | | | | P | P |
| *Megalagrion* sp. | Endemic | | | P | P | P |
| *Anax junius* | Indigenous | | | | P | |
| *Anax* sp. | Indigenous | | | P | P | P |
| *Telmatogeton* sp. | Indigenous | | | | P | |
| *Macrobrachium lar* | Introduced | | | P | P | |
| *Procambarus clarkii* | Introduced | | | P | | |
| *Poecilia reticulata* | Introduced | | | P | | |
| Poeciliid sp. | Introduced | | | P | | |
| *Xiphophorus helleri* | Introduced | | | P | | |
| *Xiphophorus* sp. | Introduced | | | P | P | |
| Chironomid sp. | Introduced | | | P | | P |
| Lymnaeid sp. | Introduced | | | | P | |
| Physid sp. | Introduced | | | | P | |

## HISTORIC RANKINGS

**Historic Rankings: These are rankings of streams from historical studies. "Yes" means the stream was considered worthy of protection by that method. Some methods include non-biotic data in their determination. See Atlas Key for details.**

Multi-Attribute Prioritization of Streams - Potential Heritage Streams (1998): No

Hawaii Stream Assessment Rank (1990): Without Data

U.S. Fish and Wildlife Service High Quality Stream (1988): No

The Nature Conservancy- Priority Aquatic Sites (1985): Yes

National Park Service - Nationwide Rivers Inventory (1982): No

**Current DAR Decision Rule Status: The following criteria are used by DAR to consider the biotic importance of streams. "Yes" means that watershed has that quality.**

| Native Insect Diversity > 19 spp. | Native Macrofauna Diversity > 5 spp. | Absence of Priority 1 Introduced |
|---|---|---|
| No | No | No |
| **Abundance of Any Native Species** | **Presence of Candidate Endangered Species** | **Endangered Newcomb's Snail Habitat** |
| No | No | No |

## CURRENT WATERSHED AND STREAM RATINGS

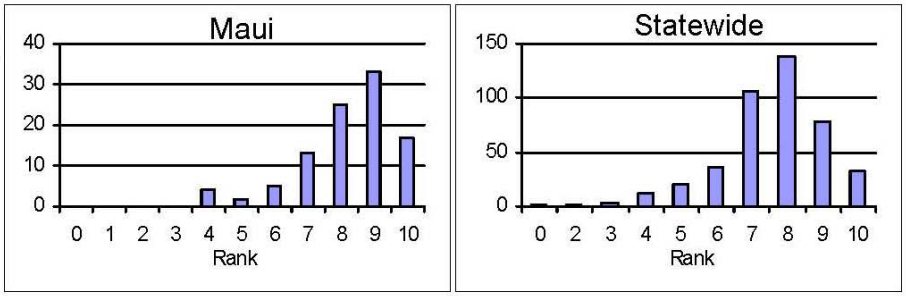
The current watershed and stream ratings are based on the data contained in the DAR Aquatic Surveys Database. The ratings provide the score for the individual watershed or stream, the distribution of ratings for that island, and the distribution of ratings statewide. This allows a better understanding of the meaning of a particular ranking and how it compares to other streams. The ratings are standardized to range from 0 to 10 (0 is lowest and 10 is highest rating) for each variable and the totals are also standardized so that the rating is not the average of each component rating. These ratings are subject to change as more data are entered into the DAR Aquatic Surveys Database and can be automatically recalculated as the data improve. In addition to the ratings, we have also provided an estimate of the confidence level of the ratings. This is called rating strength. The higher the rating strength the more likely the data and rankings represent the actual condition of the watershed, stream, and aquatic biota.

## WATERSHED RATING: Waikamoi, Maui

Land Cover Rating: Rating is based on a scoring sytem where in general forested lands score positively and developed lands score negatively.

Watershed Rating

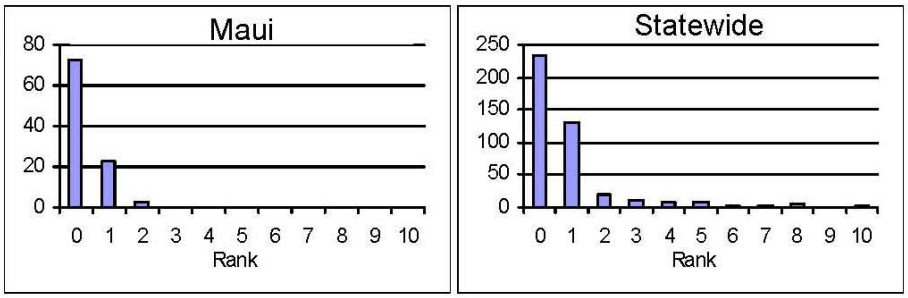
9




Shallow Waters Rating: Rating is based on a combination of the extent of estuarine and shallow marine areas associated with the watershed and stream.

Watershed Rating

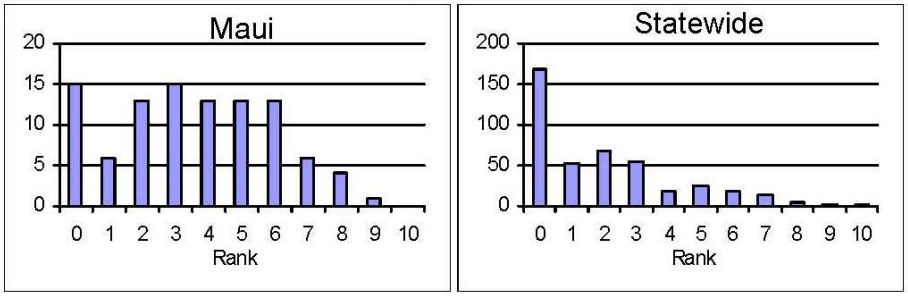
0




Stewardship Rating: Rating is based on a scoring system where higher levels of land and biodiversity protection within the watershed score positively.

Watershed Rating

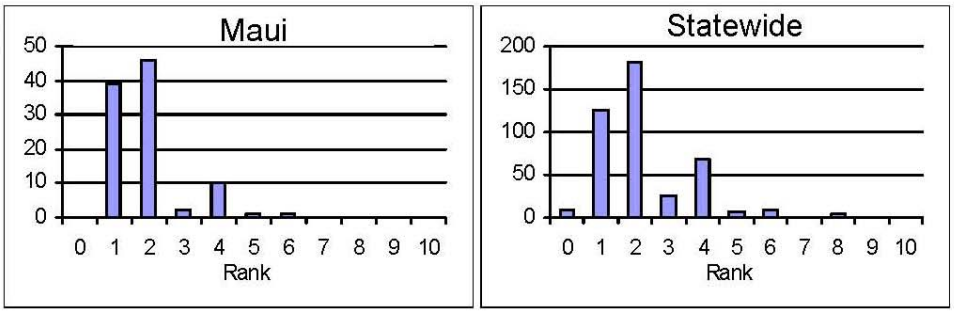
8



## WATERSHED RATING (Cont): Waikamoi, Maui

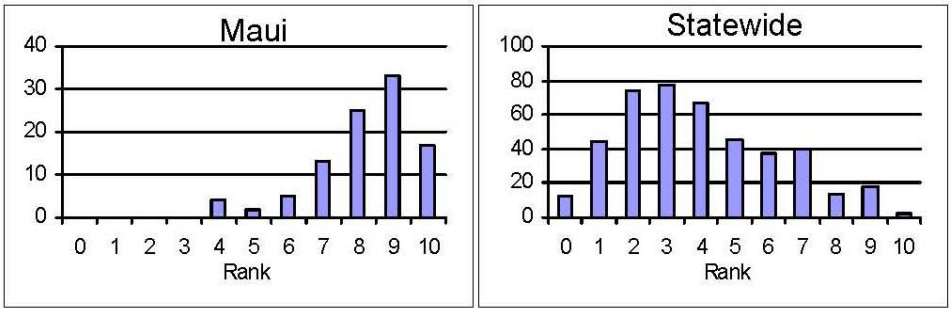
Size Rating: Rating is based on the watershed area and total stream length. Larger watersheds and streams score more positively.

Watershed Rating 2



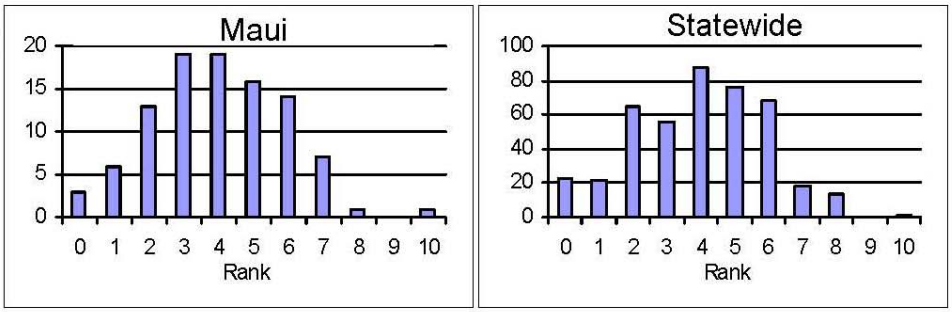

Wetness Rating: Rating is based on the average annual rainfall within the watershed. Higher rainfall totals score more positively.

Watershed Rating 5



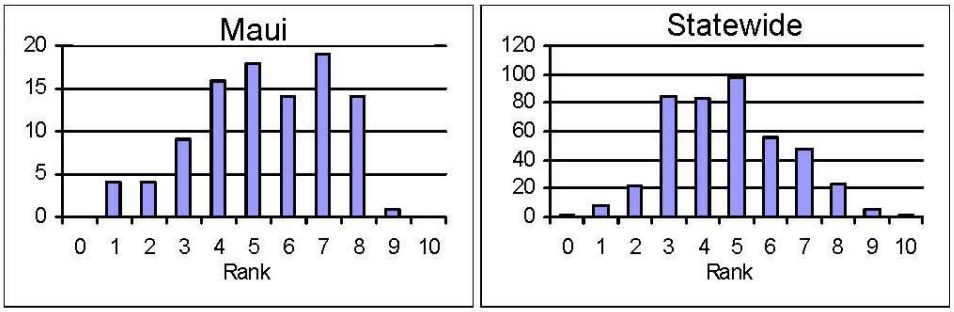

Reach Diversity Rating: Rating is based on the types and amounts of different stream reaches available in the watershed. More area in different reach types score more positively.

Watershed Rating 5




Total Watershed Rating: Rating is based on combination of Land Cover Rating, Shallow Waters Rating, Stewardship Rating, Size Rating, Wetness Rating, and Reach Diversity Rating.

Watershed Rating 7

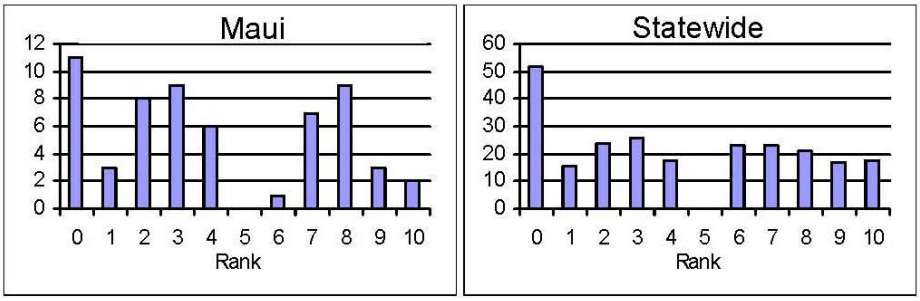


## BIOLOGICAL RATING: Waikamoi, Maui

Native Species Rating: Rating is based on the number of native species observed in the watershed.

Stream Rating

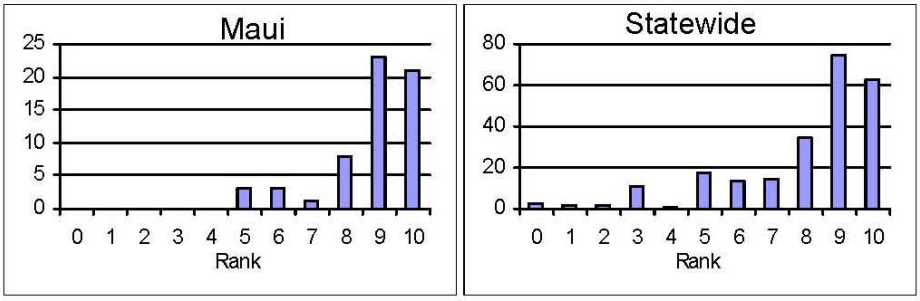
2




Introduced Genera Rating: Rating is based on the number of introduced genera observed in the watershed.

Stream Rating

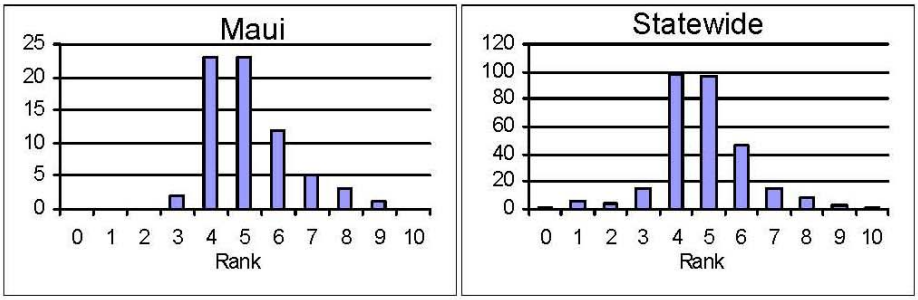
8




All Species' Score Rating: Rating is based on the Hawaii Stream Assessment scoring system where native species score positively and introduced species score negatively.

Stream Rating

4

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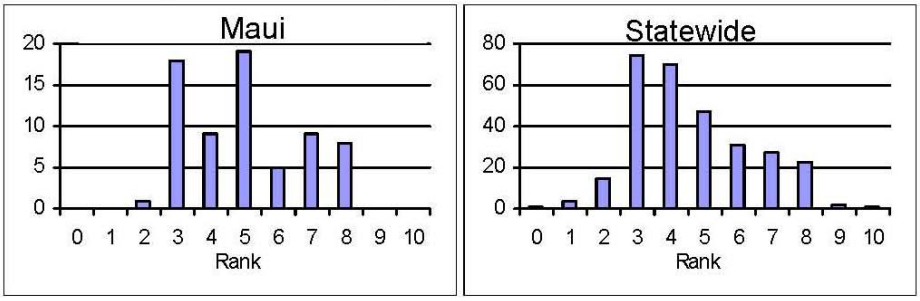
Total Biological Rating: Rating is the combination of the Native Species Rating, Introduced Genera Rating, and the All Species' Score Rating.

Stream Rating

4

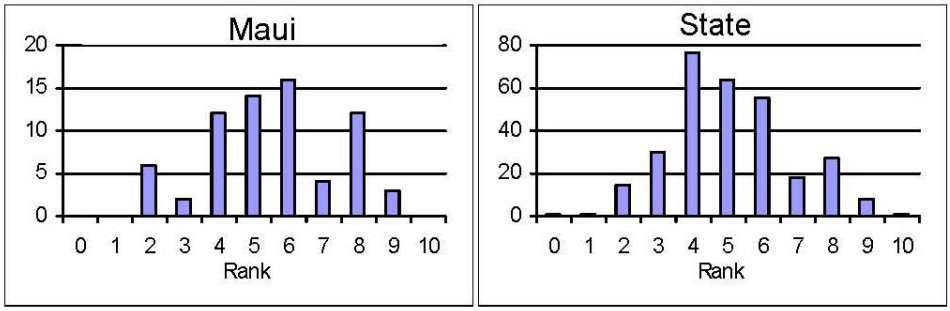


## OVERALL RATING: Waikamoi, Maui

Overall Rating: Rating is a combination of the Total Watershed Rating and the Total Biological Rating.

Watershed Rating

6

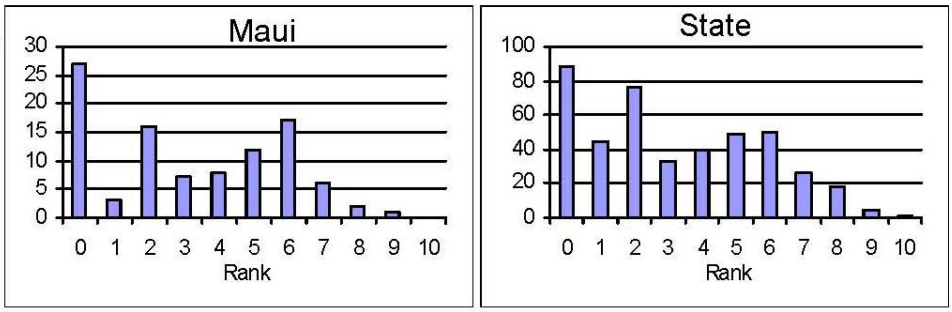



## RATING STRENGTH: Waikamoi, Maui

Rating Strength: Represents an estimate of the overall study effort in the stream and is a combination of the number of studies, number of different reaches surveyed, and the number of different survey types.

Information Rating

6

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# Section 3: DAR Point Quadrat Report for Waikamoi, Maui

For Surveys from 12/10/2008 to 7/1/2009

## Introduction

This is a report of the Hawaii Division of Aquatic Resources stream surveys using the Point Quadrat Methodology. Trained biologists and technicians survey a series of randomly located points in a stream to generate an assessment of the species and habitat in the stream. The Point Quadrat Methodology is one of several techniques that could be chosen for the surveys and is used to develop a statistically comparable stream survey. This methodology is a standardized visual survey technique involving snorkeling, and it is well suited for the physical and ecological characteristics of Hawai‘i streams. The small, steep, dynamic nature of Hawaiian streams with their unique aquatic species is easily observed with this methodology. The in-stream distribution by elevation, behavior, and amphidromous life cycles are easily observed using this technique.

## Methods

The point quadrat methodology requires underwater observation. Sampling was conducted using a dive mask, snorkel and two-piece wet suit with hood and glove. Spiked felt-soled wading boots or Japanese spiked **tabis** are also necessary for easy climbing on the wet, algae-covered rocks. After the initial survey site is chosen all the survey sites upstream are selected randomly to prevent any bias in habitat type selection (e.g., pools and runs) and to obtain a representative sample of all habitat types in the stream. At each site, fish and invertebrate observations are recorded and data is collected on the species present, number, size, and sex. Habitat and substrate type, depth and site dimension data are also collected. Other site observations recorded at each station include GPS coordinates and the following water quality parameters using a Hydrolab Quanta: temperature (° C), salinity (PSS), dissolved oxygen (mg/L), pH, conductivity (mS/cm) and turbidity (NTU). Stream flow measurements are collected using a Marsh McBirney Flo-Mate 2000 at the beginning and ending of each survey as well as at tributaries and diversions.

The watersheds (and watershed ID), region, and island surveyed in this report are:

Waikamoi (ID: 64004), Ke‘anae, Maui

Surveys were conducted by these personnel:

Hau, Skippy
Kuamo‘o, Darrell
Sakihara, Troy
Shimoda, Troy
Shindo, Tim

## Results

Table 3-1. The distribution of sites by reach during this survey effort.

| Reach | Total number of surveys |
|---|---|
| **Estuary** | 0 |
| **Lower** | 0 |
| **Middle** | 8 |
| **Upper** | 13 |
| **Headwaters** | 0 |
| **Unknown** | 0 |

## Middle Reach

Table 3-2. Number of Habitat Types surveyed in the middle stream reach.

| Reach | Total Habitats Surveyed | Plunge Pool | Cascade | Riffle | Run | Pool | Side Pool | No Water | Dirty Water | Unknown |
|---|---|---|---|---|---|---|---|---|---|---|
| **Middle** | 6 | 1 | 0 | 1 | 0 | 2 | 2 | 0 | 0 | 0 |

Table 3-3. Observed Substrates (%) in point quadrat samples in the middle stream reach.

| Reach | Detritus | Sediment | Sand | Gravel | Cobble | Boulder | Bedrock |
|---|---|---|---|---|---|---|---|
| **Middle** | 10 | 0 | 9 | 15 | 15 | 20 | 31 |

Table 3-4. Observed Water Quality in point quadrat samples in the middle stream reach.

| Reach | Temp (° C) | sCond (mS/cm) | DO (mg/L) | pH | Turbidity (NTU) |
|---|---|---|---|---|---|
| **Middle** | 19.269 | 0.267 | 8.676 | 7.654 | 0 |

Table 3-5. Summary of species observed in the middle reach of the watershed.

| Category | Status | Scientific Name |
|---|---|---|
| Crustacean | Introduced | *Macrobrachium lar* |
| Fish | Introduced | *Xiphophorus helleri* |
| Fish | Introduced | *Poecilia reticulata* |

Table 3-6. Average Density and Total number of animals observed in the middle stream reach. Density values are calculated only for random sites, not non-random or outside sites, greater than 6 by 6 inches. Density values are in number of animals per square yard.

| Category | Status | Scientific Name | Reach | Avg. Density | Total # observed |
|---|---|---|---|---|---|
| Fish | Introduced | *Poecilia reticulata* | Middle | 3.63 | 11 |

Table 3-7. Locations of the diversions found within the middle reach and their corresponding tributary.

| Latitude | Longitude | Tributary |
|---|---|---|
| 20.87096 | -156.18929 | 64004001 |

## Upper Reach

Table 3-8. Number of Habitat Types surveyed in the upper stream reach.

| **Reach** | Total Habitats Surveyed | Plunge Pool | Cascade | Riffle | Run | Pool | Side Pool | No Water | Dirty Water | Unknown |
|---|---|---|---|---|---|---|---|---|---|---|
| **Upper** | 10 | 3 | 0 | 0 | 2 | 3 | 1 | 1 | 0 | 0 |

Table 3-9. Observed Substrates (%) in point quadrat samples in the upper stream reach.

| **Reach** | Detritus | Sediment | Sand | Gravel | Cobble | Boulder | Bedrock |
|---|---|---|---|---|---|---|---|
| **Upper** | 7 | 0 | 0 | 3 | 9 | 60 | 21 |

Table 3-10. Observed Water Quality in point quadrat samples in the upper stream reach.

| **Reach** | Temp (º C) | sCond (mS/cm) | DO (mg/L) | pH | Turbidity (NTU) |
|---|---|---|---|---|---|
| **Upper** | 20.448 | 0.063 | 8.105 | 7.591 | 6.425 |

Table 3-11. Summary of species observed in the upper reach of the watershed.

| Category | Status | Scientific Name |
|---|---|---|
| Crustacean | Introduced | *Macrobrachium lar* |
| Crustacean | Endemic | *Atyoida bisulcata* |
| Fish | Endemic | *Lentipes concolor* |
| Snail | Introduced | Physid sp. |

Table 3-12. Average Density and Total number of animals observed in the upper stream reach. Density values are calculated only for random sites, not non-random or outside sites, greater than 6 by 6 inches. Density values are in number of animals per square yard.

| Category | Status | Scientific Name | Reach | Avg. Density | Total # observed |
|---|---|---|---|---|---|
| Crustaceans | Introduced | *Macrobrachium lar* | Upper | 0.63 | 3 |
| Crustaceans | Endemic | *Atyoida bisulcata* | Upper | 2.72 | 13 |
| Snails | Introduced | Physid sp. | Upper | 1.46 | 7 |

Table 3-13. Flow data taken during point quadrat in the upper stream reach.

| Latitude | Longitude | Total CFS | MGD |
|---|---|---|---|
| 20.85866 | -156.19690 | 2.13 | 1.37 |
| 20.86037 | -156.19423 | 1.05 | 0.68 |

Table 3-14. Locations of the diversions found within the upper reach and their corresponding tributary.

| Latitude | Longitude | Tributary |
|---|---|---|
| 20.85934 | -156.19620 | 64004003 |
| 20.85908 | -156.19635 | 64004003 |
| 20.86037 | -156.19423 | 64004002 |
| 20.86023 | -156.19406 | 64004002 |

## Summary

Surveys were conducted in Waikamoi Stream on 10 December 2008 and 1 July 2009. A total of 1008 m of stream length was surveyed in four discrete sections (338 m, 425 m, 225 m, and 20 m). Water flow data was collected at 3 sites and 5 diversions were observed in the survey area.

Animal species observed in Waikamoi Stream during 10 December 2008 and 1 July 2009 surveys:

| Category | Status | *Scientific Name* |
|---|---|---|
| Crustacean | Introduced | *Macrobrachium lar* |
| Crustacean | Endemic | *Atyoida bisulcata* |
| Snail | Introduced | Physid sp. |

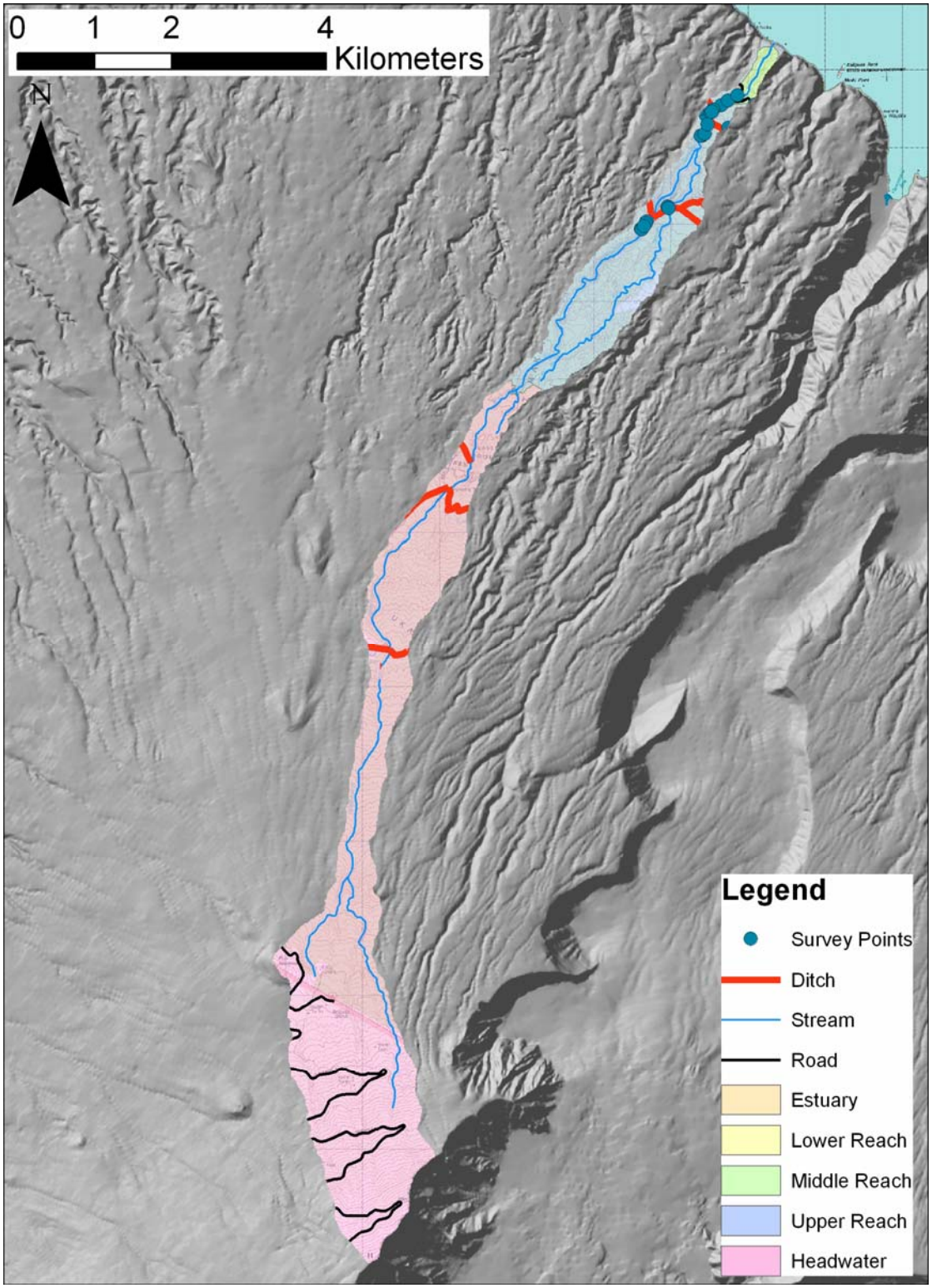


Figure 3-1. Location of point-quadrat surveys conducted in Waikamoi Stream.

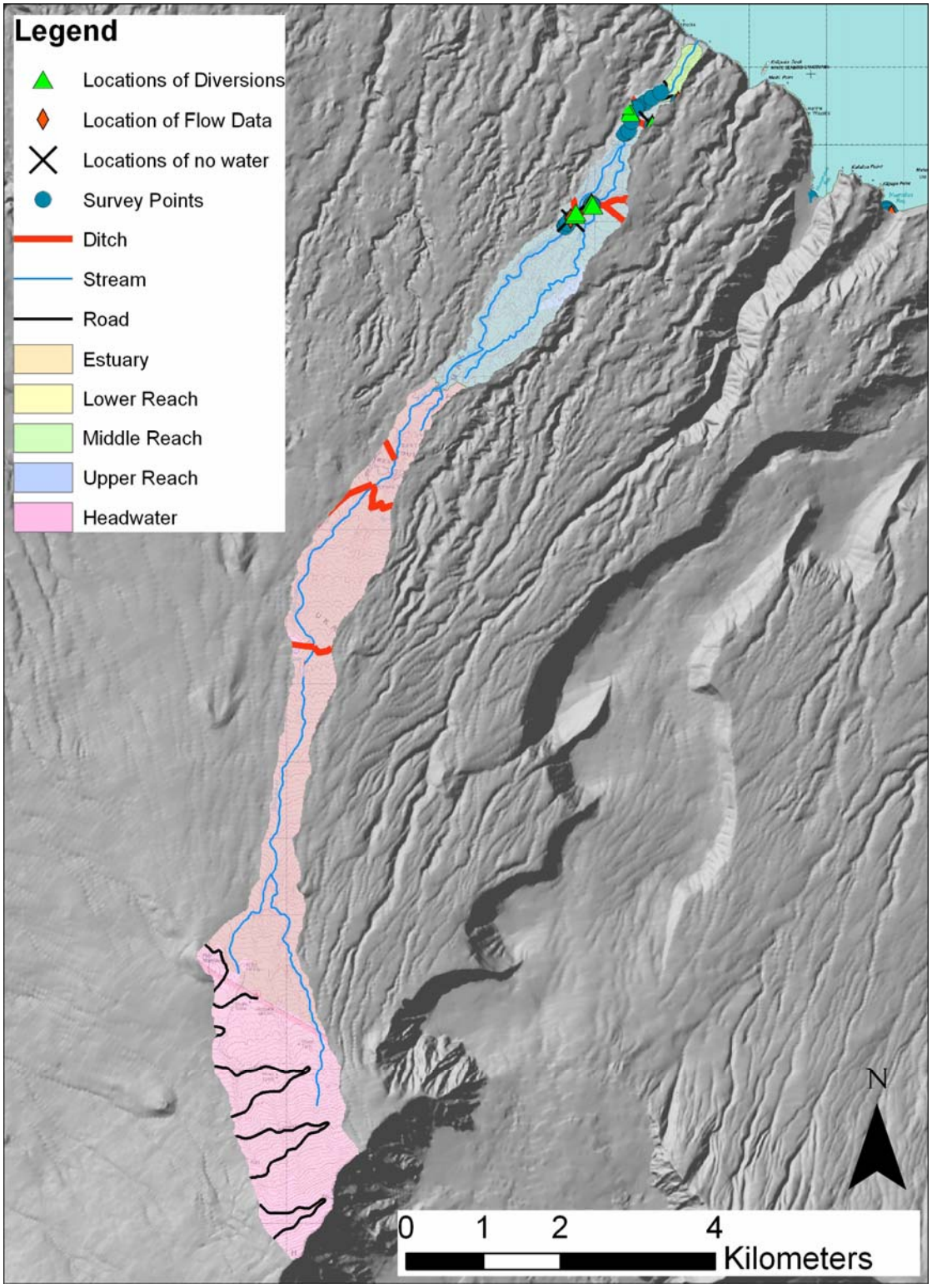


Figure 3-2. Location of diversion surveys and flow surveys conducted in Waikamoi Stream.

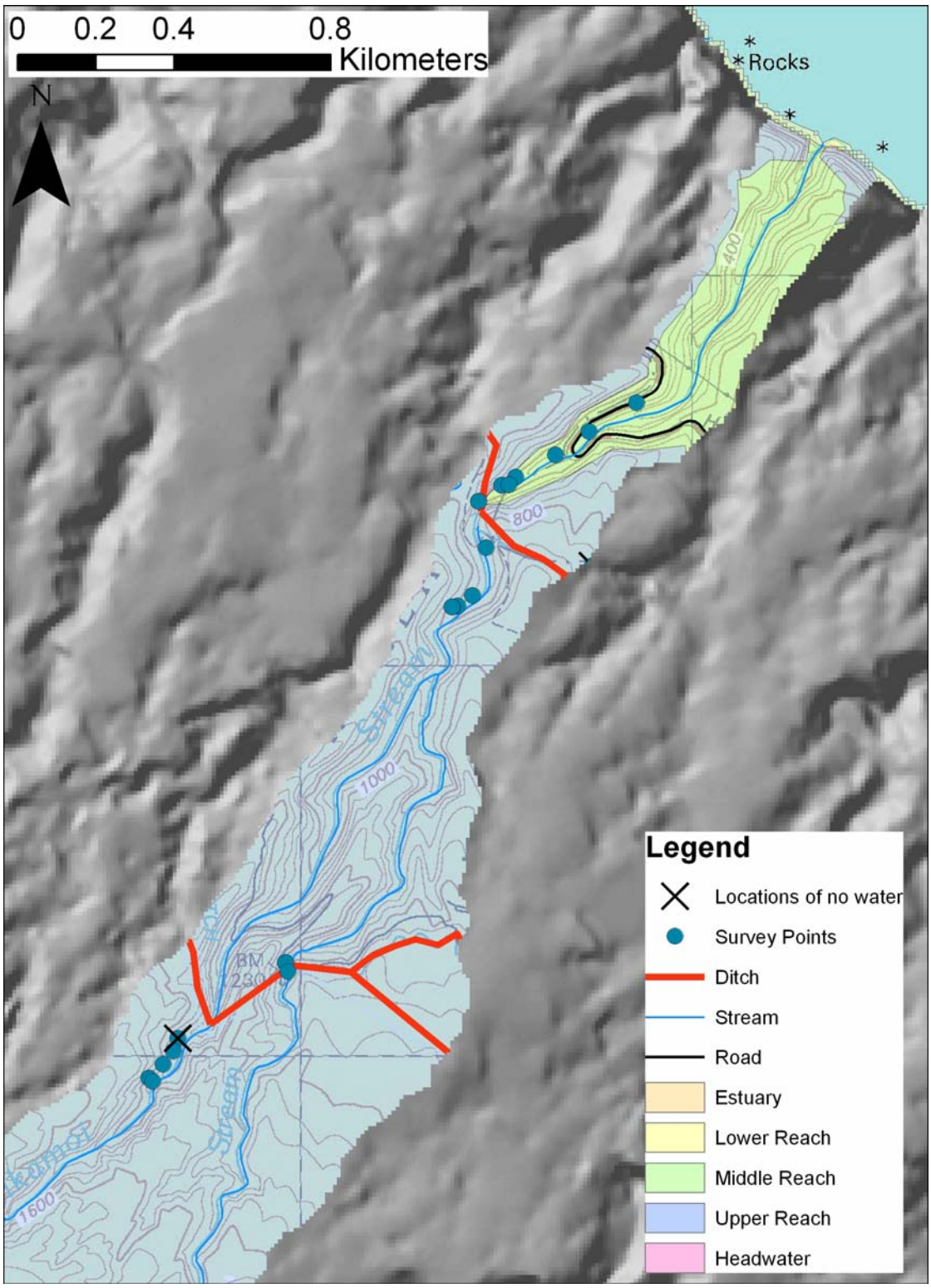


Figure 3-3. Location of no water conditions in Wakamoi Stream.

## Middle Reach

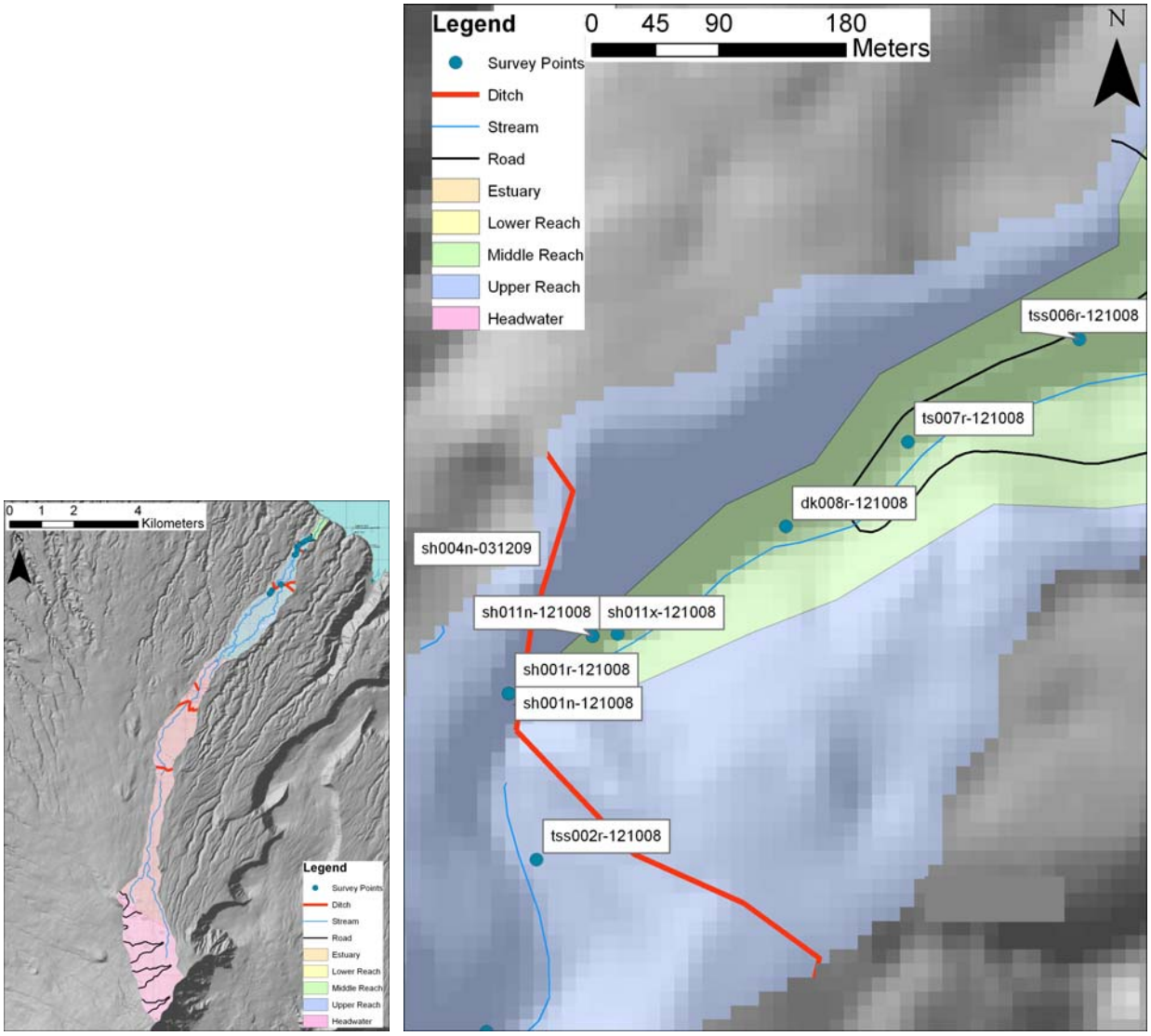


Figure 3-4. Point-quadrat survey locations in the middle reach of Waikamoi Stream.

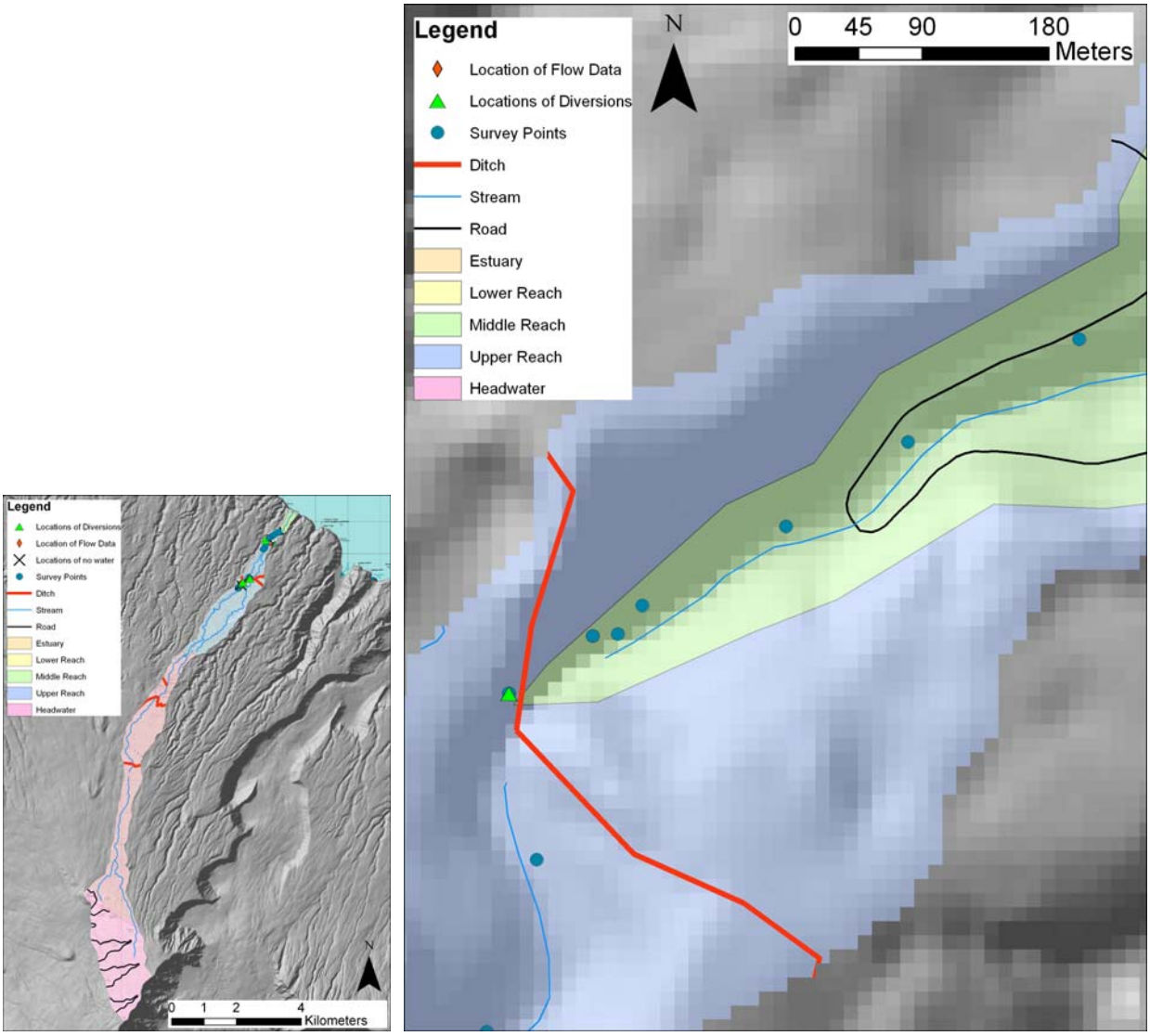


Figure 3-5. Location of diversion surveys conducted in the middle to upper reach of Waikamoi Stream.

## Upper Reach

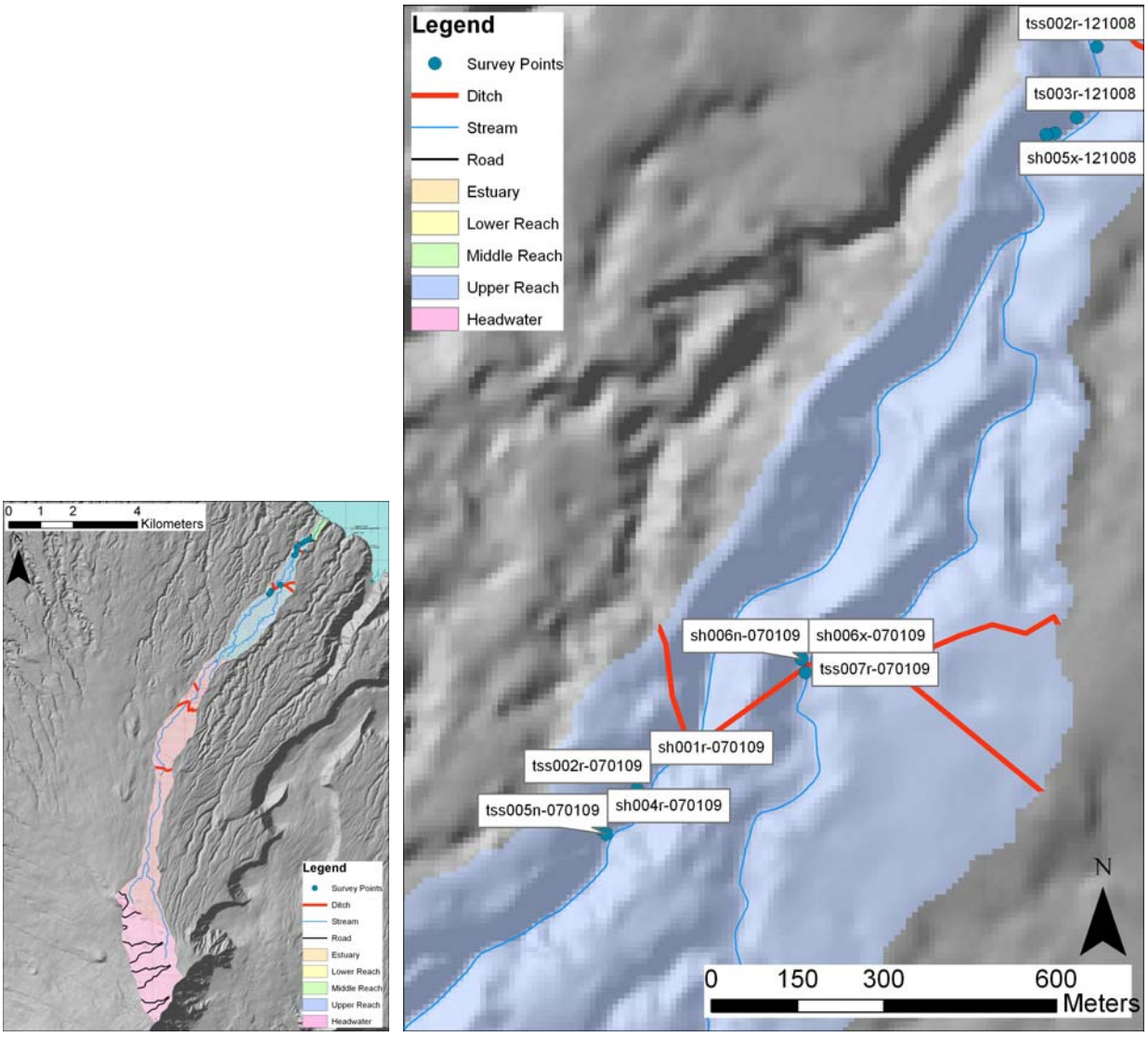


Figure 3-6. Point-quadrat survey locations in the upper reach of Waikamoi Stream.

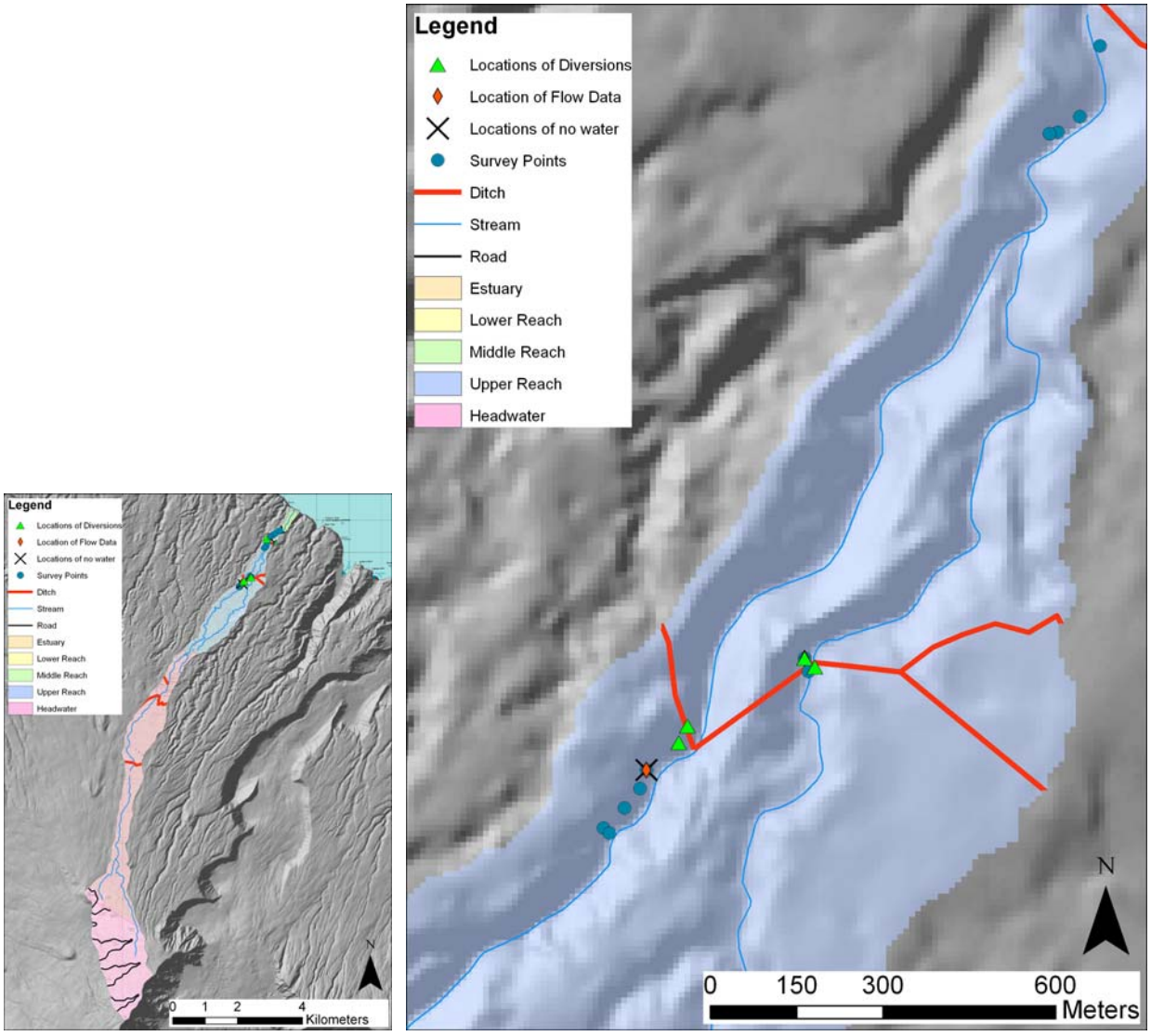


Figure 3-7. Location of no water conditions, diversion surveys and flow measurements conducted in the upper reach of Waikamoi Stream.

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# Section 4: Photographs taken during stream surveys

Middle Reach

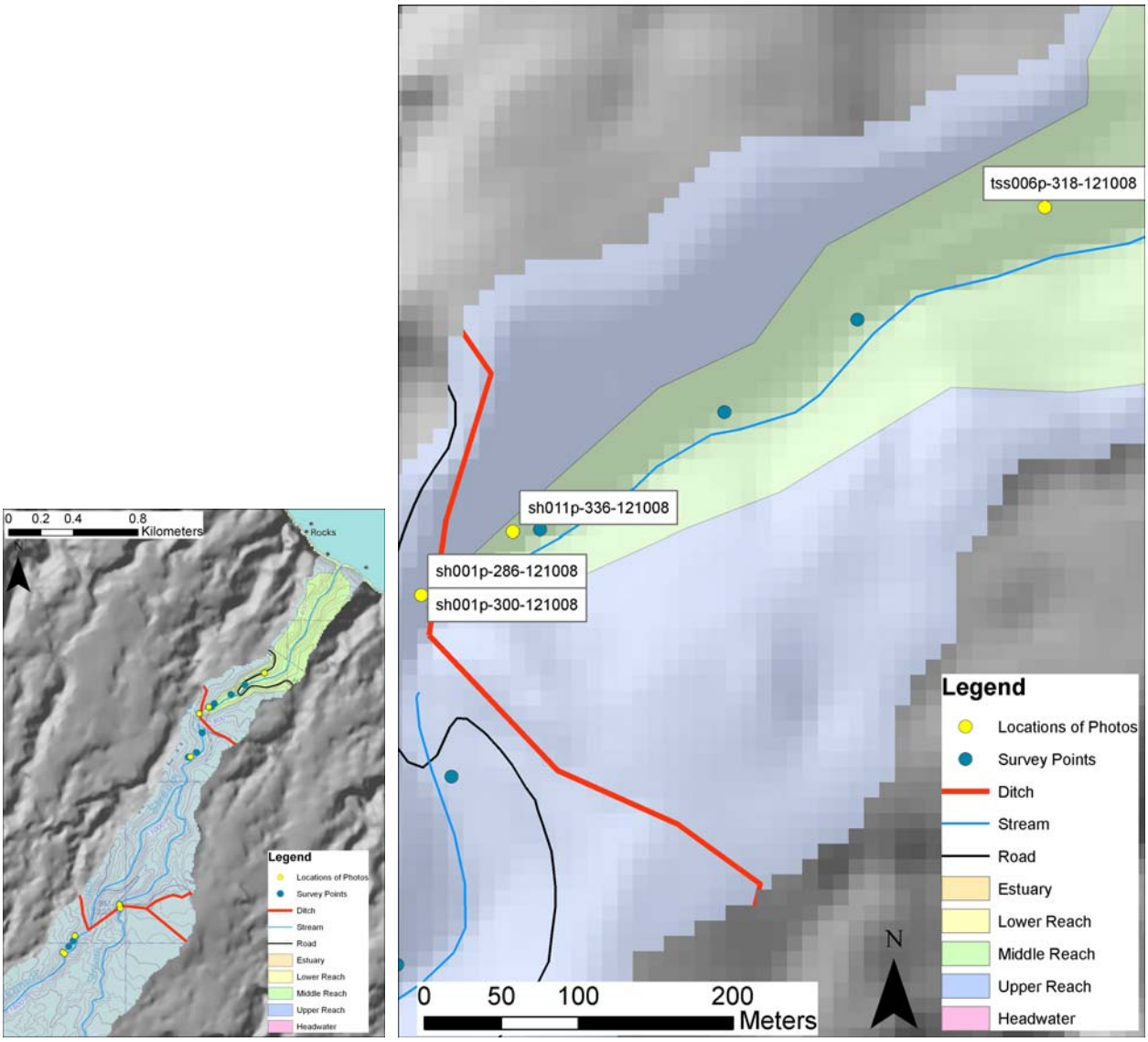


Figure 4-1. Photo locations in the middle reach of Waikamoi Stream.

Figure 4-2. Photo of plunge pool with very little flow downstream from site 6 and below Hāna Hwy and diversion on Waikamoi Stream. (12/10/2008; Tributary name: Waikamoi (64004001); PBN: tss006p-318-121008; Surveyor: Sakihara, T. Habitat type: Pool; SBN: tss006r-121008; Lat. (DD): 20.87317, Long. (DD): -156.18536).

Figure 4-3. Photo of a dry waterfall with very little flow at site 11 below the diversion on Waikamoi Stream. (12/10/2008; Tributary name: Waikamoi (64004001); PBN: sh011p-336-121008; Surveyor: Hau, S.; Habitat type: Plunge Pool; SBN: sh011n-121008; Lat. (DD): 20.87132, Long. (DD): -156.18871).

Figure 4-4. Photo showing a diversion upstream from site 1 in Waikamoi Stream. Red arrow shows natural stream flow direction. (12/10/2008; Tributary name: Waikamoi (64004001); PBN: sh001p-286-121008; Photo by: Hau, S.; SBN: sh001d-121008; Lat. (DD): 20.87096, Long. (DD): -156.18929).

Figure 4-5. Photo of control gate at diversion below site 1 in Waikamoi Stream. (12/10/2008; Tributary name: Waikamoi (64004001); PBN: sh001p-300-121008; Photo by: Hau, S.; SBN: sh001d-121008; Lat. (DD): 20.87096, Long. (DD): -156.18929).

## Upper Reach

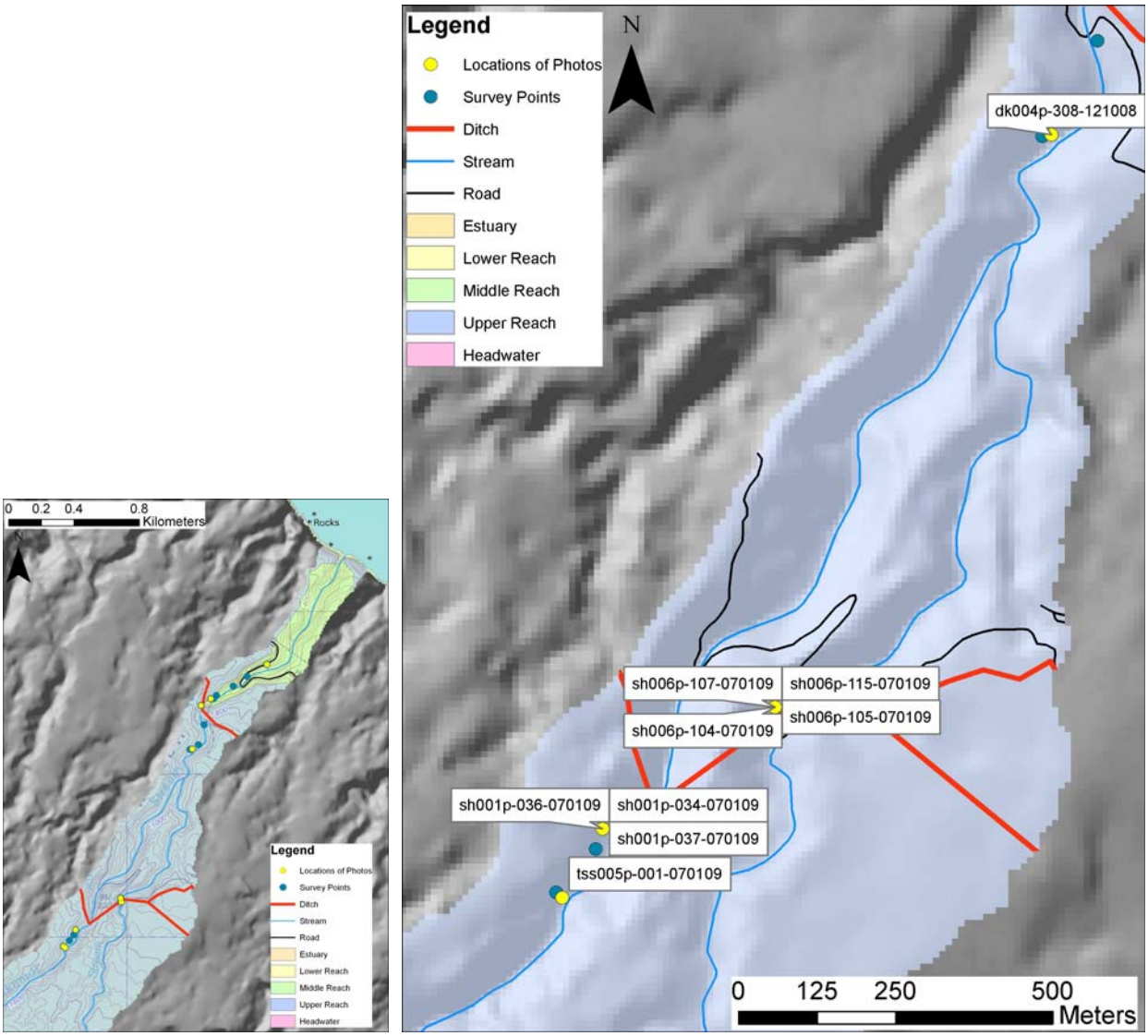


Figure 4-6. Photo locations in the upper reach of Waikamoi Stream.

Figure 4-7. Photo of a plunge pool upstream of site 4 above the first diversion in Waikamoi Stream. (12/10/2008; Tributary name: Waikamoi (64004001); PBN: dk004p-308-121008; Surveyor: Kuamoʻo, D.; Habitat type: Pool; SBN: dk004r-121008; Lat. (DD): 20.86855, Long. (DD): -156.18985).

Figure 4-8. Photo of flow measurement (100% flow capture) into the diversion on Alo Stream. (7/1/2009; Tributary name: (64004002); PBN: sh006p-104-070109; Surveyor: Hau, S.; SBN: 128; Lat. (DD): 20.86037, Long. (DD): -156.19423).

Figure 4-9. Photo downstream of diversion and flow measurement in Alo Stream. All of the water is totally diverted. (7/1/2009; Tributary name: Alo (64004002); PBN: sh006p-107-070109; Surveyor: Hau, S.; SBN: sh001d-070109; Lat. (DD): 20.86037, Long. (DD): -156.19423).

Figure 4-10. Photo shows the stream above the diversion. Red circle showing asmall amount of water coming from water tunnel on the left. (7/1/2009; Tributary name: (64004002); PBN: sh006p-105-070109; Surveyor: Hau, S.; SBN: 128; Lat. (DD): 20.86037, Long. (DD): -156.19423).

Figure 4-11. Photo from access trail of diversion below site 6 on Alo Stream. (7/1/2009; Tributary name: Alo (64004002); PBN: sh006p-115-070109; Surveyor: Hau, S.; SBN: sh001d-070109; Lat. (DD): 20.86037, Long. (DD): -156.19423).

Figure 4-12. Photo of tunnel flowing into Alo Stream. (7/1/2009; Tributary name: (64004003); PBN: sh64004003p-096-070109; Photo by: Hau, S.

Figure 4-13. Photo of water flowing from tunnel under trail into Alo Stream. (7/1/2009; Tributary name: (64004002); PBN: sh64004002p-098-070109; Photo by: Hau, S.

Figure 4-14. Photo of upstream view of Alo Stream from bridge. No surveys were conducted beyond the bridge above site 7. (7/1/2009; Tributary name: (64004002); PBN: sh64004002p-118-070109; Photo by: Hau, S.

Figure 4-15. Photo upstream view from site 1 above upper diversion on Waikamoi. (7/1/2009; Tributary name: Waikamoi (64004003; PBN: sh001p-036-070109; Surveyor: Hau, S. Habitat type: No Water; SBN: sh001r-070109; Lat. (DD): 20.85866, Long. (DD): -156.1969).

Figure 4-16. Photo of downstream view from survey site 1 (no water in site) on Waikamo'i Stream. (7/1/2009; Tributary name: Waikamoi (64004003); PBN: sh001p-037-070109; Surveyor: Hau, S. Habitat type: No Water; SBN: sh001r-070109; Lat. (DD): 20.85866, Long. (DD): -156.1969).

Figure 4-17. Stream flow measurement slightly below survey site 1. (7/1/2009; Tributary name: (64004003); PBN: sh001p-034-070109; Surveyor: Hau, S. SBN: 127; Lat. (DD): 20.85866, Long. (DD): -156.1969).

Figure 4-18. Photo of the plunge pool where the survey site 5 was conducted. (7/1/2009; Tributary name: Waikamoi (64004003); PBN: tss005p-001-070109; Surveyor: Sakihara, T. Habitat type: Plunge Pool; SBN: tss005n-070109; Lat. (DD): 20.85768, Long. (DD): -156.19754).

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Pukui, M. K. and S.H. Elbert. 1971. Hawaiian Dictionary. University of Hawaii Press

Pukui, M.K., S.H. Elbert and E. T. Mookini. 1976. Place Names of Hawaii. University of Hawaii Press.

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# Appendix: Survey Sites Latitude and Longitude

| Tributary | Stream | Survey Book # | Site | Surveyor | Date | Latitude | Longitude |
|---|---|---|---|---|---|---|---|
| 64004001 | Waikamoi | sh001n-121008 | 1 | Hau, Skippy | 12/10/2008 | 20.87096 | -156.18929 |
| 64004001 | Waikamoi | sh001r-121008 | 1 | Hau, Skippy | 12/10/2008 | 20.87096 | -156.18929 |
| 64004001 | Waikamoi | tss002r-121008 | 2 | Shindo, Tim | 12/10/2008 | 20.86989 | -156.18912 |
| 64004001 | Waikamoi | ts003r-121008 | 3 | Shimoda, Troy | 12/10/2008 | 20.86879 | -156.18948 |
| 64004001 | Waikamoi | dk004r-121008 | 4 | Kuamo‘o, Darrell | 12/10/2008 | 20.86855 | -156.18985 |
| 64004001 | Waikamoi | sh005n-121008 | 5 | Hau, Skippy | 12/10/2008 | 20.86853 | -156.18999 |
| 64004001 | Waikamoi | sh005x-121008 | 5 | Hau, Skippy | 12/10/2008 | 20.86853 | -156.18999 |
| 64004001 | Waikamoi | tss006r-121008 | 6 | Shindo, Tim | 12/10/2008 | 20.87317 | -156.18536 |
| 64004001 | Waikamoi | ts007r-121008 | 7 | Shimoda, Troy | 12/10/2008 | 20.87253 | -156.18654 |
| 64004001 | Waikamoi | sh009r-121008 | 9 | Hau, Skippy | 12/10/2008 | 20.87151 | -156.18837 |
| 64004001 | Waikamoi | tss010r-121008 | 10 | Shindo, Tim | 12/10/2008 | 20.87133 | -156.18854 |
| 64004001 | Waikamoi | sh011x-121008 | 11 | Hau, Skippy | 12/10/2008 | 20.87132 | -156.18871 |
| 64004001 | Waikamoi | sh011n-121008 | 11 | Hau, Skippy | 12/10/2008 | 20.87132 | -156.18871 |
| 64004002 | Alo | sh006x-070109 | | Hau, Skippy | 7/1/2009 | 20.86037 | -156.19423 |
| 64004002 | Alo | sh006n-070109 | 6 | Hau, Skippy | 7/1/2009 | 20.86037 | -156.19423 |
| 64004002 | Alo | tss007r-070109 | 7 | Sakihara, Troy | 7/1/2009 | 20.86016 | -156.19417 |
| 64004003 | Waikamoi | sh001r-070109 | 1 | Hau, Skippy | 7/1/2009 | 20.85866 | -156.19690 |
| 64004003 | Waikamoi | tss002r-070109 | 2 | Sakihara, Troy | 7/1/2009 | 20.85837 | -156.19701 |
| 64004003 | Waikamoi | tts003r-070109 | 3 | Shindo, Tim | 7/1/2009 | 20.85807 | -156.19728 |
| 64004003 | Waikamoi | sh004r-070109 | 4 | Hau, Skippy | 7/1/2009 | 20.85776 | -156.19763 |
| 64004003 | Waikamoi | tss005n-070109 | 5 | Sakihara, Troy | 7/1/2009 | 20.85768 | -156.19754 |

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