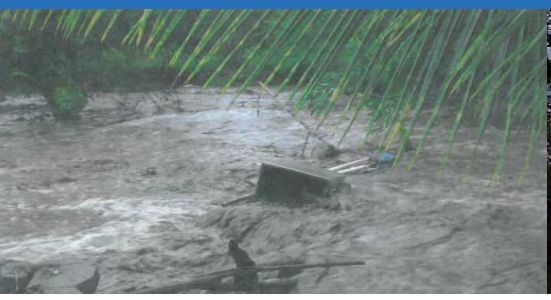
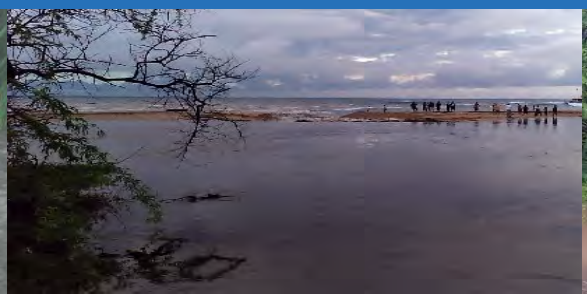
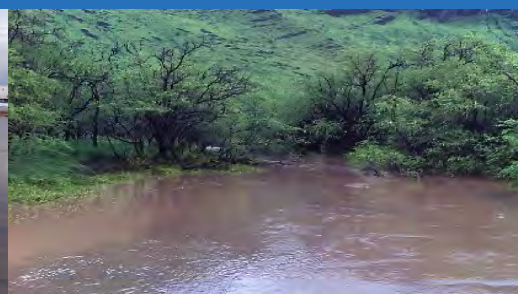
Mākaha Valley Flood Mitigation Study

PUBLIC REVIEW DRAFT- APPENDICES
AUGUST 2014

Volume II of III

Prepared for:
Department of Land and Natural Resources
Engineering Division

Prepared by:
Townscape, Inc.
with the assistance of
Okahara and Associates, Inc.

A special mahalo to community members who

contributed their time to share their mana‘o.

Photographs on the cover page (from left to right):

Flooding behind homes on Manuku Street during December 2008 storm; Sand berm break at the mouth of Mākaha Stream; Stream flow at Mākaha Stream during heavy rains (facing upstream)

APPENDIX A

STAKEHOLDER OUTREACH

In order to better understand the historical flooding and flooding issues in the area, it is best to engage with community members, major land owners, and businesses that have experienced the flooding problems "first-hand" and who are most knowledgeable about the area. Input from key stakeholders and the community to determine whether potential mitigation measures, projects and actions are realistic and feasible for the area is critical to develop a successful mitigation plan. The project team met with community stakeholders, residents, business owners, large land owners, public agencies, and elected officials. Below is a list of stakeholders consulted via one-on-one meetings, small group meetings, site visits to problem areas with stakeholders, or phone conference.

Name	Affiliation
Kea Among	Local resident
Tim Ayau	Local resident; Mākaha golf course superintendent
Bunky Bakutis	Local resident
Justin Bly	Land owner of large undeveloped parcels
Bill Bow	Bow Engineering (Consultants for Mākaha Oceanview Estates)
Brian Campbell	Bow Engineering (Consultants for Mākaha Oceanview Estates)
Lucky Cole	Mākaha Marketplace owner
John DeSoto	Local resident; President of Mauna 'Olu Estates Homeowner's Association Board
Lois Durr	Local resident
Eric Enos	Local resident
Len Furukawa	City's Department of Planning and Permitting
Al Frenzel	Local resident
Jo Jordan	State Representative
Eric Kadooka	Wilson Okamoto (Consultants for Mākaha West Golf Course renovations)
Micah Kane	Pacific Links Hawai'i
Kapua Kawelo	U.S. Army Garrison-Hawai'i, Environmental Division
Buffalo Keaulana	Local resident; long time Mākaha lifeguard
Henry Kennedy	State Department of Transportation
Glen Kila	Local resident; Koa Mana Resources
Chris Lau	Towne Realty
Dexter Liu	City's Department of Parks and Recreation
Curtis Matsuda	State Department of Transportation
Mike Matsuo	City's Board of Water Supply
Wise & Nancy Nicola	Local resident
Joe Nunuha	Mākaha Plantation Condos (General Manager)
Michael Okamoto	R.M. Towill (Consultants for Farrington Highway DOT Bridge Replacement project)
Landis Ornellas	Care taker of Kāne'ākī Heiau; local resident
Cynthia Rezentes	Local resident; Mohala I Ka Wai
Maile Shimabukuro	State Senator
Steve Sigler	State Civil Defense
Tyler Sugihara	City's Department of Facilities and Maintenance
Mark Suiso	Local resident
Larry Sumida	Pacific Links Hawai'i
Thomas Takeuchi	City's Department of Facilities and Maintenance
Amy Tsuneyoshi	City's Board of Water Supply
Barry Usagawa	City's Board of Water Supply

Mākaha Valley Flood Study

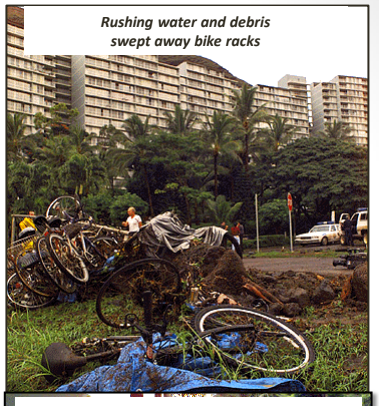
Community Meeting No. 1

March 25, 2014

1996 storm

Car overturned in upper parking lot of Mākaha Valley Towers

Mud and debris fill the lobby of Mākaha Valley Towers



Rushing water and debris swept away bike racks

Cars and debris block lobby door to Mākaha Valley Towers after heavy rains caused a mudslide

Photo credit: Star-Bulletin

2008 storm

Kili Drive mauka of Mākaha Valley Towers

Photo Credit: Hawaii State Civil Defense

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Backyard of resident on Manuku Street turns into a river

Photo Credit: KHNL

Broken berm below Mākaha West Golf Course

Photo Credit: Hawaii State Civil Defense

Flooding near Farrington Highway

Photo Credit: Hawaii State Civil Defense

Agenda

- Project Background
- Existing conditions in Mākaha
- Flood map & drainage issues
- Preliminary Flood Mitigation Measures
- Next steps

Project Background

- Funded by House Bill No. 2883 in 2012
- Appropriated $500,000 for flood study

  "The purpose of this Act is to require the department of land and natural resources to conduct a flood study for Mākaha Valley and investigate all potential funding sources to finance the flood study and any improvements or repairs as recommended by the flood study."
- Contracted Townscape, Inc. to conduct flood study
  - Subconsultants: Okahara and Associates

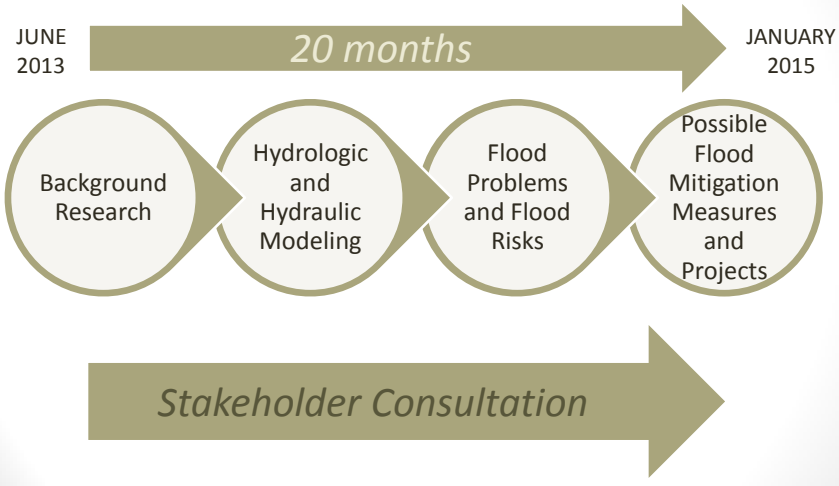
Our commitment to the Mākaha community:

- We will present FLOOD FACTS based on objective analysis.
- We will work with the Mākaha community, your elected officials and the DLNR to implement FLOOD MITIGATION PROJECTS for Mākaha Valley.

Townscape projects in Waiʻanae

- **Mākaha Flood Study**- Dept. of Land & Natural Resources
- **Maʻiliʻili Watershed Plan-** Dept. of Health
- **Kaʻala Cultural Learning Center Plan-** Kaʻala Farm, Inc.
- **Waiʻanae Sustainable Communities Plan Update**- Dept. of Planning & Permitting
- **Update of the Nānākuli and Waiʻanae/Lualualei Regional Plan**- Dept. of Hawaiian Homelands
- **Waiʻanae Watershed Management Plan-** Honolulu Board of Water Supply
- **Mākaha Special Area Plan**- Dept. of Planning & Permitting
- **Nānākuli Valley Cultural Landscape Plan-** Mālama Nānākuli Ahupuaʻa

Project Scope and Schedule



Our Stakeholder Outreach Process

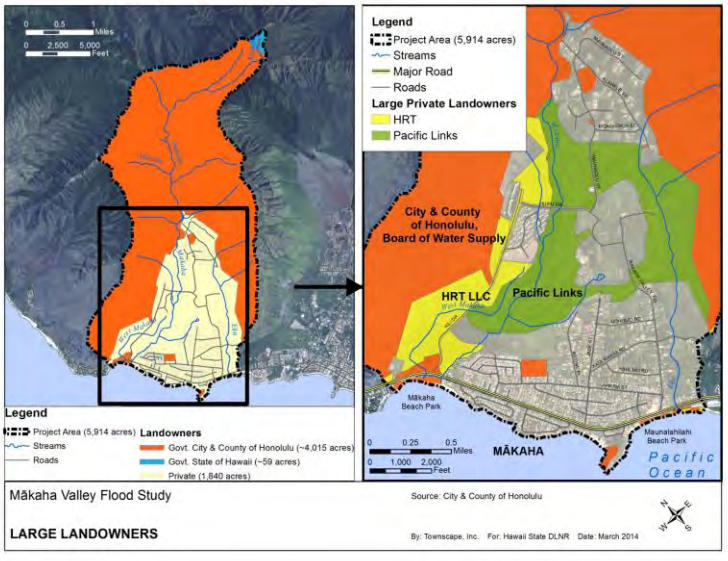
Community	• Community members • Land owners • Businesses
Public Agencies	• State Department of Transportation • State Civil Defense • City DPP Drainage • Board of Water Supply
Elected Officials	• Representative Jo Jordan • Senator Maile Shimabukuro

Wai‘anae Moku

Project Area

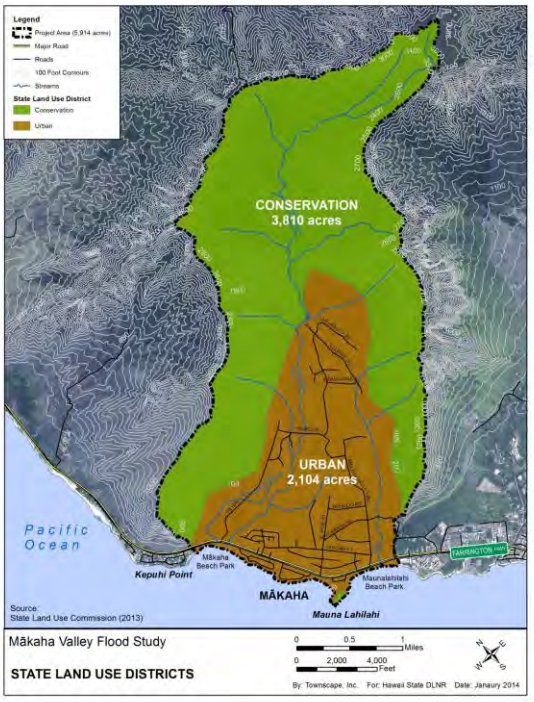
- Total area: **5,914 acres**
- Streams:
  - Mākaha
  - West Mākaha
  - Eku
- Annual Rainfall: 22 to 76 inches per year
  - 1996- 22” over 5 days
  - 2008- 12” in 1 day

Landowners



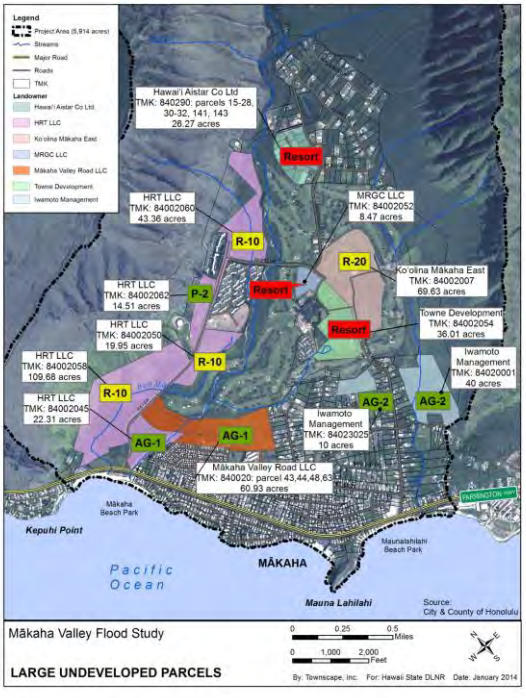
State Land Use Districts

- 35% of the valley is urban
- Largest urban district in the Wai‘anae Moku



Large Undeveloped Parcels

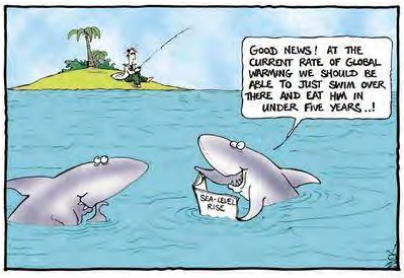
- 13+ large undeveloped parcels
- Total 462 acres
- Zoning could allow for single family homes, hotels, duplex units, recreational facilities



Runoff from a 20-acre parcel in Mākaha that is zoned for residential use for a 10-year flood is approximately :

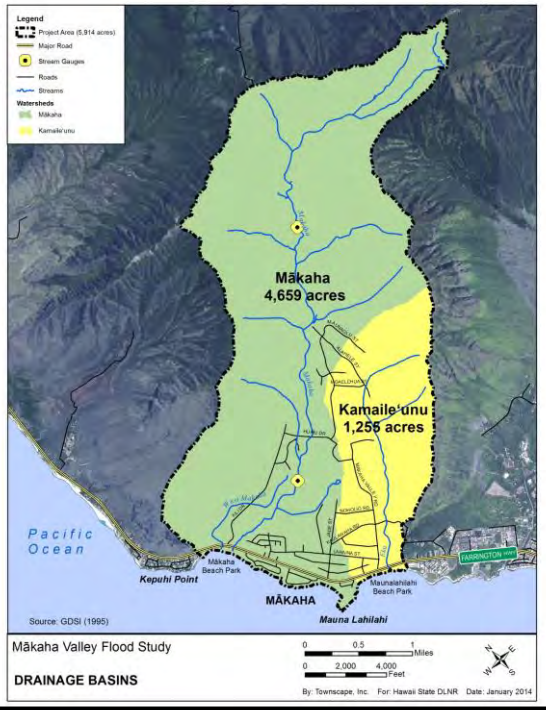
Impacts of climate change include:

- Increase in air temperature
- Decrease in rainfall
- Increase in intensity of major storms
- Increase in sea level and ocean temperatures
- Increase in ocean acidity resulting in coral reef die-off



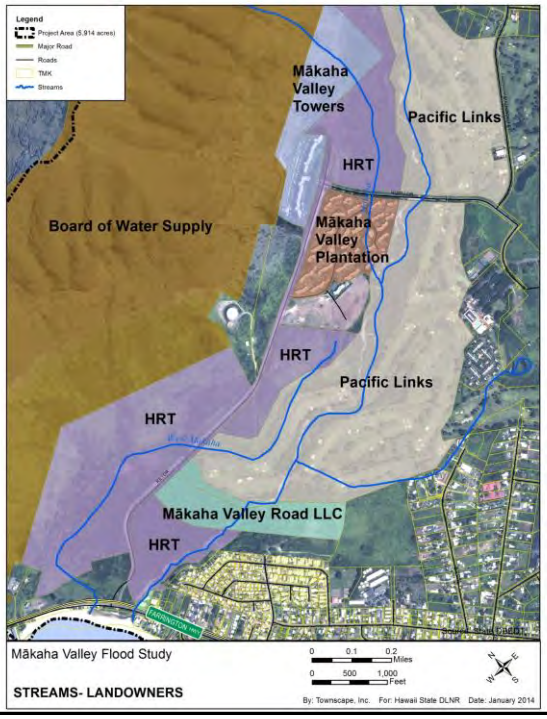
Drainage Basins

- 75% of the valley drains into Mākaha Stream
- 25% of the valley drains into Eku Stream



Mākaha and West Mākaha Streams

- Not owned by one single entity, but shared by many private landowners
- Responsibility for maintaining a stream rests with the owner of the stream



Eku Stream

- Property lines include up to the centerline of stream

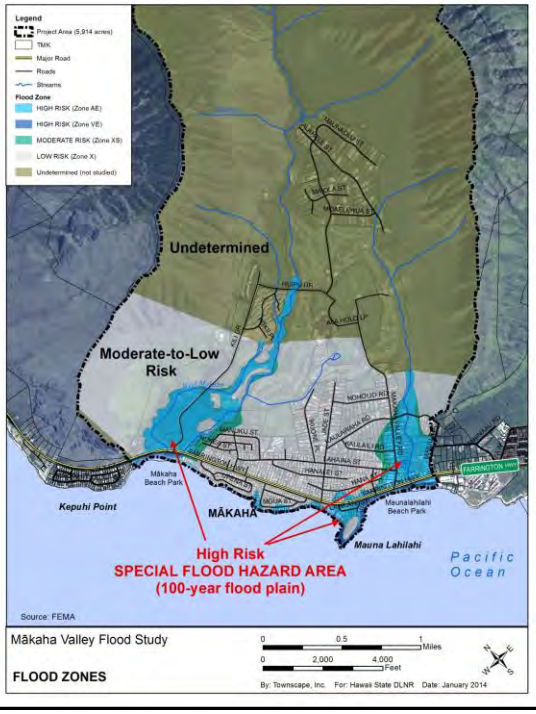
Overgrown vegetation in Eku Stream

Photo Credit: Hawaii State Civil Defense

Flood Insurance Rate Map

<u>3 general types of flood zones:</u>

- High Risk
- Moderate-to-Low Risk
- Undetermined Risk



What is a High Risk Area?

- SPECIAL FLOOD HAZARD AREA- Zones A and Zones V
  - Flood insurance requirement
  - Building standards
- At least 26% chance of flooding during a 30-year mortgage
- ISSUE- Houses built before 1980 in high risk areas may not meet FEMA building standards

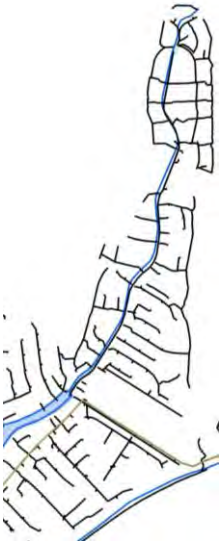
FEMA

NATIONAL FLOOD INSURANCE PROGRAM

Drainage Systems

- Includes berms, concrete channel, swales, concrete pipes
- Ditch/berm located:
  - Behind Mākaha Valley Towers
  - Behind Mauna ‘Olu Estates
  - Below golf course

Example of "Well-Planned" Drainage System



Mākaha Valley Current Drainage System: "Piece-meal"

Flooding in Mākaha is caused by:

- Damaged drainage systems

Damaged water berm wall in lower Mākaha

Flooding in Mākaha is caused by:

- Damaged drainage systems
- Depressions and lack of drainage infrastructure

Flooding in Mākaha is caused by:

- Damaged drainage systems
- Depressions and lack of drainage infrastructure
- Clogged drainage infrastructure

Rocks and debris clog storm drains along Kili Drive

Flooding in Mākaha is caused by:

- Damaged drainage systems
- Depressions and lack of drainage infrastructure
- Clogged drainage infrastructure
- Sand berm restricts discharge into ocean

Mākaha Valley Flood Study- Community Meeting No.1

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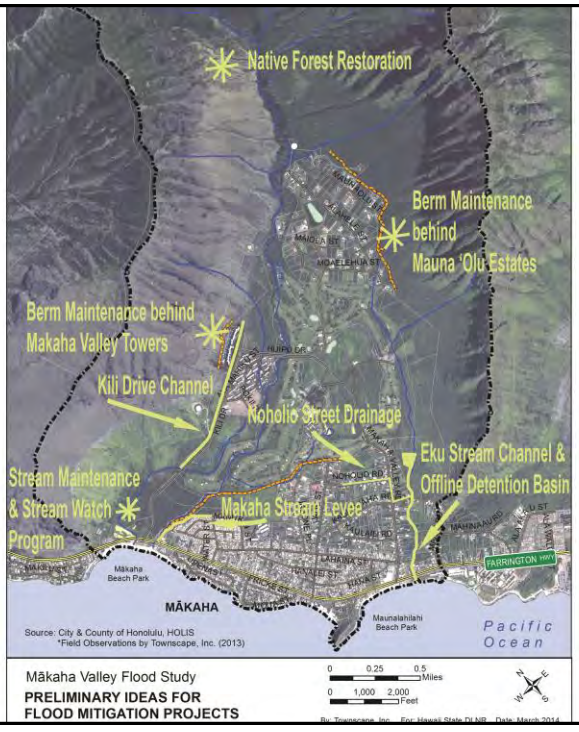

**Projects shown are for illustrative purposes only.*

Mākaha Valley Flood Study- Community Meeting No.1

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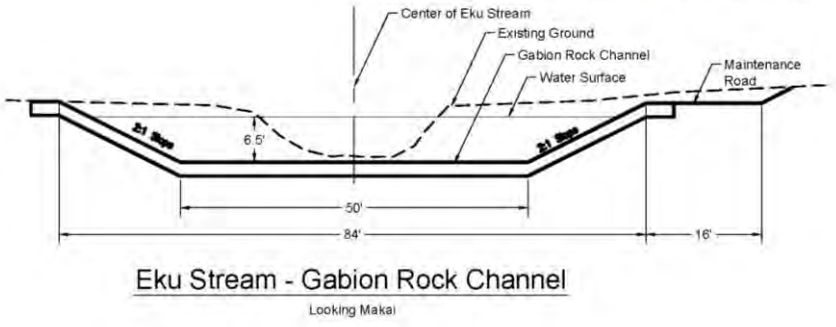
Preliminary ideas for flood mitigation measures

STRUCTURAL



Eku Stream - Gabion Rock Channel

Looking Makai

Mākaha Valley Flood Study- Community Meeting No.1

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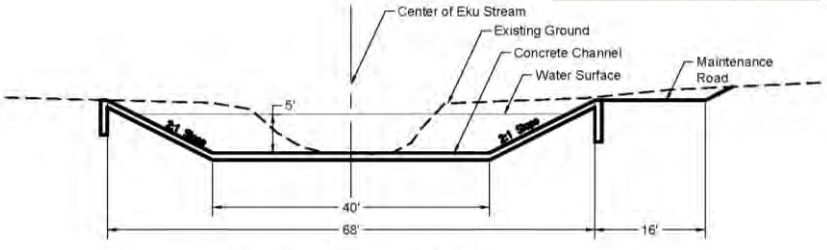
Preliminary ideas for flood mitigation measures

STRUCTURAL



Eku Stream - Concrete Channel

Looking Makai

Mākaha Valley Flood Study- Community Meeting No.1

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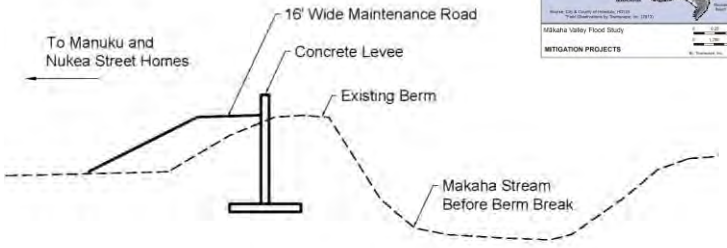
Preliminary ideas for flood mitigation measures

STRUCTURAL

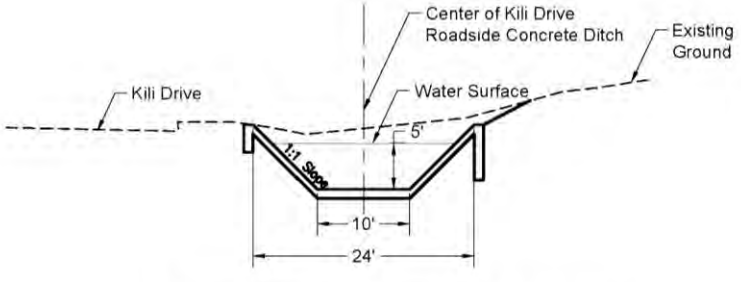


Makaha Stream Levee

Looking Makai

Preliminary ideas for flood mitigation measures

STRUCTURAL



Kili Drive - Concrete Channel

Looking Makai

Preliminary ideas for flood mitigation measures

NON-STRUCTURAL

- Stream Channel Scheduled Maintenance
  - Remove debris in channel
  - Maintain overgrown vegetation

Preliminary ideas for flood mitigation measures

NON-STRUCTURAL

- Storm Drainage Infrastructure Maintenance
  - Including berm/ditch behind Mākaha Valley Towers and Mauna ʻOlu Estates

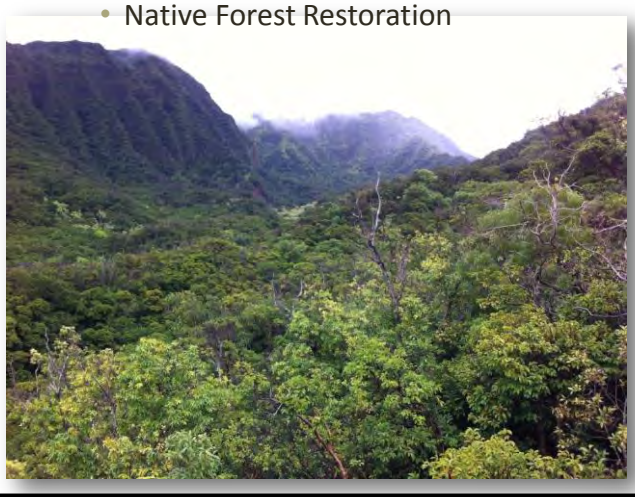
Earth berm eroding beneath gunnite

Rocks filled to the top of the debris poles

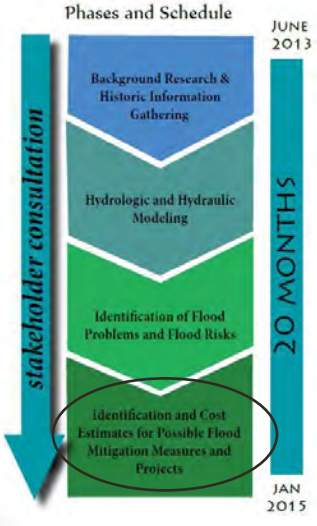
Preliminary ideas for flood mitigation measures

NON-STRUCTURAL

- Native Forest Restoration



Next steps…



- Finalize flood mitigation measures
- Provide cost estimates and “effectiveness analysis”
- Develop priority/phased list for flood control measures
- Identify funding sources for projects

Thank you for your attention.

Questions?

Contact Information:

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Environmental & Community Planning

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bruce@townscapeinc.com

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Environmental & Community Planning

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MĀKAHA VALLEY FLOOD STUDY
NOTES FROM COMMUNITY MEETING NO.1
MARCH 25, 2014

Meeting purpose

The purpose of the meeting was to share preliminary findings for Mākaha Valley Flood Study and to hear concerns about flooding in Mākaha and ideas to mitigate flooding.

State Representative Jo Jordan opened the meeting and thanked people for attending. (A total of 55 people signed in.) William J. Aila, Jr., DLNR Chairperson, gave some introductory remarks. Bruce Tsuchida, President of Townscape, Inc. introduced the members of the planning team and outlined the meeting agenda.

Gabrielle Sham of Townscape presented a slideshow that provided an overview of the following:

- Background information on the Flood Study
- Existing conditions in Mākaha Valley
- Federal Emergency Management Agency's Flood Map and drainage issues in Mākaha
- Preliminary flood mitigation ideas
- Next steps

The slideshow can be downloaded from DLNR's site at: http://dlnreng.hawaii.gov/fcds/?p=465

After the slideshow, meeting participants were asked to share their concerns about flooding in Mākaha and ideas to mitigate flooding. A summary of the various questions and comments and responses that were given by Bruce Tsuchida is provided below. Townscape's comments and responses are in Italics.

Concerns about the proposed Mākaha Stream Levee idea

- Does it extend to the bridge? *The Levee will extend to the bridge at Farrington Hwy.*
- The levee cannot be constructed since it will be within the floodplain.

Concerns about Kili Drive/ West Mākaha Stream

- Proper drainage is needed for Kili Drive.
- There is no drainage on Kili Drive. It acts like a dam and restricts water from entering into West Mākaha Stream.

- Historically, West Mākaha Stream was the major stream. Currently, Mākaha Stream receives all the flows.

- If West Mākaha Stream is restored, it will solve some of the flooding problems.
- Is Townscape aware of the history of Kili Drive? *We know that Kili Drive is a privately-owned road, and that the drainage structures in Kili Drive are not well maintained.*

Concerns about the DOT Bridge Project

- The DOT Bridge project should not move forward.
- The DOT Bridge project intentionally floods homes on Manuku and Nukea Street.
- Has Townscape reviewed the EA done for Mākaha Stream by R.M. Towill?
- The DOT Bridge project will put in a 12-foot riprap wall on HRT's side of Mākaha Stream and a 10-foot riprap wall on the Nukea/Manuku side of the Mākaha Stream. Based on R.M. Towill's map, as a result of the DOT project, homes on Nukea and Manuku Street will be in the floodplain. HRT is the big beneficiary from the DOT Bridge project.
    - Can Okahara verify the floodplain on R.M. Towill's map?

Maintenance issues

- Stream maintenance is a problem. There was a blockage in Eku Stream restricting flows from discharging during the 2008 storm. After 2008, the State Civil Defense was given authority to remove debris. Since then, there hasn't been flooding in the area that flooded previously in 2008.
- Need education on proper way to maintain the streams. What can residents do now?
- A community member said that there is a storm drain that ends in her yard that was put in by the developers. She is not sure who is responsible for maintaining the storm drain.
- What are the condition of the drainage systems behind the Towers and Mauna 'Olu Estates? Are they being maintained?

Concerns about proposed Eku Stream Channel idea

- Instead of the proposed rock or concrete flood channel, can we use check dams or vegetation to capture more of the runoff?
- Another community member later commented that the proposed detention basin at the mauka end of the proposed Eku Stream flood channel would capture some of the runoff.

General flooding issues

- Drainage systems are often clogged with trash.
- Lahaina Street itself acts like a stream. It slopes from Kea`au side to Wai'anae side. There was so much flooding in 2008 that it created a sinkhole at the intersection of Lahaina Street and Mākaha Valley Road.
- Is BWS maintaining the berms behind Mauna 'Olu Estates and Mākaha Valley Towers?

- A community member said that there is an easement on her property for a drain pipe and she has to maintain it. There is a lot of rubbish from the drain pipe that discharges onto her property. During a site visit from the City, she was told that the drain pipe was not built to the required design specifications.
- A resident on Manuku Street lost a lot of land when it flooded in 2008 and she is concerned that if the flooding continues, she will lose more land in the future.
- During the 2008 storm, the fast flowing storm waters created a v-shape in the stream. Boulders ended up settling in the lower Mākaha stream and, as a result, the streambed is now shallower.
- There is a 'concrete spillway' located makai from a community member's house on Manuku Street. She is not sure what it is.
- Just before the 2008 flood someone used a bulldozer in lower Mākaha Stream and now homes will experience even worse flooding.
- There was lots of debris from the 2008 storm, including a goat and a boat that were found in the stream.
- Flooding from sheet flow is a concern.
- There have been many changes in the valley that affects runoff particularly in the lower valley.
- A storm drain runs under and onto the Mākaha Valley Plantation (MVP) from the Towers, which causes flooding problems for MVP. Part of the MVP became a small lake during the 2008 storm.

General comments

- Future development in the valley needs to provide for flood control.
- Community members are concerned with impacts on flooding from future development in the valley. *We know that more development will increase stormwater runoff in Makaha Valley.*
- Lands designated as conservation should remain as conservation lands.
- Flooding is an ongoing problem in the valley. Profits are put before people.
- We need to understand the drainage problem first, before we propose more mitigation projects.
- The Flood Study proposes project ideas that were developed independently. The Flood Study needs to work together with other studies/projects done in the valley that may affect flooding.
- There used to be two stream gages, but there is only one in the valley now. Also, does FEMA use rain gage data to determine flood insurance rates? The rain gage is located up in the top of the valley where it rains more than the lower area. *There were two USGS stream gages on Makaha Stream: one in the upper reach of the stream and one lower, in the golf course. The upper gage is still operational, but the lower gage was discontinued in 1996 due to lack of funding.*
- There was an overflow from the pond that was used for firefighting. If detention basins are put in, we need to make sure they do not cause more damage and flooding.
- Flood waters in Eku Stream were very high in 2008 – up to the middle of a car.
- We need good communication to get to a win-win situation. Need to aloha the 'āina.
- Concerned that Pacific Links was able to rezone some of their land.

- Concerned with the hikes in flood insurance. Does the Flood Study reduce the floodplain? *Yes – the flood channel and detention basin that we are looking at for Eku Stream will contain the 100 year flood, which will mean that homes in that area will no longer be in the flood plain.*
- The City has allowed property owners to do what they want in the valley, but "we all get the damage."
- Pacific Links recently submitted their CLOMR. How does the Flood Study tie in with Pacific Links plans?
- Does the Flood Study have enforcement powers? *No, this Study does not have enforcement powers.*
- Need to improve road area and get storm drains in the lower Mākaha area. *We understand the need, but the problem is that these roads are almost all privately owned and so private entities will have to do the storm drain maintenance.*
- Need to make sure that the stormwater goes under the road and not over the road at Farrington Highway.
- The City, State and Federal government takes no responsibility and no accountability.
- In 1987, a family was not allowed to build a fale in the streambed, but now there is a concrete pad and garden in the streambed further up. Why was there such strict enforcement previously?
- What are best practices with water retention on developed land?
- Some people may be concerned about crime when keeping streams cleared because it allows people to move through the stream easily.

Flood mitigation ideas

- Detention basins in the valley make sense since they can be used as for firefighting as well. A community member remembered seeing helicopters use a bucket to retrieve water from a pond in the valley.
- Is it possible to put in underground drainage in Mākaha, for example in Mililani Mauka where there are concrete pipes under the houses? *This would be technically possible but the cost would be very high.*
- Need to provide more guidance to landowners on how to maintain the streams and share current best practices to landowners on how to properly maintaining streams and berms. Residents should be inspecting streams, culverts, and berms regularly.
- Storm water retention is needed, which will help with both runoff and recharging the aquifer.
- A riprap should be built at the bridge on Huipu Street going downstream. This would help with flooding problems on Mākaha Valley Plantation.*

***** Comments received from attendees, but not mentioned at the Community Meeting.

APPENDIX B

WATERSHED CHARACTERIZATION

Mākaha Valley Flood Mitigation Study

Draft Task 1 Report

August 2013

Prepared For:
Hawai'i State Department of Land and Natural Resources – Engineering Branch

Prepared By:
Townscape, Inc.

Mākaha Valley Flood Mitigation Study

Draft Task 1 Report

August 2013

Prepared For:
Hawai'i State Department of Land and Natural Resources – Engineering Branch

Prepared By:
Townscape, Inc.

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MĀKAHA VALLEY FLOOD MITIGATION STUDY
TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

APPENDICES

Appendix A Field Recon Memos

Appendix B USGS Stream Peakflow Data

ACRONYMS

ASCE	American Society of Civil Engineers
BFE	Base Flood Elevation
BWS	Honolulu Board of Water Supply
C&C	City & County of Honolulu
CFS	Cubic feet per second
CWRM	Commission on Water Resource Management
DLNR	Department of Land and Natural Resources
DMA	Disaster Management Act of 2000
FEMA	Federal Emergency Management Agency
FIRM	Federal Insurance Rate Map
GAP	Gap Analysis Program
GIS	Geographic Information Systems
HAR	Hawai‘i Administrative Rules
HRS	Hawai‘i Revised Statues
MAS	Mitigation Assessment Study
MGD	Million gallons per day
MS4	Municipal Separate Storm Sewer System
MSAP	Mākaha Special Area Plan
NAD83	North American Datum of 1983
NFIP	National Federal Insurance Program
NOAA	National Oceanic and Atmospheric Administration
NRCS	Natural Resources Conservation Service
RFL	Repetitive Flood Loss

ROH	Revised Ordinances of Honolulu
SCP	Sustainable Communities Plan
SFHA	Special Flood Hazard Areas
SRL	Severe Repetitive Loss
TMK	Tax Map Key
USACE	U.S. Army Corps of Engineers
USDA	United States Department of Agriculture
USGS	United States Geological Survey
UTM	Universal Transmercator (map projection)
WWMP	Waiʻanae Watershed Management Plan
WSCP	Waiʻanae Sustainable Communities Plan
WWTP	Waiʻanae Wastewater Treatment Plant

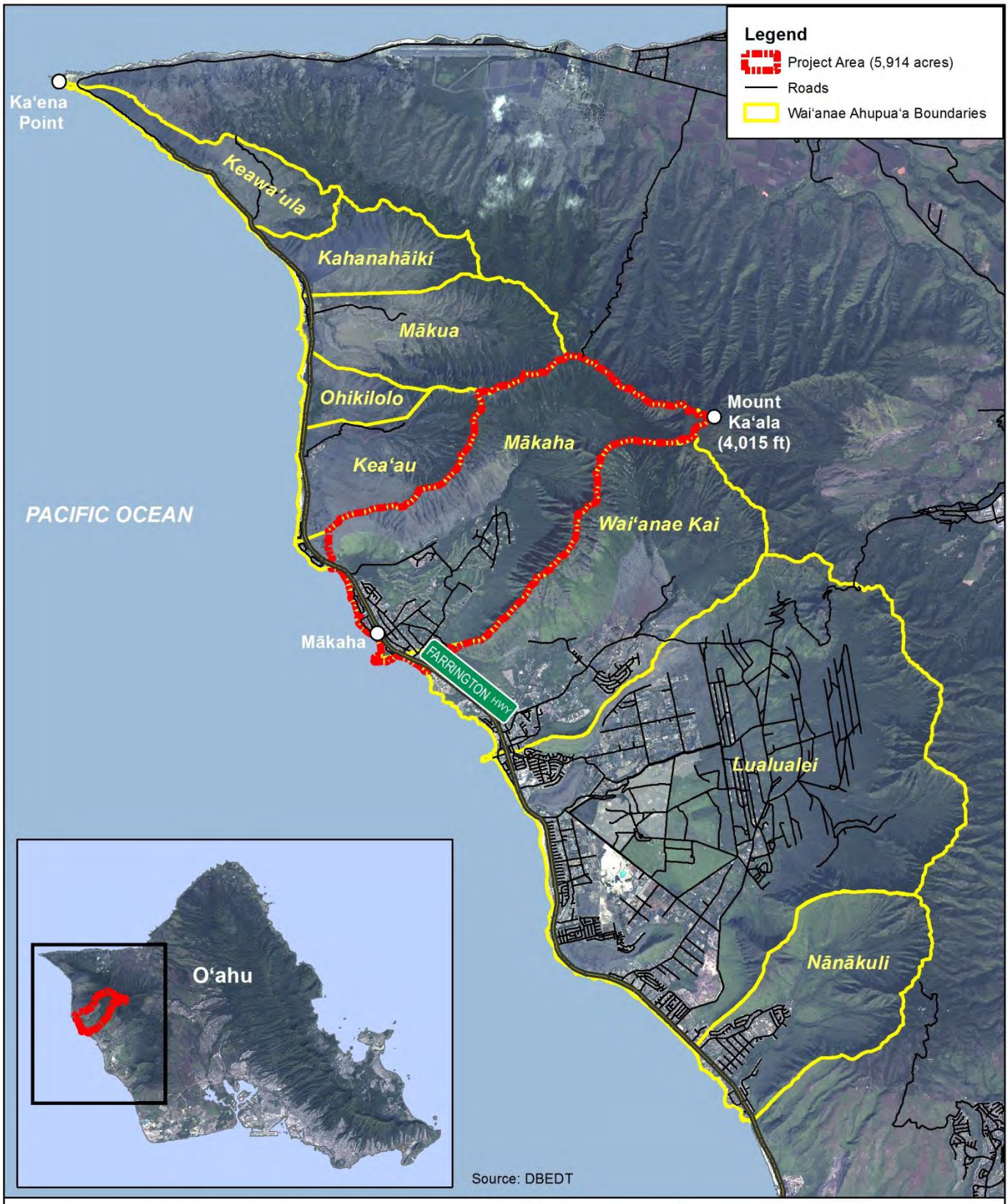


FIGURE 1. PROJECT LOCATION

1. INTRODUCTION

The Mākaha Valley Flood Mitigation Study has been conducted in accordance with Act 283, SLH 2012, which requires the Department of Land and Natural Resources (DLNR) to prepare a flood study for Mākaha Valley, to investigate all potential funding sources to finance the study, and to provide any improvements or repairs recommended to mitigate the flooding. Under the 810 program, Prevention of Natural Disasters, DLNR is responsible for addressing floodplain management issues. The goals of the 810 Program are to:

> *"protect people and their property from unwise floodplain development, and to protect society from the costs associated with developed floodplain through floodplain management activities and regulations of dams and reservoirs."*

Mākaha Valley is a major watershed on the Waiʻanae Coast on the island of Oʻahu where flooding is a major problem during heavy rains. Storm runoff causes streams to overflow because of inadequate stream capacity, causing significant property damage on several occurrences.

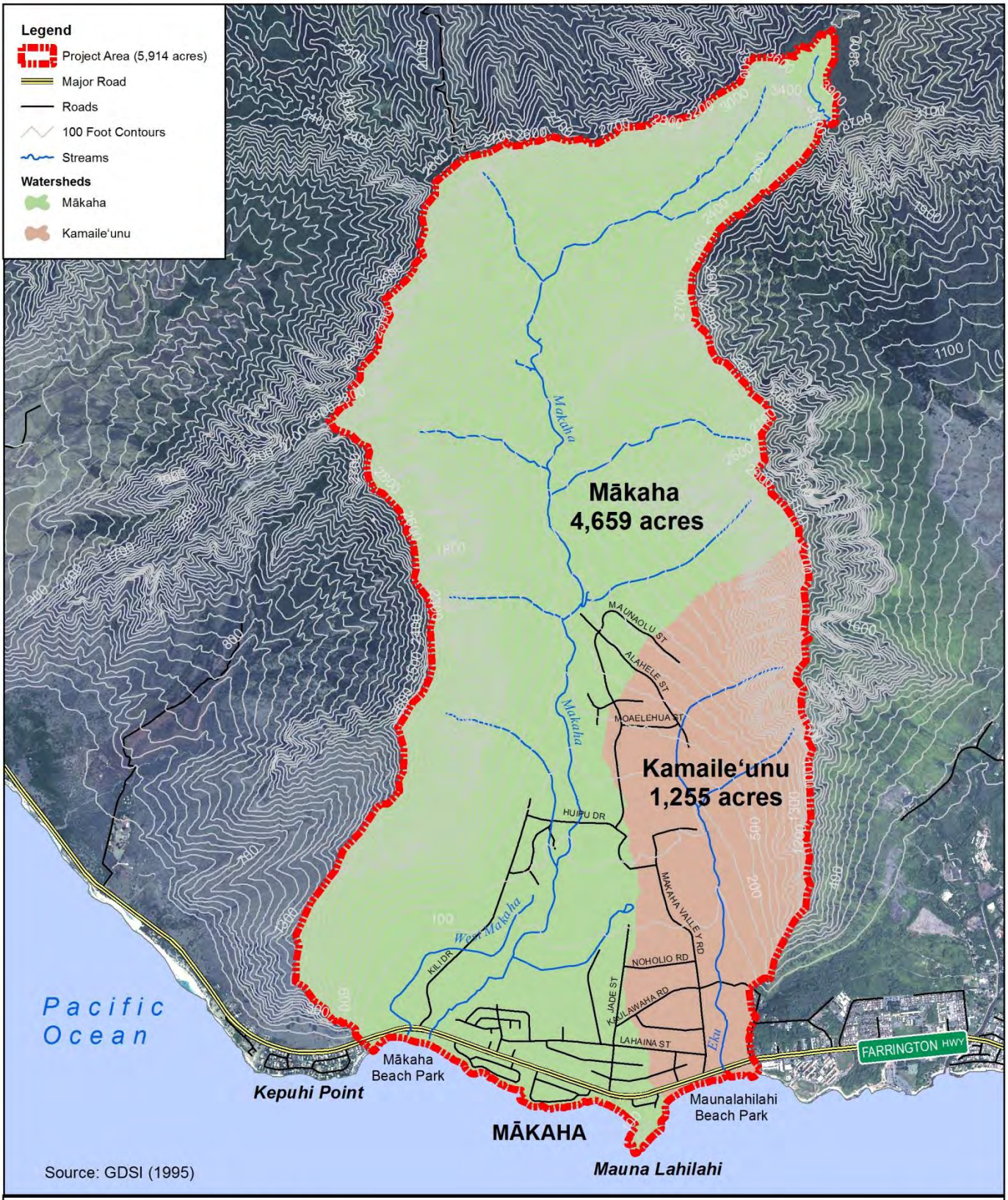
A flood study was conducted in 1982 by the U.S. Army Corps of Engineers (USACE) for South Mākaha Stream, located in Mākaha Valley. Although a debris basin, channel improvements and a new bridge were proposed, a more detailed study a year later by USACE suggested that the cost-benefit ratio did not justify the project recommendations.

Over the years, Mākaha Valley has experienced numerous floods, including a 15-day rain event in November 1996 that occurred along the Waiʻanae Coast. A total of 24 inches fell within the two weeks in an area that normally is subject to an annual rainfall of no more than 25 to 50 inches in Mākaha Valley. The flooding also caused a landslide that swept away approximately sixty cars from the Mākaha Valley Towers complex and flooded the first floor of the building. During another flooding event in December 2008, the Mākaha West Golf Course closed its seventh hole due to flood damages.

1.1 LOCATION AND GEOGRAPHIC SCOPE

Mākaha Valley is located on the west coast of Oʻahu in the State of Hawaiʻi. Situated between Waiʻanae to the south and Keaʻau to its north, it is one of five communities that make up the Waiʻanae District which also includes Nānākuli, Māʻili, Lualualei, and Waiʻanae (Figure 1). Mākaha Valley covers about 5,914 acres of land, comprised of both the Mākaha (4,659 acres) and Kamaileʻunu (1,255 acres) watersheds (Figure 2).

Mākaha Valley's boundaries are marked by the Kamaileʻunu ridge on the southern side that is shared with Waiʻanae Valley and Keaʻau ridge on the northern side. The highest peak of the Valley, and of Oʻahu, is Mount Kaʻala at an elevation of 4,015 feet. Along the coast, Mauna Lahilahi marks the southern side of Mākaha Valley, while Kepuhi Point marks the northern side. There are two long beaches along the shoreline: Mākaha Beach that starts from Kepuhi Point to the south of Mākaha Stream, and Papaoneone that is just north of Mauna Lahilahi.



Mākaha Valley Flood Study

FIGURE 2. PROJECT BOUNDARY

0 0.5 1 Miles

0 2,500 5,000 Feet

By: Townscape, Inc. For: Hawaii State DLNR Date: August 2013

1.2 SUMMARY OF RESEARCH METHODOLOGY

In order to better understand historical flooding and flooding issues in Mākaha, the study team undertook initial information gathering that consisted of:

- data compilation of existing plans, policies, and studies relevant to the area,
- stereoscopic aerial photo analysis,
- geographic information systems analysis,
- field observations,
- stakeholder outreach.

Through this process, the team identified data gaps and additional data collection needs that are required to successfully conduct this study.

Stereoscopic Aerial Photos

Stereoscopic photography recreates the illusion of depth by utilizing the binocularity of human vision. When two similar photographs are placed side by side and viewed through an instrument with special lens called a stereoscope, it creates the illusion of objects in spatial depth. Stereoscopic aerial photos taken by R.M. Towill Corporation in 1966, 1984, 1992, and 1997 were examined to understand the topography and land uses for the valley. The photos were also used to approximate the shape and location of the drainage infrastructures behind Mākaha Valley Towers and Mauna ʻOlu Estates.

Geographic Information Systems

Geographic Information Systems (GIS) served as a tool to analyze and illustrate relevant information pertaining to the study area, including land uses, land ownership, land cover, rainfall, and zoning. The geographically referenced information is integrated with both quantitative and qualitative data that is useful for analysis of the study area and production of maps that are included throughout this report.

ArcGIS 10.1 was utilized for this study, and maps were produced using the North American Datum 1983, Universal Transmercator Zone 4 North projection. Data layers that were originally created in other projections were re-projected to NAD83 UTM 4N. Most of the data layers were obtained from the State Office of Planning, Hawaii Statewide GIS Program. Satellite images used in the majority of the maps are from the “World View 2” satellite imagery.

Field work

Field work provided an overview of the current conditions of the study area and helped to verify the accuracy of existing geospatial data. Through this fieldwork approach, the study team observed possible problem areas identified by stakeholders. Landis Ornellas, a long-time resident of Mākaha and former personal assistant to Chinn Ho, the developer of the Mākaha Resort, led several of the field reconnaissances of the valley.

Stakeholder outreach and public participation

Stakeholder outreach and engagement with community members is an integral part of obtaining first-hand accounts of flooding issues and is one of the most valuable sources of information about the study area.

Table 1 shows the Stakeholder Outreach Plan developed by Townscape, Inc. that includes community members, large land owners, and businesses in Mākaha Valley. Public agencies, including both State and City, and elected officials representing the people of Mākaha were also contacted. Outreach activities included one-on-one interviews and small group meetings.

In addition to the stakeholder interviews, community members are engaged throughout this study through a series of focus group meetings and a general community meeting. The purpose of the focus group meetings is to present findings from the initial information gathering, to document additional flood-related issues, and to discuss potential flood mitigation measures, projects, and actions. The purpose of the general community meeting is to present preliminary recommendations for the drainage problems and receive feedback for the draft flood mitigation plan.

TABLE 1. STAKEHOLDER OUTREACH PLAN

Planned Activities	Stakeholders involved/details	Timeline
Interview preparation	Prepare questions for one-on-one and/or small group meeting interviews with: • community members, • land owners and businesses, • and public agencies and elected officials.	Month 1
One-on-one and small group meetings	**Community:** • Landis Ornellas • Eric Enos • Al Frenzel • Candy Suiso • Mark Suiso • Tim Ayau • Bunky Bakutis • Mākaha Ahupuaʻa Community Association • Buffalo Keaulana • Mākaha Ahupuaʻa Community Association • Gigi Cocquio • John DeSoto • Glenn Kila • Kea Among • Neighborhood Board No.24 Waianae Coast	Month 1-2
One-on-one and small group meetings	**Landowners:** • Pacific Links (Micah Kane) • HRT • Justin Bly • Towne Realty (Chris Lau) • Koʻolina • Mākaha Valley Towers • Mākaha Plantation **Businesses:** • Lucky Cole • Mākaha Resort Manager	Month 1-2
One-on-one and small group meetings	**State Public Agencies**: • DOT • DLNR- DOFAW • DLNR- OCCL • DLNR- DENG • SHPD • State Civil Defense **City Public Agencies:** • ENV- Runoff Control • DPP- Drainage/Planning • BWS **Elected Officials:** • Senator Maile Shimabukuro • Rep. Jo Jordan • Councilmember Kymberly Pine	Month 2-3

1.3 EXISTING PLANS RELATING TO MĀKAHA VALLEY

Table 2 lists relevant reports, plans, and research that are related to Mākaha Valley.

TABLE 2. LIST OF PLANS RELATING TO MĀKAHA VALLEY

Title	Year
Watershed Work Plan for Waiʻanae Iki Watershed	1960
South Mākaha Stream Flood Control Study	1983
Statewide Capital Improvement Program Flood Control Projects	1994
Waiʻanae Sustainable Communities Plan	2000 (updated 2010)
Waiʻanae Watershed Management Plan	2009
Mākaha Special Area Plan	2009
Mitigation Assessment Study	2010
State of Hawaiʻi Multi-Hazard Mitigation Plan	2010

1.3.1 WATERSHED WORK PLAN FOR WAIANAE IKI WATERSHED (1960) [(1)]

The Watershed Work Plan for Watershed Protection and Flood Prevention for Waianae Iki Watershed was written in accordance with the United States Watershed Protection and Flood Prevention Act of 1954 (Public Law 566). This Act authorized the U.S. Department of Agriculture Soil Conservation Service (which is now the Natural Resources Conservation Service) to assist local organizations with flood mitigation issues. Under this Act, the Soil Conservation Service provides technical and financial assistance to help local sponsors fund the development of planning and the implementation of projects.

This Plan provides a general overview of the Waianae Iki watershed (consisting of Mākaha Valley and Waiʻanae Valley) by describing its physical, natural, and land use characteristics. The main watershed problems identified is caused from floodwater damage. While Waianae Iki is inclusive of Mākaha Valley, the "problem area" identified in the Plan only included areas near Kaupuni Stream and Kawiwi Stream in Waiʻanae. It is unclear how the "problem area" was determined, but based on the watershed analysis, the description suggests that Mākaha Stream may be less exposed to flood water damage because it is steeper than Kaupuni Stream and generally does not have the low-lying floodplain behind the sand dune dike that occurs near Kaupuni Stream. It also states that the area is relatively undeveloped,

both from a residential and agricultural standpoint. However, since 1960 when the Plan was written, a significant amount of both residential and resort development has occurred near Mākaha Stream.

The Plan also proposes land treatment to reduce ponding and intercept runoff, and structural improvements using concrete channelization for the "problem area" in Waianae Iki. A cost-benefit analysis is provided for the proposed improvements, and as written in the Plan, flood prevention works of improvement for Mākaha Stream "are not considered justifiable at this time."

1.3.2 SOUTH MĀKAHA STREAM FLOOD CONTROL STUDY SUMMARY REPORT (1983) [2]

Section 205 of the Flood Control Act of 1948, as amended, provides the Corps of Engineers authority to plan and construct small flood damage reduction projects no larger than $7 million in both planning and construction costs. Proposed projects require detailed investigation clearly showing its "engineering feasibility, environmental acceptability, and economic justification." The South Mākaha Stream Flood Control Study Summary Report provides a summary of the preliminary plan of improvement for South Mākaha Stream (also known as Eku Stream) to minimize flood damages. It includes a brief physical, environmental, and economic analysis of the project area.

The study suggests both structural and nonstructural measures for 3,200 feet of Eku Stream starting from the ocean shoreline. Structural measures are comprised of a debris basin with a capacity of 2,200 cubic yards near the South Mākaha and unnamed Stream confluence (mauka of Kaulawaha Road), and lining 2,500 feet of the channel from the debris basin to Farrington Highway with cement rubble masonry. The ford crossing for streamflows at Kaulawaha Road would be replaced with a new bridge. Nonstructural measures are comprised of a flowage easement and floodplain management for areas makai of Farrington Highway, including flood warning signals to be used to manage flow conditions over the highway. Total cost for the project was estimated to be slightly over $5 million (at an average annual cost of $409,300 over a 50-year amortization period), but average annual benefits were estimated at only $16,000. The study concluded that costs outweigh benefits, and implementation of proposed plans is therefore not justified.

However, the Study suggests the following for the problem area:

- Proper and regular maintenance of the South Mākaha Stream.
- Administration of a floodplain management program for those areas within the 100-year floodplain. Use of zoning and building codes and standards to restrict future development in those areas.
- Development of a flood warning system and contingency plan for Farrington Highway in anticipation of overtopping by flood waters.

1.3.3 STATEWIDE CAPITAL IMPROVEMENT PROGRAM FLOOD CONTROL PROJECTS (1994) [3]

The Statewide Capital Improvement Program Flood Control Projects study is an extension of the State General Flood Control Plan which was updated by the DLNR in 1983. The purpose of the study was to develop criteria for a State Capital Improvements Program for flood control improvements.

Due to financial constraints, it is impossible for the State to address all flooding issues at the same time. Therefore, this study serves as a general guide for the State to appropriate funds sequentially for different flood control programs based on their priority level.

The Program categorizes all planned and possible projects according to their overall importance in mitigating flood problems in certain areas. Projects are grouped into one of three priority groups: high, medium, or low. Projects in the high priority group are recommended as projects to address first. Priorities were assigned based on a set of eight parameters (loss of life, historical and potential damages, land use, severity and frequency of flooding, existence and effectiveness of remedial measures, environmental and social concerns, ownership of stream right-of-way, and ownership of lands being flooded).

Based on the evaluation criteria for this study, Mākaha area (including Mākaha Stream) is categorized as "low" priority. The low priority group consists of areas with minor damages, located where proposed flood control measures have been opposed by the local communities and where costs outweigh benefits. No loss of life due to flood damages was recorded for the Mākaha area, and although the extent of flooding includes a wide area of coastal plain, more frequent floods (less than 20 years) do not affect the densely developed area within the flood plain.

1.3.4 WAIʻANAE SUSTAINABLE COMMUNITIES PLAN (2000; UPDATED 2010) [4]

The Waiʻanae Sustainable Communities Plan (WSCP) was developed in accordance with the City & County of Honolulu's General Plan. It was first adopted in 2000, and is to be reviewed and updated every five years. The WSCP is one of eight community-oriented long-range land use plans for the orderly growth of the different planning districts. Since the major growth and development are planned for both ʻEwa and urban Honolulu, these plans are called "Development Plans," while the remaining six plans for the rest of Oʻahu are called "Sustainable Communities Plans" (SCP). The SCP is intended to guide public policy and decision-making for these relatively stable regions where there are no large growth projections, but rather serve to support existing populations. The WSCP focuses on preserving the rural landscape and the rural lifestyle of the Waiʻanae District's people, with a theme of "keeping the country, country."

In the 2000 WSCP, Land Use Policy No 3.8.2.3 states that:

> "Mākaha Valley needs a 'Special Area Plan' that will address cultural preservation issues, potential future uses of the now closed Resort facilities, and appropriate and feasible development options for the four parcels of residentially-zoned, as yet

undeveloped land. The central planning issue that should be addressed is how to balance economic development and existing and proposed residential and resort development in Mākaha Valley, with the overall vision for the Waianae District that emphasizes the preservation of agriculture and open spaces."

Since then, the Mākaha Special Area Plan was developed in 2009 using a community-based planning process. Mākaha Valley was identified for a Special Area Plan because of several characteristics:

- The City (Board of Water Supply) owns about two-thirds (~4,000 acres) of land in the upper valley and the steeper valley walls.
- A large portion of the valley is designated as "Urban" land under the State Land Use system.
- There are large parcels of undeveloped land that are zoned for Residential and Resort uses.
- Mākaha Valley is an important resource area in terms of water resources, rare and endangered plants and animals, and cultural sites.

Land Use Policy No. 3.5.2 contains policies pertaining to streams and floodplains that include:

- 3.5.2.1 Establish Stream Conservation Corridors
- 3.5.2.2 Restrict Uses Within the Stream Conservation Corridors
- 3.5.2.3 Establish Minimum In-Stream Flow Standards
- 3.5.2.4 Government Agencies Should Partner with Community-based Organizations in order to Better Manage Waiʻanae Streams and Stream Corridors

1.3.5 WAIʻANAE WATERSHED MANAGEMENT PLAN (2009) [5]

The Waiʻanae Watershed Management Plan (WWMP) is a long-range plan to the year 2030 for the preservation, restoration, and balanced management of ground water, surface water, and related watershed resources in the Waiʻanae District. It is one of the eight regional plans that together make up the "Oʻahu Watershed Management Plan" that is required under the State Water Code, Chapter 174C and the City & County of Honolulu's Ordinance 90-62.

The WWMP provides an overview and analysis of water resources available for the nine watersheds of Waiʻanae moku. Although it focuses on water use and quantity, the WWMP also contains general sustainable watershed planning principles. Chapter 4 contains five objectives with multiple sub-objectives and strategies. Chapter 5 outlines 32 potential projects and programs to fulfill the objectives, sub-objectives, and strategies developed in the previous chapter. Chapter 6 provides an implementation plan for these projects.

Specific projects relating to Mākaha Stream and/or watershed include:

- Stream Conservation Corridor

- Wetland Restoration and Protection
- Stream Biological Assessments
- Forest Restoration Program
- Loʻi Kalo Expansion Program
- Mākaha Research Watershed

Mākaha Special Area Plan General projects relating to Mākaha Stream and/or watershed include:

- Stream Dumping Prevention & Clean Up
- Surface Water Inventory
- Wildfire Management Plan
- Agricultural Support Program
- Flood Mitigation Program
- Waiʻanae Watershed Partnership
- Cultural Learning Center
- Community Watershed Education
- Waiʻanae Rural Landscape Study

1.3.6 MĀKAHA SPECIAL AREA PLAN (2009) [6]

The Mākaha Special Area Plan (MSAP) was prepared in accordance with the recommendations of the Waiʻanae Sustainable Communities Plan (2000), Land Use Policy No. 3.8.2.3. It provides guidelines for accommodating future development while preserving the rural environment and character of Mākaha Valley. Special Area Plans are generally intended to give communities the opportunity to define the identity, function, organization, and character of their specific neighborhoods in accordance with the general planning framework provided by their area's Development or Sustainable Plan.

Special Area Plans allow for more detailed policies and guidelines than the Sustainable Communities Plan, and are used to guide land use development and infrastructure investment in areas designated for a Special Area Plan.

The Mākaha Special Area Plan boundary includes most of the lower and mid-valley, excluding the residential houses in the lower portion of the valley. The MSAP proposes a "Mākaha Rural Development Plan" that includes a vision for Mākaha community, a Rural Development Concept addressing the rural character, environmental protection, open space preservation, land use compatibility and circulation, and rural development standards for potential new residential and resort development.

In regards to hazards, the following planning implications should be considered for future planning policies and recommendations:

- Parcel 58, an undeveloped parcel of ~109 acres with residential (R-10) zoning, is in the 100-year flood zone.

- Some of the undeveloped land, including Parcel 84002004, is located at the foot of steep, rocky lands that may be at risk of rockslides.

Chapter 7.4 presents Mākaha Valley Rural Development guidelines, and under section 7.4.2 it addresses low density residential and resort development. The following are listed in regards to drainage:

- Establish standards for permeable surfaces- a certain percentage of any building lot
- Utilize grass-lined drainage channels rather than concrete channels

A Drainage Plan is provided in section 7.4.7 that recommends the following:

- Develop a comprehensive drainage plan
- Analyze roads and their effect on drainage
- Assess old drainage infrastructure (i.e. settling ponds)
- Design and construct "green drainageways" that provide for more water infiltration and less runoff.

1.3.7 MITIGATION ASSESSMENT STUDY (2010) [7]

The Mitigation Assessment Study (MAS) was conducted after the December 2008 flood event on Oʻahu that was later declared a major disaster (DR-1814) by the President. With technical assistance provided by the Federal Emergency Management Agency (FEMA), MAS is an evaluation of the conditions on Oʻahu following the December 2008 flood event and describes potential flood mitigation strategies. It serves as a guide for the State and City & County of Honolulu's Hazard Mitigation Plans, and for updating FEMA's Flood Insurance Study and Flood Insurance Risk Map.

MAS includes information on watershed characteristics, flood risks, and potential flood mitigation actions from both existing plans and studies, and newly identified actions based on best practices. The report focuses specifically on flooding originating in mauka areas.

The Mākaha watershed is identified as one of the 15 high risk watersheds on Oʻahu. Recommendations on flood mitigation actions specifically for Mākaha watershed include:

- Mitigate high-risk properties, elevate homes built near Farrington Highway that are at grade and that are repetitively flooded. Verify that the homes were not built in violation of the NFIP (below required elevation levels).
- Reduce stream constrictions; widen spans of the Farrington Highway bridge over the stream mouth to relieve constriction.
- Engage the newly formed Waiʻanae Mountains Watershed Partnership on flood issues affecting the watershed to determine if mutually advantageous strategies can be developed.

1.3.8 STATE OF HAWAII MULTI-HAZARD MITIGATION PLAN (2010) [8]

The State of Hawaii Multi-Hazard Mitigation Plan was prepared in accordance with the Disaster Management Act of 2000 (DMA) which required the State and counties to develop approved hazard mitigation plans in order to be eligible for federal mitigation and disaster funding. DMA amended the Stafford Disaster Relief and Emergency Assistance Act of 1988. Plans were to be completed by 2004, with State plans updated every three years, and local county mitigation plans updated every five years. DMA emphasizes the need for the State and local entities to closely coordinate mitigation planning and implementation efforts, placing emphasis on mitigation practices rather than on response and recovery.

The State of Hawai'i Multi-Hazard Mitigation Plan focuses on nine natural hazards: hurricanes, flooding, drought, wildfire, landslide, erosion, earthquake, tsunami, and volcanic activity. The Plan provides an overview of the nine natural hazards that occur in Hawai'i and their impacts to the State. It identifies critical resources and assets in the State that are most vulnerable during a disaster. The Plan also includes a risk and vulnerability assessment, overview of current mitigation policies, and identifies mitigation actions per hazard.

As a result of flooding, City & County of Honolulu suffered an average annual loss of $13 million. Properties are listed on the repetitive loss list if they have two or more National Flood Insurance Property (NFIP) claims of more than $1,000 within any 10-year period since 1878. Of the 172 properties, more than half (87 properties) are located within the City& County of Honolulu. The State and County are working together to reduce the number of properties on the Severe Repetitive Loss (SRL) list, properties having three or more claims, through mitigation measures. Mitigation measures include acquisition, re-location, or small flood control projects. Although there are no properties in Mākaha listed in the SRL list, there are two single family homes listed on the repetitive loss list with both claiming two losses as of 2010.

2. MĀKAHA VALLEY PROJECT AREA

2.1 PHYSICAL AND NATURAL FEATURES

2.1.1 CLIMATE

The temperate climate in the Hawaiian Islands is due to its geographic location near the northern margin of the tropics situated within a belt of northeasterly trade winds. Variation in temperatures from day to day and month to month is low. The two seasons are distinguished by the cooler temperatures and wet conditions during the winter months, generally between October and April, and the drier and warmer conditions with northeasterly trade winds during the summer months.

Prevailing trade winds dominate the typical weather conditions of the Hawaiian Islands throughout the year. The trade winds generally travel from east to west, carrying moisture from the ocean, creating clouds that later produce rainfall when they first hit the windward side of each island. As the winds travel toward the leeward side, most of the moisture has been removed. As a result, the leeward side is typically drier than the windward side—creating two distinctive climatic regions on each island. Most of the rainfall of the leeward areas is from major storms associated with the passage of a cold front or a Kona storm. These storms are more common in the winter and develop from the northwest and slowly move eastward, bringing extensive periods of rain to the leeward areas that may last for a week or more.

The climate in Mākaha is generally reflective of conditions for leeward areas, with rainfall ranging from about 25 inches per year in the coastal areas to about 65 inches per year in the mauka portions near Mount Kaʻala. Temperatures may reach the mid-90s near the coast, where it is generally hotter and drier than the upper valley.

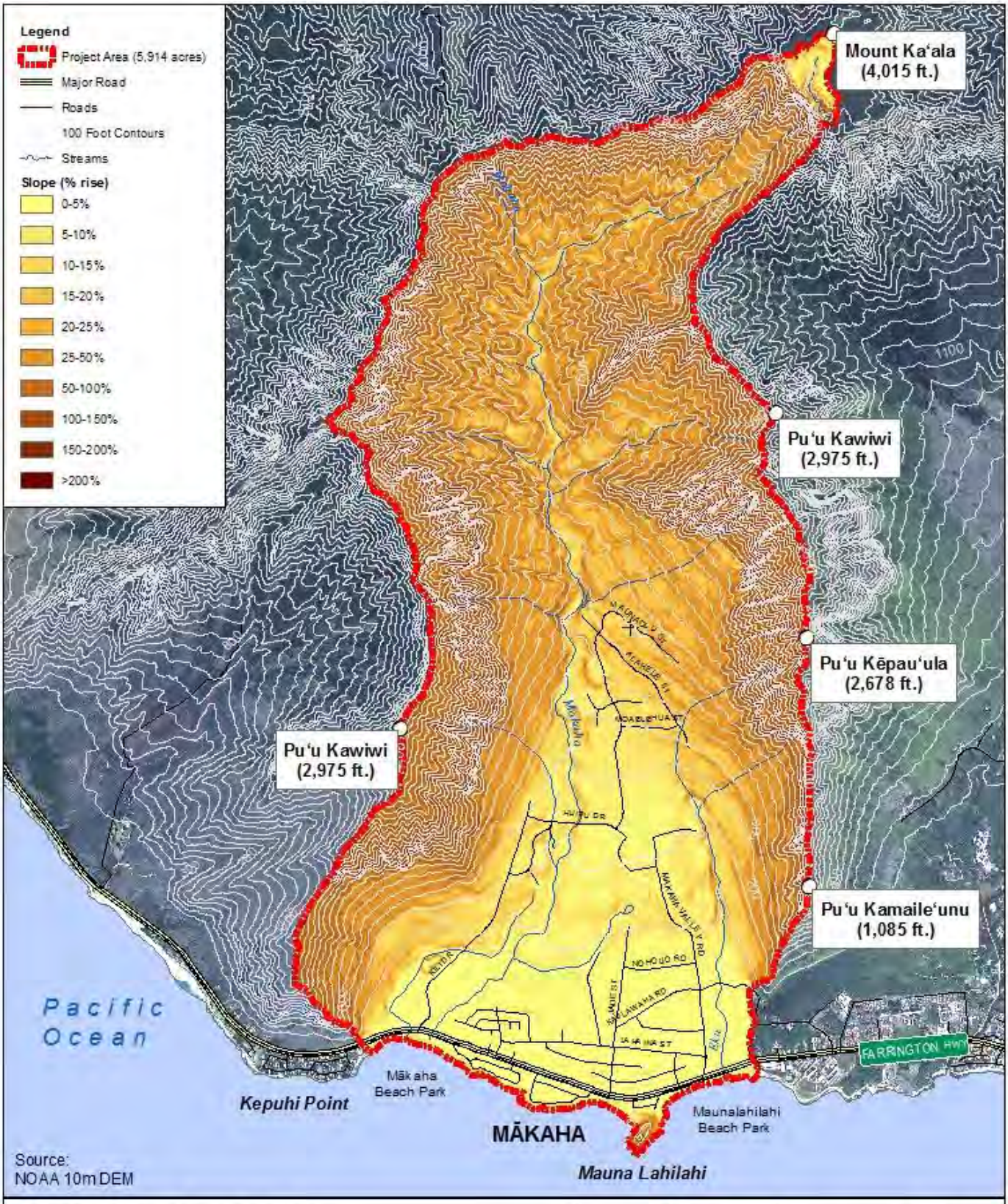


FIGURE 3. TOPOGRAPHY- SLOPES

2.1.2 TOPOGRAPHY

Land elevations in Mākaha Valley begin at sea level and rise to 4,015 feet above sea level. At the highest point of the valley is Mount Kaʻala. The valley is bounded by several other prominent peaks, including Puʻu Kamaileʻunu (1,085 feet) to the south, Puʻu Kēpauʻula (2,678 feet) to the southeast, and Puʻu Kawiwi (2,975 feet) to the east, and Puʻu Keaʻau (2,650 feet) to the northwest. The two coastal points bounding Mākaha Valley are Mauna Lahilahi to the south and Kepuhi Point to the north. The Kamaileʻunu Ridge separates Mākaha Valley from Waiʻanae Valley.

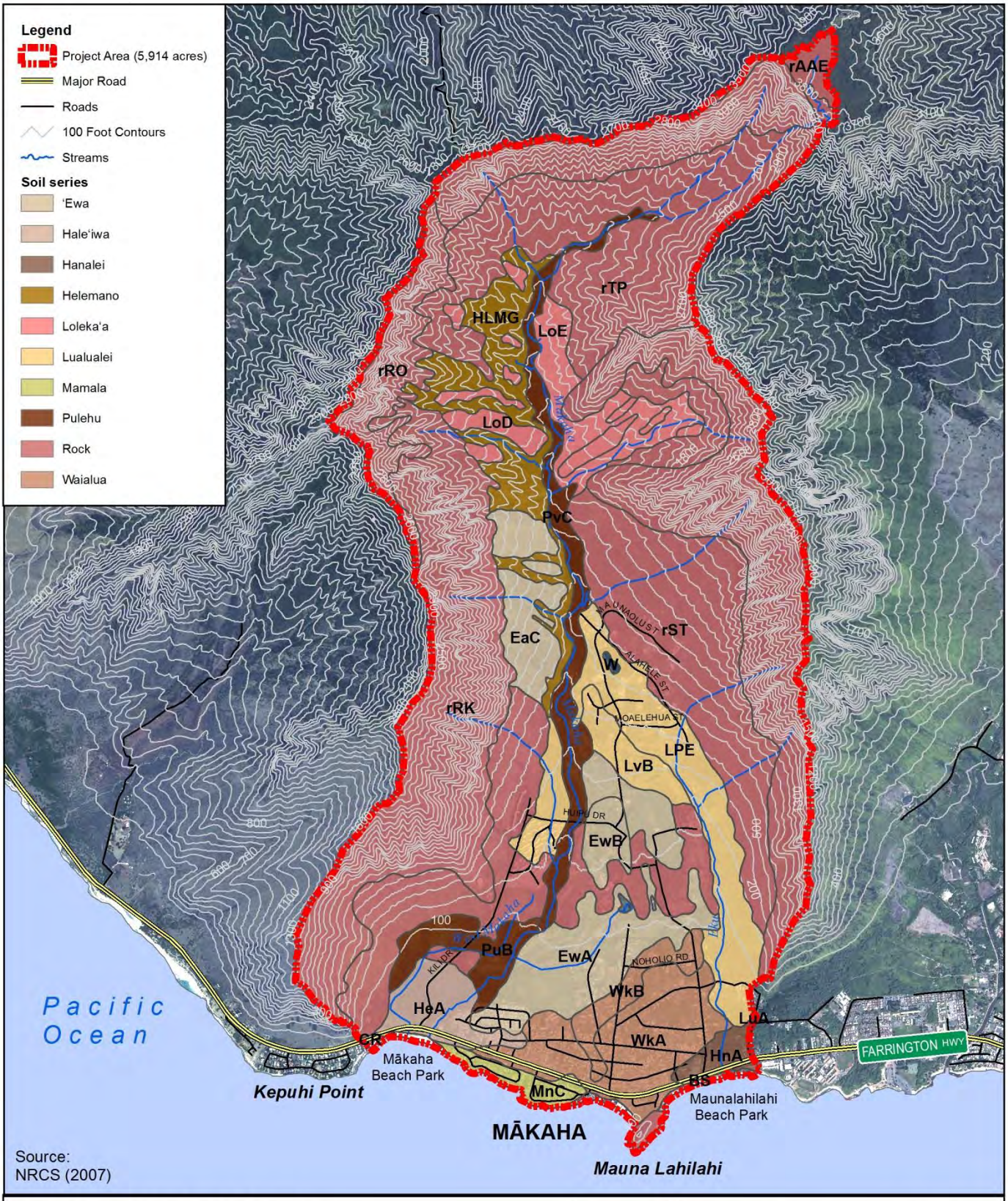
Mākaha Valley consists of steep, nearly vertical valley walls—with slopes greater than 200 percent—along both sides of the valley (Figure 3). From sea level to about 2.5 miles inland, the valley floor gradually increases to a 15 percent gradient and an elevation of about 600 feet. From there, the slope gradually gets steeper until it reaches the top of the valley which is slightly less than 5 miles inland from the coast. The width of the valley floor varies from less than a half mile wide near Kāneʻāki Heiau, to nearly two miles wide near the coast.

Mākaha Stream starts from the base of Mount Kaʻala on the southeastern side of the valley and travels about 1.5 miles before making a sharp turn to the west towards the ocean. This stream travels along the northern side of the valley and connects to the Pacific Ocean just south of Mākaha Beach Park. Eku Stream forms about 2 miles inland on the southern side of the valley and connects to the Pacific Ocean on the southern side of the valley.

2.1.3 GEOLOGY

The Hawaiian Islands were formed as a result of the Pacific Plate sliding northwestward over a hotspot, or an area with high volcanic activity. Oʻahu is composed of two shield volcanoes, Waiʻanae and Koʻolau that began as two separate submarine volcanoes. Over the years, after the Waiʻanae volcano became extinct, the Koʻolau volcano continued to grow larger. Its lava eventually overlapped the Waiʻanae lava, and joined together to form a single island. The Waiʻanae Range is composed of three groups of lavas. The lower lava is about 2,000 feet thick and consists mostly of pahoehoe. The middle basalts are similar to the composition of the lower lavas but contain more aʻa, and are also about 2,000 feet thick. The upper lavas are about 2,300 feet thick and are mostly aʻa alkalic lavas from cinder cones. The caldera of the Waiʻanae Range is located near Kolekole Pass, at the top of present-day Lualualei Valley.

The Waiʻanae Range, forming the western part of Oʻahu, is 22 miles long. After several million years of erosion, Mākaha Valley is one of the nine valleys that was formed along the western side of the Waiʻanae Range. Wave action and streams dissecting the shield contributed to the formation of these steep valley walls and gently sloping valley floors. [9]



Mākaha Valley Flood Study

FIGURE 4. SOILS

0 0.5 1 Miles

0 2,500 5,000 Feet

By: Townscape, Inc. For: Hawaii State DLNR Date: August 2013

2.1.4 SOILS

The Natural Resources Conservation Service (NRCS) of the U.S. Department of Agriculture established levels of classification for soils. The most detailed classification is the soil series.

Soil series found in Mākaha Valley include: ʻEwa, Haleiwa, Hanalei, Helemano, Lolekaʻa, Lualualei, Mamala, Pulehu, Rock Land, Stony Land, Tropohumults-Dystrandepts association, and Waialua. Soil series vary throughout the valley, but the steep, mountainous areas are dominated by the Rock Land, Stony Land, and Tropohumults-Dystrandepts association series (Figure 4). [10]

Soils are classified into one of four hydrologic soil groups (Group A-D) based on estimates of runoff potential and the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms. The ability of water to infiltrate into the soil is one factor that affects flooding. If the soil is too saturated, rainfall will have a high runoff potential.

The majority of the soils throughout the middle and upper valley are classified as Hydrologic Soil Group-B, which is classified as having moderately low runoff potential when thoroughly wet. The Waialua and Hanalei series located on the lower right side of the valley and the area near Mount Kaʻala are classified as Group-C, having moderately high runoff potential when thoroughly wet. The Lualualei series located in the middle of the valley and Rock land series along valley walls are classified as Group-D, having high runoff potential when thoroughly wet.

Of the soil series found in Mākaha Valley, the Hanalei series is most prone to frequent flooding, which is defined by NRCS as flooding that "is likely to occur often under usual weather conditions; more than a 50 percent chance of flooding in any year, but less than a 50 percent chance of flooding in all months in any year."

Table 3 provides soil details of the soils found in Mākaha Valley.

TABLE 3. SOIL DETAILS

Map Unit	Description	Slope	Frequency of Flooding	Hydrologic Soil Group	Total Acreage	% of Mākaha Valley
ʻEwa series						
EaC	ʻEwa silty clay loam	6-12%	None	B	133.9	2.3
EwA	ʻEwa stony silty clay	0-2%	None	B	308.4	5.2
EwB	ʻEwa stony silty clay	2-6%	None	B	48.5	0.8
Haleʻiwa series						
HeA	Haleʻiwa silty clay	0-2%	Occasional	B	106.2	1.8
Hanalei series						
HnA	Hanalei silty clay	0-2%	Frequent	C	41.8	0.7
Helemano series						
HLMG	Helemano silty clay	30-60%	None	B	260.4	4.4
Lolekaʻa series						
LoD	Lolekaʻa silty clay	15-25%	None	B	102.3	1.7
LoE	Lolekaʻa silty clay	25-40%	None	B	139.6	2.4
Lualualei series						
LPE	Lualualei extremely stony clay	3-35%	None	D	341.5	5.8
LuA	Lualualei clay	0-2%	Rare	D	<1	0
LvB	Lualualei stony clay	2-6%	Rare	D	66.6	1.1
Mamala series						
MnC	Mamala stony silty clay loam	0-12%	Rare	B	47.8	0.8
Pulehu series						
PuB	Pulehu stony clay loam	2-6%	Occasional	B	93.4	1.6
PvC	Pulehu very stony clay loam	0-12%	Occasional	B	186.6	3.2
rAAE	Alakai mucky peat	0-30%	None	C	32.7	0.6
rRK	Rock land	All	None	D	1693.1	28.6
rRO	Rock outcrop	All	None	D	179.5	3.0
rST	Stony land	All	None	B	1004.5	17.0
rTP	Tropohumults-Dystrandepts association	All	None	C,B	770.5	13.0
Waialua series						
WkA	Waialua silty clay	0-3%	None	C	260.9	4.4
WkB	Waialua silty clay	3-8%	None	C	68.6	1.2

Source: USDA NRCS, Custom Soil Resource Report for Mākaha Valley (2013)

2.1.5. VEGETATION

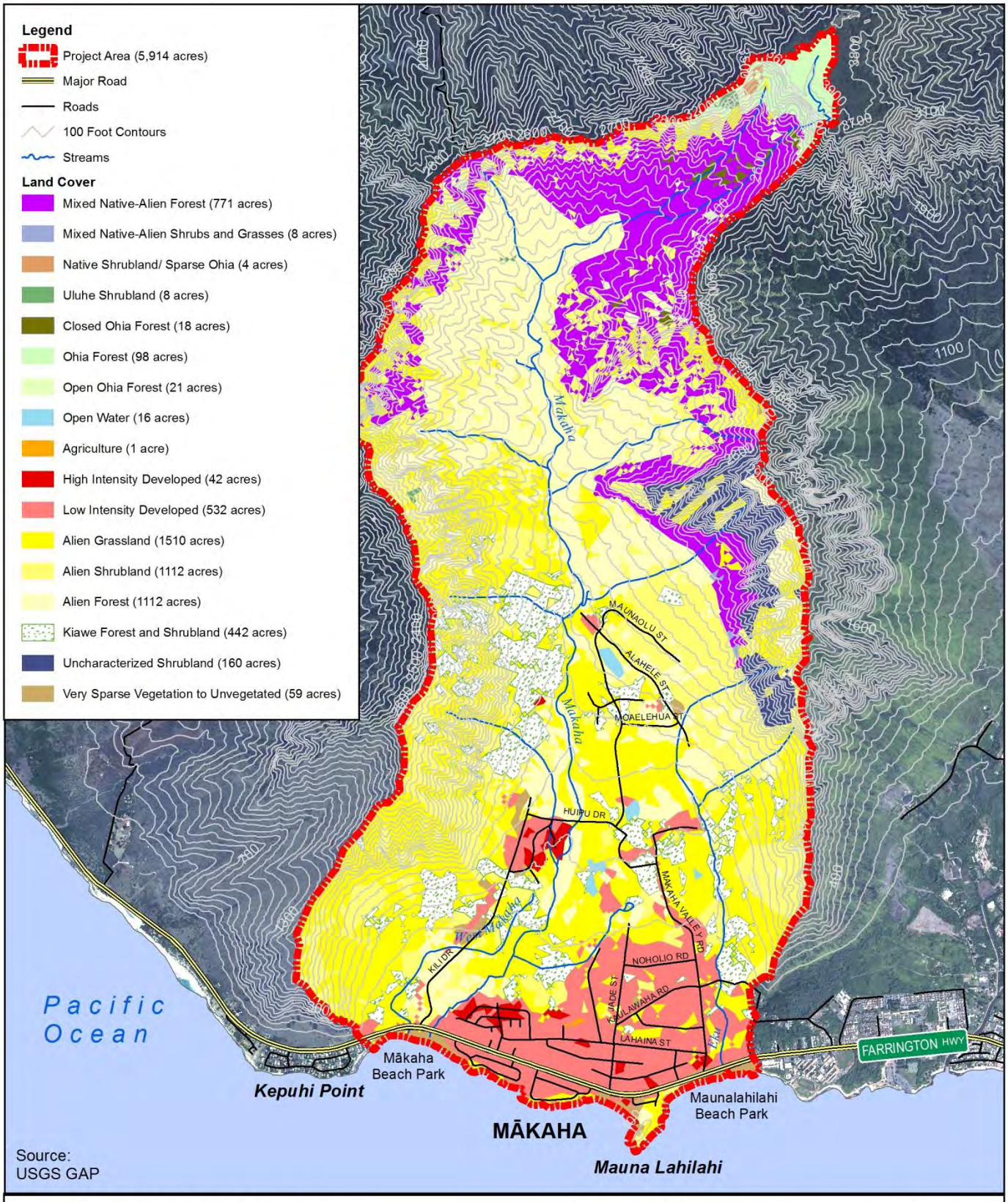
The USGS National Gap Analysis Program (GAP) provides land cover data including detailed vegetation and land use patterns. Based on the GAP data, more than half of the valley (about 3,733 acres) is covered with alien grassland, forest, or shrubland (Figure 5). The majority of the valley walls and upper valley areas are covered with non-native grasses, shrubs, and trees, with a mixture of native-alien plants covering the upper valley. Native ohia trees and tropical fern uluhe shrubland cover a small portion of the upper valley near Mount Kaʻala. Small clusters of native forest plants are located on the high ridges of Mākaha Valley. Kiawe forest and shrubland covers a significant part of the lower and mid-valley (about 441 acres, 7.47%). Slightly less than 10 percent of the land has been converted for either high or low intensity development.

In a biological resources survey conducted by *AECOS*, Inc. (2012) for the 25-acre parcel where Mākaha West Golf Course is located, only 9 of the 82 plant species observed were native plants: kukui, kākalaio, milo, ʻalaʻala wai nui, ʻaʻaliʻi, ʻuhaloa, niu, and ʻahiʻawa. Some of the other vegetation identified includes Koa haole trees, Guinea grass, Java plum, monkey pod, kukui, African tulip tree, Chinese banyan, silk oak, and Chinaberry. (11)

Through the Mākua Implementation Plan, which is a long-term protection plan for endangered species potentially impacted by live fire training in Mākua Valley, the U.S. Army Garrison and the BWS are working together on several conservation projects, including a fencing project in Mākaha Valley. The Army has constructed excluder fences on land owned by BWS in the upper valley. One fence encloses about 100 acres, and another encloses about 50 acres. The purpose of these fences is to keep out feral pigs and goats that pose a threat to the endangered species and native forest resources in the valley.

Several organizations, including the Waiʻanae Watershed Partnership and Youth Conservation Corps, have been working with the BWS to remove invasive species, including coffee and guava, in Mākaha. Further community outreach and volunteer groups are vital to continue the efforts of clearing invasive species in the forested areas. Forest restoration may help to minimize stormwater runoff.

Table 4 lists the types, acreage, and percent of land cover found in Mākaha Valley based on the USGS GAP GIS data.



Mākaha Valley Flood Study

FIGURE 5. LAND COVER

0 0.5 1 Miles

0 2,500 5,000 Feet

By: Townscape, Inc. For: Hawaii State DLNR Date: August 2013

TABLE 4. LAND COVER

Land Cover	Acreage	Percent of Mākaha Valley
Alien Grassland	1510	25.53
Alien Forest	1112	18.80
Alien Shrubland	1112	18.79
Mixed Native-Alien Forest	771	13.03
Low Intensity Developed	532	9.00
Kiawe Forest and Shrubland	442	7.47
Uncharacterized Shrubland	160	2.70
Ohia Forest	98	1.66
Very Sparse Vegetation to Unvegetated	59	1.00
High Intensity Developed	42	0.71
Open Ohia Forest	21	0.36
Closed Ohia Forest	18	0.30
Open Water	16	0.26
Mixed Native-Alien Shrubs and Grasses	8	0.14
Uluhe Shrubland	8	0.13
Native Shrubland/Sparse Ohia	4	0.07
Agriculture	1	0.02

Source: USGS GAP GIS data analysis

2.1.6 BIOLOGICAL RESOURCES

Listed below are native and introduced species found in Mākaha Stream:

TABLE 5. NATIVE AND INTRODUCED SPECIES

Type	Scientific name	Hawaiian/Common name
Native Species		
Crustaceans	*Atyoida bisulcata*	ʻŌpae kalaʻole
Fish	*Awaous guamensis*	ʻOʻopu nākea
Insects	*Megalarion hawaiiense*	Hawaiian Upland Damselfly
	Megalagrion nigrohamatum nigrolineatum	Black-lined Damselfly [1]
	Megalagrion oceanicum	Oceanic Hawaiian Damselfly [1]
Introduced Species		
Fish	*Gambusia affinis*	Mosquitofish
	Micropterus sp.	Black Bass

[1] Listed as endangered species.
Source: Atlas of Hawaiian Watersheds & Their Aquatic Resources (2008)

ʻŌpaekalaʻole *(Atyoida bisulcata)*, typically found in the upper reaches of the stream, is a spineless shrimp or mountain ʻŌpae. It is an endemic freshwater shrimp that grows to a length of about 2 inches. ʻŌpaekalaʻole is one of two kinds of native shrimp that live in Hawaii's streams. They were once abundant in streams, but are now less common due to human disturbance. Large quantities of ʻŌpaekalaʻole are found in "high quality" streams and prefer upland streams. An average size of 1-inch crustaceans were found in the upper parts of Mākaha Stream with a density of 0.71 species per square yard in a study done in 2008.

ʻOʻopu nākea *(Awaous guamensis)*, usually found in the lower and middle reaches of streams, is indigenous (meaning it is also found elsewhere in the Pacific) to the Hawaiian Islands. The Mosquito fish (*Gambusia affinis)* was first introduced to Hawaii in 1905, and typically favors standing or slow-flowing water. The Black Bass *(Micropterus sp.)* is another fish introduced to Hawaii, and can be found in still or slow-flowing water and often in reservoirs. These three fish can be found in the middle reaches of Mākaha Stream.

The Hawaiian Upland, Black-lined, and Oceanic Hawaiian Damselfly are three of the 23 damselfly species on the Hawaiian Islands that are endemic to the island of Oahu. These insects live in the mountain ranges of Waiʻanae and Koʻolau, but have been slowly disappearing from the former. They are found in the upper and headwaters of Mākaha

Stream. Two of the three damselflies are listed as Endangered Species under the U.S. Fish & Wildlife Service. [12]

Two native birds were observed during the biological resources survey conducted by *AECOS*, Inc. (2012): the ʻaukuʻu or Black-crowned Night-Heron (*Nycticorax nycticoraz hoactli)* and the indigenous migratory bird kōlea or Pacific-Golden Plover (*Pluvialis fulva)*.

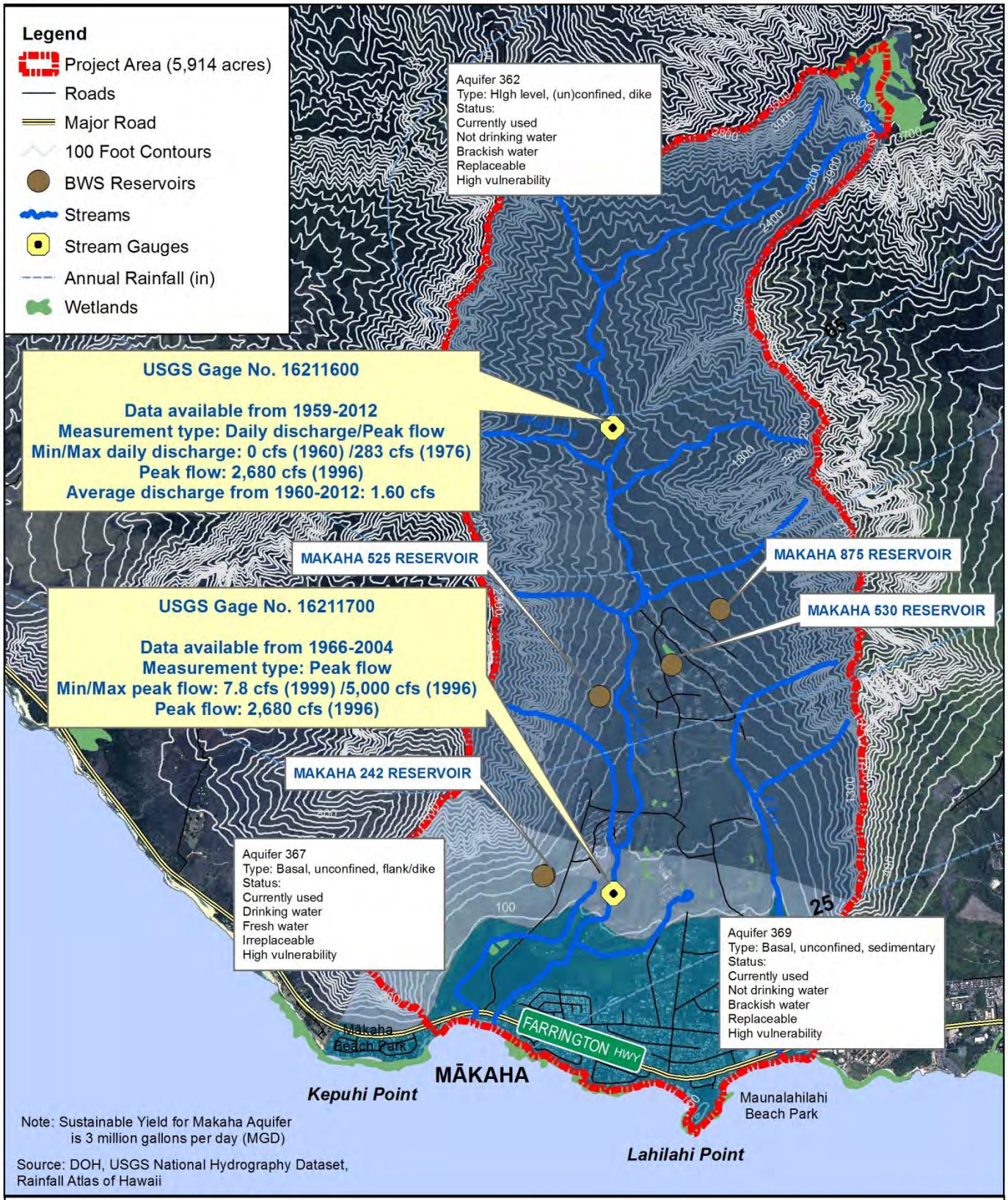


FIGURE 6. HYDROLOGICAL FEATURES

2.1.7 SURFACE AND GROUNDWATER HYDROLOGY

Under the Hawaii Stream Assessment (1990) published by the State Commission on Water Resource Management (CWRM), Mākaha Stream (State ID Number 3-5-07) is classified as a perennial stream that is interrupted, which means it "flows year-round in upper portions and intermittently at lower elevations."

Mākaha Stream is the primary stream, originating in the western slopes of the Waiʻanae mountain range and is fed by water that falls from Mount Kaʻala. It flows southwesterly and terminates behind a sand berm near Mākaha Beach Park. The Mākaha Stream drainage basin, which has a drainage network of multiple tributaries from the steep slopes of the valley walls, is about 4,282 acres in size. The main stem has a flow path length of about 7.2 miles, while the total stream length is 14.2 miles. [13]

A shorter intermittent stream, referred to as West Mākaha Stream, arises on the south slope of Puʻu Keaʻau behind the existing Mākaha Valley Towers. The stream runs on the northern side of Kili Drive, flows under Bridge 3A on Farrington Highway, and connects to Mākaha Stream on the other side of the road. Neither of the streams have a permanent connection to the ocean. Consultations with community stakeholders revealed that since the construction of Kili Drive, almost no water discharges from the West Mākaha Stream during rain events. Community stakeholders stated that the amount of streamflow from Mākaha and West Mākaha Stream has reversed, where the majority of the water used to discharge from West Mākaha Stream but now discharges from Mākaha Stream.

Eku Stream originates from the eastern side of the valley from Kamaileʻunu Ridge. The Eku Stream drainage basin is about 972.8 acres in size, and the longest flow path is about 3.3 miles [13]. Some of the flow from the steep valley slopes of the Kamaileʻunu mountain range that would naturally drain into Eku Stream have been diverted to Mākaha Stream. Some of the flow is intercepted by the Mauna ʻOlu Estates Interceptor Ditch, and conveyed to a concrete channel that discharges into Mākaha Stream.

There are two USGS gage stations in Mākaha, both of which are located on Mākaha Stream: USGS Station Number 16211600 and USGS Station Number 16211700 (Figure 6). There is also one USGS rain gage station (State Key Number 842.1) located near USGS Station Number 16211600.

TABLE 6. USGS STREAM GAGE INFORMATION FOR MĀKAHA STREAM

Station Number	Location	Drainage area (square miles)
16211600	Latitude 21°30'05.7" Longitude 158°10'48.6" NAD83	2.28
16211700	Latitude 21°28'47" Longitude 158°12'31" OLDHI	5.21

USGS Gage Station Number 16211600 is located on the right bank, and slightly less than a mile northeast of Kāneʻāki Heiau. Daily discharge (average daily flow) and annual statistics are available for this gage station starting from 1959. Due to the location of the gage above any of the modified drainage systems, the data does not include flow diverted from Eku Stream by the Mauna ʻOlu Estates drainage system into Mākaha Stream.

USGS Gage Station Number 16211700 is located near the Mākaha West Golf Course about a half mile south of Huipu Drive. Peak streamflow data is available for this gage station from 1966 to 2004. This stream gage is no longer in service and was discontinued in 2004 due to lack of funding.

Since there are no USGS gage stations for Eku Stream, peak flows for the stream after rainfall events are not known.

Figure 7 displays the annual peak discharge for Mākaha Stream at USGS Gage 16211600. The maximum discharge was recorded on November 14, 1996 (water year 1997) at 2,680 cubic feet per second (cfs)—equal to a "roomful" of water 16'x16'x10.5' every second—with a gage height of 9.54 feet.

FIGURE 7. ANNUAL PEAK STREAMFLOW FOR MĀKAHA STREAM (USGS 16211600)

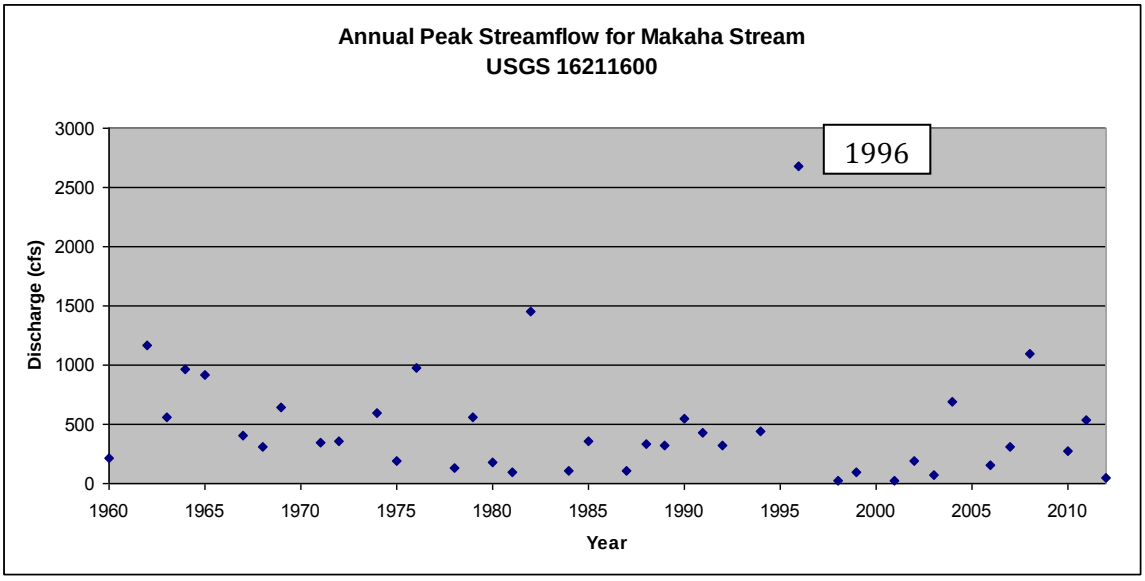
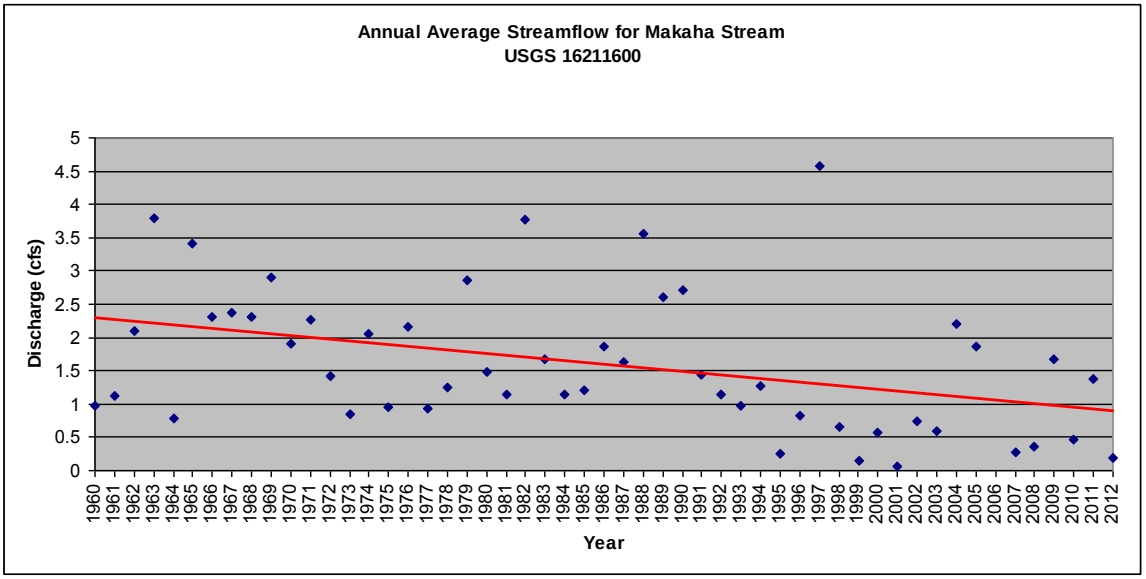


Figure 8 displays the annual average streamflow for Mākaha Stream. Although the maximum discharge of 2,680 cfs was recorded in water year 1997, the average discharge for the same year is only 4.58 cfs, implying that there was no discharge for a significant portion of the year. The red line in the figure depicts the "best fit line", or the linear trend line, for the average annual discharge for Mākaha Stream. It shows that there is a decline in this discharge, possibly due to climate change factors.

FIGURE 8. ANNUAL AVERAGE STREAMFLOW FOR MĀKAHA STREAM (USGS 16211600)



Sustainable yield for Mākaha aquifer is 3 million gallons per day (MGD). Groundwater comes from dike aquifers in the Waiʻanae mountains, including Mount Kaʻala. Glover tunnel, located makai of Kāneʻāki Heiau was completed in 1941 as part of the sugar plantation irrigation system. BWS purchased the tunnel along with other plantation water sources. It was once the primary source for the entire valley including residences, hotel, golf courses, and agriculture. Water from Glover tunnel is currently running into Mākaha Stream.

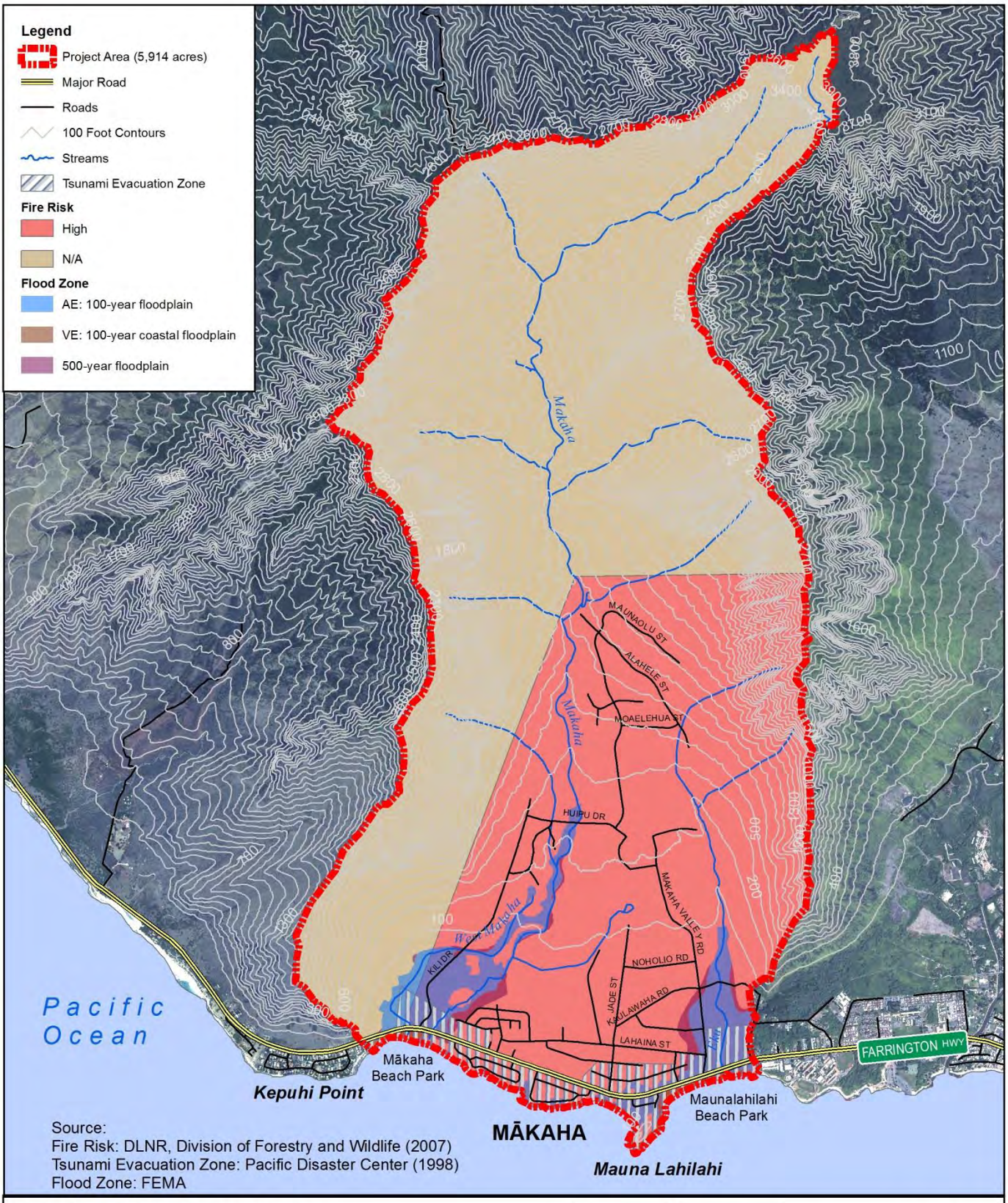


FIGURE 9. HAZARD AREAS

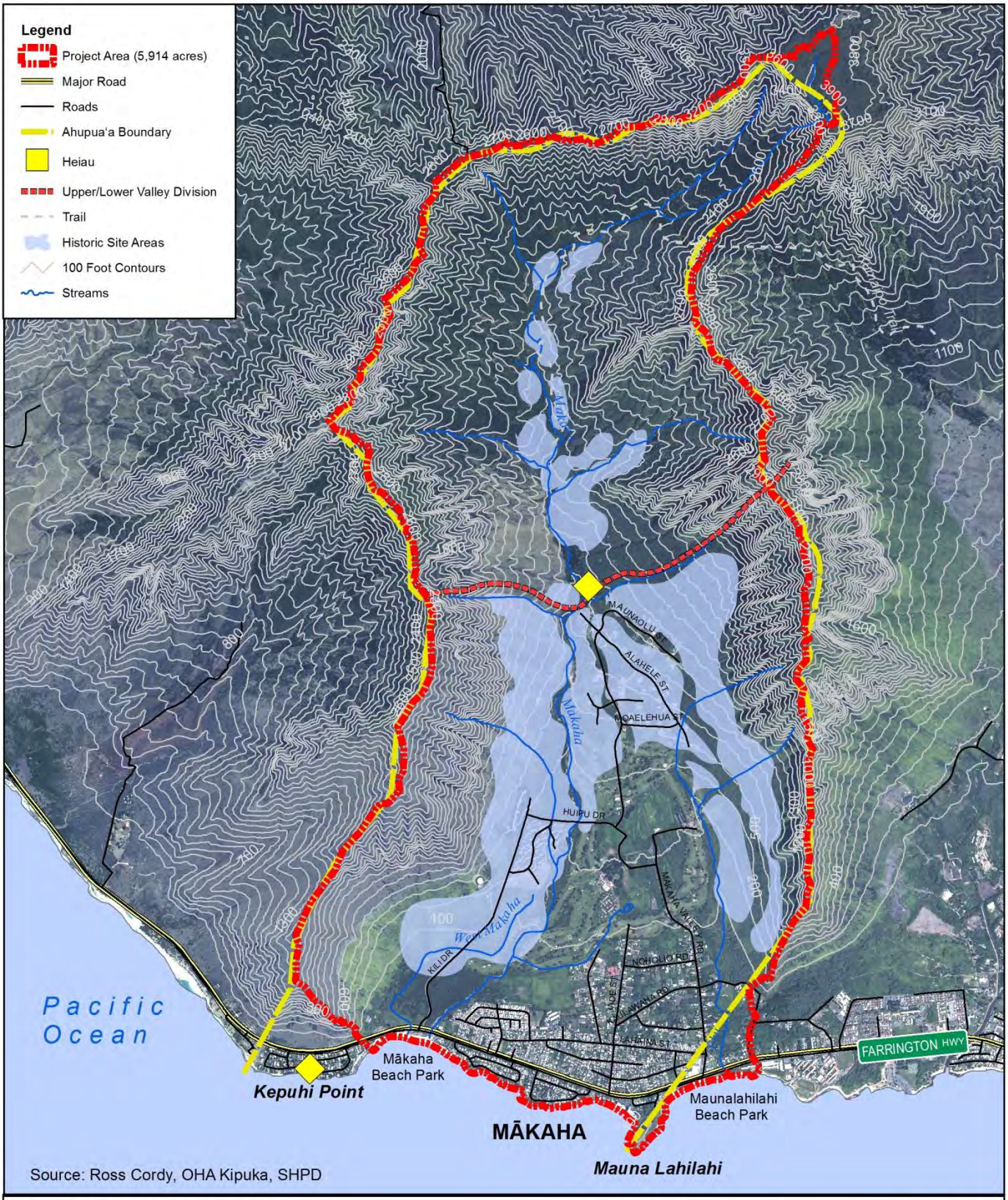
2.1.8 HAZARD AREAS

Mākaha Valley is subject to wildfire, tsunami, stream flooding, high waves, and storms. Figure 8 illustrates the areas with high fire risk, areas within the tsunami evacuation zone, and areas in the 100 and 500-year floodplain.

Fire risk for areas within the valley is high. BWS is creating a firebreak area for parts of their property by planting trees to shade out grass that are major fire fuels. In 2005, a major fire on the west mountain burned forested area from 523' elevation to 750' elevation, significantly affecting the topography and soil erosion [14].

Mākaha's coastline, including areas mauka of Farrington Highway, is located in the tsunami evacuation zone. The tsunami of April 1, 1946 had the severest effect in the Mākaha coastal areas. The maximum wave run-up elevation was recorded at 22 feet, resulting in flooding of areas approximately 500 feet inland [15].

A more detailed discussion of flood hazard areas is found in Section 2.4 of this report.



Mākaha Valley Flood Study

FIGURE 10. CULTURAL RESOURCES

0 0.5 1 Miles

0 2,500 5,000 Feet

By: Townscape, Inc. For: Hawaii State DLNR Date: August 2013

2.1.9 CULTURAL RESOURCES

Mākaha Valley contains one of the best preserved heiau on Oʻahu, Kāneʻāki Heiau (located above the upper/lower valley division in Figure 10). It was built around the 14th century, probably as an agricultural heiau to Lono, and later changed to a luakini, or sacrificial, heiau. The heiau is now owned and maintained by Mauna ʻOlu Estates, and is currently closed to the public. Consultation with community stakeholders revealed that mauka of Kāneʻāki Heiau are five other heiau.

A large number of temporary habitation shelters, particularly in the dryland fields, and permanent habitation sites are found at the border between the upper and lower valley. These permanent houses and fields across the lower valley have been severely impacted by the development of the resort and Mauna ʻOlu Estates.

Numerous long and narrow terraces, about 3 feet high, have been found about two-thirds up the valley that were used for taro cultivation. The terraces average from 20 to 50 feet in width. The upper valley's stream flats were also used for taro fields.

Historical studies show a trail going from Waiʻanae and down towards Mākaha Valley to the food patches and homes in the valley. Also, a branch of the trail led to Waialua and Mokuleia. A main coastal foot trail from Waiʻanae to Keaʻau was also located similarly to the existing Farrington Highway route. (16)

2.2 LAND USE CHARACTERISTICS

2.2.1 HISTORY OF THE AREA

Mākaha Valley is within the moku of Waiʻanae—one of the six moku (traditional districts) that constitute the island of Oʻahu. Within the moku of Waiʻanae, there are nine ahupuaʻa, including Mākaha ahupuaʻa. The Mākaha ahupuaʻa is approximately 5,930 acres, which covers about 16 acres more than the Mākaha Valley project area which is defined by the watershed boundary.

Pre-Contact History

Most of the archaeological work for Mākaha was done in the late 1960s and early 1970s by the Bishop Museum on the Chinn Ho properties.

Along the Leeward Coast, since Mākaha had the second most abundant water sources after Waiʻanae, it also had the next largest population prior to European contact. Mākaha Valley was a self-sufficient Hawaiian community, where Mākaha Stream flowed in the upper valley, and some researchers even believe that it flowed constantly to the sea. The lower valley supported extensive dryland agricultural crops and some permanent house sites that were used in the early A.D. 1100s-1300s. There were irrigated fields all along the middle of the valley towards the upper valley. Fish was available as food sources in the nearshore waters. Oral histories suggest that during the 1400s and 1500s, all of Oʻahu experienced a time of peace and prosperity. The loʻi were built by the 1500s in the upper valley along with permanent houses. By the 1600s, the valley experienced population growth and irrigated taro fields were built on the stream flats. The loʻi were extended into the lower valley in the 1700s.

Post-Contact History

The people of Waiʻanae and Waialua were the first to sight Captain Cook sailing north to Kauaʻi where he discovered the Hawaiian Islands in 1778. Shortly after discovery, an epidemic of foreign disease began decimating the native Hawaiian population, including people in Mākaha Valley. Within the first 40 years after discovery, the population of the Hawaiian Islands dropped by 50 percent.

Along the Waiʻanae Coast, there were large sandalwood forests in the valleys. By 1811, Hawaiian chiefs were trading sandalwood in exchange for luxury goods from the western sailors, who were selling the sandalwood to the Chinese. While commoners were ordered to cut sandalwood for the chiefs, work in the taro patches ceased. As a result, the sandalwood trade not only resulted in the extinction of sandalwood in the Waiʻanae mountains, but left the people to starve as fields were left unattended.

During the Great Mahele, very few commoners claimed land in Mākaha. As a result, the High Chief Abner Paki acquired title to about 5,000 acres of land, almost the entire valley.

High Chief Paki sold Mākaha Valley to the James Robinson firm, Hawaii's first shipyard, in 1855 for $5,000 in gold. Robert William Holt, a wealthy part-Hawaiian partner in the firm,

then acquired it from the company. The land was used for ranching, and later expanded to include 125-acres for growing coffee.

By the late 19th century, sugarcane cultivation began in Waiʻanae. The Holt family leased 150 acres of land in Mākaha Valley for planting sugar cane, which was later taken over by A. Hastings & Co. The sugar plantation demanded large supplies of water, but there was limited water supply in the arid Waiʻanae Coast.

By the 1940s, Waiʻanae Plantation operations declined due to limited water resources. In 1946, the plantation dug a tunnel into the base of the mountains to meet their water needs. The new source yielded 2 million gallons per day. A year later, the plantation had to cease its operations, and the 9,150 acres of plantation land was available for purchase.

Chinn Ho, the Chinese investor, immediately purchased the land including the water rights for $1.25 million, and later offered fee-simple lots for sale. In the mid-1960s, Chinn Ho built a 200-room luxury resort Mākaha Inn and a golf course; he described Mākaha as the "next Waikiki."

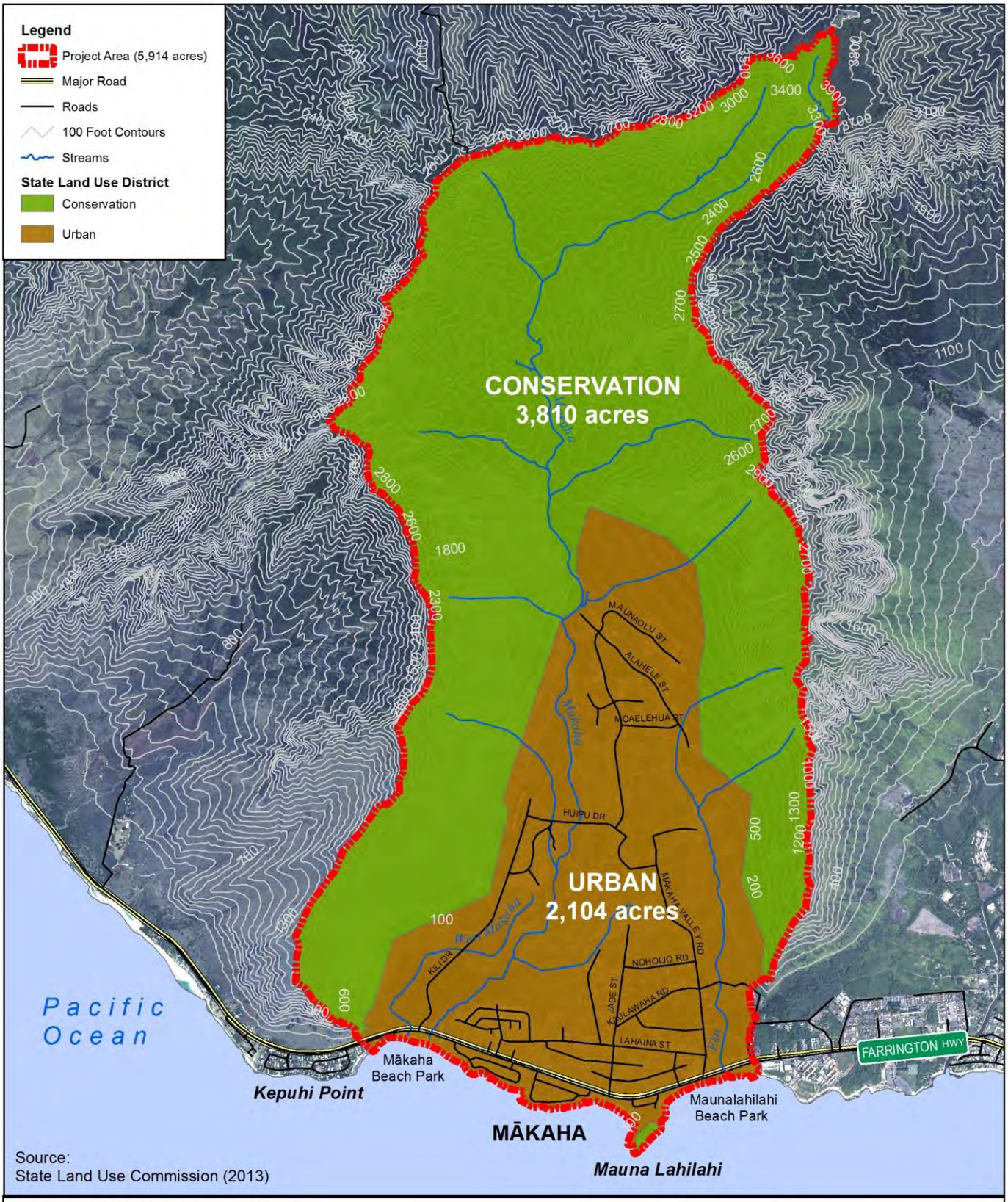
From the 1960s, development continued in the valley, including high rise apartments, a shopping center, condominiums, and single-family houses. (17)

2.2.2 DEMOGRAPHICS

Mākaha Valley's population of 8,278 people (U.S. Census Bureau, 2010) constitutes only 0.6% of the total population of Hawaiʻi. Mākaha has a slightly larger younger population (9% under 5 years, 28.8% under 18 years) compared to the rest of the state (6.4% under 5 years, 22.3% under 18 years). Slightly less than one-fourth (24%) of the population are of Native Hawaiian and Other Pacific Islander descent. More than one-third (34.1%) of the people are living below poverty level, and the median household income was $36,793. (18)

The majority of the people living in the lower sections of the valley are Hawaiian and Asian-American families of low and moderate income. Renters and homeowners in the mid-valley are mostly Caucasian people with moderate to higher incomes.

There are few jobs available within Mākaha Valley, especially since the closing of the Mākaha Resort in 2011 that laid off 95 employees and impacted the businesses at the Mākaha Shopping Center that also serviced the visitors staying at the resort (19). The majority of the existing jobs are found at Mākaha Valley East golf course and a few shops at the Mākaha Shopping Center.



Mākaha Valley Flood Study

FIGURE 11. STATE LAND USE DISTRICTS

0 0.5 1 Miles

0 2,500 5,000 Feet

By: Townscape, Inc. For: Hawaii State DLNR Date: August 2013

2.2.3 STATE LAND USE DISTRICTS

As defined by the State Land Use Law (HRS §205), land use in Hawai'i is divided into one of four broad categories: Urban, Rural, Agricultural, and Conservation. Mākaha Valley contains two of these districts, Urban and Conservation. Approximately 64 % (3,810 acres) of the land is designated as Urban, while the remaining 36% (2,104 acres) is designated as Conservation (Figure 11).

TABLE 7. MĀKAHA VALLEY STATE LAND USE DESIGNATIONS

State Land Use District	Approx. Acres	Percent of Mākaha Valley
Urban	2,104	36%
Conservation	3,810	64%

Source: State of Hawaii's GIS Data

Land classified as Urban covers the lower and middle portions of the valley until about a half mile mauka of Kāne'āki Heiau. Mākaha Valley contains one of the largest Urban State Land Use Districts, allowing for concentrations of people and infrastructure, and vacant lots for future development. This district is further managed through the City's zoning designations.

Land classified as Conservation covers the mauka portions of the valley surrounding the Urban lands. It includes mostly existing forested areas, and lands for the protection of the watershed. The majority of the Conservation land is owned by the BWS. The State owns less than 2% of Mākaha Valley, found at the summit of the valley at Ka'ala Natural Area Reserve, and a private owner (HRT) owns less than one acre of land that is designated as Conservation. Uses in the Conservation district are governed by the State DLNR.

Mākaha Valley Flood Study

FIGURE 12. CITY ZONING

0 0.5 1 Miles

0 2,500 5,000 Feet

By: Townscape, Inc. For: Hawaii State DLNR Date: August 2013

2.2.4 CITY ZONING

City zoning for parcels within Mākaha Valley includes Apartment, Agriculture, Business, Country, Preservation, Residential, and Resort (Figure 12). The majority of the valley is zoned for preservation (76%), which includes both "P-1 Restricted" and "P-2 General". Land designated as conservation under the State Land Use Districts is, by default, zoned as P-1 (Restricted) under city zoning.

Land zoned for Residential (R-5, R-10 and R-20) accounts for 8.7% of the zoned acreage, mostly located in the lower section of the valley. Land zoned for Country accounts for about 7.9 percent, and Agriculture accounts for only 4.3% of the valley. Apartment and Resort zoning make up less than 3% of the valley and less than 1% is zoned for business.

Table 8 lists the city zoning designations for Mākaha Valley.

TABLE 8. MĀKAHA VALLEY CITY ZONING

City Zoning	Acres	Percent of Mākaha Valley
Apartment	**65**	**1.1%**
A-1	*1*	
A-2	*64*	
Agriculture	**252**	**4.3%**
AG-1	*96*	
AG-2	*156*	
Business (B-2)	**10**	**0.17%**
Country	**467**	**7.9%**
Preservation	**4502**	**76.0%**
P-1	*3805*	
P-2	*697*	
Residential	**515**	**8.7%**
R-5	*202*	
R-10	*241*	
R-20	*72*	
Resort	**97**	**1.6%**
Total	**5,908**	

Source: State of Hawaii's GIS Data

Several large undeveloped parcels are zoned for resort, residential, preservation, and agriculture (Figure 13). These zoning designations allow development of single-family homes (with some zoned for minimum size lots of 20,000 square feet), hotels, duplex units, additional golf courses, and recreational facilities. The potential for development in Mākaha

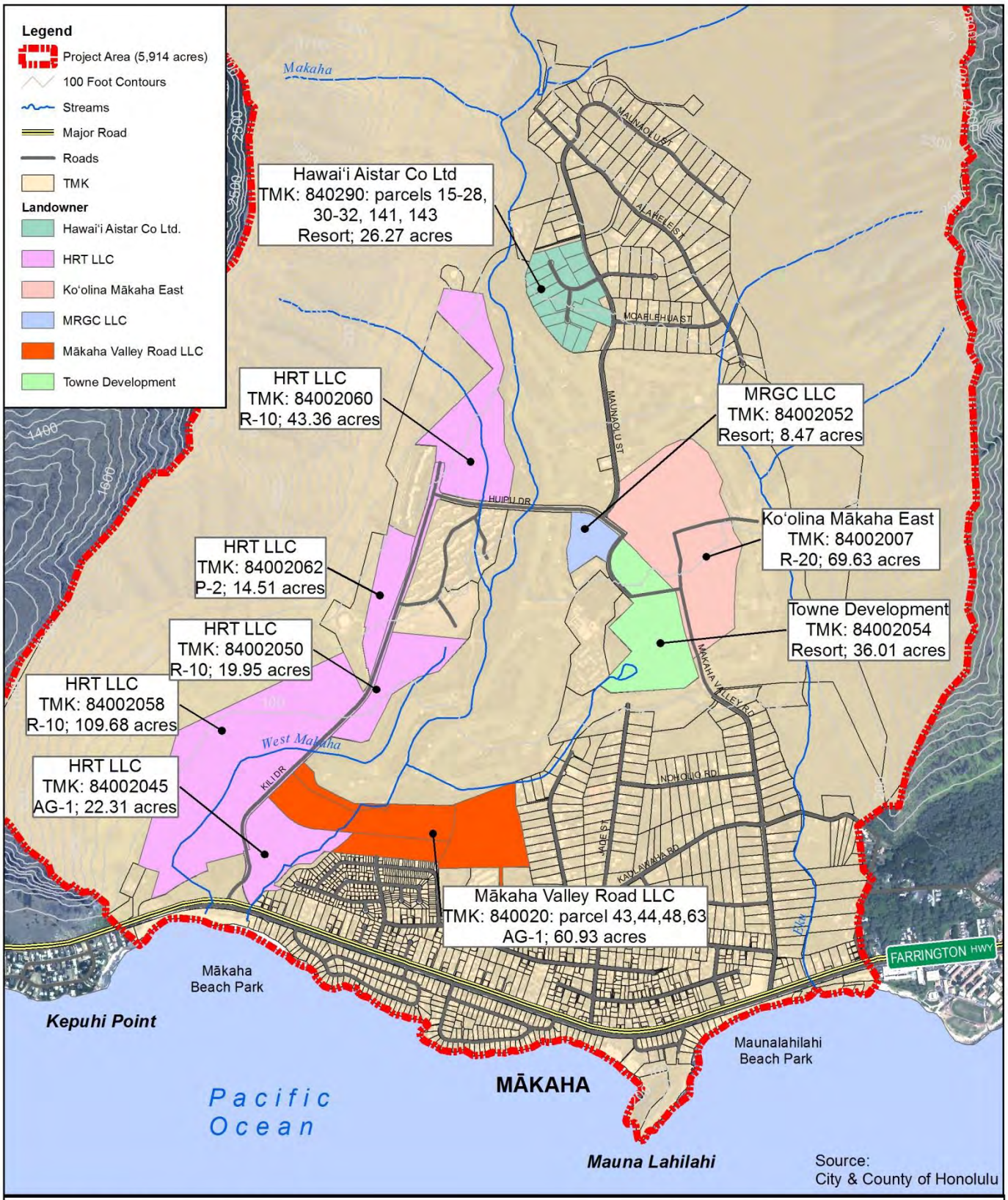
Valley increases the risk of flooding due to the impact of increased impervious surfaces and inadequate drainage infrastructure to support the built environment.

Table 9 lists the large undeveloped parcels in Mākaha State Urban District.

TABLE 9. LARGE UNDEVELOPED PARCELS IN MĀKAHA'S STATE URBAN DISTRICT

City Zoning	Acres	TMK	Owner [1]
AG-1	23.36	84002048	Mākaha Valley Road LLC
	24.54	84002043	Mākaha Valley Road LLC
	3.74	84002063	Mākaha Valley Road LLC
	9.29	84002044	Mākaha Valley Road LLC
	22.31	84002045	HRT LLC
P-2	14.51	84002062	HRT LLC
R-10	19.95	84002050	HRT LLC
	109.68	84002058	HRT LLC
	43.36	84002060	HRT LLC
R-20	69.63	84002007	Koʻolina Mākaha East
Resort	26.27	840290:parcels 15-28, 30-32, 141, 143	Hawaiʻi Aistar Co Ltd.
	8.47	84002052	MRGC LLC
	36.01	84002054	Towne Development

[1] Owner information is based on the Tax Bill Owner listed on the C&C of Honolulu's Website.
Source: The C&C of Honolulu's GIS Data.



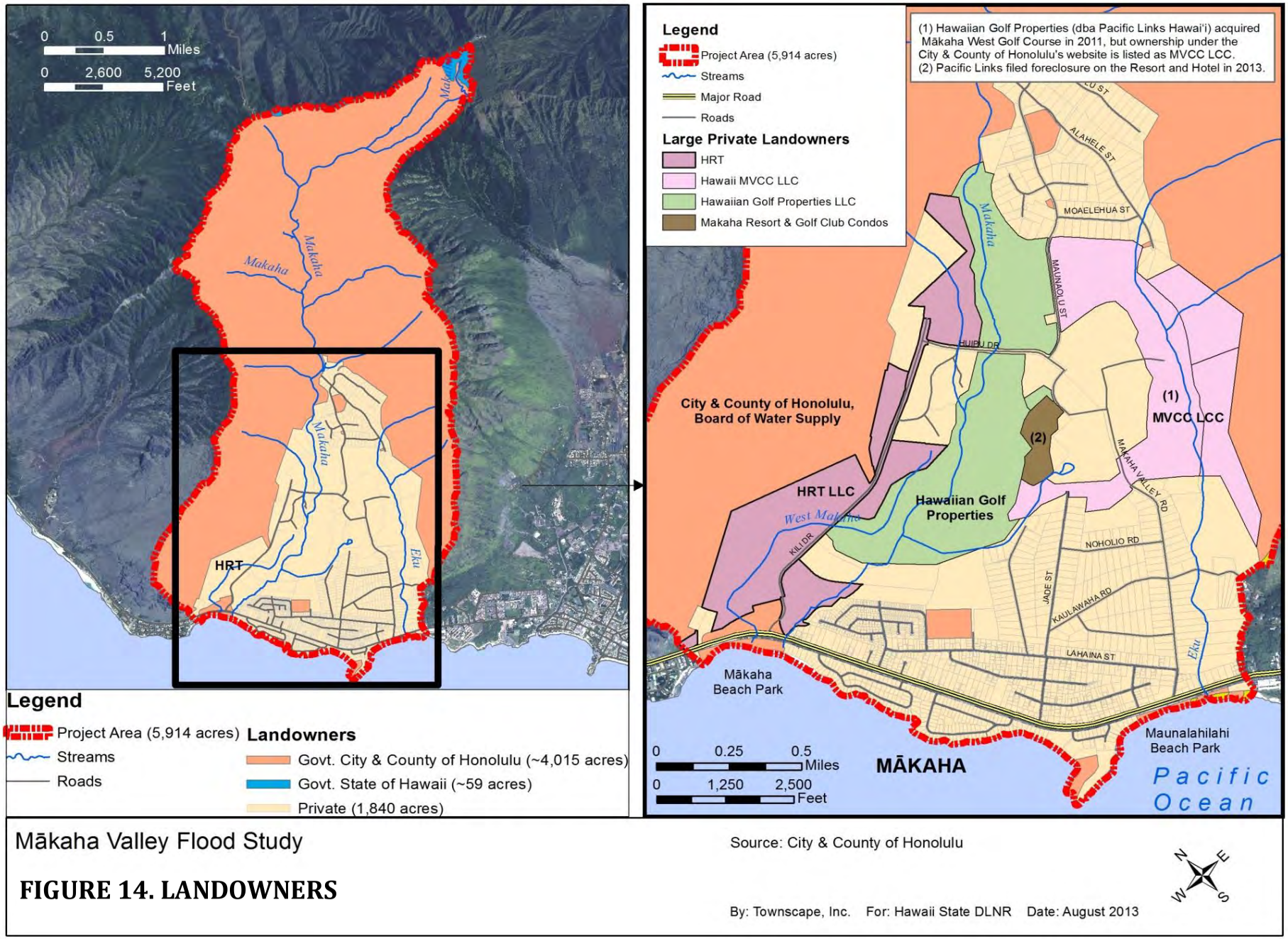
Mākaha Valley Flood Study

FIGURE 13. LARGE UNDEVELOPED PARCELS

0 0.25 0.5 Miles

0 1,250 2,500 Feet

By: Townscape, Inc. For: Hawaii State DLNR Date: August 2013



Mākaha Valley Flood Study

Source: City & County of Honolulu

FIGURE 14. LANDOWNERS

By: Townscape, Inc. For: Hawaii State DLNR Date: August 2013

2.2.5 LAND OWNERSHIP

BWS is the largest land owner in Mākaha Valley, owning about two-thirds (4,015 acres) of the valley, all of which is designated as conservation under state land use. The State owns a very small portion of land within the valley, consisting of the 59 acres of land located near Mount Kaʻala (Figure 14).

Other major land owners include Hawaiian Golf Properties, dba Pacific Links Hawaiʻi, who owns approximately 400 acres in the valley. Pacific Links acquired Mākaha West Golf Course in 2011, and Mākaha East Golf Course in 2012. In the beginning of 2013, Pacific Links filed foreclosure on the Mākaha Hotel and Resort. Another large landowner is HRT, who owns about 224 acres of undeveloped land in the valley.

Mākaha Stream flows through undeveloped parcels owned by HRT and Mākaha Valley Road LLC, and the closed Mākaha West Golf Course before passing near residential houses and discharging into the ocean. The maintenance of the stream bed within these undeveloped parcels is important for flood risk mitigation.

Responsibility for maintaining a stream rests with the owner of the stream. Mākaha Stream is not owned by one single entity, but is shared by many private landowners. As stated in the ROH 41-26.3 (adopted by Ordinance 89-59), the owner of the stream has the duty

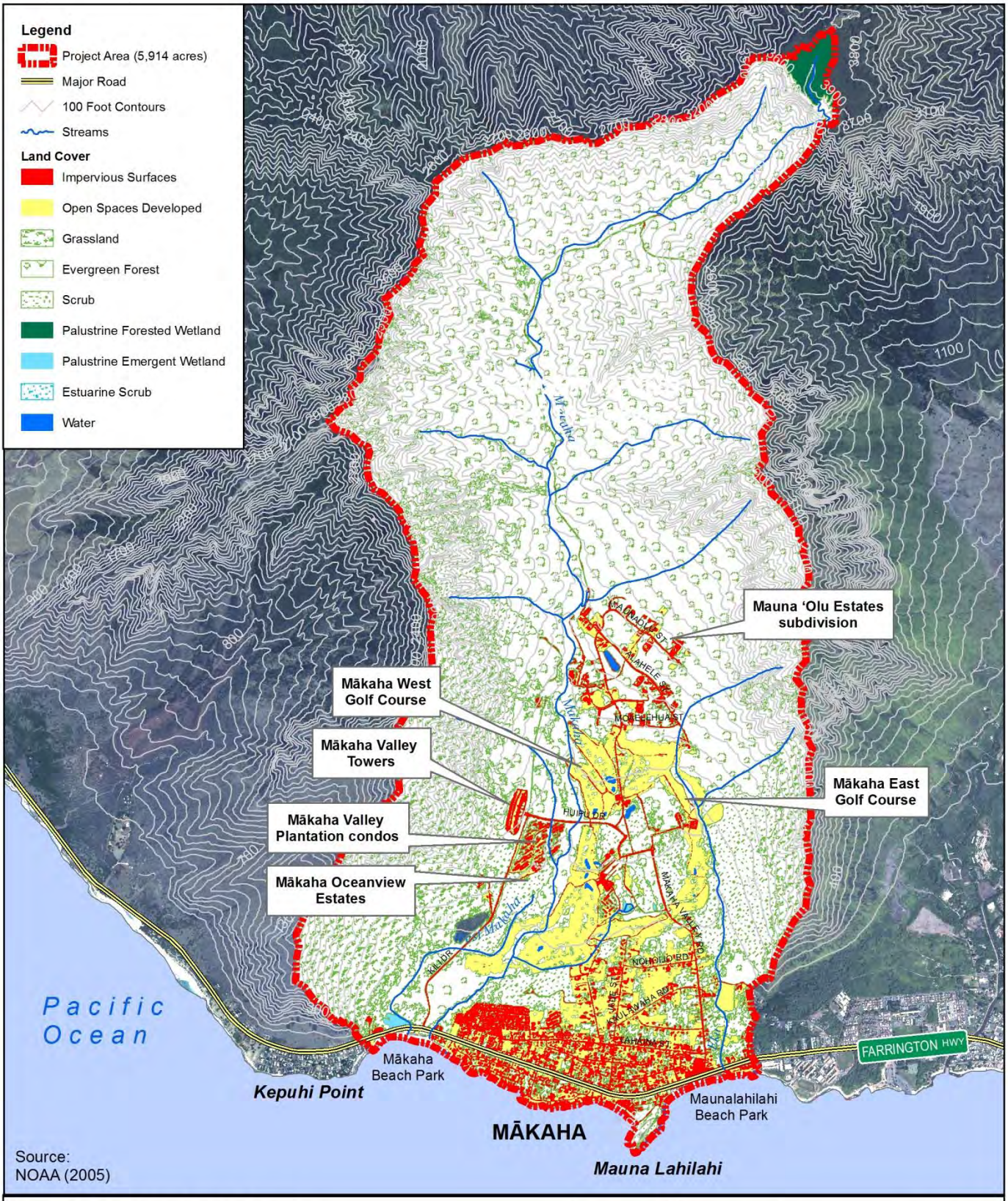
> *"to maintain, dredge, and clear such stream so that the natural flow of water runs unimpaired. The owner shall also be responsible for the removal of any debris, vegetation, silt or other items or material of any kind that may interfere with the natural flow of water."* (20)

Table 10 lists the general land ownership for Mākaha Valley.

TABLE 10. LAND OWNERSHIP

Landowner	Acreage	Percent of Mākaha Valley
City & County of Honolulu, Board of Water Supply	4015	67.88
Private	1,840	31.11
State of Hawaiʻi	59	1.00

Source: State of Hawaii's GIS Data



Mākaha Valley Flood Study

FIGURE 15. LAND USES

0 0.5 1 Miles

0 2,500 5,000 Feet

By: Townscape, Inc. For: Hawaii State DLNR Date: August 2013

2.2.6 EXISTING LAND USES

Land uses can be broadly separated into two main uses in the valley: residential and golf course. Most of the development has occurred in the lower valley and much of the mid-valley. The lower valley consists of mostly single family homes including an elementary school, while the mid-valley includes condo towers, golf courses, and a gated community. There is no active agriculture on any of the parcels zoned for agricultural use, and the upper valley consists of forested areas that are designated for conservation.

About 337 acres of the valley is covered with impervious surfaces, approximately 457 acres of open spaces have been developed, and the remainder of the valley consists of vegetated areas (Figure 15). The replacement of the natural landscape with impervious surfaces, such as roads and driveways, is a contributing factor to flooding because it increases the rate of runoff.

Residential areas in addition to the single family homes in the lower valley include the Mauna ʻOlu Estates subdivision, with lots between one to two acres in size, that is located in the middle portion of the valley; Mākaha Valley Towers, consisting of ten 16-story buildings situated at the base of the steep Keaʻau mountain range; Mākaha Valley Plantation, a complex of condominium across from the Towers; and Mākaha Oceanview Estates, a new subdivision of single-family homes makai of the condominiums.

2.2.7 PLANNED & PROPOSED LAND USES

2.2.7.1 Mākaha West Golf Course Renovation

Pacific Links Hawaiʻi acquired Mākaha West Golf Course from Northwynd Resort Properties Ltd., a Canada-based owner. Pacific Links Hawaiʻi has plans to construct a new 18-hole championship golf course on the existing Mākaha West Golf Course property. Plans include the construction of five new tee boxes (holes #3, 7, 8, 16, and 17), grubbing of existing vegetation, installing fill for new golf holes, stream bank improvements with soil gripper bag walls, and Stream bank vegetation with native plants and trees. Plans will require rezoning a small area from Agriculture (AG-2) to Preservation (P-2). A Stream Channel Alteration Permit (SCAP.3645.3) has been submitted to the State CWRM by Pacific Links Hawaiʻi for these improvements to the Mākaha West Golf Course.

2.2.7.2. Mākaha Loʻi Restoration Project

The BWS recently awarded the local non-profit organization Mōhala I Ka Wai a license for 19-acres of land (TMK 8-4-002: por. 014 at 84-890 Maunaolu Street) just below Kāneʻāki Heiau to restore historic loʻi to active agriculture.

2.2.7.3. Mākaha Valley Road LLC parcels

Mākaha Valley Road LLC plans to develop affordable housing on the 60-acres of land that they own [21]. Although the parcels are currently zoned for agricultural use (AG-1 Restricted), under Section 201H-38, HRS affordable housing projects are exempt from zoning district requirements.

2.2.8 INFRASTRUCTURE

2.2.8.1 Roadways

Farrington Highway, a major highway owned by the State of Hawai'i, is the main artery to the valley. The two main collector streets that feed into Farrington Highway are Kili Drive and Mākaha Valley Road.

The roads within the lower portion of the valley are owned by the City & County of Honolulu, while the majority of the roads mauka of Lahaina Street are privately-owned (Figure 16).

Based on the City's GIS parcel information, Kili Drive is owned by HRT. Mākaha Valley Road is owned by various owners, including Pacific Links, Ko'olina Mākaha East LLC, Mākaha Valley Farms and Mākaha Valley Inc. Mākaha Valley Inc. is also listed as the owner of Huipu Drive and several other residential streets, but stakeholder consultation revealed that both Mākaha Valley Farms and Mākaha Valley Inc. have been liquidated.

Several community members have reported flooding to occur on Farrington Highway near Mākaha Valley Road and along Kili Drive during storms.

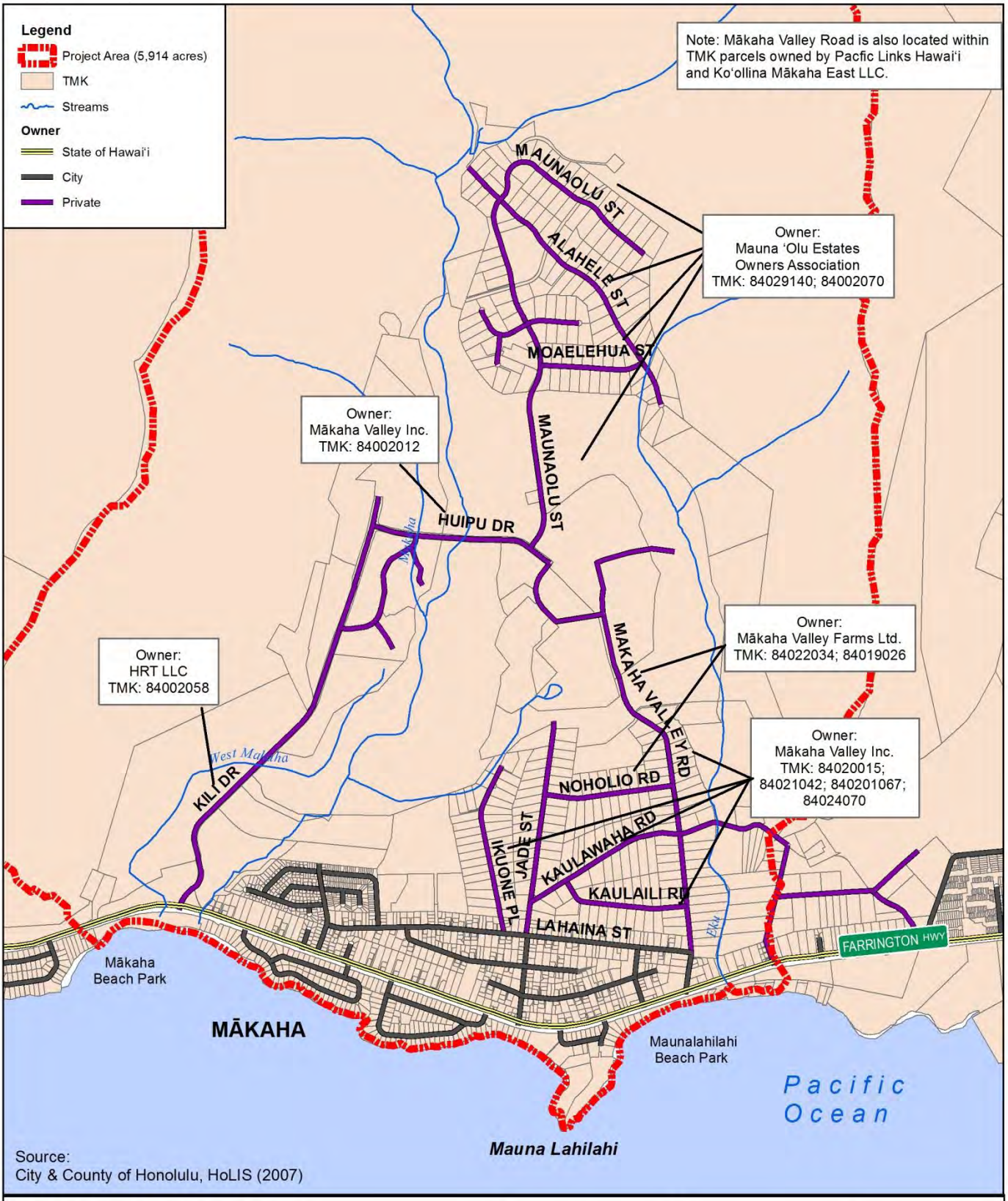
Table 11 lists the private roads in Mākaha Valley.

TABLE 11. PRIVATE ROAD OWNERSHIP

TMK	Street	Owner
84002012	Huipu Drive	Mākaha Valley Inc.
84002058	Kili Drive	HRT LLC
84002073	Maunaolu Street	Mauna 'Olu Estates Owners Association
84029140	Moaelehua Street/Alahele Street/ Maiola Street/Maiola Place	Mauna 'Olu Estates Owners Association
84019026	Mākaha Valley Road[1]	Mākaha Valley Farms Ltd.[2]
84020015	Mākaha Valley Road	Mākaha Valley Inc.
84021042	Kaulaili Road	Mākaha Valley Inc.
84021067	Kaulawaha Road	Mākaha Valley Inc.
84022034	Noholio Road	Mākaha Valley Farms Ltd.
84024070	Ikuone Place	Mākaha Valley Inc.

[1] Sections of Mākaha Valley Road is also located within parcels owned by Pacific Links and Ko'olina Mākaha East LLC.

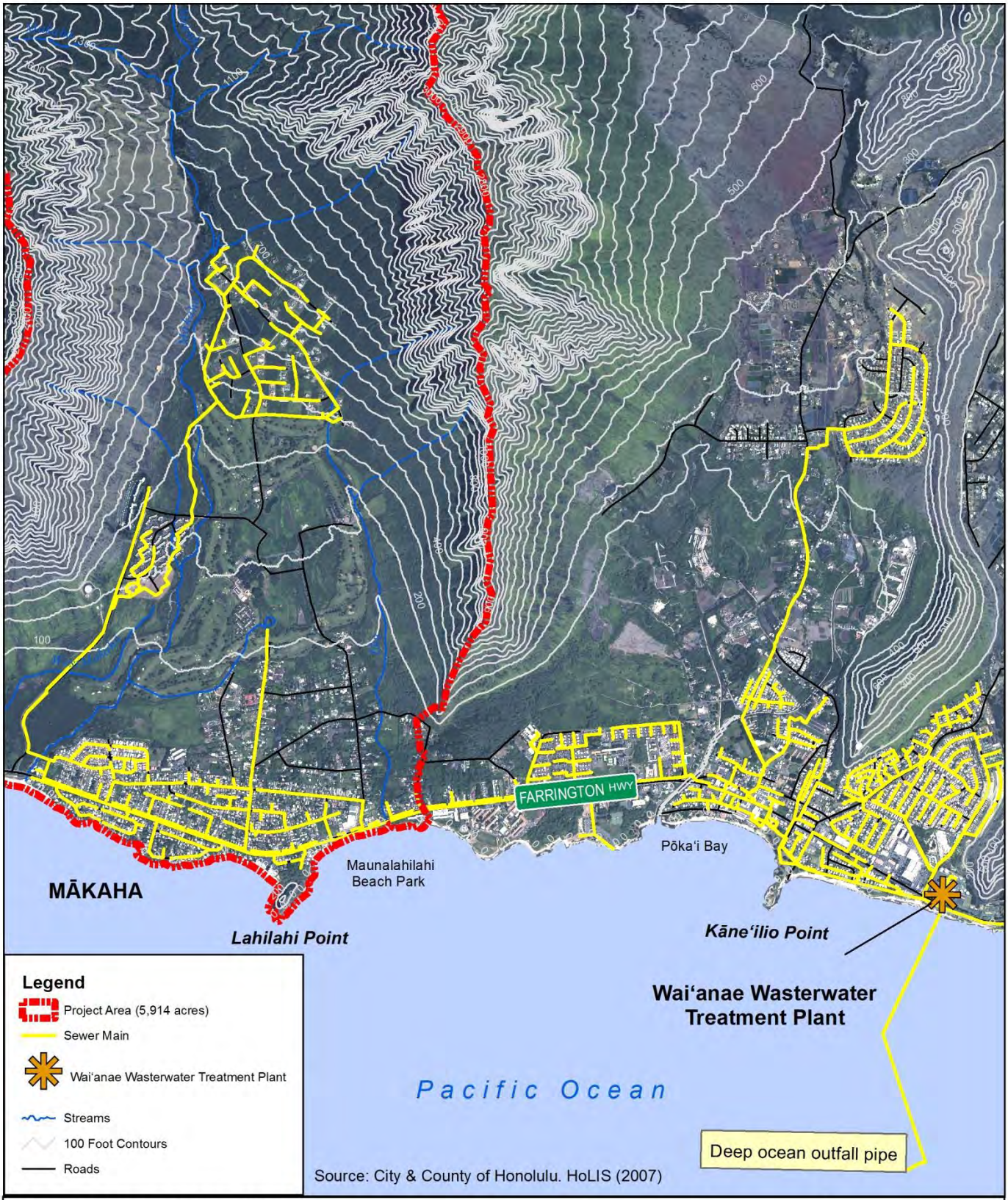
[2] Mākaha Valley Farms and Mākaha Valley Inc. have been liquidated.


Legend
Project Area (5,914 acres)
TMK
Streams
Owner
State of Hawai'i
City
Private
Note: Mākaha Valley Road is also located within TMK parcels owned by Pacfic Links Hawai'i and Ko'ollina Mākaha East LLC.
MAUNAOLU ST
ALAHELE ST
MOAELEHUA ST
Owner:
Mauna 'Olu Estates
Owners Association
TMK: 84029140; 84002070
Owner:
Mākaha Valley Inc.
TMK: 84002012
HUIPU DR
MAUNAOLU ST
Owner:
Mākaha Valley Farms Ltd.
TMK: 84022034; 84019026
MAKAHA VALLEY RD
Owner:
HRT LLC
TMK: 84002058
West Makaha
KILI DR
NOHOLIO RD
KAULAWAHA RD
KAULAILI RD
IKUONE PL
JADE ST
Owner:
Mākaha Valley Inc.
TMK: 84020015;
84021042; 840201067;
84024070
LAHAINA ST
FARRINGTON HWY
Mākaha
Beach Park
MĀKAHA
Maunalahilahi
Beach Park
Pacific
Ocean
Mauna Lahilahi
Source:
City & County of Honolulu, HoLIS (2007)
Mākaha Valley Flood Study
FIGURE 16. ROADWAYS
0 0.5 1 Miles
0 2,500 5,000 Feet
N E S W
By: Townscape, Inc. For: Hawaii State DLNR Date: August 2013

2.2.8.2 Sewer Infrastructure

A major pipeline runs generally along the Farrington Highway route conveying wastewater from Mākaha Valley to the Waiʻanae Wastewater Treatment Plant (WWTP). After the wastewater is treated, it is then discharged through an ocean outfall pipe that is located 6,184 feet offshore at an average discharge depth of 107.5 feet (Figure 17). The WWTP also serves Nānakulī, Lualualei, Maili, and Waiʻanae communities.

The WWTP is designed to treat up to 5.2 million gallons per day (mgd) with a peak capacity of 13.8 mgd. During an interview with the City of Honolulu's Department of Environmental Services for the Mākaha Special Area Plan in 2009, the staff stated that the sewer main along Farrington Highway from Mākaha Valley was "at capacity." In 2012, over 3,200 feet of 36-inch and 42-inch diameter pipelines were installed to rehabilitate the aging sewer lines as part of the Mākaha Sewer Rehabilitation/Replacement project.



Mākaha Valley Flood Study

FIGURE 17. SEWER INFRASTRUCTURE

By: Townscape, Inc. For: Hawaii State DLNR Date: August 2013

2.2.8.3 Stormwater Infrastructure

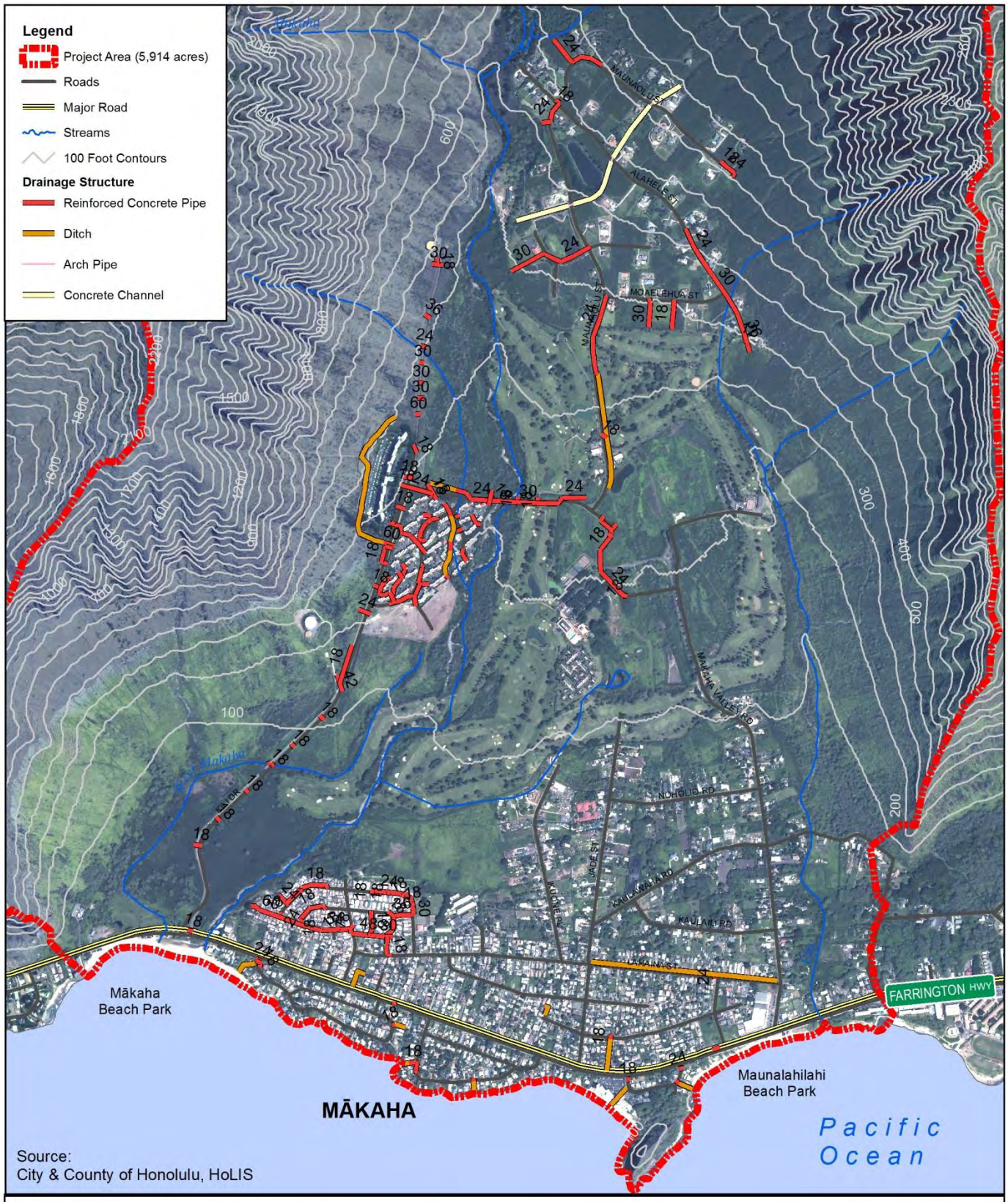
Mākaha Valley is part of the City and County of Honolulu's storm drain system known as the Municipal Separate Sewer System (MS4). Through a network of catch basins, underground pipes, open channels, and outfalls, storm water is conveyed mostly to Mākaha Stream, which eventually discharges into the ocean (Figure 18).

Drainage systems are intended to prevent flooding in areas, but community members have reported that storm water drains are often clogged with debris and rocks that fall from the side of the valley during storms and cause flooding to occur along the streets, particularly on Kili Drive.

All the underground pipes are reinforced concrete pipes, varying in sizes from 18 to 60 inches in diameter. Two of the 60-inch culverts are located along Kili Drive and the other in the R-5 zoned area on Nukea Street. A network of stormwater drains along Manuku, Water, and Kepue Streets in the residential area zoned R-5 conveys water towards Mākaha Stream. Culverts and open ditches located in the residential areas makai of Farrington Highway drain into the ocean. An open ditch is located on Lahaina Street extending from Jade Street to Mākaha Valley Road. There is insufficient drainage infrastructure for the lower portion of the valley, particularly for the residential area zoned Country near Noholio Road and Kaulawaha Road. A network of stormwater drains below the condominiums at Mākaha Valley Plantation also drains into Mākaha Stream.

The "Rules Relating to Storm Drainage Standards" (January 2000) set forth by the City and County of Honolulu provides stormwater standards and regulations for flood control.

A more detailed discussion of the drainage system is located in Section 2.4.1of this report.



Mākaha Valley Flood Study

FIGURE 18. STORMWATER INFRASTRUCTURE

0 0.5 1 Miles

0 2,500 5,000 Feet

By: Townscape, Inc. For: Hawaii State DLNR Date: August 2013

2.2.9 PLANNED & PROPOSED INFRASTRUCTURE

2.2.9.1 West Mākaha Golf Course Proposed Drainage

Proposed drainage plans for West Mākaha Golf Course include two detention basins (one located on the mauka parcel and the other on the makai parcel), new drain inlets, a new underground drainage system and a drainage outlet structure.

For the mauka parcel, new drain inlets and underground pipes will convey runoff into an irrigation lake on-site located mauka of Huipu Drive, where overflow will be discharged into a detention basin (~elevation 260 feet), and then feed into Mākaha Stream. For the makai parcel below Huipu Drive, three water features and a second detention basin (~elevation 60 feet) located mauka of the existing earth berm are proposed.

With the proposed drainage features, peak flow discharge is estimated to be reduced by approximately 30.8 cfs for a 100-year flood event. (22)

2.2.9.2 DOT Bridge Replacement Project

The Hawaii Department of Transportation proposes to replace the two wooden bridges, Mākaha Bridges 3 and 3A, both built in 1937, along Farrington Highway with reinforced concrete bridges. Mākaha Stream flows under Bridge 3, and West Mākaha Stream flows under Bridge 3A. Based on a FEMA drainage analysis, the existing bridges do not have the hydraulic capacity to accommodate a 100-year flood event. At the time of this writing, designs for the bridges were 90% complete, with R.M. Towill as the design consultant for the project. The project should be advertised by mid-summer of 2014. (23)

The new bridges are proposed in the same location as the existing bridges. The replacement of Bridge 3 will widen approximately 150 feet of Mākaha Stream in order to lower the water surface profile. Riprap revetments will be used to protect the streambed from erosion.

2.2.9.3 BWS Mauna 'Olu 530' Nonpotable Reservoir Project

At the time of writing, the BWS is working on a project to redirect overflow from the BWS Mauna 'Olu 530' nonpotable reservoir to the open concrete channel on the makai side of the reservoir. A pipe will be installed in the reservoir that drains into the culvert. Currently, reservoir overflow crosses a Mauna 'Olu Estate lot which has been causing some erosion on the property owner's lot. (24)

2.3 STAKEHOLDER ISSUES

To better understand the historical flooding and flooding issues in Mākaha, community members, businesses, major land owners, and elected officials, and public agencies were consulted. To date, eleven stakeholders had been interviewed. Additional interviews will be included in upcoming document submittals. Stakeholder issues are summarized as follows:

Drainage Systems Infrastructure - Maintenance and Responsibility

- Storm drains need to be maintained from rocks and debris that clog the drainage system, particularly along Kili Drive.
- Both of the ditches behind Mauna ʻOlu Estates and Mākaha Valley Towers are silted in; therefore, reducing their capacity. There is overgrowth and signs of erosion.
- Illegal dumping into ditches diverts stormwater from its intended pathway and often causes flooding in other areas.

Hazards - Flooding

- Homes and buildings, located at the base of the mountains, are close to very steep and almost vertical cliffs.
- Kili Drive floods when it rains, and is often referred to as "Kili River."
- Since Kili Drive was built, stream flow to West Mākaha Stream has been reduced. Kili Drive acts as a dam, and prevents runoff from going into West Mākaha Stream. Instead, the runoff flows into Mākaha Stream.
- One of the property owners has built a wall that is placed in a natural drainage path to prevent water from entering into their property. As a result, water is diverted and floods the adjacent properties.
- Mākaha Stream is blocked by a sand berm at its mouth which prevents free flow of storm water to the ocean and causes the stream water level to rise rapidly. This results in the flooding of properties adjacent to the stream.
- There are few early warning signs with flash floods, particularly with the lack of stream gage data available for the streams in Mākaha, to provide adequate warning time for flood mitigation efforts such as the removal of the sand berm.

Streambed – Policy, Maintenance and Responsibility

- The streams are not owned or maintained by the City or State, but owned by many individual landowners including some of the larger landowners.
- Property owners adjacent to the stream own up to the middle of the stream that is within their parcel's boundary. It is the landowners' responsibility to maintain the portion of the stream within their parcel. Since there is no regulatory agency enforcing this responsibility, the streambeds are not well maintained. Lack of enforcement is an issue.
- There is a lot of illegal dumping, erosion, and overgrowth within the streambeds.
- Private landowners should work together to ensure that the stream is maintained and clear of debris, and to work towards a larger goal of flood risk mitigation for the valley.

- Community members need to be more involved with taking care of their ʻāina, and more community efforts (i.e. stream clean-ups) are needed to keep costs lower for future flood damages.

Land Use Planning

- There needs to be planning for large waterways and floodways.
- Planning for Mākaha Valley as a whole, and not piecemeal.
- It is important for community members to look at the entire ahupuaʻa, and not just the effects of flooding on their own property.
- There are several large parcels of undeveloped land that with existing zoning can allow for more development in the valley. There are concerns of how this will affect drainage and flooding issues.

2.4 FLOOD HAZARDS FOR MĀKAHA VALLEY

As stated in the State of Hawaii Multi-Hazard Mitigation Plan, three major approaches to minimize flood damage include: (1) regulate use of flood plains or by evacuating the flood plain; (2) confine flood flows by manmade structural measures; and (3) use flood damage insurance to minimize economic loss from floods.

Development in Special Flood Hazard Areas (SFHA) is regulated by the National Flood Insurance Program (NFIP). Title 44 of the Code of Federal Regulations sets the minimum NFIP rules and regulations. Land use regulations for flood hazard districts are outlined in ROH 21-9.10 through 21-9.10-14. ROH 16-11 provides building code regulations within flood hazard districts and developments adjacent to drainage facilities. ROH 16-11.5 states that all buildings and structures within flood hazard districts are to be constructed in accordance with ASCE 24 standards.

2.4.1 FLOOD HAZARD AREAS

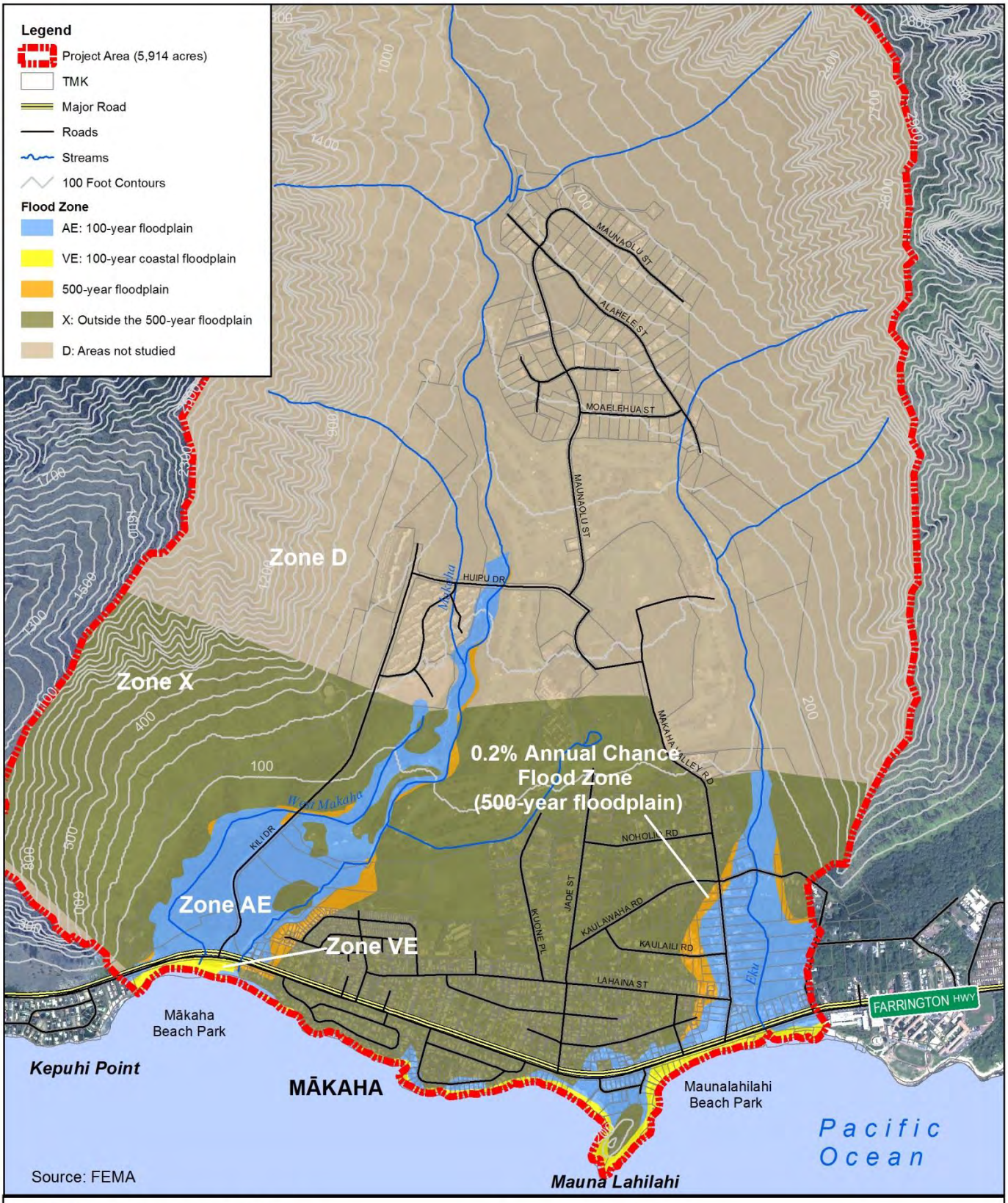
The National Flood Insurance Act of 1968 created the Federal Insurance Administration and made flood insurance available for the protection of property. Flood zones are depicted on the Flood Insurance Rate Map (FIRM) by the Federal Emergency Management Agency (FEMA), and are classified based on varying levels of flood risk. Flood zones located in Mākaha Valley consist of Zones AE, VE, X, and D (Figure 19). Both Zones AE and VE are located in SFHA and are required to purchase flood insurance according to the Flood Disaster Protection Act of 1973.

Floods are usually described in terms of their statistical frequency. SFHA are subject to inundation by the 1% annual chance flood, also referred to as a 100-year flood. In other words, a 100-year flood means that over the term of a 30-year mortgage, a home located within a SFHA has a 26% chance of flood damage.

Flooding occurs from heavy or continuous rain that exceeds the soil's absorption capacity and flow capacity of streams and coastal areas. This causes the stream to overflow onto adjacent lands. Floodplains are those lands that are most subject to recurring floods. These floodplain areas are hazardous to flooding and should be avoided for development.

Zone AE corresponds to the 100-year floodplains, and Zone VE corresponds to the 100-year coastal floodplains that have additional hazards associated with storm waves. Zone X is an area determined to be outside of the 0.2% annual chance floodplain (500-year flood). Zone D is an area with possible but undetermined flood hazards, where no flood hazard analysis has been conducted.

Base Flood Elevations (BFEs), the computed elevation that floodwater is anticipated to rise during the base flood, are shown in Figure 20. The BFE is the regulatory requirement for the elevation or floodproofing of structures.



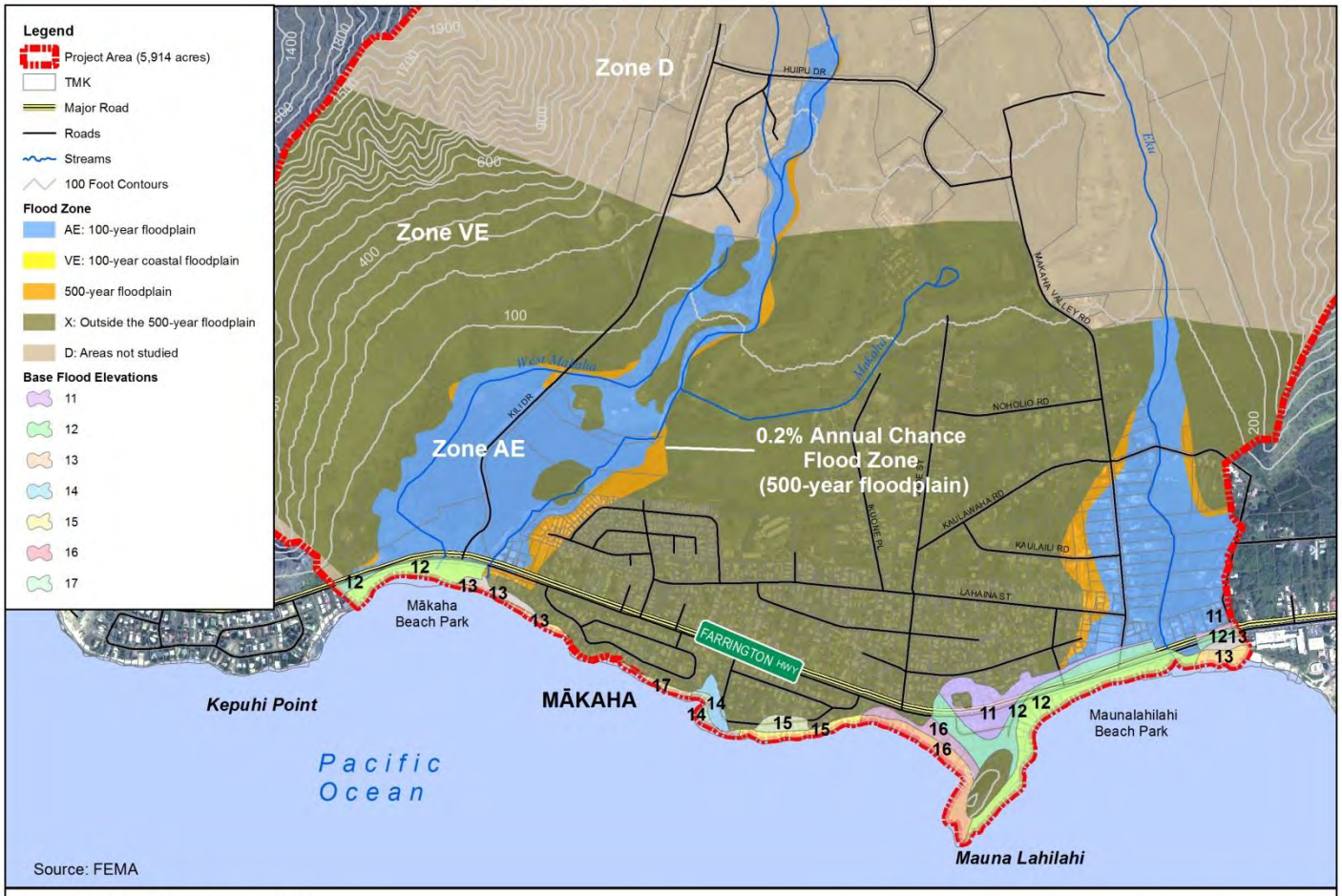
Mākaha Valley Flood Study

FIGURE 19. FLOOD HAZARD AREAS

0 0.5 1 Miles

0 2,500 5,000 Feet

By: Townscape, Inc. For: Hawaii State DLNR Date: August 2013



Mākaha Valley Flood Study

FIGURE 20. BASE FLOOD ELEVATIONS

0 0.5 1 Miles
0 2,500 5,000 Feet

By: Townscape, Inc. For: Hawaii State DLNR Date: August 2013

Most of the flooding occurs near the lower part of the stream. Based on the FIRMs, the majority of Mākaha Valley Road, from Farrington Highway to Kaulawaha Road, is subject to flooding by a 100-year flood. Other areas located within Zone AE include Farrington Highway along Mākaha Beach Park and Maunalahilahi Beach Park, residential houses, businesses located at the Wai'anae Cornet Village Shopping Center at the intersection of Mākaha Valley Road and Farrington Highway, some areas of the Mākaha West Golf Course, and undeveloped parcels zoned as Residential (R-10) and Restricted Agricultural (AG-1). Several residential houses near Lahilahi Point, including Mākaha Beach Park and Mauna Lahilahi Beach Park are located in Zone VE.

A significant acreage of the valley (4530 acres) has not been studied, which is represented by the areas in Zone D in the FIRMs. Flood hazard analysis in Zone D should be considered for the areas that are subject to flooding, as revealed by stakeholder interviews.

Based on the State of Hawaii Multi-Hazard Mitigation Plan (2010), there are two counts of Repetitive Flood Losses (RFL) in Mākaha. RFL are two or more NFIP claims of more than $1000 within any 10-year period since 1978 (Table 12).

TABLE 12. REPETITIVE FLOOD LOSSES

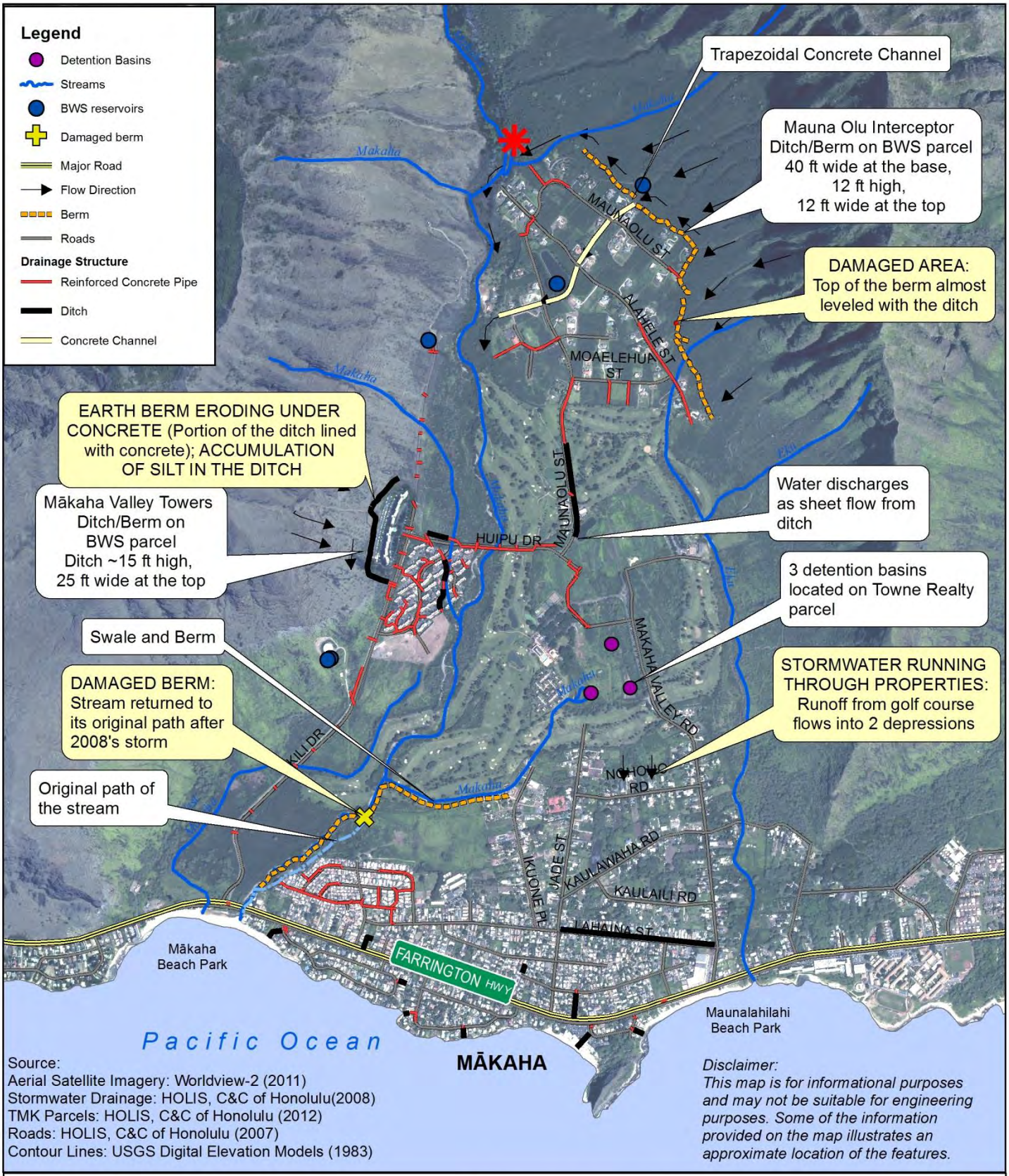
Occupancy	Zone	Total Building payment	Total Contents Payment	Losses	Total paid	Mitigated/Insured
Single Family	V22	67,504.57	30,946.92	2	98451.49	No/No
Singly Family	V22	148,607.50	35,000.00	2	183607.50	No/No

Table 13 displays the approximate acreage of land within each zone for Mākaha Valley.

TABLE 13. FIRM ZONING FOR MĀKAHA VALLEY

Zone	Description	Approximate Acres
AE [1]	Areas subject to flooding by the1% annual chance flood (100-year flood) event determined by detailed methods. Base Flood Elevations are shown.	251
VE [1]	Areas subject to flooding by the1% annual chance flood (100-year flood) event with additional hazards due to storm-induced velocity wave action. Base Flood Elevations derived from detailed hydraulic analyses are shown.	36
0.2% Annual Chance Flood Zone	Corresponds to the areas of 500-year flooding	37
X	Areas determined to be outside the 0.2% annual chance floodplain	1060
D	Areas in which flood hazards are undetermined, but possible.	4530

[1]Mandatory flood insurance purchase applies
Source: State of Hawaii's GIS Data


Legend
Detention Basins
Streams
BWS reservoirs
Damaged berm
Major Road
Flow Direction
Berm
Roads
Drainage Structure
Reinforced Concrete Pipe
Ditch
Concrete Channel
Trapezoidal Concrete Channel
Mauna Olu Interceptor Ditch/Berm on BWS parcel 40 ft wide at the base, 12 ft high, 12 ft wide at the top
DAMAGED AREA: Top of the berm almost leveled with the ditch
EARTH BERM ERODING UNDER CONCRETE (Portion of the ditch lined with concrete); ACCUMULATION OF SILT IN THE DITCH
Mākaha Valley Towers Ditch/Berm on BWS parcel Ditch ~15 ft high, 25 ft wide at the top
Water discharges as sheet flow from ditch
3 detention basins located on Towne Realty parcel
Swale and Berm
DAMAGED BERM: Stream returned to its original path after 2008's storm
STORMWATER RUNNING THROUGH PROPERTIES: Runoff from golf course flows into 2 depressions
Original path of the stream
Makaha
MAUNAOLU ST
ALAHELE ST
MOAELEHUA ST
HUIPU DR
MAKAHA VALLEY RD
NOHOMO RD
KILI DR
IKUONE PL
JADE ST
KAULAWAHA RD
KAULAILI RD
AHAINA ST
FARRINGTON HWY
Mākaha Beach Park
Maunalahilahi Beach Park
Pacific Ocean
MĀKAHA
Source:
Aerial Satellite Imagery: Worldview-2 (2011)
Stormwater Drainage: HOLIS, C&C of Honolulu(2008)
TMK Parcels: HOLIS, C&C of Honolulu (2012)
Roads: HOLIS, C&C of Honolulu (2007)
Contour Lines: USGS Digital Elevation Models (1983)
Disclaimer:
This map is for informational purposes and may not be suitable for engineering purposes. Some of the information provided on the map illustrates an approximate location of the features.
Mākaha Valley Flood Study
FIGURE 21. EXISTING DRAINAGE SYSTEMS
0 0.5 1 Miles
0 2,500 5,000 Feet
N E W S
By: Townscape, Inc. For: Hawaii State DLNR Date: August 2013

2.4.2 EXISTING DRAINAGE SYSTEMS

Figure 21 illustrates the existing drainage systems for Mākaha Valley. The drainage systems can be broadly divided into four general areas: Mauna ʻOlu Estates subdivision, Mākaha Valley Towers, golf course and residential area zoned R-5, and the residential area zoned Country.

Mauna ʻOlu Estates area

The Mauna ʻOlu Estates Interceptor Ditch, as referred to in the proposed drawing plans done by Park Engineering, was completed in 1984 and was built to protect Mauna ʻOlu Estates. It consists of a vegetated ditch and an earth filled berm about 40 feet wide at the base, 12 feet high, and 12 feet wide at the top, that runs parallel to the boundary line of the Mauna ʻOlu Estates lots on the eastern side of the valley. A trapezoidal concrete channel is located between Interceptor Ditch No.1 and No. 2 that diverts water from Eku Stream towards Mākaha Stream. Interceptor Ditch No. 3 consists of three separate berm structures following the natural topography where overflow from the top berm is captured by the second berm below, and the overflow from this berm is then captured by the third and final berm.

CONCRETE CHANNEL: VIEW FROM MAUNAOLU STREET

Inlet grates along Maunaolu Street are connected to 18 and 24-inch pipes that convey stormwater towards Mākaha Stream, where it is discharged as sheet flow from the outlets. Makai of the concrete channel, another inlet grate from Maunaolu Street conveys runoff through a 24-inch pipe and into a 30-inch pipe that discharges into the stream as well.

Pipes along the end of Maunaolu and Alahele Streets feed stormwater into Eku Stream. Two pipes run from the middle of Moaelehua Street that discharges water towards the golf course.

Near the intersection of Maunaolu and Moaelehua Streets, an inlet conveys water into a 24-inch pipe along Maunaolu Street that connects to a concrete ditch, and discharges the stormwater as sheet flow. Runoff from the ditch also spills over into the adjacent reservoir located near where the ditch ends.

DITCH AND BERM BEHIND MAUNA 'OLU SESTATES

Issues:

- During a site recon (July 18, 2013) to examine the Mauna 'Olu Estates Ditch, the ditch was silted in and a portion of berm (above TMK 84029097) was leveled with the ditch.
- In some areas the top of the berm is relatively narrow due to erosion.

Mākaha Valley Towers/Kili Drive area

In addition to the runoff from Mauna 'Olu Estates that discharges into Mākaha Stream, runoff from the Kea'au mountain range is intercepted and conveyed into Mākaha Stream. A concrete channel makai of the BWS 525' reservoir intercepts stormwater from the side of the valley and directs it into a 30-inch culvert below Kili Drive. From here, there are six inlets along Kili Drive, before reaching the Towers, conveying water into 24 to 60 inch culverts and discharging into the stream. From Mākaha Valley Towers towards Farrington Highway, seventeen catch basins, the majority of them connected to an 18-inch reinforced concrete pipe below Kili Drive, intercept stormwater and feed into the stream. Numerous concrete pipes and several ditches within the Mākaha Valley Condos convey water into Mākaha Stream as well.

CONCRETE-LINED DITCH BEHIND MĀKAHA VALLEY TOWERS

Behind Mākaha Valley Towers is an earth berm and ditch that intercepts runoff from the side of the valley. It conveys water flow through a concrete-lined ditch that turns down towards an unlined ditch and into a 60-inch culvert below Kili Drive into Mākaha Stream. The ditch is approximately 15 feet high and 25 feet wide at the top.

During the November 1996 storm, a section of the berm was damaged. Water flow went straight through the berm, and towards the Towers. The berm was repaired after the rain event, which is where the section of the drainage system is lined with concrete to reduce further erosion of the ditch and earth berm.

EARTH BERM ERODING UNDER THE CONCRETE

Issues:

- The ditch at the culvert opening has silted up as high as the debris catcher poles that are about 3 feet high above the ground.
- There are signs of the earth berm eroding under the concrete where the concrete lining begins.

Golf Course and R-5 zoned: Lower valley area

Three detention basins are located on Towne Realty parcel, where overflow travels towards the bottom area of the golf course boundary before it is intercepted by a swale that directs the water towards Mākaha Stream. A berm is located on the makai side of the swale. From the golf course, the swale and berm continues into the undeveloped parcel zoned AG-1 where a portion of the berm was damaged during the 2008 storm. The berm, which redirected the stream about 600 feet towards Kili Drive, and was possibly built to allow for the development of the subdivision below, has returned to its original Stream path.

Numerous catch basins along Manuku, Water, Kepue, and Water streets in the residential area zoned R-5 convey water towards Mākaha Stream. These catch basins are connected to pipes varying from 18 to 60 inches in diameter, discharging into the stream. A small part of Mākaha Stream is lined with concrete in the lower portion of the valley near Farrington Highway.

Towards the other side of the lower valley, a ditch runs parallel to Lahaina Street from Jade Street to Mākaha Valley Road.

Residential area zoned Country

There is no adequate drainage system for the lower residential area zoned Country. There are two swales running from the golf course towards the ocean that is the natural drainage way for stormwater runoff. Stormwater that is not infiltrated into the ground from the golf course sheet flows into these two swales. These two swales travel through properties below in the residential area. One of the property owners has built a wall to prevent runoff from entering their parcel, and as a result, runoff is diverted into the neighbor's property and floods their property.

2.4.3 SUMMARY OF HISTORICAL FLOODING & IMPACTS

Historical notable flash flood events in Mākaha occurred in 1954, 1962, 1964, and 1965. Two of the more recent flood events that significantly impacted Mākaha occurred in 1996 and 2008.

November 1996 Flood

On November 5, 1996 thunderstorms with heavy showers flooded roads from Waiʻanae to Nānākuli closing Farrington Highway temporarily due to high water. A week later, a line of heavy showers moved across Oʻahu, with 3 to 4 inches of rainfall estimated in a 2-hour period. Minor street flooding was reported in Waiʻanae areas. Rainfall continued for another four consecutive days until November 16th. During that time period, a massive mudslide hit the Mākaha Valley Tower complex and damaged the first floor of the complex at about 2 a.m. on November 14th. Between November 12th-16th, a total of 16.3 inches of rainfall was recorded. (25)

TABLE 14. RAINFALL AND STREAM DISCHARGE FOR NOVEMBER 1996 FLOOD

November	Rainfall (inches) [1]	Daily Average Discharge (cfs) from USGS 16211600
12	4.8	47
13	5.4	86
14	4.3	220
15	1.8	80
16	5.8	40

[1] Source: USGS Mākaha Rain Gage

Stream Gage Data

Maximum discharge for Mākaha Stream was recorded on November 16th for:

- Stream gage USGS 16211600 at 2,680 cfs and the gage height measured at 9.54 feet.
- Stream gage USGS 16211700 estimated at 5,000 cfs and the gage height measured at 17.60 feet.

Major Impacts

- Heavy rains caused a landslide, where mud, rocks and a flood of water hit Mākaha Valley Towers. Cars were covered with mud and reached nearly the fourth floor of the apartments. A car was shoved into the lobby of one of the buildings.
- A portion of the berm located behind Mākaha Valley Towers was damaged from the velocity of stormwater traveling down the steep mountains.

December 2008 Oʻahu Flood Disaster

A kona low developed northwest of the islands on December 10th, bringing several rounds of heavy rainfall to the islands that mostly hit Kauaʻi and Oʻahu. During the early morning of December 11th, the storm produced a lot of rain and caused significant flooding. A total of 12.38 inches was recorded for Mākaha for that day. Two days later, on the night of December 13th, heavy rainfall fell again, hitting Kauaʻi and Oʻahu once more. Mākaha and Waialua suffered from the most serious flooding problems on Oʻahu. Within those four days, a total of 19.16 inches of rain was recorded for Mākaha.

TABLE 15. RAINFALL AND STREAM DISCHARGE FOR DECEMBER 2008 FLOOD

December	Rainfall (inches) [1]	Daily Average Discharge (cfs) from USGS 16211600
10	0.14	0.11
11	12.38	231
12	1.78	34
13	4.88	114
14	0.12	48

[1] Source: USGS Mākaha Rain Gage

Stream Gage Data

- Maximum discharge (USGS 16211600) for Mākaha Stream was recorded on December 11th at 1,100 cfs and the gage height measured at 6.26 feet high.

Major Impacts

- Due to the volume and velocity of the 2008 stormwater, Mākaha Stream broke through the earth berm, located on the parcel owned by Mākaha Valley Road LLC, makai of the West Golf Course parcel, and flooded the residential homes located below. Since then, the berm has not been fixed. The berm was designed to divert Mākaha Stream to protect subdivisions below. With the damaged berm, the stream has returned to its original path, which floods homes below.
- Flood damages to homes located near Eku Stream.
- Kili Drive sustained major road damage because of debris and rocks clogged in the stormwater drains, and blocking discharge into Mākaha Stream, caused stormwater to backup.
- About 22 damage reports were documented by the Hawaii State Civil Defense in Mākaha.

2.5 DATA GAPS

- There is no stream data for Eku Stream since there are no stream gages for that stream.
- There is only one active stream gage for Mākaha Stream. The other stream gage was discontinued in 2004 due to lack of funding.
- The existing active stream gage is located above the modified drainage system, and thus is unable to capture effects as a result of the stream diversions, including from the Mauna ʻOlu Estates drainage system.
- Limited documentation on historical flood events and flooded areas.
- Limited information on drainage infrastructure plans for private landowners of large undeveloped parcels.
- Limited information on historical flow changes of West Mākaha Stream.

REFERENCES

1. **West Oahu Soil Conservation District and City & County of Honolulu.** *Wateshed Work Plan for Waianae Iki Watershed.* 1960.

2. **Department of the Army, Pacific Ocean Division, Corps of Engineers.** *South Makaha Stream Summary Report.* 1983.

3. **Fukunaga and Associates.** *Statewide Captial Improvment Program Flood Control Projects (Report R98).* 1994.

4. **Townscape, Inc.** *Waiʻanae Sustianable Communities Plan.* 2010.

5. —. *Waiʻanae Watershed Management Plan.* 2009.

6. —. *Mākaha Special Area Plan.* 2009.

7. **URS Group, Inc.** *Mitigation Assessment Study (FEMA-1814-DR-HI).* 2010.

8. **UH Social Science Research Institute and Hawaii State Civil Defense.** *State of Hawaiʻi Multi-Hazard Mitigation Plan.* 2010.

9. **Macdonald, Gordon, A.Abbott and Peterson, F.** *Volcanoes in the Sea.* Honolulu : University of Hawaii Press, 1990.

10. **United States Department of Agriculture, Natural Resources Conservation Service.** *Custom Soil Resource Report for Mākaha Valley.* 2013.

11. **AECOS, Inc.** *Biological surveys for a 25-acre parcel (TMK: 8-4-002:055 por) in Mākaha Valley, Oʻahu.* 2012.

12. *Atlas of Hawaiian Watershed & Their Aquatic Resources.* 2008.

13. **USGS.** *StreamStats.* [Online] [Cited: August 14, 2013.] http://water.usgs.gov/osw/streamstats/.

14. **Corporation), Eric Kadooka and John Tudela (Wilson Okamoto.** *Mākaha West Golf Course Renovation-Mākaha Valley Historical Overview.* September 26, 2011.

15. **City & County of Honolulu, Hawaii.** *Flood Insurance Study.* 2011.

16. **Cordy, Ross.** *An Ancient History of Waiʻanae.* Honolulu : Mutual Publishing, 2002.

17. **McGrath Jr., Edward, Brewer, Kenneth and Krauss, Bob.** *Historic Waianae.* Norfolk Island, Australia : Island Heritage, 1973.

18. U.S. Census Bureau. [Online] 2010. [Cited: July 14, 2013.] http://www.census.gov/.

19. **Sakahara, Tim.** Makaha Resort closing and renovating. *Hawaii News Now.* [Online] October 20, 2011. [Cited: 05 2013, August.] http://www.hawaiinewsnow.com/story/15746281/makaha-resort-closing-and-renovating.

20. Revised Ordinances of Honolulu 41-26, Maintenance of channels, streambeds, streambeds and drainageways.

21. **Bly, Justin.** August 13, 2013.

22. **Wilson Okamoto Corporation.** *Drainage Report for Pacific Links Hawaii.* 2012.

23. **Henry Kennedy, Department of Transportation Design.** August 13, 2013.

24. **Usagawa, Barry.** July 19, 2013.

25. **USGS.** *Rainfall Records for State Key Number 842.1 Makaha rain gage.*

Peak Streamflow USGS 16211600
Latitude 21°30'05.7", Longitude 158°10'48.6" NAD83
Drainage area 2.28 square miles
Gage datum 938.64 feet above HILOCAL

Water Year	Date	Gage Height (feet)	Streamflow (cfs)
1960	Feb. 22, 1960	3.27	189
1961	Dec. 29, 1960	3.38	218
1962	Mar. 13, 1962	6.5	1,170
1963	Jan. 31, 1963	4.67	563
1964	Mar. 24, 1964	4.1	387
1965	Dec. 23, 1964	5.91	965
1966	Nov. 13, 1965	5.78	922
1967	Mar. 06, 1967	3.99	377
1968	Dec. 10, 1967	4.08	404
1969	Dec. 03, 1968	3.83	308
1970	Dec. 27, 1969	4.97	641
1971	Jan. 28, 1971	3.98	345
1972	Feb. 04, 1972	4.04	362
1973	Dec. 17, 1972	2.55	62
1974	Apr. 19, 1974	4.8	590
1975	Feb. 01, 1975	3.38	196
1976	Feb. 07, 1976	5.93	975
1977	Nov. 16, 1976	2.68	78
1978	23-May-78	3	126
1979	Feb. 10, 1979	4.68	554
1980	Jan. 08, 1980	3.29	178
1981	7-May-81	2.81	97
1982	Jan. 06, 1982	7.4	1,450
1983	Oct. 27, 1982	3.62	255
1984	Mar. 02, 1984	2.86	104
1985	Sep. 13, 1985	2.57	66
1986	Oct. 20, 1985	4.02	356
1987	Mar. 26, 1987	2.88	107
1988	Jan. 01, 1988	3.95	338
1989	Apr. 09, 1989	3.87	318
1990	Jan. 16, 1990	4.68	545
1991	Dec. 19, 1990	2.99	124
1992	Oct. 16, 1991	4.26	428
1993	Dec. 30, 1992	3.9	325
1994	Mar. 24, 1994	4.3	440
1995	Oct. 03, 1994	2.88	106
1996	Jan. 24, 1996	3.88	306
1997	Nov. 14, 1996	9.54	2,680
1998	Jan. 17, 1998	1.73	23
1999	16-May-99	1.82	29
2000	Oct. 19, 1999	2.43	92

2001	Mar. 31, 2001	1.69	20
2002	Mar. 17, 2002	3.04	193
2003	Feb. 14, 2003	2.28	73
2004	Mar. 02, 2004	4.98	692
2005	Nov. 07, 2004	2.87	161
2006	Mar. 26, 2006	2.81	150
2007	Mar. 16, 2007	3.6	312
2008	Dec. 05, 2007	2.39	90
2009	Dec. 11, 2008	6.26	1,100
2010	Jan. 30, 2010	3.41	270
2011	Jan. 12, 2011	4.47	539
2012	Mar. 08, 2012	1.99	43

Peak Streamflow USGS 16211700

Latitude 21°28'47", Longitude 158°12'31" OLDHI

Drainage area 5.21 square miles

Gage datum 120.00 feet above HILOCAL

Water Year	Date	Gage Height (feet)	Streamflow (cfs)
1966	Nov. 13, 1965	13.77	1,530
1967	Mar. 06, 1967	9.6	640
1968	Dec. 17, 1967	9.52	608
1969	Jan. 03, 1969	10.94	1,260
1970	Dec. 27, 1969	10.09	826
1971	Jan. 28, 1971	10.05	810
1972	Feb. 04, 1972	9.66	658
1973	Dec. 17, 1972	8.09[4]	120[4]
1974	Apr. 19, 1974	10.46	1,010
1975	Feb. 01, 1975	8.95	410
1976	Feb. 07, 1976	16.4	4,310
1977	1977	--	120[2,B]
1978	23-May-78	--	2002
1979	Feb. 10, 1979	9.76	12,002
1980	Jan. 08, 1980	8.31	340
1981	7-May-81	6.92	2002
1982	Jan. 06, 1982	15.81	3,930
1983	Oct. 27, 1982	6.54	5002
1984	Mar. 02, 1984	6.96	110
1985	Jan. 14, 1985		80.02
1986	Oct. 20, 1985	10.93	1,150
1987	Apr. 26, 1987	7.19	1202
1988	Dec. 12, 1987	9.41	573
1989	Apr. 09, 1989	8.98	422
1990	Jan. 16, 1990	10.83	1,110
1991	Dec. 19, 1990	8.14	126
1992	Oct. 16, 1991	11.53	1,200
1993	Dec. 30, 1992	9.06	448
1994	Mar. 24, 1994	10.11	824
1995	Oct. 03, 1994	7.11	250[2]
1996	Jan. 24, 1996	8.31	350[2]
1997	Nov. 14, 1996	17.6	5,000[2]
1998	Jan. 17, 1998	--	--
1999	1999	7.74[4]	--
2000	Oct. 19, 1999	7.91	--
2001	Mar. 31, 2001	9.02	--
2002	Mar. 17, 2002	9.08	--
2003	Oct. 17, 2002	7.89	--
2004	Mar. 02, 2004	11.11	--

Peak Gage-Height Qualification Codes.

4 -- Gage height below minimum recordable elevation

Peak Streamflow Qualification Codes.

2 -- Discharge is an Estimate

4 -- Discharge less than indicated value, which is Minimum Recordable Discharge at this site

B -- Month or Day of occurrence is unknown or not exact

Appendix A

Field Recon Memos

TOWNSCAPE, INC.

ENVIRONMENTAL AND COMMUNITY PLANNING

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MĀKAHA VALLEY FLOOD STUDY
Memorandum No.3

Date: **June 19, 2013**
To: **Meeting participants**
From: **Townscape, Inc.**
RE: **Field Recon (6/19) with Landis Ornellas**

Participants: Landis Ornellas; Representative Jo Jordan; Darron Agawa, Edwin Matsuda (DLNR-DENG); Bruce Tsuchida, Gabrielle Sham (Townscape, Inc.)

Purpose of this field visit: Initial overview of the drainage systems in the valley and to observe changes that have been made to these systems.

Summary of recon and discussion:

- We met at the Mākaha Valley Country Club, where Landis Ornellas provided a historical overview of the development, hydrology, and major storm events in Mākaha Valley. Landis is the property manager and maintenance contractor for Mauna ʻOlu Estates. He is also the kahu for Kāneʻaki Heiau. He worked for Chinn Ho for 37 years. After the overview, Landis took us to different sites to look at the drainage systems in the valley. We started the field visit near Kāneʻaki Heiau.

<u>Mauna Olu Estates area</u>

- The hydrology for forested areas mauka of Kāneʻaki Heiau has not been modified. All of the diversions have occurred makai of the heiau.
- There is a natural drainage way from the east side of the valley that crosses over the paved road (Alahele Street) near the gate entrance for Kāneʻaki Heiau. Although dry at the time of the field visit, water flow crosses over the street and feeds into Mākaha stream.
- At the time of the field visit, water flow could be heard in Mākaha stream. The source of this flow is Glover Tunnel.
- The natural drainage way is also fed by an artificial diversion/berm located behind Mauna ʻOlu Estates.
- The construction of the drainage/berm system began around 1980-81, and was completed in 1984. It runs parallel to the boundary line of the Mauna ʻOlu Estates lots on the eastern side of the valley. The berm is located behind the houses of Maunaolu Street, between the residential lots and land owned by the BWS. It was built to

protect Mauna ʻOlu Estates. It is 40 feet wide at the base, 12 feet high, and 12 feet wide at the top. The drainage/berm system diverts water from the Eku stream watershed to Mākaha stream.

- The berm is located on property owned by the BWS. The BWS did not know the berm existed on their property when they acquired the land. There was a lawsuit against the BWS for failure to maintain and clean the drainage ditch. Some property owners blamed BWS for the flood damages that occurred on their properties from the 2008 flood event.
- There were accusations that the berm was built the wrong way.
- A concrete channel starts mauka of the property at 84-1370 Maunaolu Street, and heads towards Alahele Street and into Mākaha Stream. In 1981-82, water in the channel was as high as 6 feet and water overflowed onto the road.
- Park Engineering designed the ditch and channel in Mauna ʻOlu Estates. Landis has the design drawings for the ditch and channels, but does not have the "as-built" drawings.
- The plans include plans for Maunaolu Village #1 and #2 (two parts of the subdivision).

Mākaha Valley Towers (MVT) area

- During the 1996-97 storm, Landis recalls seeing a car on the lanai on the 7th floor of the MVT; about 60-70 cars were damaged; property damage was caused from debris due to a landslide.
- MVT were not built for a 100-year storm. Diversion ditch behind MVT was created to protect the property from a 25-year storm. MVT was developed by Mākaha Valley Inc/Capital Investment.
- There are eight 60-inch culverts, maintained by HRT, parallel to Kili Drive that dumps into Mākaha stream. The culverts became clogged up from the 2008 storm, and the ditches had to be cleaned. HRT used to belong to Capital Investment.
- Kili Drive is privately owned by HRT. City buses do not go on it. Kili Drive is paved about 1.5 miles mauka of the yellow gate in front of MVT. MVT is occupied mostly by renters (estimated 95-98% occupancy based on the amount of lights turned on at night).

Lower valley area

- In the 1970s, a berm was built to divert Mākaha stream in order to protect development in the lower area of the valley. After the 2008 flood event, 60 yards (?) of the berm was washed out, and the stream returned to its original path.
- HRT owns 200+ acres of land; Towne Realty (Chris Lau-manager) owns ~37.2 acres including the reservoirs located on their property.
- Representative for HRT Realty: Debbie Nakamura (sp?), Cid 737-9800

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MĀKAHA VALLEY FLOOD STUDY
Memorandum No.5

Date: **July 11, 2013**
To: **Meeting participants**
From: **Townscape, Inc.**
RE: **Interview Notes with Tim Ayau/ Field Visit with Landis Ornellas**

Participants: Tim Ayau; Landis Ornellas; Bruce Tsuchida, Gabrielle Sham (Townscape, Inc.)

Purpose of this meeting: Interview 2 of Stakeholder Outreach Plan to obtain information from community stakeholders; review draft "Modified Drainage System" map and field visit with Landis Ornellas.

Summary of discussion:

- Tim Ayau lives in the lower portion (southeastern side) of the valley. He manages the Mākaha East Golf Course, and used to manage the West Golf Course before it closed down.
- Ever since the Mauna 'Olu Estates berm/ditch system was damaged in 1996, stormwater usually floods the East Golf Course 18th hole when it rains.
- Since the concrete channel was built in Mauna 'Olu Estates, more water has been flowing into Mākaha stream. Before it was built, Mākaha stream used to flow "nicely".
- Chinn Ho used to maintain the streambed located on his property. Now, the streambed has accumulated a lot of silt. It needs to be cleaned.
- The Coronet store always floods when there is a storm.
- There's a bridge at the 7th and 8th hole on the West Golf Course where the stream flows through.
- The storm drains along Kili Drive clog up with rocks and debris that fall from the side of the valley when it rains.
- Tim does not recall West Mākaha stream having much stream flow.
- There are plans for a new West Mākaha Golf Course. Tim is not sure what the plans are for the Mākaha condos, but the buildings are old and should be demolished.
- When it rains, a lot of stormwater usually flows through Tim's property towards the ocean.

Field visit with Landis:

- There are numerous drain inlets along Kili Drive.

- A concrete channel is located makai of the BWS reservoir (~elevation 500') that goes up about 100 feet before turning left. The channel conveys stormwater through the culvert, and discharges into Mākaha stream.
- The Mauna ʻOlu Estates ditch has accumulated a lot of silt. It needs to be maintained regularly.
- Runoff from the northern portion of Mauna ʻOlu Estates is collected through drain inlets, and discharges into Mākaha stream.

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MĀKAHA VALLEY FLOOD STUDY
Memorandum No.8

Date: **July 18, 2013**
To: **Meeting participants**
From: **Townscape, Inc.**
RE: **Stakeholder Interview/Field Recon (7/18) with Landis Ornellas and John DeSoto**

Participants: Landis Ornellas; John DeSoto; Bruce Tsuchida, Gabrielle Sham (Townscape, Inc.)

Purpose of this field visit: To see the drainage system for (1) the lower Mākaha area (berm located below the golf course), (2) Mākaha Valley Towers, and (3) Mauna ʻOlu Estates; and to discuss possible solutions for the drainage problems in the valley.

Summary of recon and discussion:

- We met at the Mākaha Valley Country Club with John DeSoto. John lives in Mauna ʻOlu Estates, and is the current President of the Mauna ʻOlu Estates Homeowners' Association (Association).
- Regarding the existing lawsuit between the Association and the BWS, the current Board wants to work with the BWS to resolve the issue and seek a "win-win solution."
- John shared that there are 5 additional heiau mauka of Kāneʻaki Heiau.

<u>Lower valley area</u>

- A swale is located on the golf course side of the fence that is located near the southern boundary of the Mākaha West Golf Course property. The berm, built by Capital Investments, is located on the other side of the fence on the adjoining property owners' land. There are issues with property owners dumping their rubbish into the swale which causes water to divert from its course and flood surrounding areas.
- There are two depressions where runoff travels across the golf course towards the houses in the lower part of the valley, crossing over Noholio Rd. One of the depressions is located near the house at 84-1003 Noholio Rd. Since the depressions run across some of the property owners' land, one of the property owners built a wall

to block the water from entering into their property. As a result, water is diverted and floods the adjacent properties.

Mākaha Valley Towers (MVT) area

- The ditch behind MVT is about 15 feet high and 25 feet wide at the top.
- The drainage system includes an earth berm and ditch. The drainage system intercepts runoff from the side of the valley and conveys water flow through a concrete-lined ditch that turns down towards an unlined ditch and into a 60-inch culvert under Kili Drive. The ditch at the culvert opening has silted up as high as the debris catcher poles that are about 3 feet high above the ground.
- During the November 1996 rain event, a section of the berm was damaged. Water flow went straight through the berm, and towards the MVT. The berm was repaired after the rain event, which is where the section of the drainage system is lined with concrete to reduce further erosion of the ditch and earth berm. However, there are signs of the earth berm eroding under the concrete where the concrete lining begins.

Mauna ʻOlu Estates area

- Part of the berm located above TMK 84029097 is leveled with the ditch, and much of the drainage ditch has silted up.
- In some areas the top of the berm is relatively narrow due to erosion.

Possible solutions for drainage problems

- Start with the BWS lands by slowing the water flow coming down from the forested slopes. Reforestation may help reduce stormwater runoff.
- The berms/ditches and stream beds need to be maintained by property owners.
- Some detention or retention basins would help.

APPENDIX C

GENERAL ENVIRONMENTAL IMPACT ASSESSMENT

General Environmental Impact Assessment

Purpose of General Environmental Impact Assessment

The purpose of this General Environmental Impact Assessment is to preliminarily identify and evaluate potential impacts, including unintended effects in addition to the desired and intended effects, on the natural, socio-economic, cultural, and archaeological environment, that may result from proposed flood mitigation projects and measures for Mākaha Valley. Potential regulatory constraints and requirements based on the proposed projects are also included in this assessment.

This assessment provides a broad overview of environmental factors, including existing environmental conditions in Mākaha Valley and potential impacts based on published literature and some field observations. More in-depth analysis on the environmental impacts for each proposed flood mitigation project may be needed prior to implementation.

Summary of Proposed Measures, Projects, and Actions

The objective of this flood mitigation study is to identify realistic flood mitigation projects that can be implemented to protect public health and safety from existing flooding problems in Mākaha Valley. Based on field observations, hydrologic and hydraulic analysis, talk-story sessions with community members, residents, and large private landowners of Mākaha Valley, and consultation with public agencies, proposed flood mitigation projects and measures for Mākaha Valley include:

- Mākaha Stream Levee
- Repair existing berm on TMK 8-4-002:063
- Mākaha Sand Berm Maintenance
- Kili Drive Channel
- Eku Stream Channel with Offline Detention Basin
- New Eku Stream Bridge
- Drainage Infrastructure
- Native Forest Restoration

Mākaha Stream Levee ("flood wall"**)** made of reinforced concrete would be constructed on the existing earthen berm that runs parallel to Mākaha Stream on the west side of the Manuku and Nukea Street properties. The base of the proposed flood wall would extend deep into the existing ground to ensure structural stability and the height of the levee above the ground would vary depending on the existing topography. A maintenance road would be constructed on one side of the levee. This proposed Mākaha Stream Levee is intended to prevent flooding of homes near Manuku Street, Nukea Street, and Farrington Highway that currently experience flooding during large storms because of a breach in the berm upstream of these homes.

Repair existing berm on TMK 8-4-002:063 would mitigate flooding of properties near Manuku Street, Nukea Street and Farrington Highway. Repairing this berm is an alternative to the proposed Mākaha Stream

Levee. However, this proposed measure would only be a temporary solution to the flooding issue until another breach in the berm occurs. This proposed measure is intended to direct Mākaha Stream away from the homes.

Mākaha Sand Berm Maintenance includes regular sand removal from the stream mouth in order to allow storm water to discharge into the ocean rather than backwash into the stream and flood nearby properties. Creating and maintaining a relatively small channel through the existing sand berm would allow the free flow of storm water from Mākaha Stream.

Kili Drive Channel would be constructed parallel to Kili Drive to capture runoff from the steep valley walls on the northwestern side of the valley. The Channel would convey storm water into West Mākaha Stream. Much of this runoff currently drains into Mākaha Stream.

Eku Stream Channel with Offline Detention Basin would be constructed from Farrington Highway to about 3,800 feet upstream where a 5.5-acre offline detention basin would be constructed adjacent to the proposed Eku Stream Channel. The offline detention basin is intended to reduce peak flows by temporarily storing some of the storm water and then later releasing it into the stream through outlet structures. The proposed Eku Stream Channel and Offline Detention Basin would be designed to contain flows for a 100-year flood, and would prevent flooding of homes adjacent to the lower reaches of Eku Stream, including homes on Mākaha Valley Road, Maiuu Road, Lahaina Street, Lahilahi Street, Hana Street and Orange Street.

New Eku Stream Bridge with adequate capacity to handle a 100-year flood would replace the existing Eku Stream Bridge that was constructed in 1989 and does not appear to have been designed for a 100-year flood. The proposed new Eku Stream Bridge would allow for the free flow of storm water so that the bridge does not act as a bottleneck and constrict the storm water from discharging into the ocean and cause flooding upstream.

Drainage Infrastructure would alleviate flooding of homes in lower Mākaha Valley where there is no existing drainage infrastructure and where the land is generally leveled.

Native Forest Restoration is intended to improve the existing degraded forests that are filled with non-native species to more productive, healthy forests that would improve groundwater recharge by intercepting more rainfall. Healthy forests will help retain and absorb more water—reducing peak flows and runoff.

Overview of Environmental Factors and Potential Impacts

Table 1 summarizes the desired, intended, and potential unintended effects for each of the proposed actions.

Table 1. Summary of Desired, Intended, and Potential Unintended Effects for Proposed Measures, Projects, or Actions

Proposed Measures, Projects, or Actions	Desired, Intended Outcomes	Potential Unintended Effects
Mākaha Stream Levee	Prevent flooding of homes near Manuku Street, Nukea Street, and Farrington Highway that experience flooding because of a breach in the berm upstream of these homes	• Flooding on undeveloped properties on the opposite side of the stream and levee
Repair existing berm on TMK 8-4-002:063	Prevent flooding of homes near Manuku Street, Nukea Street and Farrington Highway by directing storm water away from properties	• Possible erosion from construction activities
Mākaha Sand Berm Maintenance	Allow for the free flow of storm water to discharge into the ocean rather than backwash into the stream	• May increase the amount of trash and silt that is transported into the ocean that would otherwise build-up in the streambed during smaller storms
Kili Drive Channel	Capture runoff from the northwestern side of the valley and convey it into West Mākaha Stream; prevent further flooding of Kili Drive; reduce peak flows for Mākaha Stream (?)	• May accelerate the velocity of runoff and may reduce the amount of sediment that can settle before being released into the ocean
Eku Stream Channel with Offline Detention Basin	Reduce peak flows by temporarily storing some of the stormwater and then later releasing it into the stream through outlet structures	• May accelerate the velocity of runoff and may reduce the amount of sediment that can settle before being released into the ocean
New Eku Stream Bridge	Allow for the free flow of storm water through the bridge opening so that storm water is not constricted at the bridge and cause flooding upstream	• May increase the amount of trash that is transported into the ocean that would otherwise be constricted by the narrower bridge opening
Drainage Infrastructure	Alleviate flooding of homes in lower Mākaha Valley	• May increase the amount of non-point source pollution
Native Forest Restoration	Improve existing forest to a healthy forest that can help to retain and absorb more water	• Possible erosion from construction activities and removal of invasive vegetation

State Land Use and City Zoning

About one-third of Mākaha Valley is in the State Land Use "Urban" District, while the remainder is in the State Land Use "Conservation" District. The lands designated as conservation are owned by the Board of Water Supply and consist of forested lands. Proposed projects would be within both the conservation and urban state land use districts. City zoning for Mākaha Valley includes Preservation, Agriculture, Apartment, Resort, Business, Country and Residential. Proposed projects would be within land zones Agriculture, Preservation, Residential, Apartments, and Country.

Potential Impacts and Mitigation Measures

The proposed flood mitigation projects are generally consistent with the State and City designations for the land. No changes in land use will occur as a result of the proposed mitigation projects. Proposed projects would be located on privately-owned land, except for "Mākaha Sand Berm Maintenance" (City) and "New Eku Stream Bridge" (State). Construction on conservation lands will require a Conservation District Use Permit from the DLNR. Proposed projects within the Special Management Area will require an SMA permit from the City & County of Honolulu, Department of Planning and Permitting (DPP).

Geology and Soils

Mākaha Valley is one of the nine valleys that were formed along the western side of the Waiʻanae Range. The Waiʻanae Range is 22 miles long and is composed of three groups of lavas. Soils found in the area of proposed projects belong to the Haleiwa, Hanalei, Pulehu, Rock Land, and Waialua associations (USSCS, 1972).

- HeA or Haleiwa silty clay, 0 to 2 percent slopes, occurs as large areas on alluvial fans or as long, narrow areas in drainageways. It also includes small areas of poorly drained clayey soils in depressions as well as small areas of moderately well drained clayey soils. Permeability is moderate. Runoff is slow and the erosion hazard is no more than slight.
- HnA or Hanalei silty clay, 0 to 2 percent slopes, occurs on stream bottoms and floodplains. It also includes small areas of very deep, well-drained alluvial soils and small areas of very poorly drained to poorly drained clay soils that are strongly mottled and are underlain by peat, muck or massive marine clay. Permeability is moderate. Runoff is very slow and the erosion hazard is no more than slight. Flooding is a hazard. This soil is used for sugarcane, truck crops and pasture.
- PuB or Pulehu stony clay loan, 2 to 6 percent slopes, occurs on alluvial fans and stream terraces and in basins. The soil is well-drained. Runoff is slow and the erosion hazard is slight.
- Rock Land (rRK) is made up of areas where exposed rock covers 25 to 90 percent of the surface. Soil associated with rock outcrops is very sticky and has a high shrink-swell potential. Buildings on the steep slopes are susceptible to sliding when the soil is saturated. Foundations and retaining walls are susceptible to cracking.

- WkB or Waialua silty clay, 3 to 8 percent slopes, occurs on alluvial fans with moderately well drained soils. Runoff is slow and the erosion hazard is slight.

Potential Impacts and Mitigation Measures

The proposed flood mitigation projects are not anticipated to have any long term adverse impacts on the soil. Erosion and sedimentation as a result of construction activities will be addressed by following Best Management Practices.

Topography and Drainage

Proposed projects are located on the valley floor that gradually increases to a 15 percent gradient and an elevation of about 600 feet. The topography has been affected by natural and man-made drainage features. Some of the areas may have been altered by the plantation era sugar cane production, which also created a number of drainage diversions, water distribution and water storage systems. The majority of the drainage within Mākaha Valley is directed towards Mākaha Stream, and then makes its way towards the ocean. Areas where the surface is relatively level are at greater risk of flooding since water in these areas does not readily drain towards the ocean.

Potential Impacts and Mitigation Measures

Proposed projects are not anticipated to have a significant effect on the topography. Some areas will be graded in order to direct the drainage towards the stream and into the ocean. Proposed projects would improve drainage in Mākaha Valley. The proposed flood mitigation projects will require grading and grubbing. A grading and grubbing permit will be required.

Noise and Air Quality

Impacts on noise and air quality from the proposed flood mitigation projects will be limited to short-term construction-related impacts. Ambient noise near the proposed flood mitigation projects is mostly from the sound of vehicle traffic along Kili Drive. Some of the flood mitigation projects will be located adjacent to homes.

Potential Impacts and Mitigation Measures

Proposed flood mitigation projects will not generate any additional noise with the exception of noise due to the construction of the proposed projects. Emissions from vehicles used to transport materials and workers to the construction site would be minimal. Construction noise associated with the proposed projects would be short-term and minor. No significant impact to noise and air quality is anticipated. Construction of projects will be limited to certain hours during the day to minimize noise disturbance to nearby homes.

Circulation and Traffic

The proposed flood mitigation projects are located near Kili Drive and adjacent to homes. Traffic in Mākaha Valley is mostly due to residential use. Other traffic may include visitors to the golf course. The traffic is generally light throughout the day. Farrington Highway is subject to periods of light and moderate traffic throughout the week.

Potential Impacts and Mitigation Measures

Short-term traffic impacts on Mākaha residents may occur as a result of the movement of construction-related vehicles. To mitigate potential traffic congestion and delays along Farrington Highway and Kili Drive, the movement of construction vehicles can be restricted during the morning and afternoon peak traffic hours.

Hazard

Approximately 287 acres of land are within the 100-year flood plain (Zone AE and VE) and 37 acres are within the 500-year flood plain.

Proposed flood mitigation projects would prevent flooding of some properties in Mākaha Valley. The proposed Eku Stream Channel project would contain the 100-year flood, while the proposed Mākaha Stream Levee will prevent storm water from flooding adjacent homes in the lower valley. The proposed New Eku Stream Bridge project will prevent the bridge to act as a bottle neck that would constrict the free flow of storm water discharging into the ocean and flood properties upstream. The proposed Kili Drive Channel will mitigate flooding on Kili Drive during storm events. All of the proposed flood mitigation projects are designed to improve the existing drainage in the area.

Potential Impacts and Mitigation Measures

Proposed projects will benefit public health and safety in terms of mitigating flood hazards. Approximately 57 residential units and business parcels are protected from the 100-year storm with the proposed Eku Stream Channel and New Eku Stream Bridge.

While the proposed projects would prevent flooding of properties, the structural measures may accelerate the velocity of runoff and reduce sedimentation of floodplain areas before discharging into the ocean. With the proposed berm channel maintenance, creating a small channel through the berm may increase the amount of trash and silt that is transported into the ocean that would otherwise build-up in the streambed during smaller storms. Soil erosion and sediment controls will be implemented to reduce the amount of pollutants and soil that are carried into the ocean. Regularly scheduled stream maintenance will reduce the amount of silt and trash that may be carried into the ocean during storm events.

Hydrology

Mākaha Stream is the primary stream, originating in the western slopes of the Waiʻanae mountain range and is fed by water that falls from Mount Kaʻala. West Mākaha Stream is a short intermittent stream that arises on the south slope of Puʻu Keaʻau behind the existing Mākaha Valley Towers. Eku Stream originates from the eastern side of the valley from Kamaileʻunu Ridge. Mākaha Stream flows year-round in its upper reaches, but flows only intermittently at lower elevations. Both Mākaha and Eku Stream are intermittent. None of the streams have a permanent connection to the ocean and are typically dry but with flows during heavier rain events.

Eku Stream captures the natural runoff from Kamaileʻunu Ridge and stormwater from underground pipes and conveyance structures from Mauna ʻOlu Estates and from Mākaha East Golf Course. Mākaha Stream captures the majority of stormwater runoff that is conveyed from underground pipes. Some of the runoff from the eastern side of the valley behind Mauna ʻOlu Estates feeds into Mākaha Stream and/or is conveyed through a concrete channel into Mākaha Stream.

Potential Impacts and Mitigation Measures

Sections of Mākaha, West Mākaha, and Eku Streams are located within the proposed project areas. The proposed Kili Drive Channel would convey stormwater—that currently is conveyed through underground pipes into Mākaha Stream or that causes flooding on Kili Drive—into West Mākaha Stream. This will alleviate the amount of stormwater discharged into Mākaha Stream. The proposed Mākaha Stream Levee may increase flooding on undeveloped properties on the opposite side of the stream and levee.

Proposed flood mitigation projects will involve construction within and immediately surrounding the streams. Potential construction related impacts include discharge of construction materials into the stream and stormwater runoff that mixes with sediments and construction materials. Proposed projects may also reduce the amount of sediment that can settle before being released into the ocean.

Biological Resources (Flora and Fauna)

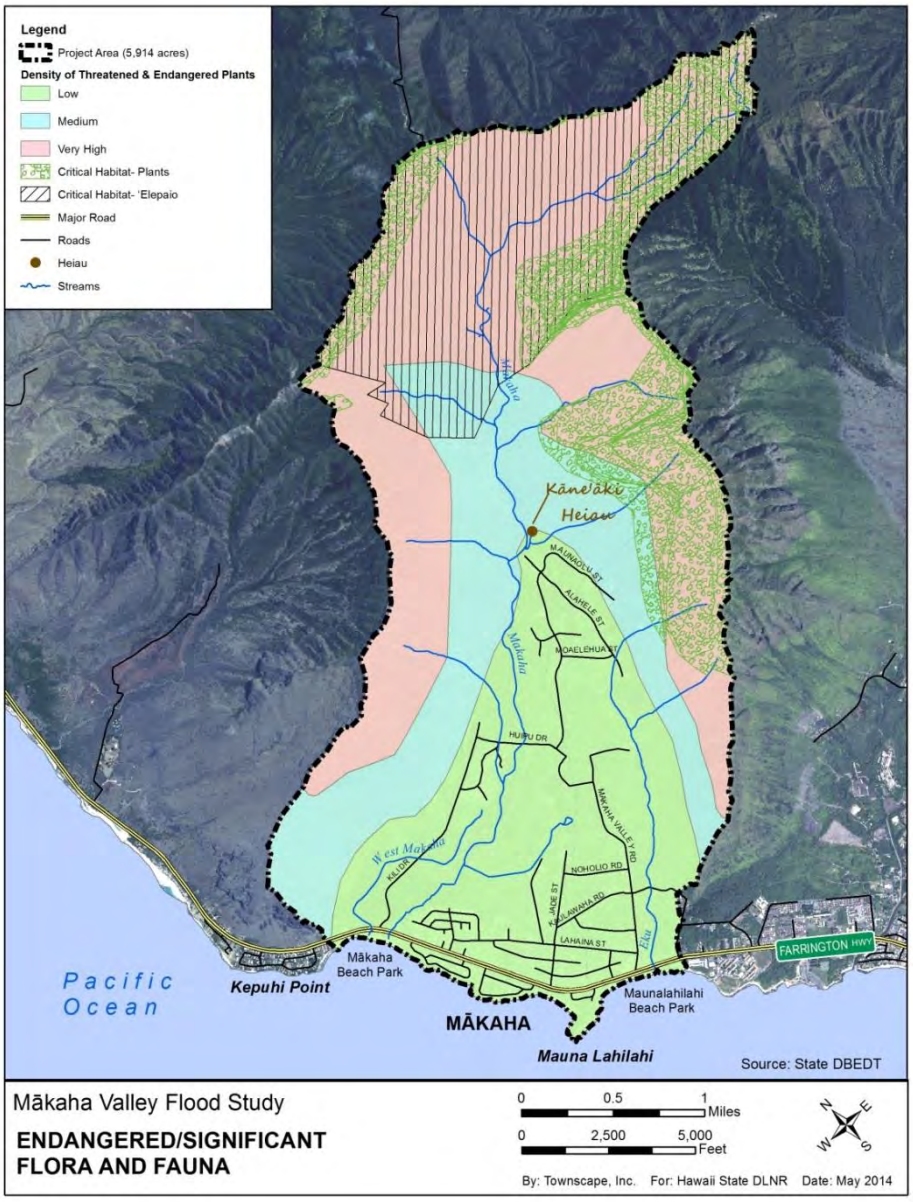
The valley is dominated by alien grassland, forest and shrubland mostly in the lower and mid-valley. The upper valley contains areas of critical habitat for the endangered endemic ʻelepaio bird and approximately 3,622 acres of critical habitat designated by USFWS for 49 endangered plant species. The density of threatened and endangered plants in the developed areas of Mākaha is “low”, while the mid-valley above the heiau is “medium” and the upper valley is “very high.” However, even though the lower developed area is classified as “low” concentration, rare plant species may still exist in those areas.

In a biological resources survey conducted by AECOS, Inc. (2012) for the 25-acre parcel where Mākaha West Golf Course is located, no plants or animals currently protected under federal or state endangered species statures were detected during their survey.

There are two damselfly species listed as Endangered Species under the USFWS that can be found in the upper and headwaters of Mākaha Stream: the Black-lined Damselfly and the Oceanic Hawaiian Damselfly.

Potential Impacts and Mitigation Measures

The majority of the flood mitigation projects would be constructed in the lower area of the valley, which would not affect the endangered damselfly species. Endangered plant species have been identified in the upper valley that are located within exclusion fences constructed by the U.S. Army Garrison, Hawai'i. The lower areas also have not been identified by USFWS as areas of critical habitat for endangered plant species or for the endemic 'elepaio bird.



Cultural Resources

Archaeological studies done for the ahupua'a of Mākaha show that there are many cultural sites in the valley, particularly in the mid- and upper- valley. In an island-wide survey conducted by McAllister (1933), seven sites were identified for Mākaha including terraces for irrigated taro cultivation, Kāne'aki Heiau, stone platforms and Luakinui Heiau. Kāne'aki Heiau is one of the best preserved heiau on O'ahu. It is located near the middle of the valley, north of the Mauna 'Olu Estates subdivision.

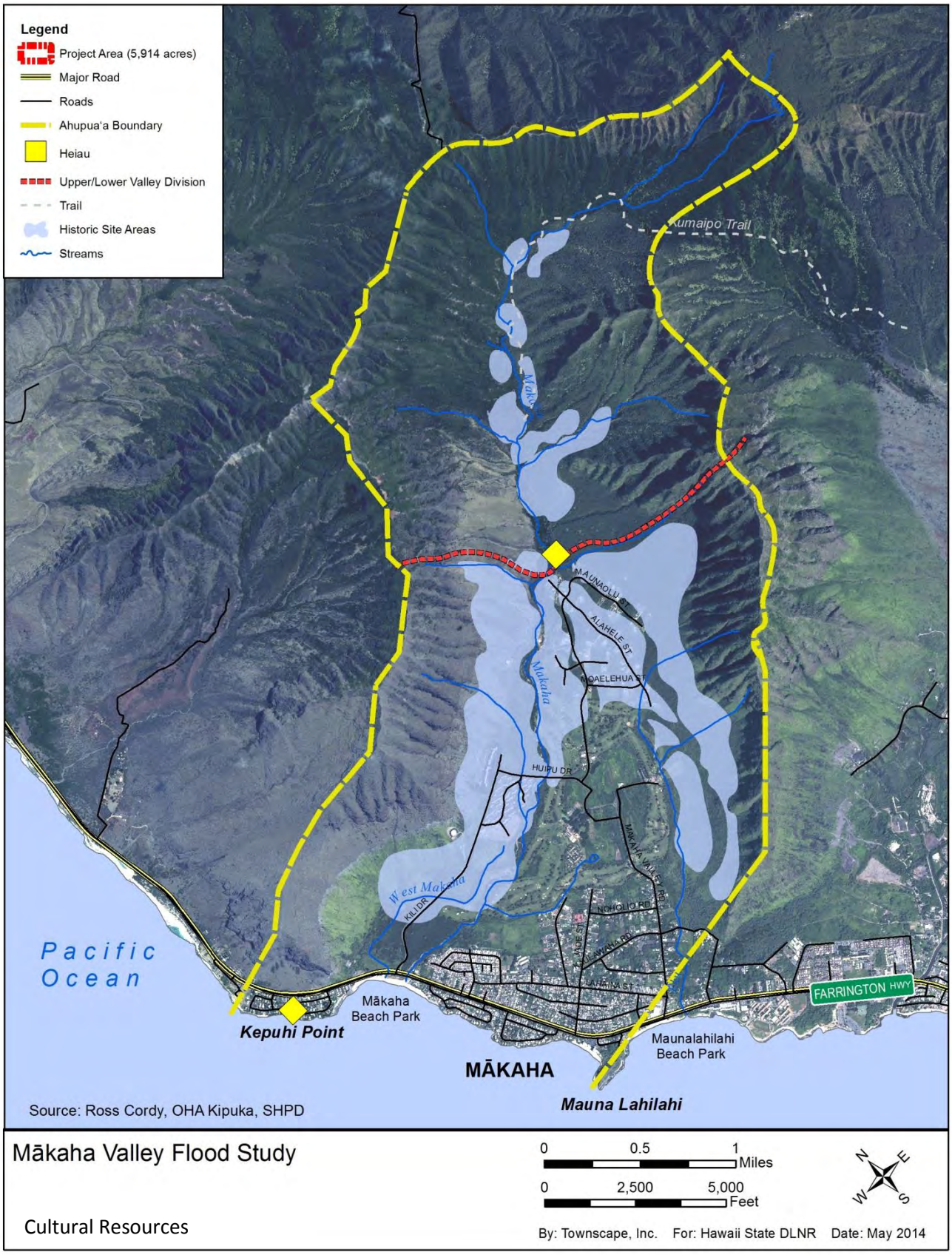
The Office of Hawaiian Affairs' GIS database, Kipuka, identified five historic site complexes in Mākaha Valley.

State Site Number	Name	Description
50-80-03-00752	Wahi Pana- Mākaha Agricultural Complex	Agricultural terraces and house sites
50-80-03-00771	Wahi Pana- Mākaha Agricultural Complex	Agricultural terraces, unpaved platform, wall, enclosure
50-80-03-00723	Wahi Pana- Mākaha Agricultural Complex	Agricultural complex system and habitation features
50-80-03-00996	Wahi Pana- Mākaha Habitation & Agricultural Complex	Agricultural, habitation and religious structures (possible heiau and graves)
50-80-03-00764	Wahi Pana- Mākaha Habitation & Agricultural Complex	Agricultural system (terraces) and possible house sites (enclosures, terraced platforms)

Sections of the proposed Kili Drive Channel would be located within an area identified as Area 1 Complex (State Site No. 50-80-07-00776). This complex is a large area containing several complexes of agricultural, habitation, and religious sites.

Potential Impacts and Mitigation Measures

Construction of proposed flood mitigation projects will require a more in-depth analysis of archaeological sites within the area, including identifying areas that may not have been previously surveyed. An Archaeological Inventory Survey may need to be undertaken for one or more of the proposed project areas.



Mākaha Valley Flood Study

Cultural Resources

0 0.5 1 Miles

0 2,500 5,000 Feet

N E S W

By: Townscape, Inc. For: Hawaii State DLNR Date: May 2014

Potential Regulatory Constraints and Requirements

Environmental Review

An environmental assessment (EA) or environmental impact statement (EIS) may be required for each of the proposed mitigation projects. The purpose of the EA or EIS is to provide decision makers and the public information on both positive and negative environmental effects of a proposed action.

Pursuant to Hawaii Revised Statues (HRS) Chapter 343, triggers for an EA or EIS include, but are limited to:

- Use of State or County lands and funds
- Use within any historic site as designated in the National Historic Register or Hawai‘i Historic Register
- Use within any shoreline area
- Use of any land classified as Conservation District

Any proposed flood mitigation project that may be funded through State funds will require an EA or EIS. Proposed detention basins or exclusion fencing for native forest restoration on Board of Water Supply land may also require an EA or EIS.

Special Management Area (SMA)

SMAs include lands near the shoreline of O‘ahu. In some areas, the SMA extends several miles inland to include areas where coastal resources are likely to be directly affected by development in those areas. An SMA permit is required for any development, structure, or activity within the SMA as defined by ROH Chapter 25. The City & County of Honolulu’s Department of Planning and Permitting is responsible for issuing SMA permits. Development projects that cost less than $450,000 only require an SMA “Minor” permit. An EA is not required for an SMA “Minor” permit. SMA “Major” permit applications can only be submitted after an EA or EIS has been completed for the proposed project.

Conservation District Use Permit

Any land use within the State Land Use Conservation District requires a Conservation District Use Application (CDUA) to the DLNR Office of Conservation and Coastal Lands (OCCL). The majority of BWS owned land is located within the Conservation District. Any proposed mitigation projects within the Conservation District will require submittal of a CDUA. An EA may also be required.

Clean Water Act (CWA)

The CWA of 1972 is the primary federal law that protects the nation's waters, including lakes, rivers, and coastal areas. The agency responsible for water quality regulation in Hawai'i is the State Department of Health Clean Water Branch.

The State Department of Health enforces Section 401, Water Quality Certification of the CWA. Under the CWA and HRS Chapter 342D, Section 401 of the CWA requires a Water Quality Certification to be obtained for activities when proposed construction or operation may result in discharge of pollutants into state waters.

Section 404 of the CWA regulates the discharge of dredged or fill material into U.S. waters, including wetlands. Activities in U.S. waters regulated under Section 404 of the CWA include fill for development, water resource projects, and infrastructure development. The EPA oversees the program, but the U.S. Army Corps of Engineers administers the permits. Proposed projects involving stream channel or stream bank alterations will require a Section 404 permit.

National Pollutant Discharge Elimination System (NPDES)

Pursuant to Section 402 of the Clean Water Act, the State Department of Health Clean Water Branch regulates discharge of pollutants into surface waters. HAR, Chapter 11-55 requires submittal of a complete NPDES application for any construction activity that disturbs one or more acres of total land area, substantially altering the quality of any discharges, or substantially increasing the quantity of any discharges. An NPDES permit may be required for the construction of proposed flood mitigation projects.

Stream Channel Alteration Permit

A Stream Channel Alteration Permit (SCAP) from the DLNR Commission on Water Resource Management (CWRM) Stream Protection and Management (SPAM) Branch is required for any temporary or permanent activity within a stream bed or banks that may (1) obstruct, diminish, destroy, modify, relocate a stream channel; (2) change the direction of the flow of water in a stream channel; or (3) remove any material or structure from a stream channel. Proposed Mākaha Stream Channel and Eku Stream Channel projects will require a SCAP application.

Floodplain Management

Title 44 of the Code of Federal Regulations (44 CFR) 65.12 states two situations when a Conditional Letter of Map Revision (CLOMR) is required to be obtained from FEMA before a project can be built:

- A project within a flood plain where a regulatory floodway has not been adopted that would result in a 1.0 foot increase in Base Flood Elevation (BFE)
- A project within the official regulatory floodway resulting in any increase of the BFE

The proposed flood mitigation projects in the Mākaha Valley Flood Study are not anticipated to increase the BFE. Therefore, a CLOMR will not be required to be submitted for any proposed improvements prior to construction. However, since proposed flood mitigation projects may change the area of floodplains, the appropriate CLOMR should be submitted for FEMA's review.