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August 11, 2021

Mr. Keith E. Kawaoka, Acting Director
Office of Environmental Quality Control
Department of Health
235 South Beretania Street, Suite 702
Honolulu HI 96813

SUBJECT: Final Environmental Assessment and Finding of No Significant Impact (FEA-FONSI) and Final Integrated Feasibility Report
Waiakea – Palai Flood Control Project
Authorized under Section 205 of the Flood Control Act of 1948, as amended
Waiakea & Palai Streams, Hilo, Hawaii

With this letter, the County of Hawaii, Department of Public Works (DPW), in partnership with the Honolulu District, U.S. Army Corps of Engineers hereby transmits the Final Environmental Assessment and Finding of No Significant Impact (FEA-FONSI) and Final Integrated Feasibility Report for the subject project in Waiakea and Palai Streams located in South Hilo, Island of Hawaii, Hawaii for publication in the next available edition of the Environmental Notice.

In addition to this letter, the online OEQC Publication Form has been submitted through the OEQC website. The online submittal includes one electronic copy of the FEA-FONSI as a PDF file.

Should you have any questions, please contact Bryce Harada of the Department of Public Works, Engineering Division at (808) 961-8327.

STEVEN IKAIKA RODENHURST, P.E.
Director

c: Army Corps of Engineers, Honolulu District

From: webmaster@hawaii.gov
To: DBEDT OPSD Environmental Review Program
Subject: New online submission for The Environmental Notice
Date: Monday, September 27, 2021 2:35:46 PM

Action Name

Waiakea-Palai Flood Control Project

Type of Document/Determination

Final environmental assessment and finding of no significant impact (FEA-FONSI)

HRS §343-5(a) Trigger(s)

- (1) Propose the use of state or county lands or the use of state or county funds

Judicial district

South Hilo, Hawaiʻi

Tax Map Key(s) (TMK(s))

(3) 2-4-002:001; (3) 2-4-035:003; (3) 2-4-035:032; (3) 2-4-036:001; (3) 2-4-036:999; (3) 2-4-065:035; (3) 2-4-065:036; (3) 2-4-076:044.

Action type

Agency

Other required permits and approvals

Numerous

Proposing/determining agency

County of Hawaii, Department of Public Works (DPW)

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Action summary

Action Summary

This integrated feasibility report and environmental assessment presents the results of a U.S. Army Corps of Engineers (Corps) study undertaken to identify and evaluate flood risk management (FRM) problems and opportunities on the Waiakea and Palai Streams near Hilo, Hawaii. The Corps is the lead federal agency conducting this study. The non-Federal sponsor is the County of Hawaii, Department of Public Works (COH-DPW). The purpose of the study is to address the risks to life, structures, property, and public infrastructure from periodic flooding in certain locations within the vicinity of Waiakea and Palai Streams.

The proposed alternatives including Kupulau Ditch Levee/Floodwall with Detention and Hilo Golf Course Detention is presented as the recommended plan.

The total project first cost is estimated to be $10.8 million dollars at a cost share between the Corps and COH-DPW with a benefit cost ratio = 3.5.

Reasons supporting determination

Refer to Page 57-90 (PDF 64-67), "Finding of No Significant Impact, Waiakea-Palai Streams, Hilo, Island of Hawaii, Hawaii" for a summary of the determination and evaluation of potential impacts that led to the determination.

Attached documents (signed agency letter & EA/EIS)

- Waiakea-Palai-Complete-Document.pdf

Shapefile

- The location map for this Final EA is the same as the location map for the associated Draft EA.

Action location map

- Action-Location-Boundary.zip

Authorized individual

Bryce Harada

Authorization

- The above named authorized individual hereby certifies that he/she has the authority to make this submission.

WAIAKEA-PALAI STREAMS
Hilo, Island of Hawaii, Hawaii

CONTINUING AUTHORITIES PROGRAM SECTION 205
FLOOD RISK MANAGEMENT

FINAL INTEGRATED FEASIBILITY REPORT
AND ENVIRONMENTAL ASSESSMENT

MARCH 2021

US Army Corps of Engineers
Honolulu District

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Executive Summary

This integrated feasibility report and environmental assessment presents the results of a U.S. Army Corps of Engineers (Corps) study undertaken to identify and evaluate flood risk management (FRM) problems and opportunities on the Waiakea and Palai Streams near Hilo, Hawaii. The study is authorized under Section 205 of the Flood Control Act of 1948, as amended. The non-Federal sponsor for the study is the County of Hawaii Department of Public Works. This report provides documentation of the plan formulation process to select a recommended flood risk management plan, along with environmental, engineering, and cost details of the recommended plan, which will allow additional design and construction to proceed following approval of this report. This Integrated Feasibility Report and Environmental Assessment was developed under the NEPA rules of 1978. All analysis, coordination, consultations, as well as outreach was complete prior to the implementation of the new NEPA rules effective September 14, 2020. This Integrated Feasibility Report and Environmental Assessment is intended to be consistent with the State of Hawaii Chapter 343, Hawaiʻi Revised Statutes.

The study area encompasses the Palai Stream watershed and the Waiakea Stream watershed near the town of Hilo, Hawaii, located on the northeastern coast of the island of Hawaii. The purpose of the study is to address the risks to life, structures, property, and public infrastructure from periodic flooding in certain locations within the vicinity of Waiakea and Palai Streams. A high risk of flooding exists within the watershed due to the magnitude and intensity of rain events, the limited capacity within stream channels, and the tendency of flood flows to disperse broadly as sheet flow within developed areas once streambanks overtop. The risk of flooding is exacerbated by the flashy nature of the streams in the watershed, with heavy rains flowing downstream extremely quickly due to steep topography and debris accumulation.

The plan formulation process identified several structural and non-structural measures to address flood risk in the study area. An initial array of eight alternatives underwent early rounds of qualitative screening. Additional evaluation, comparison, and optimization of alternatives assisted the study team in identifying and evaluating the final array of four action alternatives.

The Tentatively Selected Plan presented in the Draft FR/EA has been modified following agency, technical, and public review of the report as well as completion of feasibility-level design refinements including site visits. While the Draft FR/EA presented the Corps' tentative proposal for a selected plan, this Final FR/EA presents the Corps' recommended plan. Based on subsequent coordination efforts between the Corps, the non-Federal sponsor, and local landowners in the study area, the alternative including Kupulau Ditch Levee/Floodwall with Detention and Hilo Golf Course Detention is presented as the recommended plan. This plan does not include the Ainalako Diversion feature.

The National Economic Development (NED) Plan is the alternative that reasonably maximizes net benefits while remaining consistent with the Federal objective of protecting the environment. The alternative with the highest net benefits is the combination plan that includes a detention basin and levees at Kupulau Ditch, and a detention basin at the Hilo Golf Course. This plan maximizes annualized net benefits at $1.6

million. At the FY 2020 discount rate of 2.75 percent, the total project first cost of the NED Plan and Recommended Plan is $10.8 million with a benefit cost ratio of 3.5.

No compensatory mitigation is proposed for the Recommended Plan as no loss of wetlands or other special aquatic sites, no significant adverse effects to protected species, and no significant impacts to commercially important species or protected marine mammals are anticipated to occur based on the analyses in this document. Several avoidance and minimization measures are proposed to ensure there will be minimal and insignificant effects to environmental resources.

Table of Contents

***Sections marked with an asterisk are required content for compliance with the National Environmental Policy Act**

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Acronyms and Abbreviations

AEP Annual Exceedance Probability
ASYA Aquifer System Area
BMP Best Management Practice
CAP Continuing Authorities Program
CERCLA Comprehensive Environmental Response, Compensation and Liability Act
cfs Cubic Feet Per Second
CIS Cultural Impact Survey
CO_2 Carbon Dioxide
Corps U.S. Army Corps of Engineers
DOH Hawaii State Department of Health
CWA Clean Water Act
EAB Expected Annual Benefits
EAC Expected Annual Costs
EFH Essential Fish Habitat
EO Executive Order
EPA U.S. Environmental Protection Agency
ER Engineer Regulation
ESA Endangered Species Act
FDA Flood Damage Analysis
FPPA Farmland Protection Policy Act
FRM Flood Risk Management
FWOPC Future Without-Project Condition
FY Fiscal Year
GHG Greenhouse Gas
HEC Hydrologic Engineering Center
HTRW Hazardous, Toxic and Radioactive Waste
LERRD Lands, Easements, Right-of-Ways, Relocations, and Disposals
mgd Million Gallons Per Day
NEPA National Environmental Policy Act
NED National Economic Development
NHPA National Historic Preservation Act
NO_2 Nitrite
NO_3 Nitrate
NPL National Priority List
NWI National Wetlands Inventory
NRCS National Resources Conservation Service
OMRR&R Operations, Maintenance, Repair, Replacement and Rehabilitation
RCRA Resource Conservation and Recovery Act
TMDL Total Maximum Daily Load
TN Total Nitrogen
TP Total Phosphorous
TSP Tentatively Selected Plan
USFWS U.S. Fish and Wildlife Service
USGS U.S. Geological Survey
USACE U.S. Army Corps of Engineers
UST Underground Storage Tank
WRDA Water Resources Development Act

1 Introduction

The U.S. Army Corps of Engineers, Honolulu District (Corps) is evaluating flood risk management (FRM) problems and opportunities on the Waiakea and Palai Streams near Hilo, Hawaii. This report documents the planning process for evaluating potential flood risk management alternatives to demonstrate consistency with Corps planning policy and to meet the regulations that implement the National Environmental Policy Act (NEPA). The following sections provide background information regarding the basis for this study. The sections required for NEPA compliance are denoted with an asterisk (*). This Integrated Feasibility Report and Environmental Assessment was developed under the NEPA rules of 1978. All analysis, coordination, consultations, as well as outreach was complete prior to the implementation of the new NEPA rules effective September 14, 2020. This Integrated Feasibility Report and Environmental Assessment is intended to be consistent with the State of Hawaii Chapter 343, Hawaiʻi Revised Statutes.

1.1 Study Purpose and Scope

The study will analyze alternatives to reduce flood risk within the Waiakea-Palai Watersheds including the Waiakea and Palai Streams as well as a portion of Four Mile Creek near Hilo, Hawaii. The study will evaluate and compare the benefits, costs, and impacts (positive or negative) of alternatives including the No Action Alternative (Figure 1-1).

1.2 Study Authority*

The study is authorized under Section 205 of the Flood Control Act of 1948, as amended. The Corps' Continuing Authorities Program (CAP) is a group of nine legislative authorities under which the Corps of Engineers can plan, design, and implement certain types of water resources projects without additional project specific congressional authorization. The purpose of the CAP is to plan and implement projects of limited size, cost, scope and complexity. The maximum federal expenditure per project is $10 million, including feasibility study, design and construction costs.

1.3 Lead Federal Agency and Non-Federal Sponsor*

The Corps is the lead Federal agency conducting this study. The non-Federal sponsor for the study is the County of Hawaii Department of Public Works. A Feasibility Cost Sharing Agreement for the current CAP 205 Integrated Feasibility Study with Environmental Assessment was signed in October 2018.

1.4 Location and Description of the Study Area*

The study area encompasses the Palai Stream watershed and the Waiakea Stream watershed near the town of Hilo, Hawaii, located on the northeastern coast of the island of Hawaii (Figure 1-1). Waiakea Stream, Palai Stream, and Four Mile Creek are three of the five tributaries within the principal Wailoa River system, which drains a total of about 100 square miles and empties into Hilo Bay. The other tributaries are Kawili and Alenaio Streams; both of these tributaries have existing flood risk management projects (described below and in Section 1.6) and are not being further evaluated for flood risk management improvements as part of this study.

Waiakea Stream has a drainage area of about 35.6 square miles and is classified as an intermittent stream and is dry most of the year. Its basin is linear in shape, approximately 25 miles in length and about 2 miles in width at its widest point. The Waiakea Stream basin originates along the slopes of Mauna Loa volcano and flows northeast through the residential community of upper Waiakea-Uka Homesteads before entering the city of Hilo and ultimately emptying into Wailoa Pond and Hilo Bay.

Portions of Waiakea Stream within the proposed study area have previously been altered to reduce flood risk in the Hilo area. In 1965, the Corps built a flood control project that extends from the lower reaches of Waiakea Stream to Wailoa Pond (Figure 1-1). This project, called Wailoa Stream Flood Control Project, consists of channel improvements and levees to provide flood protection for the area of Hilo downstream of the University of Hawaii at Hilo. The project includes channels and levees to divert the Kawili Stream flows into the Waiakea Stream, plus additional channels and levees to divert the combined flows of the Waiakea and Kawila Streams into Waiakea Pond. The project was designed for a discharge of 6,500 cubic feet per second (cfs) which at that time had a recurrence interval of 125 years. Upstream, the County of Hawaii constructed the Waiakea-Uka channel in 1984. This channel consists of 3,460 feet of concrete lined and unlined trapezoidal channel improvements extending from Kawailani Street to the intersection of Komohana and Puainako Streets. These improvements were designed for a discharge of 4,460 cfs. Further upstream, the County of Hawaii replaced the Kawailani Street Bridge with a new bridge having a larger opening and improved the channel upstream and downstream of the bridge. These bridge and channel improvements were completed after severe storm damage occurred in November 2000.

The Alenaio Stream Flood Control project includes levees, concrete-lined channels, floodwalls, bridges, and an earthen channel that connects the concrete channel to the existing floodplain, allowing remaining flows to enter the Waiolama Canal and ultimately Hilo Bay. To date, the project has prevented more than $48.2 million in projected damages within the Alenaio Stream project area.

Palai Stream has a drainage area of about 7.7 square miles and is classified as intermittent and is dry most of the year. Its basin is linear in shape, approximately 11 miles in length and about two miles in width at its widest point. Palai Stream originates down slope of the broad saddle formed between the Mauna Loa and Mauna Kea volcanoes and flows for about seven miles through the Waiakea Forest Reserve with elevations ranging from 2,100 feet to 1,500 feet. The basin is largely developed below the 1,500 foot elevation. It flows an additional four miles through the City of Hilo before emptying into Wailoa Pond and Hilo Bay.

There are no federal flood risk management projects located on Palai Stream within the study area. In 1971, the County of Hawaii constructed Kupulau Ditch. This ditch diverted storm water runoff from the Palai Stream basin to Waiakea Stream upstream of Kupulau Road. The ditch consists of a trapezoidal channel about 3,500 feet long with a 12-foot bottom width and 2:1 side slopes.

Four Mile Creek is an intermittent stream that drains into undeveloped low lands near the Hilo Drag Strip south of Hilo International Airport. The creek flows away from Hilo through an unlined flood control channel that was constructed by the County of Hawaii. This 10,000-foot-long channel begins at the Kanoelehua St. Bridge and empties into an old quarry on the east side of Hilo. Upstream of this point the stream flows mainly through open land with some scattered pocket of mixed residential structures and farmland.

Engineer Regulation 1105-2-100, 3-3, b., (2), (6), minimum flows, limits Federal participation in flood risk management projects to waterways with a minimum flow of 800 cubic feet per second (cfs) at the 10 percent annual exceedance probability (AEP) event that drain watersheds with an area of at least 1.5 square miles. The Waiakea and Palai Streams as well as Four Mile Creek meet these parameters within the project area.

1.5 Proposal for Federal Action*

The purpose of the proposed Federal action is to reduce flood risks to structures, property, and critical infrastructure in the Palai Stream watershed and the Waiakea Stream watershed. The Recommended Plan includes construction of detention basins, a diversion channel, levees, and floodwalls to reduce flood risk in the study area.

1.6 Prior Studies, Reports, and Existing Water Projects

A number of prior studies and reports were completed to support evaluation of flood risk management alternatives in the study area. The Waiakea Stream and Palai Stream each had individual studies initiated under the CAP 205 authority; however, when it was determined that the two streams were interdependent in the study area the two individual draft studies were combined into a single study authorized as a general investigation study. In 2015, the study team determined the scope, objective, and recommended array of alternatives were more appropriate to pursue under the CAP 205 program authority and initiated a new study under the current FCSA. A list of existing studies and reports used to inform the formulation, evaluation, and selection of flood risk management alternatives are referenced throughout this report and included in Chapter 9. Pertinent reports include the following:

- Waiakea Stream Flood Control Reconnaissance Study, U.S. Army Corps of Engineers, Honolulu District, September 2001, revised December 2001.
- Biological Survey for the Palai Stream Flood Control Project, U.S. Army Corps of Engineers, Honolulu District, March 2005.
- Cultural Impact Study (CIS) for the Palai Stream Flood Control Project, U.S. Army Corps of Engineers, Honolulu District, May 2005.
- Hazardous, Toxic, and Radioactive Waste Assessment, Palai Stream Flood Control Project, U.S. Army Corps of Engineers, Honolulu District, August 2005.
- Socioeconomic Impact Assessment Study for the Proposed Waiakea Stream Flood Control Project, U.S. Army Corps of Engineers, Honolulu District, 2009, Usha K. Prasad.
- Flora and Fauna Surveys for the Waiakea Flood Control Project, U.S. Army Corps of Engineers, Honolulu District, March 2010.
- Stream Biological and Water Quality Surveys for the Waiakea Flood Control Project, U.S. Army Corps of Engineers, Honolulu District, March 2010.
- Draft Environmental Assessment for the Proposed Waiakea Stream Flood Control Project, U.S. Army Corps of Engineers, Honolulu District, 2011.

As described in Section 1.4, existing water projects in the study area include the following:

- Wailoa Stream Flood Control Project (Federal)
- Alenaio Stream Flood Control Project (Federal)

- Waiakea-Uka Flood Control Project (Non-Federal)
- Kupulau Ditch (Non-Federal)
- Four Mile Creek Unlined Flood Control Channel (Non-Federal)

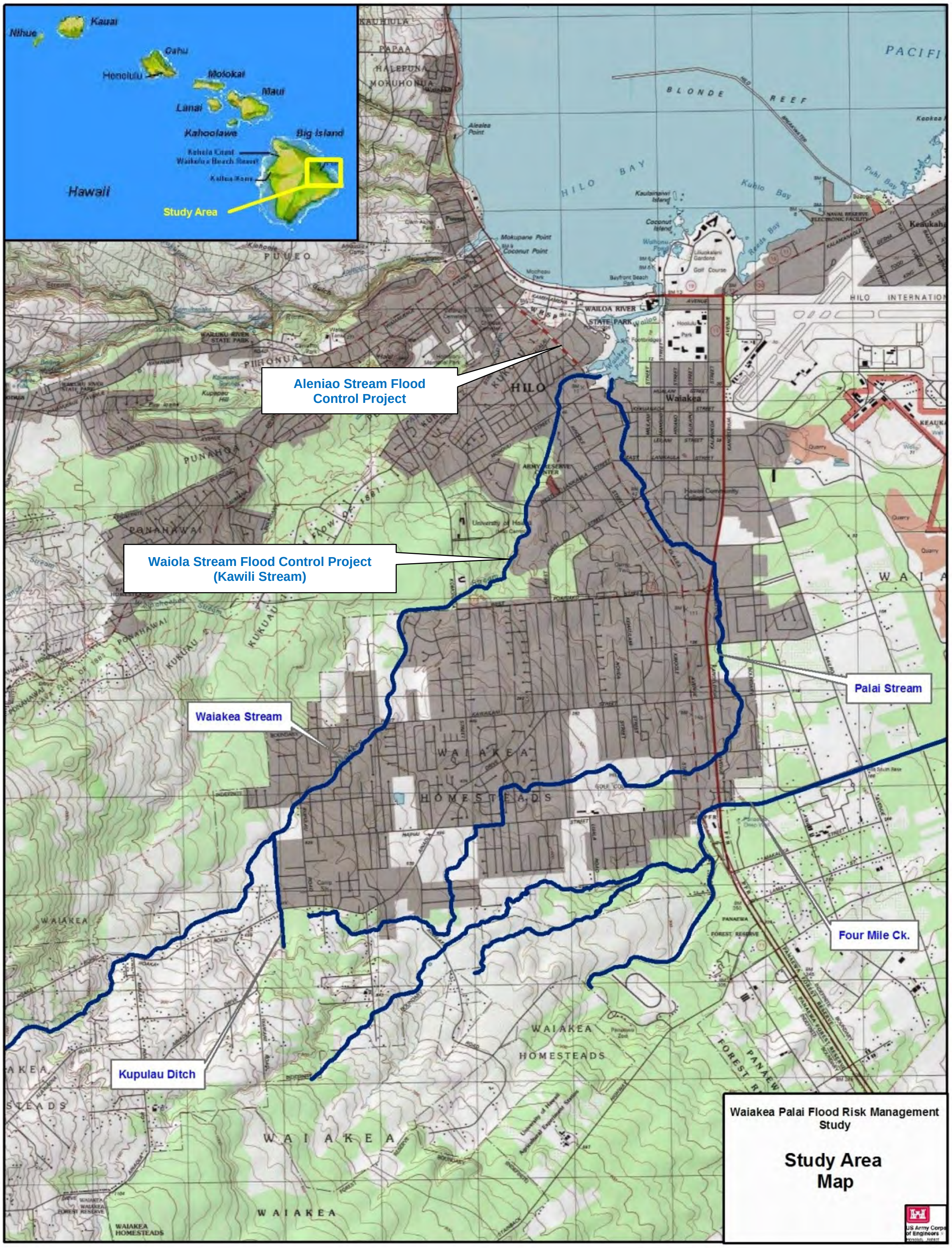

Figure 1-1. Study Area

2 Need for and Objectives of Action

This chapter presents results of the first step of the planning process, the specification of water and related land resources problems and opportunities in the study area. The chapter also establishes the planning objectives and planning constraints, which are the basis for formulation of alternative plans.

2.1 Purpose and Need for Action*

The purpose of the study is to address the risks to life, structures, property, and public infrastructure from periodic flooding in certain locations within the vicinity of Waiakea and Palai Streams. A high risk of flooding exists within the watershed due to the magnitude and intensity of rain events, the limited capacity within stream channels, and the tendency of flood flows to disperse broadly as sheet flow within developed areas once streambanks overtop. The risk of flooding is exacerbated by the flashy nature of the streams in the watershed, with heavy rains flowing downstream extremely quickly due to steep topography and debris accumulation.

2.2 Problems and Opportunities

The Waiakea and the Palai Streams are susceptible to flash flooding events where peak discharges typically occur within two hours of heavy rainfall. Local storm events can produce flood conditions in a matter of hours. Significant rainfall events result in overland flow of water throughout the watershed, flowing towards the streams (Figure 2-1). The existing stream channels have limited capacity to transport flood waters, which has led to water overtopping the channel and flooding downstream areas. As described in Chapter 4, Waiakea Stream above Kupulau Ditch is characterized by poorly-defined channels. It has a channel capacity of less than 1,020 cfs, which is comparable to a 50% AEP storm event. Excess water leaves the Waiakea Stream by overtopping the right bank at the 50% AEP event and flows overland eastward toward Kupulau Ditch. Between Kupulau Ditch and the Kupulau Rd Bridge, Waiakea Stream has has an average channel capacity of about 1,630 cfs, which is comparable to a 20% AEP storm event. Flows greater than the 20% AEP event flood the right and left overbanks.

Figure 2-1. Floodwater at Kupulau Ditch (2008)

In addition, the City of Hilo has experienced significant growth over recent decades. In addition to some of Hilo's busiest intersections, thoroughfares and shopping areas, the project area floodplain also contains about 100 businesses, several schools, a university and other critical infrastructure. With this surge in urbanization, flooding problems have intensified for homes and businesses built close to the city's streams. Property losses, road and bridge closures, and life-threatening situations caused by flooding have become a risk that the people of Hilo must cope with. Major flood damages occurred in February 2008, November 2000, August 1994, March 1980, February 1979, July 1966, and March 1939, in the Hilo area (Figure 2-2). A summary of impacts from recent events is described below:

- August 2018: Approximately 58 inches of rain was recorded in a 55-day period resulting from Hurricane Lane. The Waiakea-Uka Flood Control Project (described in Section 1.4) functioned as designed and prevented approximately $15 million in damages to the local community (USACE 2019). However, damages to Hawaii County infrastructure were estimated to be approximately $20 million. The peak flow was 3,560 cfs, which is characterized as a 2.8% AEP event. The storm was uncharacteristically slow delivering precipitation to the same area for essentially four straight days until the storm weakened to a tropical storm on day 5.
- February 2008: Approximately 16 inches of rain was recorded in a 24-hour period. Approximately 150 homes were damaged by floodwaters rising up to 4 feet deep in Hilo.
- November 2000: Approximately 29 inches of rain was recorded in a 24-hour period and rainfall intensities of 2.57-3.24 inches per hour were recorded over a four-hour period. A U.S. Geological

Survey (USGS) stream gauge on Waiakea Stream recorded a peak flow of 5760 cfs, estimated at a 70-year discharge recurrence interval. In the Waiakea Stream area, bridge crossings at Kawailani Street and Kupulau Road were washed away. Entire neighborhoods were isolated and cut off from the rest of Hilo for several days. Emergency services could only reach these residents by boat or helicopter. Damages totaled approximately $70 million on the island of Hawaii, including approximately $6.3 million in damages in the Waiakea/Palai floodplain. In addition, an estimated $12.4 million in municipal property damages, clean up costs, and emergency costs within the Waiakea/Palai watershed were incurred by the County of Hawaii.

- August 1994: Approximately 4 inches of rain was recorded with damages estimated at $1 million. A USGS stream gauge on Waiakea stream recorded a peak flow of 3670 cfs, estimated at a 10-15 year discharge recurrence interval.
- March 1980: Approximately 25 inches of rain was recorded in a 72-hour period with damages estimated at $3.8 million.

Figure 2-2. Residential flooding along Hoolaulea Street in 2008

A summary of problems in the study area include the following:

- The Waiakea and Palai Streams as well as Four Mile Creek are susceptible to flash flooding events resulting in peak discharges occurring soon after heavy rainfall events.

- The natural stream channels have limited capacity to transport flood waters, resulting in water overtopping the channels and inundating downstream areas. Water disperses broadly as sheet flow within developed areas once streambanks overtop.
- Roads and bridges are overtopped during flood events, resulting in increased hazards to motorists and delays associated with road closure.

Opportunities for the study include the following:

- Increase community resiliency to flood events.
- Decrease emergency response and recovery costs for floods.
- Improve system capacity for flood conveyance to attenuate flow.
- Provide recreation enhancements to the watershed.
- Reduce the frequency and cost of repairs to Federal and non-Federal projects located downstream of the study area including the Wailoa Stream Flood Control Project and Waiakea-Uka channel.

2.3 Planning Objectives

Over the 50-year period of analysis (beginning in 2023), the objective of the study includes:

- Reduce flood risks to property and critical infrastructure in the Palai Stream watershed and the Waiakea Stream watershed for the 50-year period of analysis.

2.4 Planning Constraints

A constraint is a restriction that limits the extent of the planning process. Constraints for the study include:

- Alternatives will not transfer risk from one section of the population without fully mitigating for the increase in risk to those negatively affected by the project.
- Alternatives will seek to minimize impacts to private residences wherever possible. Given the study area's proximity to the ocean, acquisition of multiple residences would likely be met with large public outcry and acquisition costs could likely be sufficiently high as to make an alternative that requires a great deal of acquisition economically uncompetitive.
- Alternatives will seek to minimize environmental impacts, particularly to those pristine, undisturbed lands or habitats that are more likely to contain species of concern. While avoidance and minimization will be employed, there is a relative lack of opportunities to perform compensatory mitigation at costs that can be incrementally justified due to the highly urbanized nature of the study area. In cases where alternatives are of similar cost and provide similar levels of flood risk management, the alternative with greater environmental impacts will be screened out.

3 Plan Formulation

The guidance for conducting civil works planning studies, Engineer Regulation (ER) 1105-2-100, Planning Guidance Notebook, requires the systematic formulation of alternative plans that contribute to the Federal objective. This chapter presents the results of the plan formulation process. Alternatives were developed in consideration of study area problems and opportunities as well as study objectives and constraints with respect to the four evaluation criteria described in the Principles and Guidelines (completeness, effectiveness, efficiency, and acceptability).

3.1 Management Measures

A management measure is a feature or activity that can be implemented at a specific geographic site to address one or more planning objectives. A preliminary list of structural and non-structural management measures is included below.

Structural Measures

- **Detention basins (surface and sub-surface):** Create surface and/or subsurface temporary storage facilities to collect flood flows during larger storm events; operate to control storm flow.
- **Dams / reservoirs:** Create larger storage facilities than detention basins to collect and store flood flows during larger storm events; operate to control storm flow.
- **Diversion / bypass structures (surface and sub-surface):** Create sub-surface diversions to divert flows from constricted channel areas; create surface diversions to divert high flows to less densely populated areas.
- **Pump system:** Install pump system to pump peak flows out of streams.
- **Widen / deepen / channelize stream channel:** Widen or deepen stream channels to increase flow capacities.
- **Levees and floodwalls:** Construct levees and floodwalls to reduce flood risk.
- **Grade control structure:** Install concrete filled trenches at changes in slope to control bed erosion.
- **Ring Walls or Berms:** Construct small ring wall or berm around the exterior of a single structure or small group of structures.

Non-Structural Measures

- **Flood Warning Systems:** Alert the community or key officials of imminent hazardous flooding conditions. This measure also includes Emergency Action Plan implementation by key officials, development of risk communication plans, and improving evacuation awareness in the community.
- **Property Buyouts:** Acquire lands and structures either by purchase or through the powers of eminent domain.
- **Flood Proofing:** Seal structures from water damage by waterproofing walls and floors and installing floodgates at entry points.
- **Elevating Structures:** Lift the building from its foundation and raise it above the flood level.

3.2 Screening of Measures

Screening is the process of eliminating, based on planning criteria, those measures that will not be carried forward for consideration. Criteria are derived for the specific planning study, based on the planning objectives, constraints, and the opportunities and problems of the study/project area. Criteria used to screen measures as well as qualitative metrics associated with each criteria included:

- Does the measure meet the planning objective? (YES/NO); measure is screened if response is "no")
- Based on site-specific conditions, is the measure technically feasible or applicable as a flood risk management measure? (YES/NO); measure is screened if response is "no")
- Would the measure avoid or minimize significant adverse environmental impacts? (YES/NO); measure is screened if response is "no")
- Is the measure anticipated to be a cost effective solution to reduce flood risk in the study area? (YES/NO; measure is screened if response is "no")

Table 3-1 below displays the measures screening outcomes. Rows highlighted in red indicate measures that were screened out.

Table 3-1. Measures Screening Summary

Measure	Screening Criteria			
	Meets Planning Objectives	**Technically Feasible**	**Avoids Environmental Impacts**	**Cost Effective**
Detention Basin	Yes	Yes	Yes	Yes
Dams / Reservoirs	Yes	Yes	No	No
Diversion Channel	Yes	Yes	Yes	Yes
Pump System	Yes	Yes	Yes	Yes
Widen / Deepen Channels	Yes	Yes	Yes	Yes
Levees / Floodwalls	Yes	Yes	Yes	Yes
Grade Control Structure	Yes	Yes	Yes	Yes
Ring Walls or Berms	Partially	Yes	Yes	Yes
Flood Warning System	Partially	Yes	Yes	Yes
Property Buyouts	Partially	Yes	Yes	Yes
Flood Proofing	Partially	Yes	Yes	Yes
Elevate Structures	Partially	Yes	Yes	Yes

Based on the results of the screening process summarized above, all measures were carried forward with the exception of the dam/reservoir measure. Construction of a new dam would have significant environmental impacts in more pristine, environmentally sensitive upstream areas and would also be cost prohibitive due to the magnitude of construction costs for this type of feature. As such, this measure was not carried forward for further evaluation.

Although the non-structural measures would only partially address planning objectives, they were carried forward for further consideration. These measures would reduce flood risk to property and critical infrastructure but would not directly reduce the frequency and cost of repairs to Federal and non-Federal projects located downstream of the study area. It is anticipated that one or more of these measures can function as a viable component of an integrated system of flood risk management in place of or in combination with structural measures.

3.3 Formulation of Alternatives

Alternative plans are a set of one or more management measures functioning together to address one or more planning objectives. An initial array of alternative plans has been formulated through combinations of management measures. A summary of the initial array of seven action alternatives is presented below:

No Action Alternative

The No-Action Alternative is synonymous with no Federal Action. This alternative is analyzed as the future without-project conditions for comparison with the action alternatives. The No Action Alternative would result in continued flood risk along Waiakea and Palai Streams.

Alternative 1: Kupulau Ditch Levee/Floodwall with Detention

Alternative 1 includes construction of a detention basin on property located to the north of the New Hope Church and adjacent to the right bank of Kupulau Ditch (located east of the confluence of Kupulau Ditch and Waiakea Stream). Impounding of the runoff would be accomplished by constructing a series of three levees and one floodwall to enclose the landscape by utilizing the natural topography of the area.

Alternative 2: Waiakea Stream Channelization

Alternative 2 includes various in-channel improvements of Waiakea Stream combined with levees and floodwalls. Waiakea Stream would be excavated to increase channel capacity. In addition, levees or floodwalls would be constructed along both banks of the stream near excavated areas. This alternative also includes grade control structures consisting of concrete filled trenches to be installed in areas where stream slope changes. The grade control structures would help to control bed erosion.

Alternative 3: Hilo Municipal Golf Course Diversion

This alternative includes construction of a diversion channel beginning in the Hilo Municipal Golf Course and traveling around the perimeter of the Catholic Church property down to HaiHai St., where it enters an underground conduit before emptying into Four Mile Creek. A 2.5 acre-foot detention pond would be constructed in the Hilo Municipal Golf Course to capture flood flows with an outlet weir leading to a diversion channel. In addition, a 2,840-foot long diversion channel from Hilo Golf Course would be constructed for flows to empty into Four Mile Creek. The channel would be comprised of both an open cut for the first 1,000 feet and then would enter a concrete box culvert for the remainder of the length. The box culvert would travel east under HaiHai Street to the Paneawa bridge located at the crossing of Four Mile Creek and Kanoelehua Avenue.

Alternative 4: Hilo Municipal Golf Course Detention

This alternative includes construction of a detention basin in the Hilo Municipal Golf Course to attenuate flow and reduce damage to properties in the downstream reaches of Palai Stream. A 21 acre-foot detention pond would be constructed at the Hilo Municipal Golf Course to capture flood flows with an outlet structure designed to release flow to minimize flood damage to downstream property.

Alternative 5: HaiHai Street Detention
Alternative 5 includes construction of a 28 acre-foot detention basin on Palai Stream upstream of HaiHai Street. The proposed detention basin would be located on a 69-acre vacant parcel surrounded by existing or planned residential developments. In order to comply with State of Hawaii dam safety regulations, the basin would be designed to have a maximum water depth of 6 feet, requiring a maximum area of about 35 acres. The embankment constructed to create the detention basin would have a maximum height of about 10 feet from the existing channel bottom.

Alternative 6: Ainalako Diversion
The main component of Alternative 6 is the construction of a diversion structure to divert excess flows into Four Mile Creek. This diversion structure is located just downstream of Ainalako Road on Palai Stream. It takes advantage of the natural topography along the right overbank of Palai Stream and the natural drainage pattern of the immediate area.

Alternative 7: Non-Structural Alternative
Alternative 7 includes non-structural measures that can also function as a viable component of an integrated system of flood risk management in place of, or in combination with, structural measures. This alternative includes some combination of flood proofing, elevating or buying out selective structures, or constructing short ring walls around small groups of structures.

An initial screening-level analysis suggests that there are 121 homes and businesses in the Palai Stream flood plain and 17 in the Waiakea Stream flood plain (138 total) with sufficient expected annual flood damages to justify an expenditure of the magnitude it would take to present them with an individual non-structural flood prevention option. These structures that passed this initial screening process will be screened again on an individual basis to ensure they are indeed viable candidates for some form of cost-effective non-structural alteration.

Figure 3-1 shows the initial array of alternatives in the study area.

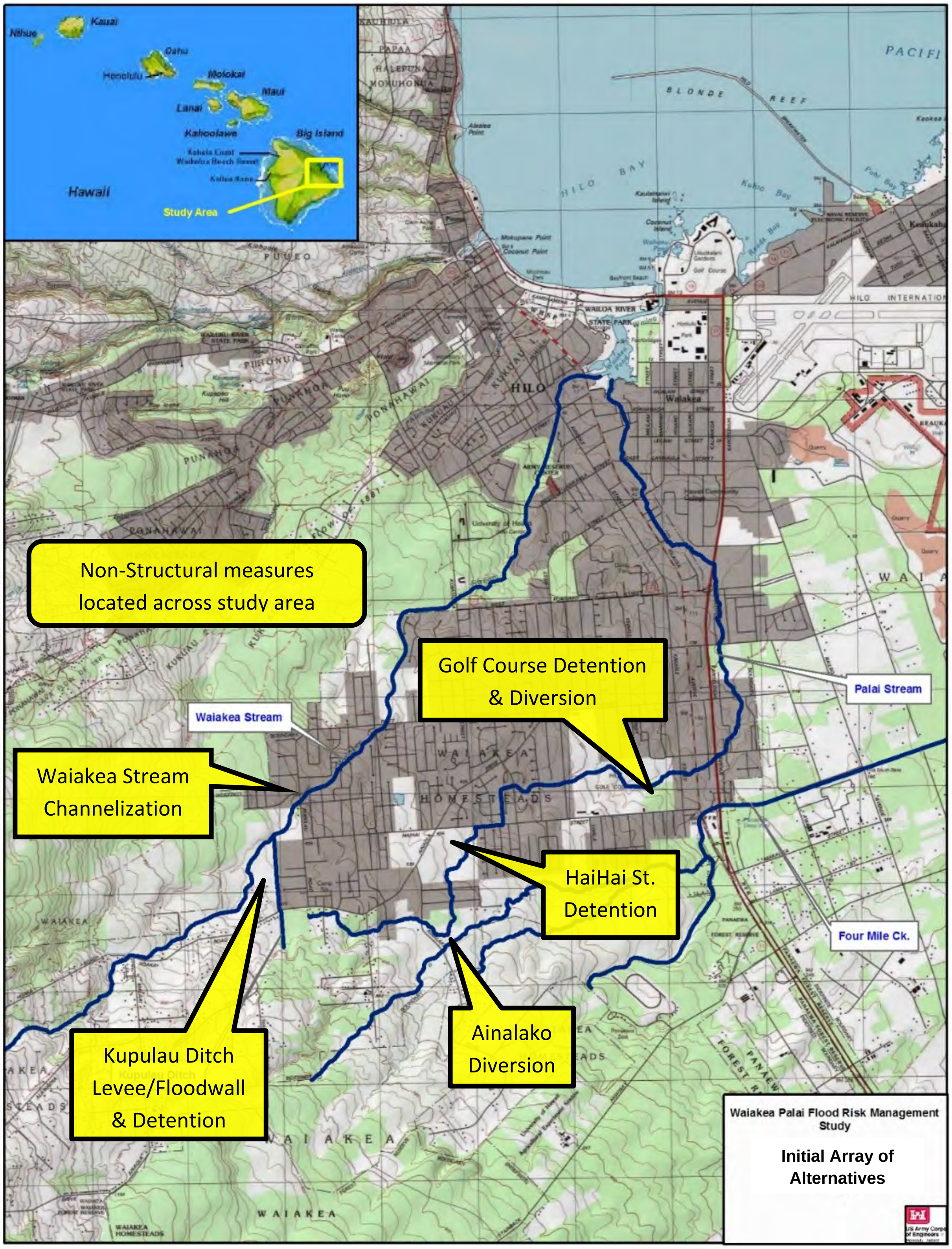

Figure 3-1. Initial Array of Alternatives

3.4 Evaluation of Alternatives

Completeness, effectiveness, efficiency, and acceptability are the four evaluation criteria specified in the Council for Environmental Quality Principles and Guidelines (Paragraph 1.6.2(c)) in the evaluation and screening of alternative plans. Alternatives considered in any planning study should meet minimum subjective standards of these criteria to qualify for further consideration and comparison with other plans.

Completeness is the extent to which a given alternative plan provides and accounts for all necessary investments or other actions to ensure the realization of the planned effects.

Effectiveness is the extent to which an alternative plan alleviates the specified problems and achieves the specified opportunities.

Efficiency is the extent to which an alternative plan is a cost effective means of alleviating the specified problems and realizing the specified opportunities, consistent with protecting the nation's environment.

Acceptability is the workability and viability of an alternative plan with respect to acceptance by State and local entities, tribes, and the public and compatibility with existing laws, regulations, and public policies.

Table 3-2 evaluates compares the final array of alternatives as well as optimized scales of the final array against these criteria.

Table 3-2. Evaluation of Alternatives using Principles and Guidelines Criteria

Alternative	Complete	Effective	Efficient	Acceptable
Kupulau Ditch Detention	Yes	Yes	Yes	Yes
Waiakea Stream Channelization	Yes	No	No	Yes
Hilo Municipal Golf Course Diversion	Yes	No	No	Yes
Hilo Municipal Golf Course Detention	Yes	Yes	Yes	Yes
HaiHai Street Detention	Yes	No	No	Yes
Ainalako Diversion	Yes	Yes	Yes	Yes
Non-Structural	No	No	No	Yes

Based on the results of the screening process summarized above, the following alternatives were not carried forward into the final array:

Alternative 2: Waiakea Stream Channelization

The Waiakea Stream Channelization alternative is not considered effective or efficient. As currently formulated, it is anticipated that there will be significant induced flooding or tailwater effects as a result of the channelization and large-scale levee system proposed for implementation. Costs for additional features required to mitigate for induced flooding are anticipated to be substantial. A smaller-scale alternative that does not involve channelization or significant levee improvements is anticipated to have similar flood risk management benefits without substantial induced flooding.

Alternative 3: Hilo Municipal Golf Course Diversion

The diversion at the Hilo Municipal Golf Course is not considered complete or efficient. Construction of nearly 2,000 feet of an underground box culvert through a residential channel would have a significant cost associated with construction work required under the roadway to install the culvert. It is anticipated that another alternative will be a more cost effective solution to addressing study objectives.

Alternative 5: HaiHai Street Detention

The HaiHai Street Detention alternative is not considered effective or efficient. Based on preliminary qualitative cost estimates, the HaiHai Detention is expected to cost more than similarly sized structures located in other areas of the watershed while providing similar levels of flood risk management. In addition, there are likely substantial induced flooding impacts to the residential areas located directly adjacent to the proposed site as water pools in the detention basin. As such, it is anticipated that another alternative will be a more cost effective solution to addressing study objectives.

Alternative 7: Non-Structural Alternative

After closer inspection of ground, floor, and flood elevations, square footage and construction type, and applicability of the generalized cost figures used in the screening, there are 74 prospective structures that could be eligible for non-structural improvements. However, this alternative is not considered complete, effective, or efficient. Implementation of a stand-alone non-structural alternative would not provide comprehensive flood risk management solutions in the study area. A more likely application of non-structural and flood proofing techniques to reduce flood risks could be implemented for individual buildings that still exhibit substantial residual flood damages after the Recommended Plan is constructed.

3.5 Final Array of Alternatives

Based on the evaluation and screening of alternatives described in Section 3.4, a final array of four alternatives was carried forward for further evaluation. The final array of alternatives includes the following:

- No Action Alternative
- Kupulau Ditch Levee/Floodwall with Detention
- Hilo Municipal Golf Course Detention
- Ainalako Diversion
- Combination Plan (details below)

The three action alternatives can be implemented individually or combined with each other. They are not dependent on each other and are not mutually exclusive. As such, evaluation and comparison of the final array of alternatives included evaluation of various combinations of these alternatives (e.g., Kupulau Ditch plus Golf Course Detention) to identify the optimized plan that reasonably maximizes net benefits.

3.6 Evaluation and Comparison of Final Array of Alternatives*

The Hydrologic Engineering Center Flood Damage Analysis (HEC-FDA) Version 1.4 Corps-certified model was used to calculate expected annual damages and benefits over the period of analysis. The economic and engineering inputs necessary for the model to calculate damages include structure inventory, content-to-structure value ratios, vehicles, first-floor elevations, depth-damage relationships, ground elevations, and stage-probability relationships. More information about these economic and engineering inputs are described in Appendix A (Economics).

Evaluation and comparison of the final array of alternatives included an assessment of costs and benefits for the each of the alternatives included in the final array as well as an evaluation of various combinations of these alternatives to identify the optimized plan that reasonably maximizes net benefits. The breakdown of costs and benefits for each of the three alternatives is presented in Table 3-3.

The Kupulau Ditch feature is the costliest feature at $7.8 million and expected annual cost (EAC) of $446,000, but it also yields the highest expected annual benefits (EAB) of $1,953,000. During the period of completing this feasibility study there was a change in conditions in the Ainalako Diversion project footprint. The change in condition had significant impacts on real estate footprint, design criteria, as well as scope due to a new subdivision constructed adjacent to the project area. The project team qualitatively screened the Ainalako Diversion out of the array carried forward due to the aforementioned change in conditions. Finally, the Hilo Golf Course Detention measure is less expensive than the Ainalako Diversion at $3.4 million and EAC of $203,000, but also produces the least amount of expected annual benefits of $286,000. While all three measures could be added as pairs as shown in Table 3-3, the net benefits are maximized when Hilo Golf Course Detention and Kupulau Ditch are combined.

Table 3-3. Costs and Benefits of Alternatives
$1000s; FY 2020 Discount Rate (2.75%)

	Kupulau Ditch Levee/Floodwall with Detention	Ainalako Diversion**	Hilo Golf Course Detention
Plans & Specs	$1,492	$556	$593
Construction Management	$711	$264	$281
Lands	$458	$129	$501
Construction Contract	$4,855	$1,800	$1,925
Total First Cost	$7,516	$2,749	$3,300
Interest During Construction	$275	$80	$80
Total Investment	$7,791	$2,829	$3,380
Equivalent Annual Cost	$296	$107	$128
Annual O&M	$150	$25	$75
Expected Annual Cost (EAC)	$446	$132	$203
Expected Annual Benefits (EAB)	$1,953	$358	$286
Incremental Net Benefits	$1,508	$226	$83
Inc. Benefit/Cost Ratio	4.4	2.7	1.4

* The interest during construction for the TSP is spread over a longer period than that of its individual measures; therefore, these columns are not additive.

** Updated Costs based on change in condition, not included; Ainalako Diversion was qualitatively screened out based on the change in condition.

As described above, the three action alternatives can be implemented individually or combined with each other. As such, evaluation and comparison of the final array of alternatives included evaluation of various combinations of these alternatives (e.g., Kupulau Ditch plus Golf Course Detention) to identify the optimized plan that reasonably maximizes net benefits. The expected annual cost, net benefits, and benefit-to-cost ratio for possible combinations of alternatives is displayed in Table 3-4.

Table 3-4. Net Benefits of Possible Alternative Combinations
$1,000s; FY 2020 Price Level; FY 2020 Federal Discount Rate (2.75%)

Project Alternatives - Possible Combinations	Expected Annual Benefits	Expected Annual Cost	Net Benefits	Benefit-to-Cost Ratio	Remarks
Kupulau Ditch Levee/Floodwall with Detention	$1,953	$446	$1,508	4.4	
Ainalako Diversion*	$358	$132	$226	2.7	Costs due to change in conditions not included.
Hilo Golf Course Detention	$286	$203	$83	1.4	
Kupulau Ditch + Ainalako Diversion*	$2,312	$578	$1,734	4.0	Costs due to change in conditions not included.
Kupulau Ditch + Hilo Golf Course Detention	$2,239	$649	$1,591	3.5	
Ainalako Diversion + Hilo Golf Course Detention	$645	$336	$309	1.9	Costs due to change in conditions not included.
Kupulau Ditch + Ainalako Diversion* + Hilo Golf Course Detention	$2,598	$781	$1,880	3.3	Costs due to change in conditions not included.

* Change in conditions would require additional real estate and materials costs not included in this calculation.

3.7 Summary of the Tentatively Selected Plan

The alternative with the highest net benefits is the combination plan that includes Kupulau Ditch, Ainalako Diversion, and the Hilo Golf Course Detention, which maximizes annualized net benefits at $1.8 million. This plan was selected as the Tentatively Selected Plan (TSP). At the FY 2020 discount rate of 2.75 percent, the total project first cost of the TSP is $14 million with expected annual costs of $781,000, expected annual benefits of $2.6 billion, and a benefit cost ratio of 3.3. The TSP identified for the Draft FEIS and published for concurrent review in June, 2019 was considered complete, effective, efficient, and acceptable.

3.8 Plan Adjustments – Recommended Plan

The TSP presented in the Draft FR/EA has been modified following agency, technical, and public review of the report as well as completion of feasibility-level design refinements including site visits. While the Draft FR/EA presented the Corps' tentative proposal for a selected plan, this Final FR/EA presents the Corps' recommended plan. Based on subsequent coordination efforts between the Corps, the non-Federal sponsor, and local landowners in the study area, the alternative including Kupulau Ditch Levee/Floodwall with Detention and Hilo Golf Course Detention is presented as the recommended plan (Figure 3-2). This plan does not include the Ainalako Diversion feature. Based on public input and site visits conducted by the study team, it was determined that the Ainalako Diversion would require substantial design modifications and additional real estate requirements in order to be implemented successfully to reduce flood risk, avoid transferring of flood risk to Four Mile Creek, and minimize impacts of induced flooding. Ultimately, the cost to redesign and construct the Ainalako Diversion feature would reduce overall cost effectiveness for this feature and the NED plan. As such, a risk-informed decision was made to remove the Ainalako Diversion from the array of alternatives for consideration.

Once removed from the array of alternatives, the study team reassessed costs, benefits, and net benefits for the final array of alternatives. The combination plan including Kupulau Ditch Levee/Floodwall and Hilo Golf Course Detention is now the alternative the reasonably maximizes net benefits. This alternative is still considered complete, acceptable, efficient, and effective, and it reduces flood risk in the study area. As the plan that reasonably maximizes net benefits, this alternative was identified as the NED Plan and Recommended Plan.

At the FY 2020 discount rate of 2.75 percent, the total project first cost of the Recommended Plan is $10.8 million with expected annual costs of $649,000, expected annual benefits of $2.2 million, and a benefit cost ratio is 3.5.

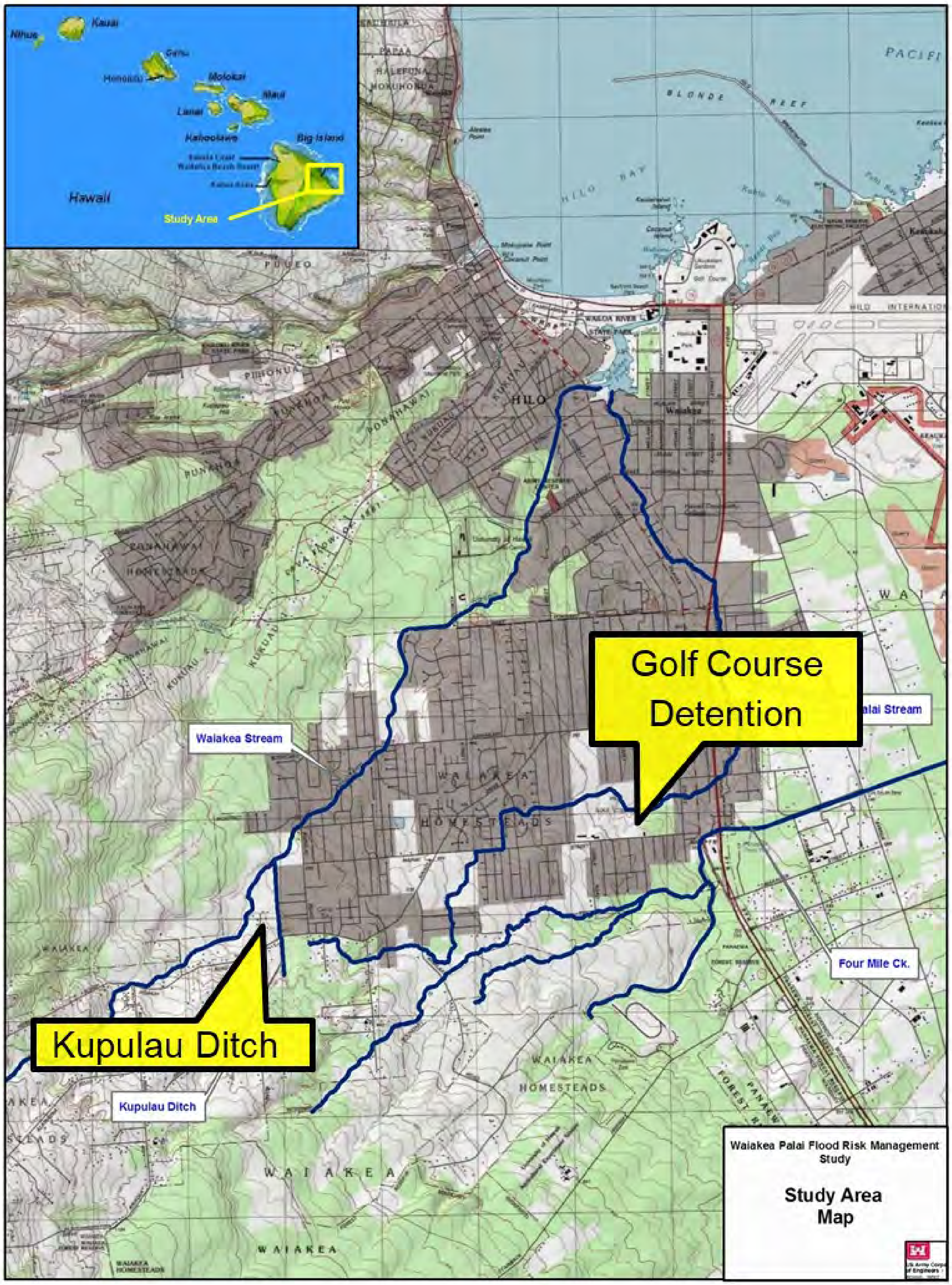

Figure 3-2. Recommended Plan

4 Affected Environment and Environmental Consequences of the Alternatives*

This chapter provides the existing conditions and regulatory setting for each of the resources that could be affected by the No Action Plan or by implementing the Recommended Plan as identified in Chapter 4. The assessment of environmental effects is based on a comparison of conditions with and without implementation of the proposed plan and a reasonable range of alternatives and are compared to the No-Action Alternative. Each resource in sections 4.2 through 4.8 is analyzed for direct and indirect effects and whether these would accrue a significant cumulative effect. The time scale for analysis is a 50-year period beginning in 2023 and extending to 2073.

4.1 Alternatives Analyzed for Environmental Effects

Chapter 3 outlines the formulation, evaluation, and comparison of alternatives. This chapter provides a comparison of potential environmental effects of the No Action Alternative as well as the Recommended Plan. The Recommended Plan presented in this chapter represents the largest combined footprint of the two sites included in the final array: Kupulau Ditch and the Hilo Golf Course. This chapter only presents the results of the evaluation of the Recommended Plan (both sites) in order to disclose the greatest possible environmental effects associated with the alternatives evaluated in this study. Therefore, the action alternatives analyzed in this chapter represent a greater potential environmental impact that what is now proposed as the Recommended Plan. Appendix C presents a more detailed evaluation of the effects of each individual site included in the Recommended Plan as standalone alternatives (e.g., Kupulau Ditch Alternative and Hilo Golf Course Alternative) as well as the Recommended Plan that combines both sites. A summary of the potential impacts of the alternatives evaluated in this chapter are presented below.

4.1.1 Alternative 1 – No-Action Alternative

The No-Action Alternative is synonymous with no Federal Action. This alternative is analyzed as the future without-project conditions for comparison with the action alternatives. The No Action Alternative would result in continued flooding problems in the areas around Waiakea and Palai Streams.

4.1.2 Alternative 2 – Recommended Plan

The Recommended Plan includes the Kupulau Ditch Detention and the Hilo Municipal Golf Course Detention.

4.2 Water Resources

Water resources include both surface water and groundwater resources, associated water quality, and floodplains. Surface water includes all lakes, ponds, rivers, streams, impoundments, wetlands and estuaries within the watershed. Subsurface water, commonly referred to as ground water, is typically found in certain areas known as aquifers. Aquifers are areas with high porosity rock where water can be stored within pore spaces. Water quality describes the chemical and physical composition of water affected by natural conditions and human activities.

Hydrology and Hydraulics

As described in Appendix B2, Waiakea and Palai Streams are two of five streams that form the larger Wailoa River system (Figure 4-1). Waiakea and Palai Streams drain into Waiakea Pond, which is contiguous with Hilo Bay and the Pacific Ocean (USDA, 2009).

At the upstream end of the study area, Waiakea Stream contains a poorly defined channel. When the stream overflows, floodwaters travel east to enter Kupulau Ditch. Waiakea Stream above Kupulau Ditch is characterized by poorly-defined channels. The channel bed is composed of basalt rock and the overbanks are highly vegetated. It has a nominal slope of 0.01479 ft/ft (1.48%). The high velocities dislodge rock and vegetation and transport them downstream. It has a channel capacity of less than 1,020 cfs, which is comparable to a 50% AEP storm event. The channel bed is a mix of earth and volcanic rock. Excess water leaves the Waiakea Stream by overtopping the right bank at the 50% AEP event and flows overland eastward toward Kupulau Ditch.

Between Kupulau Ditch and the Kupulau Rd Bridge, Waiakea Stream has a nominal slope of 0.02249 ft/ft (2.25%). It has an average channel capacity of about 1,630 cfs, which is comparable to a 20% AEP storm event. Flows greater than the 20% AEP event flood the right and left overbanks, but due to the surrounding topography this flow ultimately makes its way downstream to the bridge.

Kupulau Ditch was built in 1971 to divert water from the Palai basin into Waiakea Stream in order to reduce flood problems. The ditch is about 3,500 ft long, has an average depth of 7 ft, and a bed slope of 0.006 ft/ft made up of lava rock. Kupulau Ditch receives the overflow from Waiakea Stream and quickly reaches its capacity. The ditch begins to spill over its right (east) bank. The overflow begins to flood the New Hope Church, which is located adjacent to the ditch, and then crosses Kupulau Road, and flows overland in an eastward direction, flooding residential structures along HaiHai Street, and Ainalako Road.

Floodwater from the overtopping of Kupulau Ditch flows into the Hai Hai reach, adding to flooding there, and then enters Palai Stream at the Hilo Municipal Golf Course before continuing down-stream to the developed industrial, commercial and residential areas within Hilo. The channel capacity of Palai Stream is about 1,000 cfs, equivalent to a 20% Annual Exceedance Probability (AEP) flood, from the Hilo Municipal Golf Course downstream to Kawailani Street, with a bed slope of 0.026 ft/ft. At Kawailani Street, the channel slope flattens out to about 0.006 ft/ft, but the channel capacity reduces to about 800 cfs, which is equivalent to about a 50% AEP flood. Downstream of Kawailani Street, Palai Stream floodwaters are conveyed mainly by overland flow. Stream channels are poorly defined with low-lying areas serving as pockets of storage areas.

Figure 4-1. Flood Prone Areas in Waiakea and Palai Streams

Waters of the U.S.

The Clean Water Act (CWA)(33 U.S.C §§1251 *et seq*.) establishes the basic structure for regulating discharges of pollutants into the waters of the United States and regulating quality standards for surface waters. For the purposes of CWA regulatory jurisdiction, the term, "Waters of the U.S." is defined at 33 CFR 328.3(a). Waters of the U.S. include all tributaries to those waters currently or previously used or susceptible for interstate of foreign commerce, including all waters which are subject to the ebb and flow of the tide. Three main waterways occur within the project areas, the Waiakea Stream, Kupulau Ditch and Palai Stream. Both Waiakea and Palai streams feature intermittent flow while the Kupulau Ditch conveys ephemeral flow.

The Waiakea Stream is a tributary to a navigable water, conveying continuous surface connectivity to Hilo Bay and as such, is a water of the U.S. subject to regulatory jurisdiction under the CWA. The Waiakea Stream flows intermittently in the project area and perennially downstream prior to its confluence with a navigable water.

The Kupulau Ditch was artificially-constructed in uplands to convey stormwater flows to the downstream Waiakea Stream, flowing only in response to precipitation events. The Kupulau Ditch conveys ephemeral flow downstream to the Waiakea Stream and features a trapezoidal channel constructed of earthen bed and banks. Under the Navigable Waters Protection Rule, the Kupulau Ditch is not a water of the U.S. e.g. "non-jurisdictional".

The Palai Stream bifurcates the Hilo Municipal Golf Course. The Palai Stream channel and banks are defined within the project areas. However, based on a site visit attended by USFWS in February 2019, the Corps confirmed that flow within the Palai Stream, downstream of the Golf Course at the intersection of Mamalahoa Highway and Puainako Street, eventually vanishes into swales and storm water conduits. The tributary lacks continuous surface connectivity to a navigable water and according to the Navigable Waters Protection Rule, is not a water of the U.S. e.g. "non-jurisdictional".

The U.S. Fish and Wildlife Service (USFWS) (2019) has mapped wetlands within the study area as part of the National Wetlands Inventory (NWI). Within the Waiakea-Palai watershed, the NWI identifies five freshwater ponds (three PUBHh, one PUBH, and one PUBHx); however, these ponds are 1,600 to 5,700 feet from the floodplains of the streams. The first letter of the NWI designation refers to the Palustrine hydrology of the wetland. The rest of the designation refers to an unconsolidated bottom (UB), permanently flooded (H), diked or impounded (h), or excavated (x). The NWI characterizes Waiakea Pond as an Estuary (E1UBL). For estuarine systems, the first letter of the wetland designation refers subtidal estuarine (E1) hydrology of the wetland. Waiakea pond has an unconsolidated bottom (UB) and is subtidal (L). According to the NWI, no riverine or palustrine wetlands occur along the streams.

Groundwater

The study area is underlain with the Hilo and Keaau Aquifer System Area (ASYA) of the Northeast Mauna Loa Aquifer Sector Area. Water in the study area aquifer occurs as a lens of basal water floating on saline groundwater (Takasaki, 1993). The aquifer is unconfined and occurs in basalt originating from flank lava flows. The aquifer is designated as a drinking water source, is irreplaceable, and is highly vulnerable to contamination (Mink and Lau, 1990). Wells in the study area indicate that the depth to groundwater is estimated to be greater than 100 feet. The sustainable yield of the Hilo ASYA is 347 million gallons per day (mgd) and the Keaau ASYA provides a yield of 393 mgd. The combined ASYAs provide the highest yield of all the sector areas on the island. The watersheds associated with Mauna Loa slope contributes 50 to 100 inches per year of groundwater recharge. The aquifer provides water resources for municipal, agricultural, and industrial uses in the Hilo area.

Water Quality

Surface water quality in the study area is influenced by agricultural practices as well as residential, commercial, and industrial development. Palai Stream and Four Mile Creek are not include the 2018 Section 303(d) list of impaired waters (HSDOH, 2018). Therefore, the water quality of these two streams has not been assessed. Waiakea Stream (Water Body ID 8-2-61) has been classified as an impaired waterbody due to elevated Total Nitrogen (TN), nitrite (NO_2) and nitrate (NO_3), and total phosphorous (TP). The Hawaii State Department of Health categorizes the priority for establishing Total Maximum Daily Loads (TMDLs) for streams as high, medium, or low. Waiakea Stream has been assigned as a medium TMDL priority category.

The specific water quality impairments of Waiakea Stream are typical of streams that bisect agricultural areas as TN, nitrate, nitrite, and TP are common constituents of fertilizers used in cultivation. The agricultural areas within the study area are located in the upstream portions of the watershed; therefore, these pollutants are carried downstream into the urban areas and ultimately into Hilo Bay.

4.2.1 Alternative 1 – No-Action Alternative/Future Without-Project Conditions

Hydrology and Hydraulics

Under the No Action Alternative, the Waiakea Stream is susceptible to flooding at a 50% AEP event and the Palai Stream is susceptible to flooding at a 20% AEP event, resulting in continued flood risk to the affected Hilo community in the future without-project condition.

Waters of the U.S.

Under the No Action Alternative, the Waiakea Stream would remain a water of the U.S. The Corps is not aware of any local government effort to define surface connectivity from Palai Stream into a navigable water such as Hilo Bay; the Corps anticipates the Palai Stream will continue to lack surface connectivity to a navigable water and will continue to not meet the definition of a water of the U.S. The Corps expects that the Kupulau Ditch will continue to flow only in response to precipitation events and remain excluded from the definition of waters of the U.S.

Wetlands

No wetlands associated with Waiakea Stream or Palai were identified; therefore, the future without-project condition for wetlands within the study area would not differ from the existing conditions.

Groundwater

The freshwater aquifers within the study area would be infiltrated by saline groundwater as regional sea level change increases in the future without-project condition. The infiltration would result in a shallower freshwater lens in which to draw irrigation and drinking water. Deeper wells may no longer be viable as the saline ground water rises.

Water Quality

Water quality changes under the future without-project are difficult to predict. The Hawaii State Department of Health has not established TMDLs for the Waiakea Stream; however, the agency is required to set the limits according to the Clean Water Act (CWA). The establishment of the TMDLs is the first step in addressing the water quality of the streams. The water quality impairments associated with Waiakea Stream are the result of agricultural practices within the watershed. As the urbanization of the watershed extends into neighboring agricultural lands converting the land to residential and other urban land uses, the contribution of the criteria pollutants identified for the stream should decrease. However, an increase in the application of lawn and garden fertilizers and an increase in runoff from residential areas could result in a conversion of non-point sources resulting in no change, or possibly a decrease, in water quality. If the City of Hilo initiates best management practices to address the future TMDLs, the water quality of Waiakea Stream could improve under the future without-project conditions.

4.2.2 Alternative 2 – Recommended Plan

Hydrology and Hydraulics

The detention areas associated with the Golf Course and Kupulau Ditch features would capture floodwaters from higher intensity flood events and mediate the flows of the water downstream. The impact of these alternatives would result in the extension of time when the intermittent streams are inundated as waters are released over a longer period of time from the detention basins.

For both of these features included in the Recommended Plan, intermittent stream flow could be slightly altered if natural flow is interrupted during construction activities. However, construction activities would be planned to maintain a natural stream channel during the construction period.

With the Kupulau Ditch feature in place, stormwater flows from the Kupulau Ditch would be captured by the floodwalls and levees and temporarily detained in the resulting detention basin. The detention basin would mediate stormwater flows into Waiakea Stream, reducing flooding elevations downstream. The detention of the stormwaters would result in prolonged flows into Waiakea Creek as the basin drains after the rain event. However, the temporal increase of released flows would not be considered a significant impact on the stream resources.

The design features would only address stormwater flows. Consistent with USFWS recommendation, the recommended plan would have no impact on normal surface flows of any water of the U.S.

Waters of the United States

The Recommended Plan would not alter the circumstances under which the Waiakea Stream, Palai Stream or Kupulau Ditch do or do not meet the definition of waters of the U.S. under the Clean Water Act. No Clean Water Act Section 404 discharges of dredged or fill material into Waiakea Stream are proposed, however, during the design phase when construction means and methods are further detailed, any Section 404 discharge into the Waiakea Stream will be addressed accordingly and compliance with all applicable sections of the Clean Water Act will be pursued.

Wetlands

There are no wetlands in the project areas for the final array of alternative; therefore, no impacts to wetland resources would occur from the implementation of the project.

Groundwater

Because the estimated depth to groundwater is greater than 100 feet below the surface and the shallow depth of grading required to construct the alternatives, groundwater is not anticipated to be encountered. Under the future with-project conditions for the final array of alternatives, there would be no anticipated impacts to groundwater.

Water Quality

Construction activities associated with each of the action alternatives could temporarily affect water quality due to grading, excavation and stormwater runoff. Best Management Practices (BMPs) employed during construction (e.g., sediment erosion control barriers such as silt fencing, tarping/covering exposed and stockpiled soils, surface revegetation, etc.) would minimize/eliminate storm water flow from the proposed construction site and any associated degradation of water quality for proximal surface waters. The Corps lacks sufficient information during the feasibility phase of the project to determine if temporary ancillary construction activities such as staging and access would result in the discharge of dredged or fill material into any water of the U.S., as regulated under the CWA. If, during the design phase of the study the Corps determines the Recommended plan would result in a regulated discharge, then the Corps will ensure compliance with all applicable sections of the CWA.

4.3 Biological Resources

Biological communities include plants, animals and the habitats in which they occur. They are important because they influence ecosystem functions and values, have intrinsic value, contribute to the human environment, and are the subject of a variety of statutory and regulatory requirements.

The study area is located in the Lowland Wet ecological system of the Tropical Moist Forest ecoregion. The Lowland Wet ecological system consists of natural communities below 3,000 feet in elevation and receiving greater than 75 inches of annual precipitation. Vegetative communities associated with this system include wet grasslands, shrublands, and forests. Biodiversity in the Lowland Wet system is high and supports specialized plants and animals.

Three separate biological surveys were conducted to assess the existing conditions within the project area, as well as the projected impacts on biological resources from the Recommended Plan (USACE, 2005; USACE, 2010a; and USACE, 2010b). The results of these surveys, and information from additional research were used to characterize and assess the biological resources within the project area.

Vegetation

The vegetative community within the study area has been altered as native habitats have been converted to agriculture and urbanization has introduced ornamental plant species. In addition, non-native invasive species have become established within the study area. These species include strawberry guava, gunpowder, African tulip, common guava, albizia, melochia, and kukui. Native vegetation extends upslope of the study area and is dominated by ʻōhiʻa trees and dense patches of ʻuluhe. A full list of plant species observed in the study area is described in USACE (2005, 2010a, 2010b).

In consultation with USFWS and by letter dated June 8, 2018, USFWS recommended the Corps implement the following conservation measure based on the project's location on Hawaii Island, in order to avoid and minimize adverse impacts to the native ohia trees (*Metrosideros polymorpha*). While the tree is not a federally protected species, USFWS has expressed concerns regarding increasing the spread of the newly identified disease, Rapid Ohia Death, caused by a vascular wilt fungus (*Ceratocystis fimbriata*). Per recommendation from USFWS, the Corps has agreed to implement the following avoidance and minimization measures:

- A survey of the proposed project site will be conducted within two weeks prior to any tree cutting to determine if there are any infected ohia trees. If infected ohia are suspected at the site, the following agencies will be contacted for further guidance:
  - USFWS – Jodi Charrier, 808-342-6607 or Jodi_charrier@fws.gov
  - Dr. J.B. Friday, University of Hawaii Cooperative Extension Service, 808-969-8254 or jbfriday@hawaii.edu
  - Dr. Flint Hughes, USDA Forest Service, 808-854-2617 or fhughes@fs.fed.us
  - Dr. Lisa Keith, USDA Agriculture Research Service, 808-959-4357 or Lisa.Keith@ars.usda.gov
- Both prior to cutting ohia and after the project is complete:
  - Tools used for cutting infected ohia trees will be cleaned with a 70 percent rubbing alcohol solution. A freshly prepared 10 percent solution of chlorine bleach and water can be used as long as tools are oiled afterwards, as chlorine bleach will corrode metal tools. Chainsaw blades will be brushed clean, sprayed with cleaning solution, and run briefly to lubricate the chain.
  - Vehicles used off-road in infected forest areas will be thoroughly cleaned. The tires and undercarriage of the vehicle will be cleaned with detergent if they have travelled from an area with ROD or travelled off-road.
  - Shoes and clothing used in infected forests will also be cleaned. Shoes will be decontaminated by dipping the soles in 10 percent bleach or 70 percent rubbing alcohol to kill the ROD Fungus. Other gear can be sprayed with the same cleaning solutions. Clothing can be washed in hot water and detergent.
- Wood of affected ohia trees will not be transported to other areas of Hawaii Island or interisland. All cut wood will be left on-site to avoid spreading the disease. The pathogen may remain viable for over a year in dead wood. Additionally, per the State Department of Agriculture interisland movement, except by permit, of all ohia plant or plant parts is prohibited.

Aquatic Resources

Swordtails and marine toad tadpoles are abundant throughout the study area. Dragonfly and damselfly naiads and crayfish are also common. Guppies are occasionally encountered schooling with swordtails. The full list of observed aquatic fauna species within the study area is included in the reports that document the biological surveys conducted for the study (USACE, 2005; USACE, 2010a; and USACE, 2010b).

Terrestrial Resources

Avian species identified within the project area were dominated by non-native species. The only native species identified was the Pacific-golden Plover. Similarly, no native mammals were identified within the study area; non-native species included the Indian mongoose, dogs, and pigs. A full list of terrestrial wildlife species observed in the study area is described in USACE (2005, 2010a, 2010b).

Threatened and Endangered Species

The USFWS provided the Corps a species list on July 16, 2008 identifying the following three endangered species that may occur within the project vicinity: the endangered Hawaiian hoary bat *(Lasiurus cinereus semotus),* Hawaiian coot *(Fulica americana alai)* and Hawaiian hawk *(Buteo solitarius).* No critical habitat for these, or any other endangered species, are located within the ESA action area e.g. project areas. Additionally, the project area consists of intermittent bedrock streams that do not support any permanent aquatic biota e.g. Hawaiian coot, and trees that lack the height and breadth adequate to support the Hawaiian hawk. As recommended by the USFWS, the Corps evaluated the potential impacts to these species and determined the proposed action may affect, but is not likely to adversely affect the above listed species. This determination was based on the following: lack of suitable habitat to support the Hawaiian coot or Hawaiian hawk, no threatened or endangered species were observed during field investigations, within the survey area, e.g. project areas (USACE 2005, 2010a, 2010b), and the Corps would implement the USFWS conservation measures recommended in the July 16, 2008 letter intended to avoid and/or minimize adverse impacts to the above listed species. The Corps initiated informal consultation with USFWS by letter dated November 1, 2016 and a follow-up phone call on May 23, 2018 seeking concurrence on the Corps' determination. The USFWS issued its concurrence by letter dated June 8, 2018 and concluding the Corps' Section 7 ESA consultation.

Per the completed ESA consultation, the Corps will implement the following USFWS' recommended conservation measures:

- Hawaiian hoary bat. -Do not disturb, remove, or trim woody plants greater than 15 feet tall during the bat birthing and pup rearing season (June 1 through September 15)*.
- Hawaiian coot. Ensure surface water flows into Waiakea Pond are not appreciably reduced as a result of the proposed projects. Ensure any ponded or standing water e.g. stockpile or pit, within ancillary construction staging and stockpiling areas is covered overnight or any break lasting more than 1 hour to eliminate attraction of endangered waterbirds.
- Hawaiian hawk. No clearing of vegetation or construction activities should occur within 1,600 feet of any active hawk nest during the breeding season (March 1 through September 30) until the young have fledged. Regardless of the time of year, trimming or cutting trees containing a hawk nest is prohibited, as nests may be re-used during consecutive breeding seasons.

*Note, this particular conservation measure has been updated from the conservation measure stipulations recommended in consultation with USFWS to be consistent with current guidance provided on the USFWS Pacific Islands Fish and Wildlife Office website as of March 2020.

4.3.1 Alternative 1 – No-Action Alternative/Future Without-Project Conditions

Vegetation

Historically, the streams within the project area were stable enough to maintain the riparian forest cover as a buffer between the creek channel and overbanks of the two cemetery areas. More frequent flood events in recent years have undercut and eroded the streambanks, destabilizing the channel and jeopardizing the trees that shade and protect the upper slopes of the streambank. Under the No Action Alternative, these destabilizing conditions would continue and eventually lead to loss of the existing mature tree buffer and subsequent degradation of the riparian corridor.

Aquatic Resources, Terrestrial Resources, and Threatened/Endangered Species

Under the future without-project conditions, fish and wildlife resources would remain generally unchanged. As land use changes in the future, it is reasonable to expect that shifts in the distribution of fish and wildlife communities may occur as communities seek habitat which meets their life requisites. However, such range shifts are only feasible with adequate habitat, an ability to disperse and colonize, availability of food resources, and absence of physical barriers which might preclude movement. Displaced species may be subject to increased predation, be susceptible to disease, or be maladapted to their new habitat.

4.3.2 Alternative 2 – Recommended Plan

Vegetation

The flood frequency and detention time is unlikely to impact vegetation at the Kupulau Ditch or Hilo Golf Course. The levees and floodwall at Kupulau Ditch would result in the conversion of approximately six acres of grassland and riparian vegetation into flood risk management features. Although the detention basin would be comprised of another six acres of maintained land associated with the baseball field, the frequency of flooding events and the short length of time the detention basin would be inundated is unlikely to result in adverse impacts to vegetation in the basin. The Hilo Golf Course feature would convert approximately two acres of maintained golf course vegetation to flood risk management features. Approximately seven acres of the golf course would be temporarily inundated in the resulting detention basin. Similar to the Kupulau Ditch feature, the flood frequency and detention time is unlikely to adversely impact vegetation on the golf course.

During construction, all vegetation disturbance conservation measures will be implemented, including construction windows during life cycle seasons of endangered species and minimizing risk of spread of ROD. Additionally, the Corps will ensure appropriate vegetation of all areas impacted during construction to the pre-construction condition, where possible, as a means of sediment-erosion control. In areas where vegetation type is converted within the flood risk management features, the Corps will grass these areas. To ensure the future structural integrity of these features, restoration to the pre-construction condition is not proposed; these areas will be properly grassed.

Aquatic Resources

The footprint of the Recommended Plan occurs within the intermittent portions of the Waiakea and Palai Streams. The flood risk management features included in the Recommended Plan would be designed to manage the higher flows associated with storm events, but also be designed to maintain lower flows associated with more frequent rainfall events. The levees and detention basins would not result in creating barriers for aquatic organisms immigrating/emigrating from downstream habitats to the upstream habitats. Minor short term adverse impacts to aquatic organisms may result during construction as significant rain events may displace soil from the construction site and increase turbidity in the streams.

However, best management practices such as silt fence and temporary vegetation would minimize the water quality impacts to the aquatic biota. The effect of the flood risk management features on aquatic resources may be of minor benefit to aquatic resources as the extended flows associated with the detention basins would prolong the time the streams flow allowing additional time for species to migrate to and from the higher reaches of the streams. The Recommended Plan will have no effect on normal surface flows of waters of the U.S., accordingly long-term adverse impacts to aquatic resources are not expected.

Terrestrial Resources

Implementation of the Recommended Plan would have temporary, localized adverse impacts during construction, with some loss of less mobile species within the footprint of the levees. Mobile resident wildlife species would be temporarily displaced into adjacent habitats until construction activities were completed, with a minor loss of habitat associated with the approximately ten acres associated with the levee footprints. The maintained nature of these habitats associated with the levee footprints (baseball field, golf course, and maintained pasture) are not considered high quality habitats; therefore, there would be no substantial adverse impacts to terrestrial species resulting from the implementation of any of the alternatives.

Threatened and Endangered Species

As described above, a letter from USFWS dated 16 July 2008 identified three species that may occur in the project area: the Hawaiian hoary bat, Hawaiian Hawk, and the Hawaiian Coot. No critical habitat for these, or any other endangered species, are located within the project areas. The USFWS also indicated the project area is absent of suitable habitat for both the Hawaiian coot and Hawaiian hawk.

There is a chance that Hawaiian hoary bats could utilize native and non-native woody plant species in the study area for nesting habitat and the Hawaiian hawks for intermittent resting during flight. However, most woody vegetation is located on the fringes of the project areas and would not be permanently impacted by the construction of the levees and floodwalls. The removal of woody vegetation would be limited to the extent practicable and in accordance with the conservation measures recommended by USFWS, above, to minimize impacts to endangered species and their preferred habitat. Should the construction contractor determine clearing of woody vegetation must occur during the pup-rearing season for Hawaiian hoary bats or nesting season for Hawaiian hawks, then the trees in the project area would be surveyed, in coordination with USFWS, to determine the presence of Hawaiian hoary bats, Hawaiian hawks, or their nests. If bats, hawks or their nests are observed, regardless of the season, construction activities would cease until the USFWS has been consulted and tree trimming/removal is approved.

The Corps evaluated the potential impacts to these species and determined the Recommended Plan may affect, but is not likely to adversely affect the Hawaiian hoary bay and Hawaiian hawk. The Corps concluded this effect determination based on the following: neither the bat nor the hawk, were observed during field investigations, the site lacks suitable habitat to support the coot and the hawk, and as an integral component of the proposed action, the Corps will ensure implementation of the recommended USFWS conservation measures identified above, to avoid and/or minimize adverse impacts to the above listed species.

The Hawaiian Coot utilizes the wetland habitats surrounding Waiakea Pond in Hilo, located approximately 2.5 miles downstream of the project area. Although the streams terminate into Waiakea Pond, the mediated flows would not substantially affect the wetland habitats of the pond. The design of the Recommended Plan is consistent with conservation measures recommended by the USFWS to minimize adverse impacts to the endangered Hawaiian Coot. The implementation of the Recommended Plan would allow base stream flows to continue downstream and would lessen the impacts of high velocity floodwaters entering the pond.

Although the project areas are void of permanent aquatic habitat necessary for Hawaiian Coot, due to their known proximal occurrence, the Corps will implement conservation measures to avoid and/or minimize adverse impacts to the Hawaiian Coot. Because the Hawaiian Coot has the potential to occur within the project area, the Corps has determined the Recommend plan may affect, but is not likely to adversely affect the endangered Hawaiian Coot. As an integral component of the proposed action, the Corps will ensure implementation, of the USFWS' recommended conservation measures.

4.4 Cultural Resources

Listed Historic Properties

A total of 331 properties and historic districts are listed on the National Register of Historic Places (NRHP) for the State of Hawaii; of these, 73 are located on Hawaii Island. The listed historic property closest to the study area is the Waiakea Mission Station – Hilo Station (NPS, 2014). The Waiakea Mission Station – Hilo Station is located on Haili Street, approximately 4.8 miles from the study area.

The Hawaii Register of Historic Places formally recognizes historic properties in the categories of district, site, structure, building, and object for their architectural, archaeological, cultural, or engineering significance. There are no Hawaii Register of Historic Places-listed historic properties within the vicinity of study area (SHPD, 2014). The historic property closest to the study area is the S. Hata Building, approximately 5.0 miles from the study area.

Archaeology

Several archaeological surveys have been conducted as part of various development projects in the vicinity of the study area. These were reviewed to evaluate the potential for archaeological resources within the study area. Following this, a comprehensive archaeological inventory survey was completed for the entire project area (Reeve and Cleghorn, 2019). This work produced no evidence of archaeological or historic resources and confirmed the highly disturbed and modified nature of the landscape.

The majority of the study area has been developed with residential and community land uses (e.g., parks, community centers, churches) and a few small-scale commercial uses. Due to the land use history of intensive commercial agriculture and residential development, extant archaeological or cultural features are most likely to be associated with former sugarcane cultivation or other Historic Period activities in the area. Any pre-contact resources would likely have been destroyed by the agricultural operations or during subsequent suburban development of the area. (Escott, 2004; Geometrician Associates, 2006; Pacific Legacy, 2005).

The Hawaii State Historic Preservation Division, the Office of Hawaiian Affairs, and the Hawaiian Civic Club of Hilo were consulted on the findings of the Archaeological Survey and the potential for unknown historic and cultural resources in the project area (See Section 6.5). This produced no further evidence of historic or cultural resources.

Traditional or Cultural Practices

Hawaii Revised Statutes Section 7-1 has codified some recognized traditional and cultural practices. These traditional and cultural practices include the right to gather firewood, house-timber, *aho* cord, thatch, or *ki* leaf, for private use. Other traditional or cultural practices not specifically enumerated in the Constitution of the State of Hawaii or its statutes have also been recognized. These practices may include the stewardship and healing/restoration of lands established by actual practice.

A Cultural Impact Study (CIS) was conducted for the study area in 2005. The CIS concluded that, based on the results and findings from interviews and archival research, there are no known culturally significant traditional properties or resources in the study area; and the study area does not appear to support any traditional cultural practices.

4.4.1 Alternative 1 – No-Action Alternative/Future Without-Project Conditions

The study area would remain unchanged from current conditions and there would be no impacts to any potential archaeological, historic, or cultural resources in the study area.

4.4.2 Alternative 2 – Recommended Plan

There are no known historic properties or cultural resources in the study area. In addition, the area does not support any traditional cultural practices. Therefore, the Recommended Plan would not impact these resource types.

4.5 Socioeconomics

Hilo is a Census-Designated Plan in the State of Hawaii with a population of about 43,000 based on 2010 U.S. Census data. Hilo functions as the industrial, commercial, distribution, and population core of the island. The median household annual income for the County of Hawaii in 2012 was $52,098. This is 22.8% lower than the mean household income for the State of Hawaii, at $67,492 (U.S. Census Bureau, 2014). The County of Hawaii's racial distribution is such that individuals with one race are 34.2% White, 0.8% Black or African American, 0.6% American Indian and Alaska Native, 22.5% Asian, 12.5% Native Hawaiian and other Pacific Islander, and 29.7% of some other race. Persons of two or more races made up 29.6% of the census tract population (U.S. Census Bureau, 2014).

The County of Hawaii experienced a population increase of 30.6 percent over the 2000-2014 timeframe, the largest of any of the Hawaiian Islands. Population growth has been steady within the study area, but not as extraordinary as for the County. Within the County of Hawaii, the South Hilo District, which includes this study area, population increased 7.5 percent between 2000 and 2013.

4.5.1 Alternative 1 – No-Action Alternative/Future Without-Project Conditions

Under the future without-project condition, there would be no changes to the health risks for children or changes in the minority/low income populations.

4.5.2 Alternative 2 – Recommended Plan

Based on the U.S. Census data and field observations, the implementation of the Recommended Plan would not have a disproportionate adverse impact on specific racial, ethnic, or socioeconomic group living in the vicinity of the project area and would not adversely impact environmental justice populations.

Children would be expected to concentrate at the New Hope Church and the adjacent baseball field in the vicinity of the Kupulau Ditch feature footprint. Measures would be incorporated to ensure the safety of children in the project area such as exclusion fencing, signage, and securing construction equipment. With these mitigative measures in place, the alternative would not have substantial adverse impacts on the local population of children.

The Hilo Golf Course feature would be implemented within an access controlled facility. In addition, children on the golf course would need to be accompanied by an adult; therefore, there would be no adverse impacts to children as it relates to EO 13045 as long as the mitigative measures identified above are implemented.

4.6 Hazardous, Toxic, and Radioactive Waste

To complete the Phase I HTRW survey, the Corps reviewed existing environmental documentation and environmental regulatory databases. The Corps contacted the Hawaii State Departments of Health (DOH), Land and Natural Resource, and Office of Environmental Quality Control, and the Hawaii County Planning Department to obtain information about property history, environmental conditions, and any HTRW incidents, violations, or permit actions which may have occurred within the areas encompassing the final array of alternatives. Federal, state, and local agency environmental records and regulatory databases were searched to determine the existence of any license or permit actions, violations, enforcements, and/or litigation against property owners, and to obtain general information about potential past incidents of HTRW releases. Results of the database searches include:

- No U.S. Environmental Protection Agency (EPA) National Priority List (NPL) or Superfund sites are within a one mile radius of the project alternative areas
- No Comprehensive Environmental Response, Compensation, and Liability Information System site is located within a 0.5-mile radius of the project alternative areas
- No Resource Conservation and Recovery Information System treatment, storage, or disposal facility is located with a 0.5-mile radius from the project alternative areas
- No Resource Conservation and Recovery Act (RCRA) Corrective Action Reports were identified within a one mile radius of the project alternative areas
- No RCRA generators are located within the project alternative areas or adjacent properties
- No underground storage tanks are located within a 0.25-mile radius of the project alternative areas
- One leaking underground storage tank was located within a one mile radius of the project alternative areas
- No active landfills are located within a 0.5-mile radius of the project alternative areas
- No spills or incidents connected with the properties of the project alternative areas are entered in the Emergency Response Notification System database.

The records search of the DOH Solid and Hazardous Waste Branch, Underground Storage Tank Section was conducted for information on the leaking underground storage tanks within, and in the vicinity of the project alternative areas. As stated in the synopsis above, the database revealed one underground storage tank (Kawailani Laundromat, 511 West Kawailani Street) with a confirmed release of diesel fuel on 13 November 1997. The release was less than 25 gallons and resulted in appropriate remedial action including removal of the underground storage tank. This site is located approximately one mile northwest of the project alternative areas.

A visual survey was conducted for areas included in the final array of alternatives on 12 January 2005 to look for evidence of potential HTRW or impacts therefrom. Follow-up HTRW surveys were performed on 5 February and 7 May 2019. Project alternative sites were reconnoitered for evidence of possible HTRW contamination including partially buried containers, discolored soil, seeping liquids, film or sheen on water surfaces, abnormal or dead vegetation or animals, malodors, dead-end pipes, anomalous grading, fills, depressions, or other evidence of possible environmental contamination. Based on the visual survey of the area, no apparent signs of HTRW contamination exists within the proposed alternative project areas.

4.6.1 Alternative 1 – No-Action Alternative/Future Without-Project Conditions

As described above, the study area has been essentially built out and no new HTRW sources are expected to be introduced into the area. As such, there are no expected changes to HTRW sites in the future without-project condition.

4.6.2 Alternative 2 – Recommended Plan

In the short-term, the Recommended Plan may generate solid waste from the clearing of vegetation and unused construction materials in the proposed project area. During construction of the Recommended Plan, the contractor would be responsible for such solid waste disposal. In the long-term, the Recommended Plan would require infrequent solid waste disposal of cleared debris, in accordance with applicable regulations. Overall, implementation of the Recommended Plan is expected to have a less than significant impact on solid waste generation in the affected environment for the foreseeable future.

During construction of the Recommended Plan, there may be the potential of petroleum and petroleum-related products spillage associated with construction vehicles and equipment. To minimize this hazard, all applicable County of Hawaii Spill and Prevention Control BMPs would be implemented to ensure that accidental releases are minimized and contained. For example, vehicles and equipment would be regularly inspected for leaks and performance and maintained accordingly to prevent spills from occurring. Any potentially hazardous materials required for the project or any resultant hazardous waste will be managed and disposed of in compliance with all applicable state and federal regulations, including RCRA. In the long term, the potential for petroleum spillage exists from maintenance vehicles. Again, all applicable County of Hawaii Spill and Prevention Control BMPs would be implemented. Implementation of the Recommended Plan is expected to have less than significant solid waste generation in the affected environment for the foreseeable future.

4.7 Air Quality

The U.S. Environmental Protection Agency (EPA) has the primary responsibility for regulating air quality nationwide. The Clean Air Act (42 U.S.C. 7401 *et seq.*), as amended, requires the EPA to set National

Ambient Air Quality Standards (NAAQS) for wide-spread pollutants from numerous and diverse sources considered harmful to public health and the environment.

EPA has set NAAQS for six principal pollutants, which are called "criteria" pollutants. These criteria pollutants include carbon monoxide (CO), nitrogen dioxide (NO_2), ozone (O_3), particulate matter less than 10 microns (PM_{10}), particulate matter less than 2.5 microns ($PM_{2.5}$), sulfur dioxide (SO_2), and lead (Pb). If the concentration of one or more criteria pollutants in a geographic area is found to exceed the regulated "threshold" level, the area may be classified as a non-attainment area. Areas with concentrations of criteria pollutants that are below the levels established by the NAAQS are considered in attainment.

There are no non-attainment areas within the State of Hawaii (EPA, 2019).

4.7.1 Alternative 1 – No-Action Alternative/Future Without-Project Conditions

No impacts to air quality and no violations of existing air quality standards would be anticipated to occur if the proposed project is not implemented.

4.7.2 Alternative 2 – Recommended Plan

Ground disturbance could generate fugitive dust (e.g., PM) and use of construction equipment and personal vehicles to access the project area could lead to temporary increases in vehicular airborne pollutant concentrations. These impacts would be temporary, and applicable best management practices, including silt fence and watering stockpiled soil, would be implemented. To reduce vehicle and equipment emissions, idling of vehicles and equipment would be minimized to the extent practicable and equipment would be maintained.

The Council on Environmental Quality requires a quantitative assessment of Greenhouse Gas (GHG) emissions for activities that result in more than 25,000 tons of CO_2-equivalent per year. The Recommended Plan would contribute less than 25,000 tons of CO_2 into the atmosphere. With the possible exception of maintenance vehicles, each of the features included in the Recommended Plan is passive, with no further contribution of GHG.

5 Recommended Plan

This chapter discusses the details of the Recommended Plan, which include material quantities and classifications, requirements for operations, maintenance, repair, rehabilitation, and replacement (OMRR&R), cost and benefits, and risk and uncertainty.

5.1 Description of the Recommended Plan

The Recommended Plan includes the Kupulau Ditch Detention and Hilo Municipal Golf Course Detention (Figure 5-1). The following sections provide more information about each of the features included in the Recommended Plan.

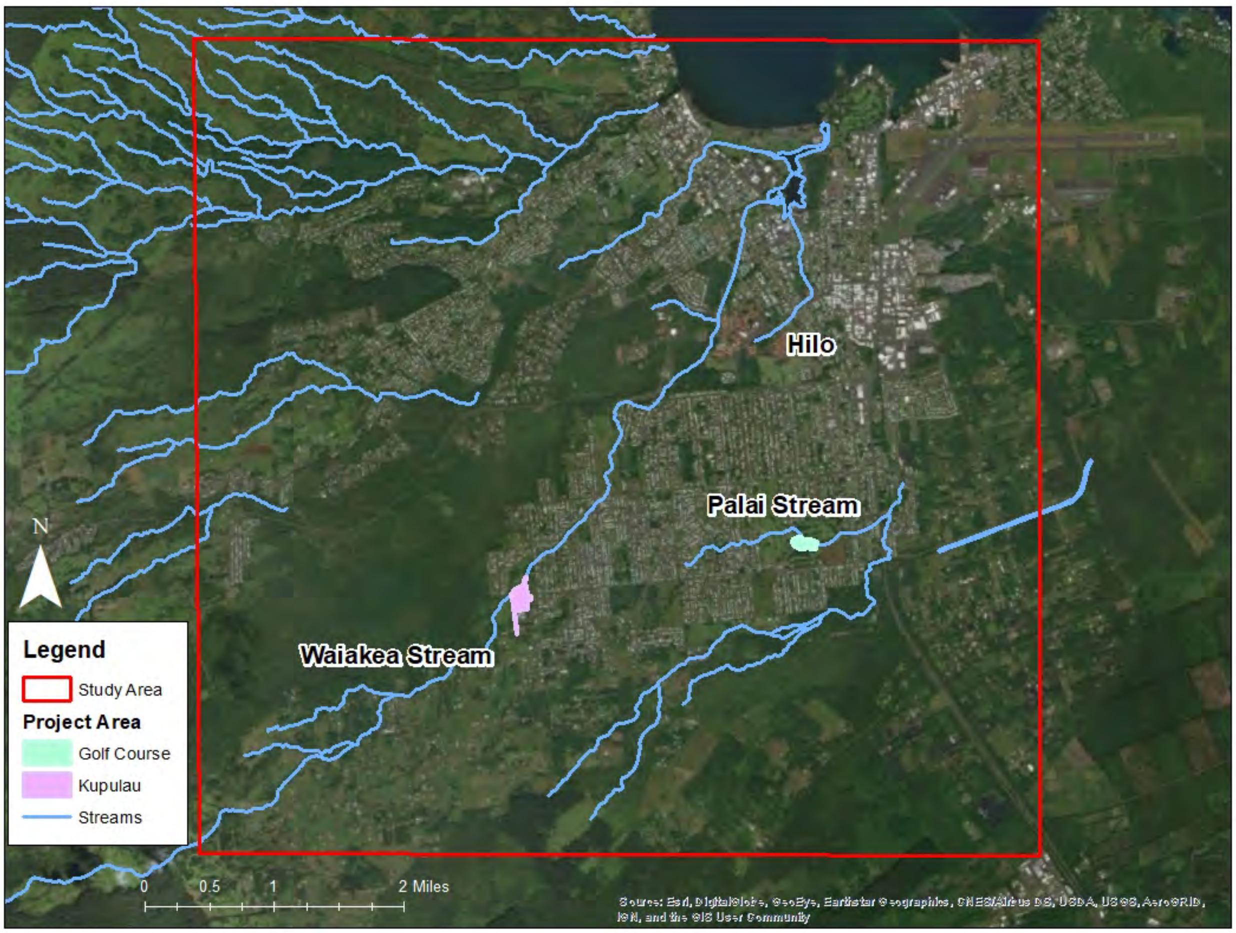

Figure 5-1. Recommended Plan

5.1.1 Kupulau Ditch Detention

The Kupulau Ditch Detention (Figure 5-2) includes construction of a detention basin on property located to the north of the New Hope Church and adjacent to the right bank of Kupulau Ditch (located east of the confluence of Kupulau Ditch and Waiakea Stream). Impounding of the runoff would be accomplished by constructing a series of three levees and one floodwall to enclose the landscape by utilizing the natural topography of the area. The detention basin would reduce peak flows along Waiakea Stream downstream of Kupulau Road, resulting in a reduction of flood damages in the Waiakea Stream damage reach by 42%.

The total project first cost for Kupulau Ditch is $7.8 million with expected annual costs of $446,000 and expected annual benefits of $1.9 million. As described in Section 5.3.2, real estate requirements for this feature include flowage easements (perpetual and occasional), channel improvement easements, flood protection levee easements, road easements, and temporary work area easements on both public and private lands. Ten parcels (one public parcel and nine private parcels) are affected for the Kupulau Ditch feature. Finally, please refer to section 5.4 for a discussion of residual risk associated with this feature.

Figure 5-2. Kupulau Ditch Detention

5.1.2 Hilo Municipal Golf Course Detention

The embankment constructed to create the detention pond would have a maximum height of approximately 22 feet from the channel bottom (Figure 5-3). An in-channel barrier with an uncontrolled outlet consisting of three (3) four-foot diameter aluminized steel pipes would be constructed. The barrier has a total length of about 823 feet. Side embankments located on the north and south sides of Palai

Stream prevent flow from escaping the stream. The in-channel portion of the structure has a height of about 10 feet. The north embankment has an average height of about 2.4 feet, while the south embankment has an average height of about 2.1 feet. Grouted riprap on both the upstream and downstream face of the in-channel embankment is required to protect it from erosion. Analysis of this structure has a storage volume of about 7 acre-ft. at the 1% AEP event and about 12 acre-ft. at the 0.2% AEP event.

The total project first cost for the Hilo Golf Course Detention is $3.4 million with expected annual costs of $203,000 and expected annual benefits of $286,000. As described in Section 5.3.2, real estate requirements for this feature include flowage easements (perpetual and occasional), channel improvement easements, flood protection levee easements, road easements, and temporary work area easements on both public and private lands. Four parcels (all public ownership) are affected for the Hilo Golf Course feature. Finally, please refer to section 5.4 for a discussion of residual risk associated with this feature.

It should be noted that a new residential development is being constructed near the southeast corner of the Hilo Golf Course. While the development is outside of the proposed footprint of the detention basin feature, the height and alignment of the detention basin may require refinement to ensure the Recommended Plan will not negatively impact the housing development. The Corps will continue to coordinate with the County of Hawaii to assess permitting requirements for floodplain developments and may refine the design of the Hilo Golf Course detention basin during the Design and Implementation phase of the project. Potential design refinements are expected to be minimal and would not significantly impact costs, benefits, or overall justification of the Recommended Plan.

Figure 5-3. Hilo Municipal Golf Course Detention

5.2 Cost Estimate and Economic Summary

The total project first cost (Constant Dollar Cost at FY2020 price levels) of the Recommended Plan is $10,768,000. The fully funded total project cost (Constant Dollar Cost) for the Recommended Plan is $11,501,000, including escalation to the midpoint of construction. In accordance with the cost share provisions of Section 104 of the Water Resources Development Act (WRDA) of 1986, as amended (33 U.S.C. 2213), the Federal share (65%) of the project first cost is estimated to be $6,390,150 and the non-Federal share (35%) is estimated to be $4,377,850 which includes $937,000 in lands, easements, rights-of-way, relocations, and disposal (LERRD). Table 5-3, Table 5-2, and Table 5-3 provides the cost breakdown for total project first cost, equivalent annual benefits and costs, and cost-share information. Detailed information on Project costs can be found in Appendix E.

Table 5-1. Total Project First Cost Summary

Construction Item Cost	Project First Cost (FY20 Price Level)
Construction	6,781
LERRDs	937
Preconstruction Engineering & Design	2,068
Construction Management	982
Total First Cost ($1000s)	10,768

Table 5-2. Equivalent Annual Benefits and Costs

(October 2020 Price Level; 50-year Period of analysis, 2.75% Discount Rate)

Investment Costs	
Total Project Construction Costs	$10,816
Interest During Construction	$355
Total Investment Cost ($1000s)	$11,171
Average Annual Costs	
Interest and Amortization of Initial Investment	$424
OMRR&R	$225
Total Average Annual Costs ($1000s)	$649
Average Annual Benefits	$2,239
Net Annual Benefits	$1,591
Benefit-Cost Ratio	3.5

Table 5-3. Estimated Project First Cost and Cost-Share

Item	Project First Cost (FY20 Price Level)	Federal Cost	Non-Federal Cost
Construction	6,781	4,408	2,373
LERRDs (non-cash contribution)	937	0	937
Preconstruction Engineering and Design	2,068	1,344	724
Construction Management	982	638	344
Total ($1000s)	**10,768**	**6,390**	**4,378**

5.3 Plan Implementation

The following sections outline the requirements for implementation of the recommended plan.

5.3.1 Non-Federal Sponsor

The County of Hawaii is supportive of the recommended plan. Non-Federal cost requirements are described in section 5.2. Self-certification of financial capability documentation will be included in subsequent agreements between the County and Corps.

5.3.2 Real Estate Requirements

Requirements for LERRDs include flowage easements (perpetual and occasional), channel improvement easements, flood protection levee easements, road easements, and temporary work area easements on both public and private lands. Ten parcels are affected for the Kupulau Ditch feature and four parcels are affected for the Hilo Golf Course Detention. Additional details of the real estate requirements for this project are presented in Appendix D.

5.3.3 Operations, Maintenance, Repair, Rehabilitation and Replacement Requirements

Operations, Maintenance, Repair, Rehabilitation, and Replacement (OMRR&R) requirements include standard activities for detention and diversion structures as well as levees and floodwalls. Maintenance would include yearly inspections of the levees and floodwalls at Kupulau Ditch, cutting or clearing of vegetation within the cleared zone at both sites, clearing of accumulated debris at both sites following flood events or annually (whichever is greater), and possibly minor grouted riprap replacement at the Hilo Golf Course Detention and after large events. The estimated annual O&M costs for the Project would be approximately $225,000, which is approximately 1/50 of the initial construction and construction management cost. OMRR&R is a non-Federal sponsor responsibility and final O&M requirements will be confirmed during the detailed design phase.

5.4 Residual Risk

Residual risk is the risk remaining after implementation of a plan; that is, it is the difference in damages between the with- and without-project conditions. Depending on the current conditions and the changes created by the alternative plan, inundation at a reach usually starts to occur at different AEPs. These changes in AEPs are correlated to structure and content dollar damages. In the case of the Waiakea-Palai project, the residual risk is computed as the remaining dollar damages to commercial, public, and residential structures and contents after implementing the Recommended Plan. According to Table 5-4, there are residual expected annual damages of approximately $2.5 million following the implementation of the Recommended Plan. The largest portion of these residual damages come from Palai Stream, but Waiakea Stream has significant residual damage as well since the Kupulau Ditch improvement is the only one of the Recommended Plan measures that reduces the risk of flooding to properties along Waiakea. Table 5-4 also shows that after incorporating the Recommended Plan, there will be approximately 53% of existing condition damages that remain as residual damages. Further information on residual risk is available in the Economics Appendix.

Finally, the Recommended Plan reduces without-project damages (no Federal project) by approximately 47 percent. Table 5-5 shows that there is a greater than 75 percent chance that expected annual benefits for the combination plan will exceed $1.4 million. Compared with the current expected annual cost estimate of $649,000 for the Recommended Plan, this means there is a greater than 75 percent change that the benefit to cost ratio for the Recommended Plan exceeds 2.0.

Table 5-4. Residual Damages ($1000s)
(FY2020 Price Level; FY2020 Federal Discount Rate 2.75%)

Project Alternatives	Existing Condition Damages	Damage Reduced		Residual Damages
		Ainalako Diversion - 1% ACE Plan	Golf Course Detention - 1% ACE Plan	
4 Mile Creek	91	-	-	91
Ainola	173	111	-	62
Debris	25	-	-	25
HaiHai	128	71	-	57
Kupulau	816	816	-	-
Palai	2,785	709	286	1,790
Puhau	5	5	-	-
Waiakea	715	240	-	475
Total	4,739	1,953	286	2,500

Table 5-5. EAD Probability Distribution ($1000s)
(FY2020 Price Level; FY2020 Federal Discount Rate 2.75%)

Project Alternatives	Expected Annual Benefits	Probability Damage Reduced Exceeds Indicated Values		
		75%	50%	25%
Kupulau Ditch	$1,953	1,236	1,917	2,699
Golf Course Detention	$286	173	269	405
Combination Plan (Recommended Plan)	$2,239	1,409	2,186	3,104

6 Compliance with Environmental Statutes*

This chapter provides documentation of how the Recommended Plan complies with all applicable Federal environmental laws, statutes, and executive orders (EOs). Appendix C includes a full discussion of environmental compliance activities, including relevant correspondence and supporting documentation.

6.1 Endangered Species Act of 1973

The District has determined that the Recommended Plan may affect, but is not likely to adversely affect the Hawaiian bat, Hawaiian hawk, and Hawaiian coot and the study area is absent of designated critical habitat. The Corps will implement the conservation measures recommend by the USFWS in Section 4.3 to avoid and/or minimize adverse impact to the above listed species. By letter dated June 8, 2018, the USFWS concurred with the Corps' effect determination, thereby concluding informal consultation pursuant to Section 7 of the ESA.

6.2 Clean Water Act of 1972

The Palai Stream that bifurcates the Hilo Municipal Golf Course within the project area does not provide continuous surface flow to a navigable water. It is not a tributary to a navigable water and therefore does not meet the definition of a water of the U.S. Accordingly, the Palai Stream is not subject to regulation under the Clean Water Act (CWA).

The Waiakea Stream is a tributary to a navigable water that conveys continuous surface flow to Hilo Bay, a navigable water. It is a water of the U.S. subject to regulation under the CWA.

The Kupulau Ditch was artificially-constructed in uplands to convey stormwater flows to the downstream Waiakea Stream, flowing only in response to precipitation events,. The Kupulau Ditch conveys ephemeral flow downstream to the Waiakea Stream and features a trapezoidal channel constructed of earthen bed and banks. Under the Navigable Waters Protection Rule, the Kupulau Ditch is not a water of the U.S. e.g. "non-jurisdictional".

The feasibility level of design neither requires construction activities nor proposes discharges of dredged or fill material into the Waiakea Stream channel. Accordingly, the proposed action would not result in the loss of waters of the U.S. and does not warrant preparation of a proposal for compensatory mitigation at this time. If, during the design phase of the study the Corps determines the Recommended plan would result in a 404 discharge, then the Corps will ensure compliance with all applicable sections of the CWA e.g. 404, 401, etc. Additionally, if during the design phase, the Corps determines the construction activity will trigger the need to obtain a Section 402 National Pollutant Discharge Elimination System permit from the State of Hawaii, then the Corps will ensure one is obtained.

The Corps met with the State of Hawaii Department of Health Clean Water Branch (CWB) on November 23, 2020 to discuss the project details and to propose a process by which the Corps would comply with Section 401 of the CWA. The Corps, in coordination with CWB, determined that the level of detail available at the feasibility level of the study is insufficient to successfully apply for and obtain a Section 401 Water Quality Certification. Accordingly, the Corps proposed to CWB to apply for the Section 401 WQC during the design phase, and prior to construction, when adequate information regarding the design and any discharges are adequately defined in order to apply for and obtain a Section 401WQC. By letter dated December 14, 2020 the CWB confirmed the Corps' coordination of this approach, preliminarily determined there is no issue with the Corps furthering the design of the alternatives, and concurred with the Corps' plan to apply for and obtain a Section 401 WQC during the design phase and prior to construction.

6.3 Clean Air Act of 1972

Federal agencies are required by this Act to review all air emissions resulting from federally funded projects or permits to insure conformity with the State Implementation Plans in non-attainment areas. The Hilo/Waiakea-Palai Stream area is currently in attainment for all air emissions; therefore, the proposed project would be in compliance with the Clean Air Act.

6.4 Coastal Zone Management Act

Section 307(c) of the Coastal Zone Management Act (CZMA) requires federal agency activities and development projects affecting any coastal use or resource to be undertaken in a manner consistent to the maximum extent practicable with the state's CZM program. Such federal actions are reviewed by the State Office of Planning to ensure the proposed action is consistent with state enforceable policies and objectives.

The Corps has developed the Recommended Plan to be compatible and consistent with the policies and objectives of the state's CZM program and will not adversely impact coastal recreation opportunities, impede economic uses, increase coastal hazards, or conflict with development within the coastal zone. The Corps requested and received conditional concurrence from the State CZM Office by letter dated September 14, 2020. The Corps will implement all conditions of the CZM concurrence letter to ensure the project, when implemented, is compatible and consistent with the State CZM policies and objectives.

6.5 National Historic Preservation Act of 1966

Federal agencies are required under Section 106 of the National Historic Preservation Act (NHPA) of 1966, as amended, to "take into account the effects of their undertakings on historic properties" and consider alternatives "to avoid, minimize, or mitigate the undertaking's adverse effects on historic properties" [(36 CFR 800.1(a-c)]. This is to be completed in consultation with the State Historic Preservation Officer (SHPO) and other appropriate consulting parties (e.g., Native Hawaiian Organizations). Additionally, at the State level, Hawaii Revised Statutes (HRS) Chapter 6E requires consultation on effects to historic properties under a very similar process. Federal-level Section 106 and State-level 6E consultations were conducted concomitantly.

In accordance with Section 106 of the NHPA and HRS Chapter 6E, USACE consulted with the Hawaii State Historic Preservation Division, the State of Hawaii's Office of Hawaiian Affairs, and the Hawaiian Civic Club of Hilo regarding the presence of historic and cultural properties in the project area, and the potential for adverse impacts due to the preferred alternative (Appendix C). No response was received within the statutory time limit from any of the consulting parties. The consultation was thus completed with a standing determination of "no effect" to historic properties. Archaeological Inventory Survey conducted in support of the consultation produced no evidence of historic properties eligible for listing on the National Register of Historic Places or historic properties considered "significant" under Hawaii Administrative Rules (HAR) §13-275-6. Copies of all correspondence documenting the Section 106 consultation, as well as supporting technical investigations, are included in Appendix C.

6.6 Fish and Wildlife Coordination Act of 1934

The FWCA and its amendments require federal agencies to consult with the USFWS, and give equal consideration to other water resources development programs regarding the fish and wildlife impacts of projects that propose to impound, divert, channel, or otherwise alter a body of water. A final FWCA Planning Aid Report was provided in February 2020, which indicated that the USFWS concurred with the preferred alternative if best management practices are implemented during construction. The Corps accepted all USFWS recommendations in the FWCA Planning Aid Report, will incorporate the USFWS recommended standard best management practices into any construction contract and will coordinate any future modification to the preferred alternative with USFWS.

6.7 Magnuson-Stevens Fishery Conservation and Management Act

Essential Fish Habitat (EFH) is identified and conserved under the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA) of 1976, as amended, (16 U.S.C. 1801 *et. seq.*). The study area is absent designated EFH. The Recommended Plan would have no effect on designated EFH located downstream of the study area.

6.8 Farmland Protection Policy Act

The Farmland Protection Policy Act (FPPA) require federal agencies to coordinate with the Natural Resources Conservation Service (NRCS) when a federal action impacts prime farmland soils. The Recommended Plan project area is not located on prime farmland soils; therefore, the FPPA does not apply and coordination with the NRCS is not required.

6.9 Migratory Bird Treaty Act of 1918 and Executive Order 13186 Migratory Bird Habitat Protection

Potential effects to migratory birds were considered during the planning of this project. Because of the generally urbanized nature of landcover and ongoing disturbance from proximity to human activities, there would be little potential for migratory bird take as defined by the Act. The Recommended Plan would not adversely affect migratory birds and is in compliance with the applicable laws and policies.

6.10 Executive Order 12898 Environmental Justice

Compliance with EO 12898, Environmental Justice, requires consideration of social equity issues, particularly any disproportionate impacts to minority or low income groups. Environmental justice impacts have been considered during the planning of this project and no minority or low-income populations would be disproportionately affected by the Recommended Plan. Even though minorities account for a large portion of the local population and the low-income population is above the national averages, construction of the proposed alternatives would not have a disproportionately high or adverse effect on these populations.

6.11 Executive Order 11988 Floodplain Management

Executive Order 11988 requires Federal agencies to recognize the significant values of floodplains and to consider the public benefits that would be realized from restoring and preserving floodplains. It is the general policy of the Corps to formulate projects that, to the extent possible, avoid or minimize adverse impacts associated with use of the base floodplain and avoid inducing development in the base floodplain unless there is no practicable alternative that meets the project purpose. Per the procedures outlined in ER 1165-2-26 (Implementation of Executive Order 11988 on Flood Plain Management), the Corps has analyzed the potential effects of the Recommended Plan on the overall floodplain management of the study area.

Implementation of the Recommended Plan would avoid, to the extent possible, long- and short-term adverse impacts associated with the occupancy and modification of the base floodplain. The Recommended Plan also avoids direct and indirect support of development or growth (construction of structures and/or facilities, habitable or otherwise) in the base floodplain. Therefore, the Project would be in full compliance.

7 Public Involvement, Review, and Consultation

Public involvement activities and agency coordination are summarized in this chapter.

7.1 Public Involvement Process

Corps Planning Policy and NEPA emphasize public involvement in government actions affecting the environment by requiring that the benefits and risks associated with the Recommended Plan be assessed and publicly disclosed. Throughout the planning process, the District has been coordinating with other Federal, state, and regional agencies, and Native Hawaiian Organizations.

There were three large audience engagements and several smaller engagements with various stakeholders. The first meeting was April 30, 2019 with homeowners, and property owners in the project area; the second meeting was a public meeting on May 21, 2019, after which a copy of the draft report was left in the Public Library. The draft Feasibility Report and Environmental Assessment was released for a 30-day public review and comment period between June 23, 2019 and July 23, 2019. A total of 12 comment submittals were received on the Draft FR/EA via email submittals, handwritten comments, and letters. The team conducted a final public meeting on September 12, 2019 after the public and Agency review and the final plan was complete; without Ainalako Diversion included. All comments and responses are presented in Appendix F.

7.2 Agencies and Persons Consulted*

The Corps consulted the following list of agencies, tribes, and individuals during the plan formulation and environmental compliance of this feasibility study and preparation of the Integrated FR/EA.

- Hawaii Department of Health Clean Water Branch
- State of Hawaii Office of Planning
- Hawaii Division of Aquatic Resources
- Hawaii Division of Forestry and Wildlife
- Hawaii State Historic Preservation Office
- Hawaiian Civic Club of Hilo
- National Marine Fisheries Service
- Office of Hawaiian Affairs
- U.S. Fish and Wildlife Service

7.3 Public and Agency Review of Final Recommended Plan

The final recommended plan removed Ainalako Diversion from the project due to changes in conditions, including, anticipated impacts to costs, real estate, environment, as well as increased risk to a new subdivision constructed adjacent to Four Mile Creek. The impacts of removing Ainalako Diversion from the project were determined less than the impacts of leaving Ainalako Diversion in the recommended plan. The team notified Agencies, and the public prior to the completion of coordination requirements so all recommendations and coordination are based on a final plan without Ainalako Diversion.

8 Recommendations

I have considered all significant aspects of this project, including environmental, social and economic effects; and engineering feasibility. I recommend that the Recommended Plan for flood risk management for the Waiakea-Palai project area as generally described in this report be authorized for implementation as a Federal project, with such modifications thereof as in the discretion of the Commander, USACE may be advisable. The estimated first cost of the recommended plan is $10,768,000. Operations, maintenance, repair, rehabilitation, and replacement (OMRR&R) expenses are estimated to be approximately $215,000 per year at this time. The Federal portion of the estimated first cost is $6,390,150. The non-Federal sponsors' portion of the required 35 percent cost share of total project first costs is $4,377,850. The non-Federal partner shall, prior to implementation, agree to perform the following items of local cooperation:

a. Provide the non-federal share of total project costs, including a minimum of 35 percent but not to exceed 50 percent of total costs of the NED Plan, as further specified below:

1. Provide 35 percent of design costs in accordance with the terms of a design agreement entered into prior to commencement of design work for the project;

2. Provide, during construction, a contribution of funds equal to 5 percent of total costs of the NED Plan;

3. Provide all lands, easements, and rights-of-way, including those required for relocations, the borrowing of material, and the disposal of dredged or excavated material; perform or ensure the performance of all relocations; and construct all improvements required on lands, easements, and rights-of-way to enable the disposal of dredged or excavated material all as determined by the government to be required or to be necessary for the construction, operation, and maintenance of the project;

4. Provide, during construction, any additional funds necessary to make its total contribution equal to at least 35 percent of total costs of the NED Plan;

b. Shall not use funds from other federal programs, including any non-federal contribution required as a matching share therefore, to meet any of the non-federal obligations for the project, unless the Federal agency providing the funds verifies in writing that such funds are authorized to be used to carry out the project;

c. Not less than once each year, inform affected interests of the extent of protection afforded by the flood risk management features;

d. Agree to participate in and comply with applicable federal flood plain management and flood insurance programs;

e. Comply with Section 402 of WRDA 1986, as amended (33 U.S.C. 701b-12), which requires a non-federal interest to prepare a flood plain management plan within one year after the date of signing a project partnership agreement, and to implement such plan not later than one year after completion of construction of the project;

f. Publicize flood plain information in the area concerned and provide this information to zoning and other regulatory agencies for their use in adopting regulations, or taking other actions, to prevent unwise future development and to ensure compatibility with protection levels provided by the flood risk management features;

g. Prevent obstructions or encroachments on the project (including prescribing and enforcing regulations to prevent such obstructions or encroachments) such as any new developments on project lands, easements, and rights-of-way or the addition of facilities which might reduce the level of flood risk management the project affords, hinder operation and maintenance of the project, or interfere with the project's proper function;

h. Comply with all applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, as amended (42 U.S.C. 4601-4655), and the Uniform Regulations contained in 49 CFR Part 24, in acquiring lands, easements, and rights-of-way required for construction, operation, and maintenance of the project, including those necessary for relocations, the borrowing of materials, or the disposal of dredged or excavated material; and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act;

i. For so long as the project remains authorized, OMRR&R of the project, or functional portions of the project, including any mitigation features, at no cost to the federal government, in a manner compatible with the project's authorized purposes and in accordance with applicable federal and state laws and regulations and any specific directions prescribed by the federal government;

j. Give the federal government a right to enter, at reasonable times and in a reasonable manner, upon property that the non-federal sponsor owns or controls for access to the project for the purpose of completing, inspecting, operating, maintaining, repairing, rehabilitating, or replacing the project;

k. Hold and save the United States free from all damages arising from the construction, OMRR&R of the project and any betterments, except for damages due to the fault or negligence of the United States or its contractors;

l. Keep and maintain books, records, documents, or other evidence pertaining to costs and expenses incurred pursuant to the project, for a minimum of 3 years after completion of the accounting for which such books, records, documents, or other evidence are required, to the extent and in such detail as will properly reflect total project costs, and in accordance with the standards for financial management systems set forth in the Uniform Administrative Requirements for Grants and Cooperative Agreements to State and Local Governments at 32 Code of Federal Regulations (CFR) Section 33.20;

m. Comply with all applicable federal and state laws and regulations, including, but not limited to Section 601 of the Civil Rights Act of 1964, Public Law 88-352 (42 U.S.C. 2000d) and Department of Defense Directive 5500.11 issued pursuant thereto; Army Regulation 600-7, entitled "Nondiscrimination on the Basis of Handicap in Programs and Activities Assisted or Conducted by the Department of the Army"; and all applicable federal labor standards requirements including, but not limited to, 40 U.S.C. 3141-3148 and 40 U.S.C. 3701-3708 (revising, codifying and enacting without substantial change the provisions of the Davis-Bacon Act (formerly 40 U.S.C. 276a et seq.), the Contract Work Hours and Safety Standards Act (formerly 40 U.S.C. 327 et seq.), and the Copeland Anti-Kickback Act (formerly 40 U.S.C. 276c et seq.);

n. Perform, or ensure performance of, any investigations for hazardous substances that are determined necessary to identify the existence and extent of any hazardous substances regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), Public Law 96-510, as amended (42 U.S.C. 9601-9675), that may exist in, on, or under lands, easements, or rights-of-way that the federal government determines to be required for construction, operation, and maintenance of the project. However, for lands that the federal government determines to be subject to the navigation servitude, only the federal government shall perform such investigations unless the federal government provides the non-federal sponsor with prior specific written direction, in which case the non-federal sponsor shall perform such investigations in accordance with such written direction;

o. Assume, as between the federal government and the non-federal sponsor, complete financial responsibility for all necessary cleanup and response costs of any hazardous substances regulated under CERCLA that are located in, on, or under lands, easements, or rights-of-way that the federal government determines to be required for construction, operation, and maintenance of the project;

p. Agree, as between the federal government and the non-federal sponsor, that the non-federal sponsor shall be considered the operator of the project for the purpose of CERCLA liability, and to the maximum extent practicable, OMRR&R of the project in a manner that will not cause liability to arise under CERCLA; and

q. Comply with Section 221 of Public Law 91-611, Flood Control Act of 1970, as amended (42 U.S.C. 1962d-5b), and Section 103G) of the WRDA 1986, Public Law 99-662, as amended (33 U.S.C. 2213G), which provides that the Secretary of the Army shall not commence the construction of any water resources project or separable element thereof, until each non-federal interest has entered into a written agreement to furnish its required cooperation for the project or separable element.

The recommendations contained herein reflect the information available at this time and current departmental policies governing the formulation of individual projects. They do not reflect program and budgeting priorities inherent in the formulation of the national civil works construction program or the perspective of higher levels within the executive branch.

ERIC MARSHALL
Lieutenant Colonel, Corps of Engineers
District Commander

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FINDING OF NO SIGNIFICANT IMPACT

WAIAKEA-PALAI STREAMS
HILO, ISLAND OF HAWAII, HAWAII

The U.S. Army Corps of Engineers, Honolulu District (Corps) has conducted an environmental analysis in accordance with the National Environmental Policy Act of 1969, as amended. The final Integrated Feasibility Report and Environmental Assessment (IFR/EA) dated 17 June 2021, for the Waiakea-Palai Streams addresses Flood Risk Management opportunities and feasibility in Hilo, Island of Hawaii, Hawaii.

The Final IFR/EA, incorporated herein by reference, evaluated various alternatives that would reduce flood risk in the study area. The recommended plan includes:

- The construction of a detention basin on property located to the north of the New Hope Church and adjacent to the right bank of Kupulau Ditch (located east of the confluence of Kupulau Ditch and Waiakea Stream);
- The construction of a series of three levees and one floodwall to enclose the Kupulau Ditch detention basin;
- The construction of a detention basin at the Hilo Municipal Golf Course with a maximum height of 22 feet from the channel bottom;
- and construction of a ten foot tall in-channel barrier with an uncontrolled outlet consisting of three four foot diameter aluminized steel pipes on the north (average height of 2.4 feet) and south (average height of 2.1 feet) sides of the Palai Stream at the Hilo Municipal Golf Course detention basin;

In addition to a “no action” plan, four alternatives were evaluated. The alternatives included the detention basin at the Kupulau Ditch, the detention basin the Hilo Municipal Golf Course, the diversion channel at Palai Stream and Four Mile Creek, and the combination of all three features.

For all alternatives, the potential effects were evaluated, as appropriate. A summary assessment of the potential effects of the recommended plan are listed in Table 1:

Table 1: Summary of Potential Effects of the Recommended Plan

	Insignificant effects	Insignificant effects as a result of mitigation*	Resource unaffected by action
Aesthetics	☒	☐	☐
Air quality	☒	☐	☐
Aquatic resources/wetlands	☐	☒	☐
Invasive species	☒	☐	☐
Fish and wildlife habitat	☒	☐	☐
Threatened/Endangered species/critical habitat	☐	☒	☐
Historic properties	☐	☐	☒
Other cultural resources	☐	☐	☒
Floodplains	☒	☐	☐
Hazardous, toxic & radioactive waste	☐	☐	☒
Hydrology	☒	☐	☐
Land use	☒	☐	☐
Navigation	☐	☐	☒
Noise levels	☒	☐	☐
Public infrastructure	☐	☐	☒
Socio-economics	☐	☐	☒
Environmental justice	☐	☐	☒
Soils	☐	☐	☒
Tribal trust resources	☐	☐	☒
Water quality	☐	☒	☐
Climate change	☐	☐	☒

All practicable and appropriate means to avoid or minimize adverse environmental effects were analyzed and incorporated into the recommended plan. Best management practices (BMPs) as detailed in the IFR/EA will be implemented, if appropriate, to minimize impacts. BMP's would include, but not be limited to, the installation of silt fence to minimize erosion and sedimentation and minimizing areas of disturbance to the extent practicable.

No compensatory mitigation is required as part of the recommended plan.

Public review of the draft IFR/EA and FONSI was completed on 3 July 2019. All comments submitted during the public review period were responded to in the Final IFR/EA and FONSI.

Pursuant to Section 7 of the Endangered Species Act of 1973, as amended, the U.S. Army Corps of Engineers determined that the recommended plan may affect, but is not likely to adversely effect federally listed species and that the action area is absent of designated critical habitat.

Pursuant to Section 106 of the National Historic Preservation Act of 1966, as amended, the U.S. Army Corps of Engineers determined that the recommended plan has no effect on historic properties.

Pursuant to the Clean Water Act of 1972, as amended, the U.S. Army Corps of Engineers determined the recommended plan will not result in the discharge of dredged or fill material into waters of the United States. Any regulated discharges proposed in the pre-construction engineering and design phase necessary to achieve the recommended plan will comply with the CWA.

CLEAN WATER ACT SECTION 401 COMPLIANCE:

401 WQC TO BE OBTAINED IN THE DESIGN PHASE:

A water quality certification pursuant to section 401 of the Clean Water Act will be obtained from the Hawaii Department of Health, Clean Water Branch (CWB) prior to construction, if applicable. The Corps determined, in coordination with the CWB, that there is not sufficient information available during the current feasibility phase of the project to meet the minimum requirements to complete the application for a water quality certification (WQC). By letter dated December 14, 2020, the CWB confirmed the Corps' coordination of the study with the CWB, preliminarily determined it has no issue with the Corps furthering design and confirmed the Corps' plan to apply for and obtain a water quality certification during the pre-construction engineering and design phase. All conditions of the water quality certification will be implemented during construction to minimize adverse impacts to water quality.

COASTAL ZONE MANAGEMENT ACT

CZMA CONSISTENCY CONDITIONAL CONCURRENCE OBTAINED:

A determination of consistency with the Hawaii Coastal Zone Management program pursuant to the Coastal Zone Management Act of 1972 was obtained from the Hawaii Coastal Zone Management Office by letter dated September 14, 2020, including conditions necessary to be implemented in the design phase to ensure consistency. The Corps has developed the Recommended Plan to be compatible and consistent with the policies and objectives of the State's CZM program. All conditions of the consistency determination shall be implemented as stated in the State's conditional concurrence in order to minimize adverse impacts to the coastal zone.

All applicable environmental laws have been considered and coordination with appropriate agencies and officials has been completed.

Technical, environmental, economic, and cost effectiveness criteria used in the formulation of alternative plans were those specified in the Water Resources Council's 1983 Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies. All applicable laws, executive orders, regulations, and local government plans were considered in evaluation of alternatives. Based on this report, the reviews by other Federal, State and local agencies, input of the public, and the review by my staff, it is my determination that the recommended plan would not cause significant adverse effects on the quality of the human environment; therefore, preparation of an Environmental Impact Statement is not required.

17 JUN 21

Date

ERIC MARSHALL
Lieutenant Colonel, Corps of Engineers
District Commander

Waiakea-Palai Flood Risk Management, Hilo, Island of Hawaii, Hawaii

January 2020

Contents

Introduction

General.

This document presents the results of the economic analysis in support of the flood risk management project for the Waiakea-Palai FRM, Hilo, Island of Hawaii, Hawaii. The primary benefit associated with a flood risk management project is the reduction in inundation damages to structures and their contents. Reducing potential flood damages to structures and contents are the only categories of benefits analyzed in the economic justification for this project. They are unquestionably the most significant National Economic Development (NED) benefits in terms of monetary impacts and the economic justification of the recommended plan. However, these are not the only NED benefits that would be realized by implementing the recommended plan.

Additional economic impacts would undoubtedly include other NED benefits, such as reductions in flood damages to utilities, roadways, automobiles, landscaping, emergency relief costs, and reducing damages to other federal projects downstream. These other categories of benefits are difficult to forecast to a reasonably degree of accuracy and create problems when added to structure and content damages which have been computed to a higher level of reliability and account for uncertainty within key variables. Further, these secondary benefits altogether would likely make up no more than an additional 20 percent of the total structural and content damages and the project already demonstrates a strong benefit-cost ratio (BCR) without them. Most importantly, inclusion of these secondary benefits would not impact the plan selection since they tend to be closely correlated with reductions in flood damages to structures and contents, and they would be roughly the same for all the structural alternatives considered; thus, they would not change the ranking order of structural solutions considered, and contribute far less to nonstructural plans.

Economic benefits for reducing structure and content damages are calculated using hydrologic and economic data. The official Corps model, HEC-RAS calculated the water surface AEP profiles associated with the different probability events. The economic analysis utilizes FY20 price levels and a 2.75 percent discount rate. Net benefits and benefit-cost ratios (BCR) are provided for two project increments: the Kupulau Ditch Levee/Floodwall with Detention and the Hilo Municipal Golf Course Detention. The analyses were performed over a 50-year period of analysis from 2023 to 2073.

Project Area Description and Location. The Waiakea-Palai Flood Risk Management Project area is located in the Hilo Metropolitan area in the County of Hawaii, commonly referred to as the Big Island. Within Hawaii County are the North and South Hilo Districts. The City of Hilo and the project study area is in the South Hilo District. The majority of the structures in the study area are residential with a much smaller number of commercial and public buildings mixed in as shown in Table 1. About 1,300 of these 1,701 structures numbers are outside the 0.2 percent AEP floodplain but within the project area floodplain; thus, they were included in the structure database used in the analysis.

Table 1
Number of Structures in the Project Area

Residential	Commercial	Public	Total
1,582	88	31	1,701

Waiakea and Palai Streams are unlined in some locations throughout the study area, not very well defined and have inadequate capacity. Poorly defined channels provide inadequate capacity to transport flood waters. Stream flow is typically intermittent and flows in direct response to rain events. These two streams are susceptible to flash flooding events. Local storm events can produce flood conditions in a matter of hours. Significant rainfall events result in overland flow of water throughout the watershed flowing towards the streams, and the natural stream channels have limited capacity to transport flood waters. Water overtops the channel and floods downstream areas. During flood events, accumulation of woody debris and vegetation can cause blockages within the channel and at bridge locations. This has historically reduced the channel capacity to convey flows and exacerbated flooding.

Historical Damages. For as long as flood records have been kept, there has not been an actual flood in these watersheds of the magnitude included in the basin model developed herein. The record keeping on historical flooding in the area has been erratic and unreliable, especially in terms of damage estimates. However, it is known that the existing lined and unlined portions of Waiakea and Palai Streams within the project area are not able to adequately contain flood water flows, as evidenced by major flood damages that occurred in the project area in November 2008, February 2000, August 1994, March 1980, and February 1979. During the November 2000 flood, residents along Awapuhi Street were stranded by floodwaters and required rescue by firefighters. Flooding at the intersection of Kanoelehua Avenue and East Puainako Street caused damage to the Prince Kuhio Plaza. In February 2008, almost 11 inches of rain fell in a 24 hour period, resulting in approximately 150 homes being damaged by floodwaters rising up to 4 feet in depth in Hilo.

At the upstream end of the project area, Waiakea Stream contains a poorly defined channel, with a channel capacity of about 800 cfs which is equivalent to about a 50 percent AEP event. When the stream overflows floodwaters travel east to enter Kupulau Ditch. At the 1 percent Annual Exceedance Probability (AEP) flood, the stream velocity ranges from 10 to 15 ft/s. The channel bed is composed entirely of lava rock and the overbanks are highly vegetated. The high velocities dislodge rock and vegetation and transport them downstream.

Kupulau Ditch (see Figure 3) was built in 1971 to divert water from the Palai basin into Waiakea Stream in order to reduce flood problems. The ditch is about 3,500 ft long, has an average depth of 7 ft, and a bed slope of 0.006 ft/ft made up of lava rock. Kupulau Ditch receives the overflow from Waiakea Stream and quickly reaches its capacity. The ditch begins to spill over its right (east) bank at the 20 percent AEP event. The overflow begins to flood the New Hope

Church, which is located adjacent to the ditch; then, crosses Kupulau Road and flows overland in an eastward direction, flooding residential structures along HaiHai Street, and Ainalako Road.

Along Kupulau Road, there are a few locations where the natural topography and roadway elevation is very low. Flood flows in response to heavy rain events can cause Kupulau Ditch to overtop resulting in the flooding of homes and Kupulau Road, causing a safety risk for drivers and residents. When Kupulau Ditch reaches capacity and overtops, the flood waters cross Kupulau Road near Kawaiolu Place and proceeds overland along Haihai Street, eventually flowing into Palai Stream causing flooding to homes and roadways. Homes in this area were flooded in the 2000 and 2008 storms.

Upstream of the Kupulau Road Bridge, the natural topography of the stream bed is higher than the invert under the bridge. As a result, a hydraulic jump is induced during high flood events, causing flood water to overtop Kupulau Road Bridge causing a life safety risk and hazard to motorists. Flood waters also cause Kupulau Road to flood in low lying areas causing a hazard to motorists and road closure.

Downstream of Kawailani Street, Palai Stream floodwaters are conveyed mainly by overland flow. Stream channels are poorly defined with low-lying areas serving as pockets of storage areas. Intense urbanization in Hilo has resulted in many residential, commercial, and industrial structures built in close proximity to the stream.

Population and Life Safety. There are approximately 5,000 residents in the project area.[1] 2014 population for Hilo Hawaii, the State's second largest city, has been estimated at 45,158. Hawaii County experienced an increase of 30.6 percent over the 2000-2014 timeframe, the largest of any of the Hawaiian Islands. Population growth has been steady within the study area, but not as extraordinary as for the County. Within Hawaii County, the South Hilo District, which includes this study area, population increased 7.5 percent between 2000 and 2013.[2]

The annual growth rate in population for Hawaii County is expected to gradually decline from about 1.8 percent (2010-2015) to 1.3 percent (2035-2040). However, by 2040 nearly 100,000 more people are expected to be calling Hawaii County home, an increase of about one-third.[3]

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[1] This population estimate uses several inputs and sources: the number of single-family residential structures, the number of single-family residential structures, the number of multi-family residential structures, and the average persons per household for Hawaii County (Hawaii Data Book, 2013). The number of multi-family structures was multiplied by 20 to estimate the number of units within each structure. The average persons per household value is the five-year average from 2009 to 2013 developed by the U.S. Census Bureau. This average of 2.83 was multiplied by the number of single-family residential structures and by the number of component units within the multi-family structures. The sum of these products approximates the total population in the study area.

[2] Source: 2014 State of Hawaii Data Book; http://dbedt.hawaii.gov/economic/databook/2014.

Life safety within the floodplain of Waiakea and Palai Streams is a major problem. There are approximately 30,000 people residing within the greater Waiakea and Palai watersheds, about 2,300 of which live within the 0.2 percent AEP floodplain, and about that many people again live between the 0.2 percent AEP floodplain and the project area floodplain. Additionally, there are thousands more people temporarily occupying or traversing the watershed on a daily basis, including tourists, school children, workers and others. In addition to some of Hilo's busiest intersections, thoroughfares and shopping areas, the project area floodplain also contains about 100 businesses, several schools, a university and other critical infrastructure.

Economic and Engineering Inputs to the HEC-FDA Model

HEC-FDA Model Description. The Hydrologic Engineering Center Flood Damage Analysis (HEC-FDA) Version 1.4 Corps-certified model was used to calculate expected annual damages and benefits over the period of analysis. The economic and engineering inputs necessary for the model to calculate damages include structure inventory, content-to-structure value ratios, vehicles, first-floor elevations, depth-damage relationships, ground elevations, and stage-probability relationships.

The uncertainty surrounding each of the economic and engineering variables was also entered into the model. Either a normal probability distribution, with a mean value and a standard deviation, or a triangular probability distribution, with a most likely, a maximum and a minimum value, was entered into the model to quantify the uncertainty associated with the key economic variables. A normal probability distribution was entered into the model to quantify the uncertainty surrounding the ground elevations. The number of years that stages were recorded at a given gage was entered for each study area reach to quantify the hydrologic uncertainty or error surrounding the discharge and stage-probability relationships.

Development of Structure Inventory. Field surveys were conducted in 2012 to develop a structure inventory consisting of residential, commercial and public structures. The commercial structure category contains 11 non-residential occupancy types. Public contains one occupancy type and residential contains five. Table 2 includes the number of buildings by structure category that comprise the HEC-FDA structure file, and shows the average depreciated replacement value for each structure type.

Most of the data on the structures in the floodplain and their characteristics were obtained from on-site, field surveys performed by USACE economists, or through the County of Hawaii Real Property Tax Office, or a combination of the two. With the goal being to determine a reasonable estimate of the depreciated replacement cost for each structure in the inventory, economists in the field relied on Marshall and Swift Valuation Service software to compute a structural value estimate independent of the assessment by the tax office. Data was also taken from both sources on square footage, condition and age of the structures throughout the floodplain.

After collecting hundreds of the sample data representative of each neighborhood and comparing the two estimates (County tax assessed vs. Marshall and Swift) for each structure, it became apparent that patterns in the data were measurable and predictable. To account for the uncertainty surrounding the structure value, a standard deviation of 19 percent was computed and incorporated into the calculation of a hybrid estimate of the depreciated replacement value for each structure. Similar techniques were used to perform an update of all the structural values to bring them up to October 2014 price levels. The structure inventory was further price indexed to FY2020 price levels from 2014 using Hawaii based RS Means index factors.

Table 2
Number of Structures and Average Depreciated Replacement Value
by Occupancy Type
FY2020 Price Levels

Structure Category	Number	Avg. Depreciated Replacement Value
Single Family Residential 1-story	1,362	$142,000
Single Family Residential 2-story	101	$241,000
Single Family Residential Split	101	$188,000
Multi-Family Residential 1-story	30	$126,000
Multi-Family Residential 2-story	10	$2,637,000
Warehouse	35	$259,000
Church	10	$187,000
Convenience Store	2	$240,000
Commercial 2 story	1	$439,000
Office	29	$2,703,000
Retail Store	2	$22,253,000
Restaurant	3	$364,000
Garage	2	$405,000
Hospital	9	$973,000
Bank	1	$648,000
Public Building 1-story	3	$99,000

Future Development. USACE planning guidance for civil works projects (Department of the Army, 2000; ER 1105-2-100) requires that the planning process incorporate a future without-project scenario. The future without-project condition attempts to describe the Waiakea-Palai Streams watershed's future makeup if there is no Federal action taken to solve the flood risk problem. This forecast becomes the basis for evaluation of project alternatives. For the Waiakea-Palai flood risk management project, the base year is 2027. Thus, the 50-year forecast period starts at 2027 and ends in 2077.

Given the great deal of uncertainty, the future condition represents a best guess of conditions in the watershed over the 50-year planning horizon. The guidance states that the planning process accounts for such future conditions such as climate variability, sea-level rise, subsidence, seismic influences, geomorphological changes, and changes from development which can place demands on the project systems during their life-cycle. The most significant of these changes over the next 50 years will likely be changes in development patterns and sea-level rise (SLR).

Given the degree of uncertainty, projections were not made of the future residential and non-residential development to take place in the study area under without-project conditions. Most of the developable land within the Hilo floodplain under current zoning ordinances is already fully developed. With the nearly built-out status of the present watershed, new development will be almost entirely restricted to replacing old structures with new ones. It is highly unlikely that these redevelopment efforts will include any high-rise, residential towers in the foreseeable future. Similarly, commercial development is expected to follow suit. Exactly which buildings will be replaced and by what is impossible to say. Therefore, this study assumes that no significant changes will occur to the structure inventories or other assets on which damage categories are based, and that future conditions will be the same as present conditions for the purposes of calculating damages or costs. However, given the continued anticipated increase in Hawaii County population, it is very likely that the number of people potentially placed in harm's way from a flood in the Waiakea-Palai watershed, whether they are residents, workers, shoppers, tourists and motorists traveling through the floodplain, will increase over the 50-year planning horizon.

Another forecast requirements is to account for future hydrologic changes in the project evaluations, and sea level rise (SLR) can be a significant contributing factor in causing flood damages to increase over time. As sea-level rises over the coming decades, tidal and backwater impacts during periods of rainfall induced flooding will cause water surface elevations to rise slightly in the lower reaches of the floodplain, primarily Reaches R6 (Palai Stream) and W5 (Waiakea Stream). Given all the uncertainty surrounding the impacts of SLR, and the relatively small role in the total damage picture these two reaches play, the economic model does not attempt to capture any resulting increase in flood damages over time due to an upward shift in the stage-frequency relationship. This phenomenon is not expected to have any bearing on selecting one plan over another and would only impact a few of the many reaches.

First-Floor Elevations of Structures. The datum used in the analysis is the same datum used to determine the water surface profiles, and the source of ground elevations for this study is the same for H&H as economics. All GIS data was projected to a common projection, Hawaii State Plane, which uses the NAD1983 datum.

Basic elevation data for this study was obtained by the Honolulu District in 2005. Aerial topography and digitized mapping methods were used to derive contours at a 4 foot interval and spot elevations at a 0.1 foot accuracy. Supplemental contour data and spot elevations were obtained by the project sponsor, Hawaii County, and areas where gaps still existed were closed by using USGS 10 meter digital elevation models (DEM).

Using current aerial imagery and GIS software, structures were positioned and compared with building footprints obtained as part of the Honolulu District photogrammetry contract. Centroids of the building footprints were calculated inside the GIS software and the ground elevation at the centroid point was extracted from the elevation grid. Additional foundation heights to determine an estimate of first floor elevation were added to the structure database using a variety of methods, including actual building elevation certificates and field verification of elevations. County data was used to further refine the structure elevations by examining the data to estimate the information to determine whether the structures were build slab-on-grade or built up on piers. Finally, Google Earth was used to obtain images of structures in question to determine estimates of pier height to further refine first floor elevations.

A First Floor Elevation (FFE) Uncertainty formula was applied to calculate an uncertainty of 0.5 feet for all structures in the inventory. The formula, $\sqrt{(0.4^2 + 0.02^2)}$, was based on using equal weights for each of the types of ground surface elevation and structural survey data. For example, each of the three ways a structure was surveyed (elevation certificate, field survey, and Google Street View) all carry different levels of uncertainty. The standard deviation used in the FFE formula for each survey type was taken from the HEC-FDA User's manual, version 1.2.4. It was assumed Google Street view represented the accuracy of a hand level, elevation certificates represented an automatic level, and field surveys represented a conventional level. Equal weight was assigned between each survey type due to the uncertain amount of structures surveyed using each method.

Depth-Damage Relationships. The generic depth-damage relationships for one-story structures with no basement and for two or more story structures with no basement from EGM, 01-03, dated 4 December 2000, were used for single-family residential structures and for multi-family residential structures respectively. These curves indicate the percentage of the total structure value and their contents that would be damaged at various depths of flooding. The non-residential depth-damage relationships were developed based on curves from the Jefferson-Orleans, Donaldsonville to the Gulf, and Morganza to the Gulf evaluations. New Orleans short duration fresh water curves were used due to similar occupancies (retail, warehouses, and public buildings) and similar sources of flooding (freshwater inundation in a tropical climate). More information about the data source can be found in the CSVR discussion.

Damage percentages were determined for each foot increment from -8 feet to -1 foot, then half foot increments between -1 and 2 feet, and one foot increments between 2 feet to 15 feet above the first floor elevation.

A normal distribution was used to represent the uncertainty surrounding the residential structures and their contents. Uncertainty surrounding the commercial and public buildings and their contents is not included. Figure 1 shows the residential and non-residential depth-damage relationships developed for structures used for damage calculations by the HEC-FDA computer program.

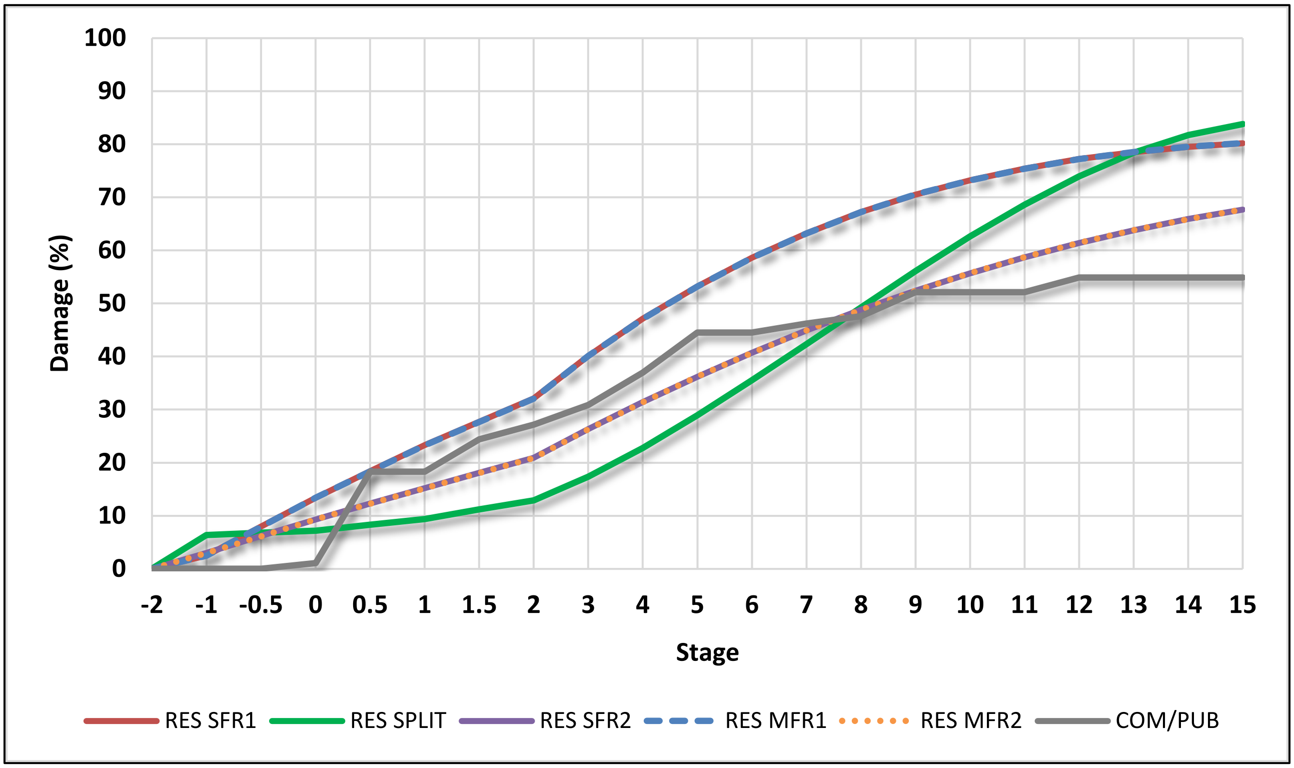

Figure 1. Waiakea-Palai Depth-Damage Relationships

Residential and Non-Residential Content-to-Structure Value Ratios. Content-to-Structure Value Ratios (CSVRs) were taken from two different sources. The single-family residential CSVR is based on the generic depth damage curves. The CSVR for the non-residential structures were developed based on the on-site interviews conducted as part of the Jefferson-Orleans, Donaldsonville to the Gulf, and Morganza to the Gulf evaluations. These interviews were conducted with the owners of a sample of structures from each of the three residential content categories and each of the eight non-residential content categories from each of the three evaluation areas. Thus, a total of 96 residential structures and 210 non-residential structures were used to determine the CSVRs for each of the residential and non-residential categories.

Since only a limited number of property owners participated in the field surveys and the participants were not randomly selected, statistical bootstrapping was performed to address the potential sampling error in estimating the mean and standard deviation of the CSVR values. Statistical bootstrapping is a method that uses re-sampling with replacement to improve the estimate of a population statistic when the sample size is insufficient for straightforward statistical inference. The bootstrapping method has the effect of increasing the sample size. Thus, bootstrapping provides a way to account for the distortions caused by the specific sample that may not be fully representative of the population.

As shown in Table 3, a CSVR was computed for each residential and non-residential structure in the sample based on the total depreciated content value developed from the surveys. The model used a normal probability density function to describe the uncertainty surrounding the CSVR for each content category. An average CSVR and standard deviation for each of the five residential structure categories and eleven commercial structure classifications was calculated as the average of the individual structure CSVRs.

Table 3
Content-to-Structure Value Ratios (CSVR)
and Standard Deviations (SD)
For Each Structure Category

Structure Category	
Residential	CSVR
Single Family Residential 1-story	100
Single Family Residential 2-story	100
Single Family Residential Split	100
Multi-Family Residential 1-story	100
Multi-Family Residential 2-story	100
Non-Residential	CSVR, SD
Warehouse	207, 325
Church	76, 52
Convenience Store	134, 78
Commercial 2 story	119, 105
Office	54, 54
Retail Store	119, 105
Restaurant	170, 293
Garage	55, 80
Hospital	54, 54
Bank	54, 54
Public Building 1-story	55, 80

Note: The generic depth-damage curves were used for single-family residential categories

Discharge and Stage-Probability Relationships and Levee Features. Discharge and Stage-probability relationships were provided for the following conditions for 41 reaches (see Figure 2) within the study area:

- Without-project conditions
- Kupulau Ditch Levee/Floodwall with Detention (0.02, 0.01, 0.005 annual exceedance probability (AEP)
- Ainalako Diversion (0.01 AEP)
- Hilo Municipal Golf Course (0.01 AEP)
- The Combination Plan which includes the three previous measures at the following levels of risk reduction:
    - Kupulau Ditch Levee/Floodwall with Detention (0.02 AEP)
    - Ainalako Diversion (0.01 AEP)
    - Hilo Municipal Golf Course (0.01 AEP)

Discharge and water surface AEP profiles were based on the following eight Annual Exceedance Probability (AEP) events: 0.5 (2-year), 0.2 (5-year), 0.1 (10-year), 0.04 (25-year), 0.02 (50-year), 0.01 (100-year), 0.005 (200-year), and 0.002 (500-year).

Discharge and stage-probability relationships were developed for 2013 conditions. Top of levee elevations were incorporated for the Kupulau Ditch Levee/Floodwall with Detention measure at the 0.02 ACE (4.3 feet levee height), 0.01 ACE (5.7 feet levee height) and the 0.005 ACE (6.7 feet levee height) to calculate damages and benefits. The combination plan, however, includes only the 0.02 ACE (50-year) Kupulau Ditch Levee/Floodwall with Detention measure with the 0.01 ACE (100-year) Ainalako Diversion and Hilo Municipal Golf Course measures.

A 25-year equivalent record length was used to quantify the uncertainty surrounding the discharge-probability relationships for each study area reach. The record length was determined by the hydraulic engineer and is based on the amount of historical gage data available in the basin. Based on this equivalent record length, the HEC-FDA model calculated the confidence limits surrounding the discharge-probability functions. Uncertainty surrounding the stage-discharge relationship was calculated using a normal distribution. Unique standard deviation values by reach are based on sensitivity analysis using multiple HEC-RAS “N values”. The standard deviation for stage was developed by varying the Manning’s "n" value by +/- 20 percent and running the profiles in the HEC-FDA model. The standard deviations take into account backwater effects, variations in soil makeup, absorption rates and other sources of water loss such as volcanic geotechnical conditions.

Figure 2. Study Area Damage Reaches

National Economic Development (NED) Flood Damage and Benefit Calculations

HEC-FDA Model Calculations. The HEC-FDA model was utilized to evaluate flood damages using risk-based analysis. Damages were reported at the index location for each of the forty-one reaches for which engineering data was available. A range of possible values, with a maximum and a minimum value for each economic variable (first-floor elevation, structure and content values, and depth-damage relationships), was entered into the HEC-FDA model to calculate the uncertainty or error surrounding the elevation-damage, or stage-damage, relationships. The model also used the number of years that stages were recorded at a given gage to determine the hydrologic uncertainty surrounding the stage-probability relationships.

The possible occurrences of each variable were derived through the use of Monte Carlo simulation, which used randomly selected numbers to simulate the values of the selected variables from within the established ranges and distributions. For each variable, a sampling technique was used to select from within the range of possible values. With each sample, or iteration, a different value was selected. The number of iterations performed affects the simulation execution time and the quality and accuracy of the results. This process was conducted simultaneously for each economic and hydrologic variable. The resulting mean value and probability distributions formed a comprehensive picture of all possible outcomes.

Without Project Expected Annual Damages. The model used Monte Carlo simulations to sample from the stage-probability curve with uncertainty. For each of the iterations within the simulation, stages were simultaneously selected for the entire range of probability events. The sum of all damage values divided by the number of iterations run by the model yielded the expected value, or mean damage value, with confidence bands for each probability event. The probability-damage relationships are integrated by weighting the damages corresponding to each magnitude of flooding (stage) by the percentage chance of exceedance (probability). From these weighted damages, the model determined the expected annual damages (EAD) with confidence bands (uncertainty). The FY2020 price levels are used in HEC-FDA model to calculate the damages and benefits. The without-project damages by probability event are displayed by damage category in Table 4, and the number of structures receiving damage is displayed by damage category in Table 5.

Table 4
Damages by Probability Event
Without-Project Condition
($1,000s)

Annual Exceedance Probability Event (AEP)	Residential	Commercial	Public	Total
0.5 (2 yr)	1,014	-	-	1,014
0.20 (5 yr)	4,388	234	-	4,622
0.10 (10 yr)	6,659	2,529	-	9,188
0.04 (25 yr)	12,199	3,183	-	15,382
0.02 (50 yr)	15,130	3,476	-	18,606
0.01 (100 yr)	18,329	3,791	-	22,120
0.005 (200 yr)	23,264	4,821	465	28,550
0.002 (500 yr)	28,090	6,653	593	35,336

Table 5
Structures Damaged by Probability Event
Without-Project Condition

Annual Exceedance Probability Event (AEP)	Residential	Commercial	Public	Total
0.5 (2 yr)	15	0	0	15
0.20 (5 yr)	53	3	0	56
0.10 (10 yr)	90	6	0	96
0.04 (25 yr)	160	7	0	167
0.02 (50 yr)	196	7	0	203
0.01 (100 yr)	236	8	0	244
0.005 (200 yr)	282	11	21	314
0.002 (500 yr)	344	19	22	385

Project Alternatives

An array of alternatives was evaluated and compared based on several decision-making criteria that were used to evaluate the economic feasibility, environmental effectiveness and flood protection capability of each alternative. The alternatives were screened during the preliminary design of the project components. The final array of alternatives is summarized below:

No Action Plan

The No-Action Alternative is synonymous with no Federal Action. This alternative is analyzed as the future without-project conditions for comparison with the action alternatives. The No Action Alternative would result in continued flood risk along Waiakea and Palai Streams.

Kupulau Ditch Levee/Floodwall with Detention

This alternative includes construction of a detention basin on property located to the north of the New Hope Church and adjacent to the right bank of Kupulau Ditch (located east of the confluence of Kupulau Ditch and Waiakea Stream). Impounding of the runoff would be accomplished by constructing a series of three levees and one floodwall to enclose the landscape by utilizing the natural topography of the area.

Hilo Municipal Golf Course Detention

This alternative includes construction of a detention basin in the Hilo Municipal Golf Course to attenuate flow and reduce damage to properties in the downstream reaches of Palai Stream. A 21 acre-foot detention pond would be constructed at the Hilo Municipal Golf Course to capture flood flows with an outlet structure designed to release flow to minimize flood damage to downstream property.

Ainalako Diversion

The main component of this alternative is the construction of a diversion structure to divert excess flows into Four Mile Creek. This diversion structure is located just downstream of Ainalako Road on Palai Stream. It takes advantage of the natural topography along the right overbank of Palai Stream and the natural drainage pattern of the immediate area. This alternative was originally considered as a third component of the TSP until public meetings and discussions with local stakeholders

Identifying the NED Plan and TSP. The three action alternatives can be implemented individually or combined with each other. They are not dependent on each other and are not mutually exclusive. As such, evaluation and comparison of the final array of alternatives will include various combinations of these alternatives (e.g., Kupulau Ditch plus Golf Course Detention) to identify the optimized plan that reasonably maximizes net benefits. Table 6 shows the possible combinations that each of the alternatives could have formed.

Table 6
Net Benefits of Possible Combinations ($1,000s)
FY 2020 Price Level
FY 2020 Federal Discount Rate 2.75%

Project Alternatives - Possible Combinations	Expected Annual Benefits	Expected Annual Cost	Net Benefits	Benefit-to-Cost Ratio
Kupulau Ditch (2% AEP Plan)	$1,953	$446	$1,508	4.4
Ainalako Diversion	$358	$132	$226	2.7
Golf Course Detention	$286	$203	$83	1.4
Kupulau Ditch + Ainalako Diversion	$2,312	$578	$1,734	4.0
Kupulau Ditch + Golf Course Detention	$2,239	$649	$1,591	3.5
Ainalako Diversion + Golf Course Detention	$645	$336	$309	1.9
Kupulau Ditch + Ainalako Diversion + Golf Course Detention	$2,598	$781	$1,880	3.3

The alternative with the highest net benefits from Table 6 is the combination plan that includes Kupulau Ditch, Ainalako Diversion, and the Golf Course Detention. This table helps show the screening results of measures that became the TSP, which maximizes annualized net benefits at $1.8 million. The breakdown of costs and benefits for each of the three alternatives and the combination plan (TSP) are found in Table 7. Figure 3 shows the spatial locations of each of the three measures that make up the combination plan alternative.

Table 7
Screening Results Using Incremental Costs of Measures ($1,000s)
FY 2020 Federal Discount Rate 2.75%

	Kupulau Ditch Levee/ Floodwall w/ Detention	Ainalako Diversion	Re-Configured Golf Course Detention	TSP/ NED Plan
Plans & Specs	$1,492	$556	$593	$2,322
Construction Management	$711	$264	$281	$1,105
Lands	$458	$129	$501	$896
Construction Contract	$4,855	$1,800	$1,925	$7,498
Total First Cost	$7,516	$2,749	$3,300	$11,821
Interest During Construction	$275	$80	$80	$514
Total Investment	$7,791	$2,829	$3,380	$12,335
Equivalent Annual Cost	$296	$107	$128	$468
Annual O&M	$150	$25	$75	$250
Expected Annual Cost (EAC)	$446	$132	$203	$718
Expected Annual Benefits (EAB)	$1,953	$358	$286	$2,598
Incremental Net Benefits	$1,508	$226	$83	$1,880
Inc. Benefit/Cost Ratio	4.4	2.7	1.4	3.6

* The interest during construction for the TSP is spread over a longer period than that of its individual measures; therefore, these columns are not additive.

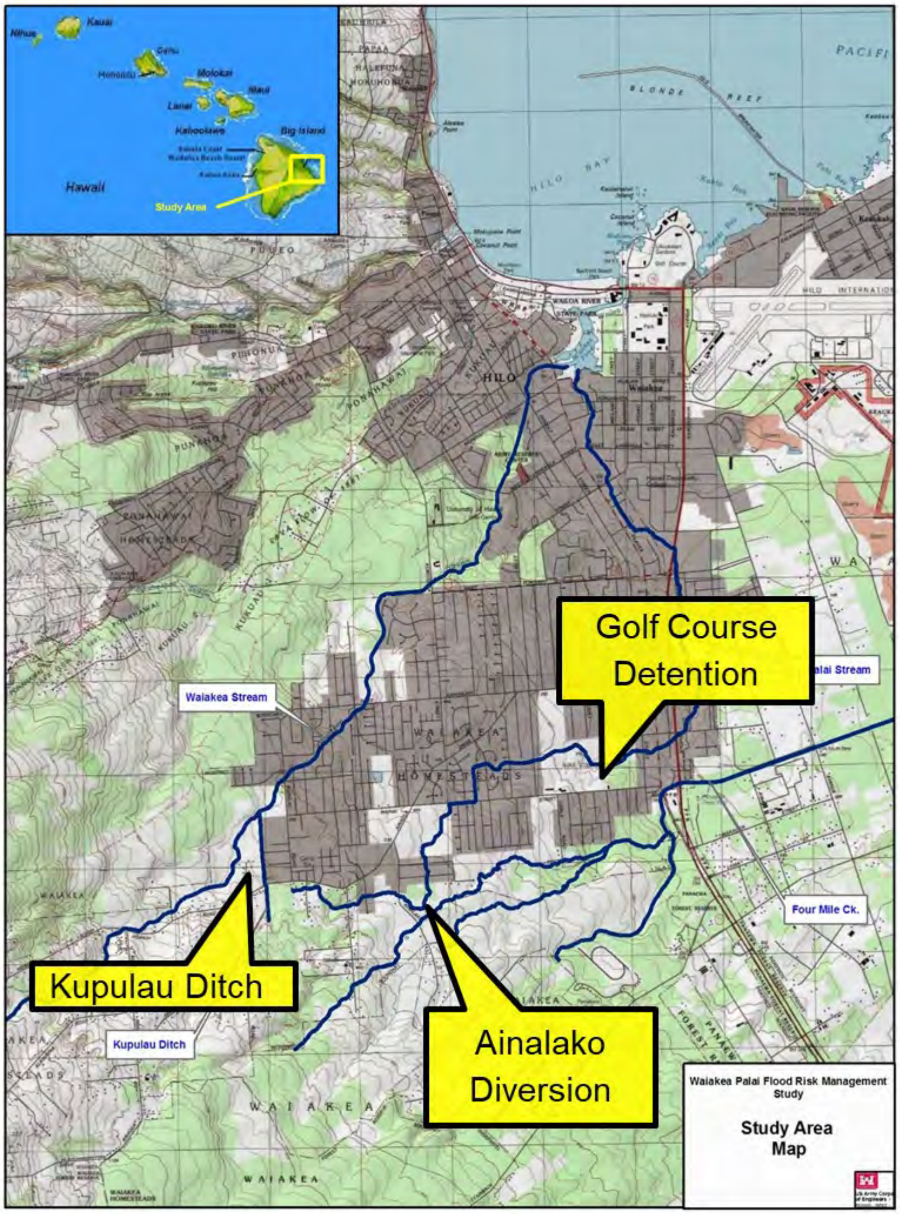

Figure 3. Location of Project Measures

Project Benefits. Table 8 shows a summary of net benefits for the final array of alternatives, that includes the combination plan that was determined to be the TSP and alternative that maximizes net benefits. The Kupulau Ditch measure is the costliest measure at $7.5 million and expected annual cost (EAC) of $446,000 but it also yields the highest benefit cost ratio (BCR) of 4.4. Incrementally, Ainalako Diversion, with an EAC of $132,000, has a BCR of 2.7, and produces net benefits of $226,000. The Golf Course Detention measure has a total cost of $3.3M, and $203,000 expected annual cost, and produces the least amount of expected annual benefits of $83,000. While all three measures could be added as pairs as shown previously in Table 6, the net benefits are maximized when combined together.

Table 8
Net Benefits ($1,000s)
FY 2020 Price Level
FY 2020 Federal Discount Rate 2.75%

Project Alternatives	Expected Annual Benefits	Expected Annual Cost	Net Benefits	Benefit-to-Cost Ratio
Kupulau Ditch L/FW w/ Detention - 2% ACE Plan	$1,953	$446	$1,508	4.4
Ainalako Diversion - 1% ACE Plan	$358	$132	$226	2.7
Reconfigured Golf Course Detention - 1% ACE Plan	$286	$203	$83	1.4
Combination Plan (TSP)	$2,598	$718	$1,880	3.6

These three measures, collectively referred to as the combination plan, reduce expected annual damages in the overall study area by approximately 50 percent. Other individual structural measures and combinations of measures were investigated, but they were found to be incrementally infeasible producing no net benefits or captured the same benefits as the three measures comprising the combination plan, only they did so less efficiently.

Project Costs. The schedule of project costs begin in the year 2021 and end in August 2023. The remaining cost estimates were provided for the authorized project in FY 2020 price levels. The initial construction cost (first costs), along with the schedule of expenditures, were used to determine the interest during construction. Interest during construction was calculated based on two years of construction for the Kupulau Ditch, one year of construction for the Ainalako Diversion and one year of construction for the Reconfigured Golf Course Detention. The combination plan assumed the three measures were separate and independent and therefore could be fully constructed in two years.

The FY 2020 Federal discount rate of 2.75 percent was used to compound the costs to the base year and then amortize the costs over the 50-year period of analysis, as previously shown in Table 7 and Table 8.

Net Benefit Analysis

Calculation of Net Benefits. The expected annual benefits attributable to the project alternative are calculated using the FY20 Federal discount rate of 2.75 percent. The base year for this conversion is the year 2021 for the Tentatively Selected Plan (TSP). The expected annual benefits were then compared to the average annual costs to develop a benefit cost ratio for the alternative. The net benefits for the alternative were calculated by subtracting the average annual costs from the expected annual benefits. The net benefits were used to determine the economic justification of the project alternative.

Table 8 summarized the expected annual damages and benefits, total annual costs, benefit cost ratio, and expected annual net benefits for each component of the TSP. Net benefits for the TSP of $1,880,000 were calculated by subtracting the average annual costs from the expected annual benefits. The benefits and costs are displayed FY 2020 price levels. At the prescribed FY 2020 discount rate of 2.75 percent, the benefit cost ratio for the TSP is 3.6.

Plan Adjustments – Recommended Plan

The TSP presented in Table 8 has been modified following agency, technical, and public review of the report as well as completion of feasibility-level design refinements including site visits. Based on subsequent coordination efforts between the Corps, the non-Federal sponsor, and local landowners in the study area, the alternative including Kupulau Ditch Levee/Floodwall with Detention and Hilo Golf Course Detention is presented as the recommended plan (Table 9). This plan does not include the Ainalako Diversion feature. Based on public input and site visits conducted by the study team, it was determined that the Ainalako Diversion would require substantial design modifications and additional real estate requirements in order to be implemented successfully to reduce flood risk, avoid transferring of flood risk to Four Mile Creek, and minimize impacts of induced flooding. Ultimately, the cost to redesign and construct the Ainalako Diversion feature would reduce overall cost effectiveness for this feature and the NED plan.

Per ER 1105-2-100, a categorical exemption to the NED plan may be pursued. In this instance, the without-project residual risk is not unreasonably high and the alternative that does not include the Ainalako Diversion still has greater net benefits than smaller-scale plans (e.g., implementation of Kupulau Ditch only). While less comprehensive than the original recommended plan, this alternative is still considered complete, acceptable, efficient, and effective, and it reduces flood risk in the study area. At the FY 2020 discount rate of 2.75 percent, the total project first cost of the Recommended Plan is $10.8 million, and the benefit cost ratio is 3.5.

Table 9
Net Benefits ($1,000s)
FY 2020 Price Level
FY 2020 Federal Discount Rate 2.75%

Project Alternatives	Expected Annual Benefits	Expected Annual Cost	Net Benefits	Benefit-to-Cost Ratio
Kupulau Ditch L/FW w/ Detention - 2% ACE Plan	$1,953	$446	$1,508	4.4
Reconfigured Golf Course Detention - 1% ACE Plan	$286	$203	$83	1.4
Revised Combination Plan (TSP)	$2,239	$649	$1,591	3.5

TSP Optimization

Net benefits for the Kupulau Ditch alternative are reasonably maximized at the 4.3-foot average height (roughly equivalent to a 2 percent AEP flood). The average height of 4.3 feet includes about +2.5 feet of height to achieve a conditional non-exceedance probability (CNP) of at least 95%. Net benefits decline about 5 percent as the height of the wall goes to an average height of 5.7 feet (roughly equivalent to a 1 percent AEP flood), and further declines with a 6.7-foot average height (roughly equivalent to a 0.5 percent AEP flood), optimizations for the 1 percent and 0.5 percent designs also included the necessary additional height to achieve a CNP of at least 95 percent.

The HEC-FDA model was also used to help inform if either of the two measures within the TSP could be designed to a reduced level of protection to ensure that the selected TSP was optimized. This analysis exclusively looked at economic damages by stage for both alternatives and did not receive tailored cost estimates to determine the maximization of net benefits, as was explained in the previous paragraph. The results of the analysis are found in Figure 4 and show vertical lines where both alternatives are limited in its damage reduction. The data for Figure 4 was pulled from the reach that the alternative reduced the most damage in and is represented as total damage, not average annual damages. Table 4 shows that damages reduce for Kupulau Ditch by 33% by moving from a 2% AEP to a 4% AEP design level of protection. Similarly for the Golf Course Detention, damages reduced fall by 18% by moving from a 1% AEP to a 2% AEP design level of protection. This analysis alone does not fully inform the lower bracketing of alternatives since net benefits cannot be calculated without originating new cost estimates for the reduced LOP alternatives.

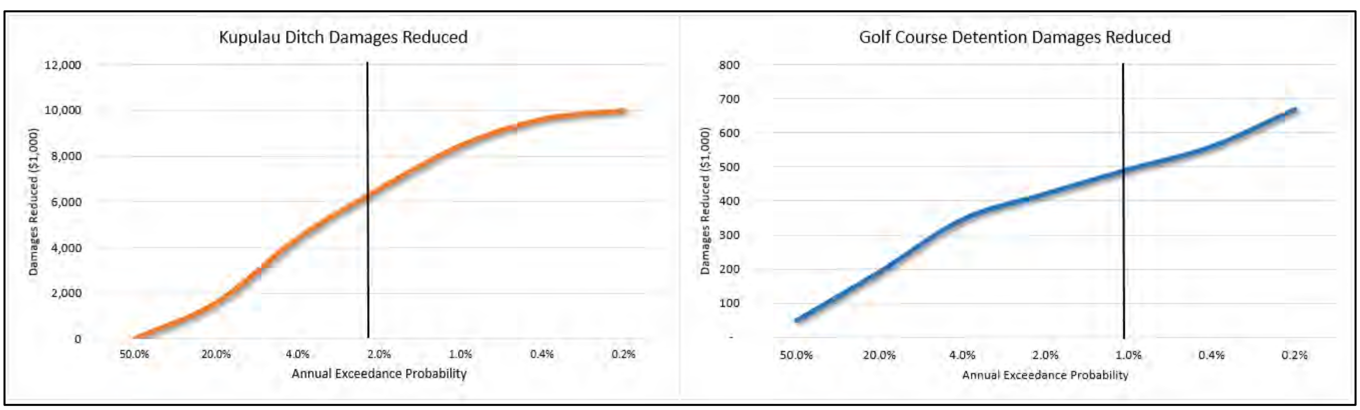

Figure 4. Stage-Damage Functions for TSP Alternatives

With its wall height set at an average of 4.3 feet, the size of the detention site has been designed to take full advantage of the existing topographic constraints and capture as much flood reduction as practical at this site while working in concert with the two other properly sized measures. To construct the levee/floodwall any higher would have little to no impact on the optimal sizes of the reconfigured golf course detention, and would not be as good of return on the investment and would cost more than would be gained in flood reduction benefits.

Residual Risk Metrics for Flood Risk Management Reporting

Residual Risk. Residual risk is the risk remaining after implementation of a plan; that is, it is the difference in damages between the with- and without-project conditions. Depending on the current conditions and the changes created by the alternative plan, inundation at a reach usually starts to occur at different AEPs. These changes in AEPs are correlated to structure and content dollar damages. In the case of the Waiakea-Palai project, the residual risk is computed as the remaining dollar damages to commercial, public, and residential structures and contents after implementing the TSP/NED Plan.

According to Table 10, there are residual expected annual damages of approximately $2.5 million following the implementation of the TSP. The largest portion of these residual damages come from Palai Stream, but Waiakea Stream has significant residual damage as well since the Kupulau Ditch improvement is the only one of the TSP measures that reduces the risk of flooding to properties along Waiakea. Table 10 also shows that after incorporating the TSP, there will be approximately 53% of existing condition damages that remain as residual damages.

Table 10
Residual Damages ($1,000s)
FY 2020 Price Level
FY 2020 Federal Discount Rate 2.75%

Study Area Reach	Existing Condition Damages	Damage Reduced		Residual Damages
		Kupulau Ditch - 2% AEP Plan	Golf Course Detention - 1% AEP Plan	
4 Mile Creek	91	-	-	91
Ainolako	173	111	-	62
Debris	25	-	-	25
HaiHai	128	71	-	57
Kupulau	816	816	-	-
Palai	2,785	709	286	1,790
Puhau	5	5	-	-
Waiakea	715	240	-	475
Total	4,739	1,953	286	2,500

Project Effectiveness. The TSP reduces without-project damages (no Federal project) by approximately 47 percent. Table 11 shows that there is a greater than 75 percent chance that expected annual benefits for the combination plan will exceed $1.6 million. Compared with the current expected annual cost estimate of $649K for the TSP, this means there is a greater than 75 percent change that the benefit to cost ratio for the TSP exceeds 2.0.

Table 11
EAD Probability Distribution ($1,000s)
FY 2020 Price Level
FY 2020 Federal Discount Rate 2.75%

Project Alternatives	Expected Annual Benefits	Probability Damage Reduced Exceeds Indicated Values		
		75%	50%	25%
Kupulau Ditch - 2% ACE Plan	$1,953	1,236	1,917	2,699
Reconfigured Golf Course Detention - 1% ACE Plan	$286	173	269	405
Revised Combination Plan (TSP)	$2,239	1,409	2,186	3,104

Project Performance. How a project performs can be described three different ways within a risk-informed decision process that includes Mean Annual Exceedance Probability (AEP), Long-Term Exceedance Probability (LTEP), and Conditional Non-Exceedance Probability by Frequency (CNP). Table 12 and Table 13 shows similar conclusions to Table 10, that the TSP does not reduce significant flood risk for 4 Mile Creek, Ainolako, Debris, and Puhau. As it relates to Kupulau, the TSP reduces flood risk to having a 100% chance of containing the 1% AEP flood event, despite the project being designed for a 2% AEP event. The 4.3 foot average height includes an additional 2.5 feet in order to achieve a (CNP) of at least 95 percent. Therefore, with the additional height, the Kupulau Ditch contains the 1% and even the .2% AEP flood event. For Waiakea, the TSP reduces flood risk to having a 65% chance of containing the 1% AEP flood event.

Table 12
Existing Condition Project Performance By Study Area
FY 2020 Price Level
FY 2020 Federal Discount Rate 2.75%

Study Area Reach	Mean AEP	Long-Term Exceedance Probability			Conditional Non-Exceedance Probability by Frequency					
		10	30	50	0.10	0.04	0.02	0.01	0.004	0.002
4 Mile Creek	0.999	100%	100%	100%	0%	0%	0%	0%	0%	0%
Ainolako	0.579	100%	100%	100%	0%	0%	0%	0%	0%	0%
Debris	0.999	100%	100%	100%	0%	0%	0%	0%	0%	0%
HaiHai	0.999	100%	100%	100%	0%	0%	0%	0%	0%	0%
Kupulau	0.501	100%	100%	100%	0%	0%	0%	0%	0%	0%
Palai	0.948	100%	100%	100%	0%	0%	0%	0%	0%	0%
Puhau	0.013	15%	39%	56%	100%	88%	58%	42%	36%	35%

Waiakea	0.035	43%	72%	86%	81%	53%	36%	24%	19%	19%

Table 13
TSP Project Performance By Study Area
FY 2020 Price Level
FY 2020 Federal Discount Rate 2.75%

Study Area Reach	Mean AEP	Long-Term Exceedance Probability			Conditional Non-Exceedance Probability by Frequency					
		10	30	50	0.10	0.04	0.02	0.01	0.004	0.002
4 Mile Creek	0.999	100%	100%	100%	0%	0%	0%	0%	0%	0%
Ainolako	0.312	98%	100%	100%	0%	0%	0%	0%	0%	0%
Debris	0.999	100%	100%	100%	0%	0%	0%	0%	0%	0%
HaiHai	0.999	100%	100%	100%	0%	0%	0%	0%	0%	0%
Kupulau	0.000	0%	0%	0%	100%	100%	100%	100%	100%	100%
Palai	0.058	48%	82%	93%	75%	41%	27%	20%	8%	4%
Puhau	0.000	0%	0%	0%	100%	100%	100%	100%	100%	100%
Waiakea	0.004	5%	14%	21%	100%	100%	90%	65%	47%	41%

WAIAKEA-PALAI STREAMS
Hilo, Island of Hawaii, Hawaii

CONTINUING AUTHORITIES PROGRAM SECTION 205
FLOOD RISK MANAGEMENT

Appendix B-1: Hydrology

MAY 2020

US Army Corps of Engineers
Honolulu District

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APPENDIX B2 - HYDROLOGY ANALYSIS

WAIAKEA-PALAI FLOOD RISK MANAGEMENT PROJECT
HILO, HAWAII

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HILO, HAWAII
HYDROLOGY APPENDIX
May 2019

1.0 INTRODUCTION

1.1 Purpose and Scope. The purpose and scope of this appendix is to document the a hydrologic engineering analysis used to determine discharge-frequency relationships at key points for Waiakea and Palai Streams, and Four Mile Creek. Hydrologic analysis was originally done separately for Waiakea Stream and for Palai Stream and Four Mile Creek prior to the combination of these continuing authorities program studies under the current continuing authorities program study. As such, the hydrologic analysis for Waiakea Stream was originally completed in 2006 and that for Palai Stream and Four Mile Creek in 2004.

1.2. Study Authority. The Waiakea-Palai Streams Flood Risk Management (FRM) Project investigation is authorized under Section 205 of the Rivers and Harbors Act of 1962, Public Law 87-874, as amended (76 U.S.C. 1197s; hereinafter Section 205). Section 205 is an authority allowing the Secretary of the Army to initiate surveys for flood control and allied purposes.

1.3 Project Location. Waiakea and Palai Streams, and Four Mile Creek, located in Hilo, Hawaii, are part of the Waiakea-Uka district and extend upstream southwest of Hilo Harbor. Waiakea Stream originates in the upper watershed along the slopes of Mauna Loa (elevation 13,653 feet) volcano and flows through the residential community of upper Waiakea-Uka Homesteads (Figure 1). Palai Stream and Four Mile Creek originate down slope of the broad saddle formed between the Mauna Kea (elevation 13,796 feet) and Mauna Loa volcanic masses and flows thru the City of Hilo. The other volcanic masses on the island are the Kohala Mountains, Hualalai Mountains, and Kilauea Crater. Mauna Loa and Kilauea Crater located in the southern half of the island are the only remaining active volcanoes on the island. See Figure 1, Location Map.

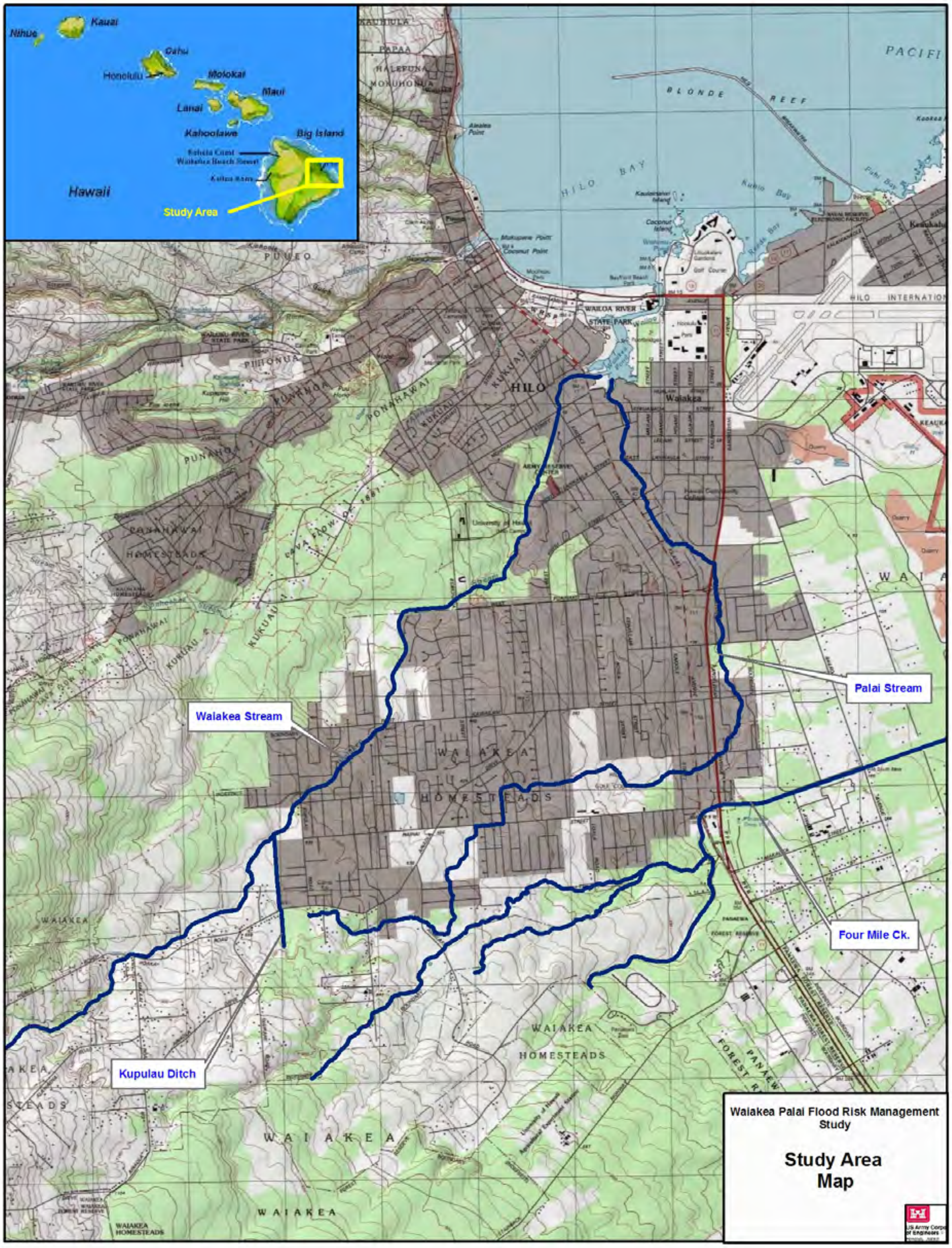


Figure 1. Study Area/Location Map

1.4 Study Area Description.

1.4.1 Basin Description, Topography, Vegetation, and Land Use. Waiakea Stream, Palai Stream, and Four Mile Creek are three of the five tributaries within the principal Wailoa River system, which drains a total of about 160 square miles. The other tributaries are Kawili, and Alenaio Streams.

The Waiakea Stream drainage basin is linear in shape, approximately 25 miles in length and not more than 2 miles wide with an area of about 35.6 square miles, measured upstream from USGS gage station 16701300 (Figure 2a). The thin soil layer over the volcanic subsurface erodes quickly with fast moving water. Hence, the drainage path keeps changing as new paths expose with erosion. In particular, the drainage pattern in the upper watershed keeps evolving with time and stream alignments are not well defined as a result. The drainage area begins at about elevation 8,600 feet and ends at 80 feet above mean sea level for an approximate channel slope of about 0.06 ft/ft. Due to the undefined flow patterns, previous studies have used the term “effective drainage area” to differentiate the portions where the stream channels are more clearly defined from the upper basin and limit their runoff analysis to the drainage area below the 2,500 foot elevation (Wilson, Okamoto and Associates, 1967; Department of the Army, 1982). The “effective drainage areas” that were computed for Waiakea Stream ranged from 11.8 to 14.8 square miles depending on the stream location starting measuring point. Above the 1,500 foot elevation, the basin is covered with ohia, tree fern, and uluhe fern vegetation of the Waiakea Forest Reserve. Below the 1,500 foot elevation, the basin is largely developed for agricultural uses with farming and pastoral land and some residential areas. Vegetation in this region is mixed ohia, tree fern, and guava forest and shrubs with tall dense Wainaku and California grasses. The highly urbanized residential area begins at about the 600 foot elevation and continues down slope into Hilo Town. Waiakea Stream is intermittent and dry during most of the year.

The Palai Stream basin has a drainage area of 7.66 square miles, extends about 4 miles from the mouth at Waiakea Pond through the town of Hilo and another 7 miles through the Waiakea Forest Reserve with elevations ranging from sea level to 2,100 feet. Below the 1,500-foot elevation (Figures 2a and 2b), the basin is largely developed or planned for commercial, residential, and agricultural development. The Palai Stream is intermittent and dry during most of the year. Stream patterns throughout many reaches above the 500-foot elevation are indefinite and not discernable.

The Four Mile Creek basin (2b) has a drainage area of 7.21 square miles, and drains to an old quarry south of the airport and east of Railroad Avenue. This basin extends through the Waiakea Forest Reserve with elevations ranging from sea level to 2,100 feet. Below the 1,500-foot elevation, the basin is largely developed or planned for commercial, residential, and agricultural development. The Four Mile Creek is intermittent and dry during most of the year. Stream patterns throughout many reaches above the 500-foot elevation are indefinite and not discernable.

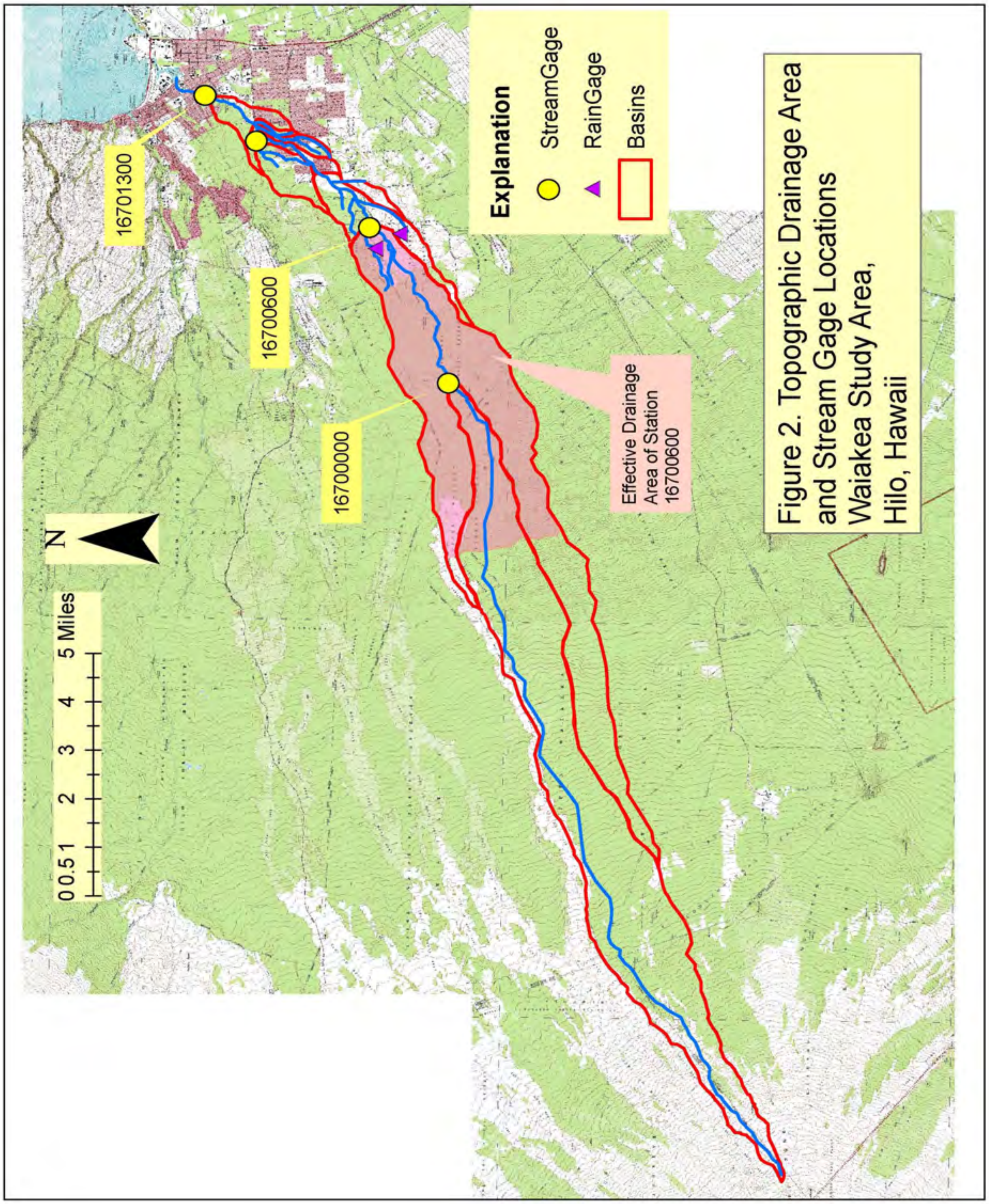
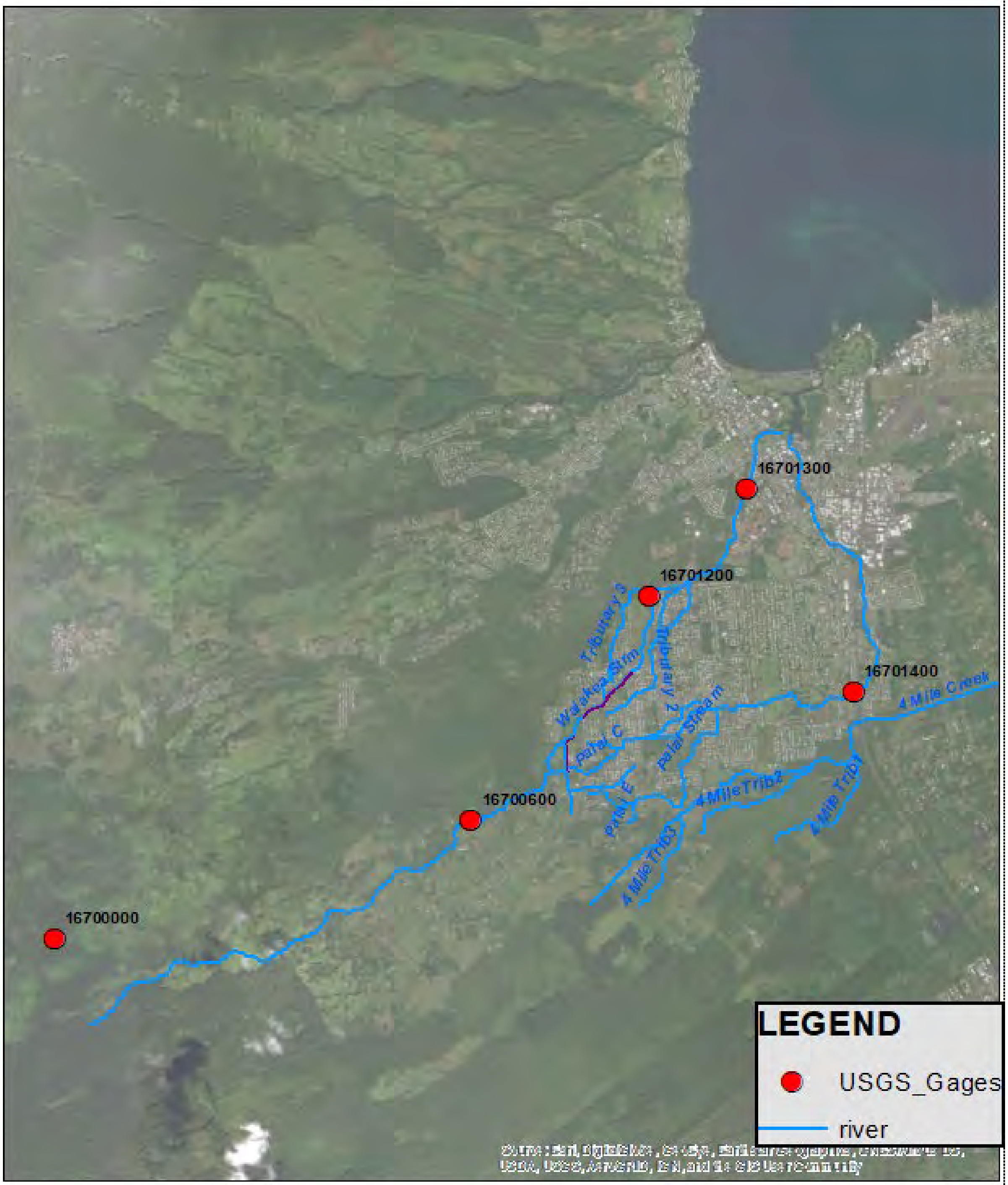


Figure 2. Waiakea Stream Drainage Basin



Waiakea Palai CAP 205 Study - Big Island, HI
Gage Locations Map

Figure 2a. Waiakea Basin Stream Gage Location Map

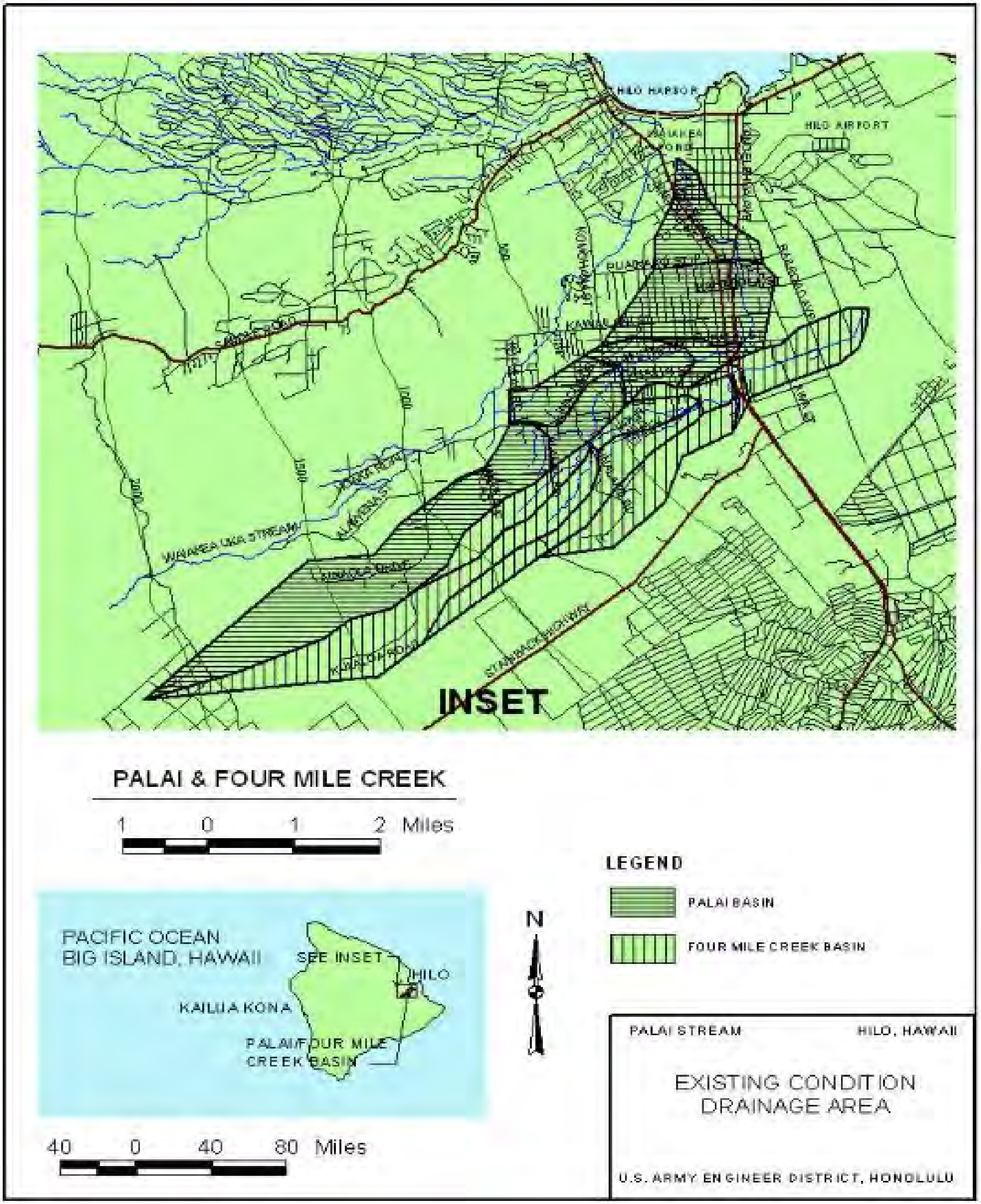


Figure 2b. Drainage Area map for Palai Stream and Four Mile Creek, Hilo, Hawaii

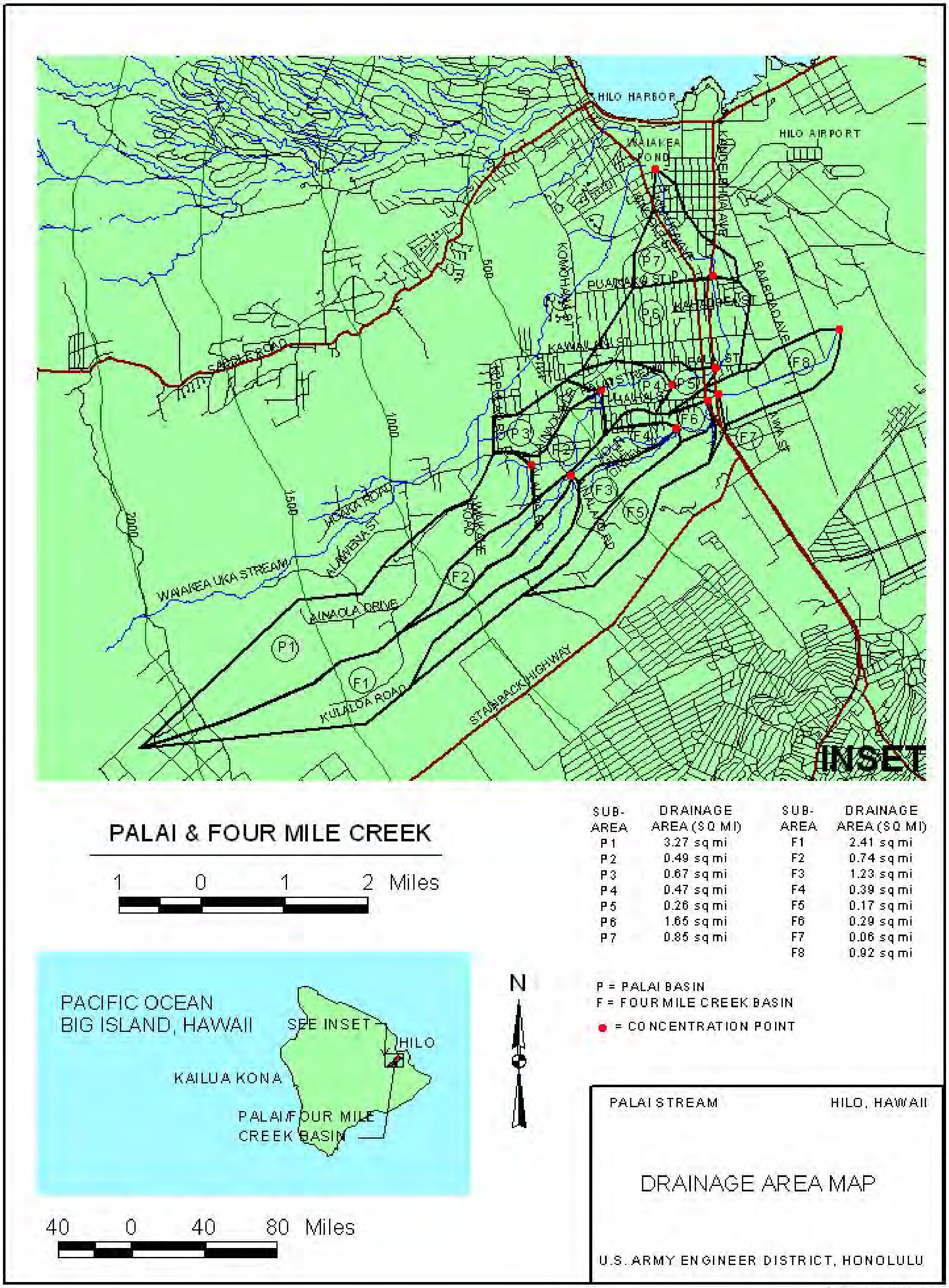


FIGURE 4

Figure 2c. Sub-Basin Areas for Palai Stream and Four Mile Creek, Hilo, Hawaii

1.4.2 Geology and Soils. The Waiakea Stream, Palai Stream, and Four Mile Creek basins lie on top of basaltic aa and pahoehoe lava flows of the Kau Volcanic Series extruded from Mauna Loa (Macdonald and others, 1983). The last historic eruption occurred in 1942 and these aa lava flows exist in the upper basin area with pockets of Pahala Ash covering Kahuku Basalts southwest of Hilo. All of the geologic materials are highly permeable, with aa lava flows having the highest permeability and almost no runoff, pahoehoe flows are less permeable except through cracks, and Pahala Ash is the least permeable (Macdonald and others, 1983; Sato and others, 1973). North of the study area, the Wailuku River forms the approximate boundary between the Mauna Kea and Mauna Loa volcanoes. According to Macdonald and others (1983, p.372) the flow of Wailuku Stream is kept flowing by runoff from the tributaries of the ash covered Mauna Kea slopes despite losing water into the Mauna Loa lavas. The larger number of well defined stream channels with greater runoff potential north of Wailuku River can probably be attributed to the geology of Mauna Kea compared to the more permeable material of Mauna Loa.

Aa lava flows are a mass of rough, sharp fragments. Aa lava tends to drain very well through all the cracks and greatly reduces runoff. Pahoehoe lava flows have smooth, curvy surfaces. Pahoehoe does not drain well unless the infiltration reaches the cracks, and runoff tends to be moderate. Based on Soil Survey of the Island Of Hawaii (Sato and others, 1973), the bedrock of Pahoehoe lava underlays most of the Four Mile Creek basin. The bedrock combination of Aa and Pahoehoe lava is found below the 500-foot elevation of the Palai basin. The portion of Palai basin at higher elevations than 500 feet is made up of mostly Aa lava bedrock.

Soils in the study area consist of Ohia silty clay loam. Olaa extremely stony silty clay loam, and Keaukaha extremely rocky muck in the lower basin, below 1000 foot elevation area and Ohia silty clay loam, Hilea silty clay loam, and Keei extremely rocky muck in the upper basin areas (Sato and others, 1973). Permeability is considered rapid and runoff medium to slow for these soil types. Most of the soils, 8-72 inches in depth, in the study area have rapid permeability even at full depth if underlain by aa lava. Permeability rates for the soil types within the basin range from 6.3 to 20 in/hr (Sato and others, 1973) and can be variable due to a decrease in permeability at shallow depths in areas underlain by pahoehoe lavas and Pahala Ash. Areas underlain with pahoehoe lava and ash can generate shallow subsurface flow during heavy rainfall (Fontaine and Hill, 2002).

1.5 Climate and Hydrology. The climate near Hilo, Hawaii is generally warm and humid. The semi-tropical climate consists of a two-cycle season: dry, which is between May and October, and wet, which is between October and April. The ranges of rainfall and temperature values reflect the variety of physiographic characteristics of the island. Seasonal variations in rainfall are much smaller in the wetter Hilo area where rainfall comes from both winter storms and year round trade wind showers.

Average annual temperatures near the study area at Hilo Airport range from 66 to 81 ^{o}F with an average of 74 ^{o}F (Western Regional Climate Center, general climate survey website; http://www.wrcc.dri.edu/summary/ito.hi.html). Average monthly rainfall near the study area ranges from 6.5 inches in June to 14.7 inches in November with an average annual value of 126 inches (Data from 1949-2012, Rainfall Atlas of Hawaii website, http://rainfall.geography.hawaii.edu; Giambelluca and others, 2013). The highest recorded monthly rainfall was 50.8 inches in December 1954; the lowest was 0.14 inches in January 1998. Rainfall also varies with elevation due to the orographic effect of the high broad volcanic mountains. Average annual rainfall varies from 130 inches near the coast in Hilo and increases to about 200 inches between the 1,000 to 3,000 foot elevations only to decline to 60 inches at the 8,000 foot elevation (Giambelluca and others, 1986). Rainfall frequency intensity values also diminish above the 3,000 foot elevation (U.S. Department of Commerce, 1962). The mean annual rainfall in the Palai Stream basin ranges from 150 inches at Hilo to 220 inches at the higher elevations. The average annual precipitation is estimated at 160 inches for the Palai Stream and Four Mile Creek Basin. Table 1 provides a statistical summary of monthly temperature and Table 2 provides a statistical summary of monthly rainfall taken from readings between the years 1949 to 2012 near Hilo Airport also known as General Lymann Field.

Table 1. Hilo Airport Monthly Statistical Temperature Summary (1949-2005)

Month	**Average Temperature (ºF)**	**Maximum Temperature (ºF)**	**Minimum Temperature (ºF)**
January	71.5	79.5	63.5
February	71.3	79.2	63.4
March	71.8	79.2	64.3
April	72.5	79.6	65.4
May	73.7	81.0	66.5
June	75.0	82.5	67.6
July	75.8	82.9	68.7
August	76.3	83.5	69.1
September	76.1	83.7	68.6
October	75.5	83.0	68.0
November	73.9	45.9	66.7
December	72.1	81.0	64.7
Annual	73.8	81.2	66.4

Table 2. Hilo Airport Monthly Statistical Rainfall Summary (1949-2012)

Month	Average Rainfall (in)	Maximum Rainfall (in)	Minimum Rainfall (in)
January	9.59	38.35	0.14
February	11.38	45.55	0.52
March	13.12	49.93	0.88
April	12.30	43.24	2.93
May	8.64	25.01	1.46
June	6.53	22.70	1.38
July	9.60	28.59	3.53
August	9.72	26.92	2.66
September	8.10	21.82	1.59
October	9.63	26.10	2.40
November	14.70	45.90	1.01
December	12.40	50.82	0.28
Annual	125.71	195.92	63.22

1.5.1 Runoff Characteristics. Waiakea Stream, Palai Stream and Four Mile Creek and their tributaries are intermittent, flowing only in direct response to heavy rainfall. During storms much of the runoff may quickly seep into the ground depending on the subsurface permeability and exist as subsurface flow or possibly enter into lava tubes and reappear as spring flow in the downstream area. The exact number and locations of lava tubes in the Waiakea area has not been determined (Wilson Okamoto and Associates, 1967). One tube that has been mapped is the Kaumana Cave which is about 1 mile north of the Waiakea study area (Halliday, 2003). The movement of subsurface flow is unknown and may or may not affect peak flows, in some cases downstream spring flows have developed 2-3 days after the heaviest rainfall (U.S. Army Corps of Engineers, 1990).

The U.S. Geological Survey (USGS) has operated both continuous record and crest-stage gages along Waiakea Stream since 1931 in the upper basin and 1957 in the lower basin. A crest-stage gage collects only peak water level stage and flow for the purpose of flood-frequency analysis. Station 16701300, a crest-stage gage, is the only gage on Waiakea Stream currently in operation. Previous and current gaging efforts are listed in Table 3. Recorded flood flow hydrographs from Waiakea Stream are characterized by sharp rises of relatively short duration followed by sharp recessions; most runoff hydrographs have durations of 4 to 6 hours (Wilson Okamoto and Associates, 1967). Peak discharges typically occur within 2 hours after the end of the heavy rainfall and the flash flood characteristics of Waiakea Stream result in inadequate flood warning for the lower floodplain downtown Hilo area. In 2004, the USGS operated two continuous record gages on Waiakea Stream (Table 3). Peak flow records from two peaks, one on January 25 and the other on April 12, 2004 indicate that flood peak attenuation exists between these two sites which are about 4.2 miles apart. An approximate calculation shows an average linear reduction of 0.02 cubic feet per second per linear foot distance. However, the actual flow loss reduction may be greater than this value because of inflow from tributary drainage areas that need to be factored in. As part of the data collected after the November 2000 flood, the USGS also computed a peak discharge on Waiakea Stream upstream of Hoaka Road near the Gage station 16700600 site (Fontaine and Hill, 2002). This discharge was 6,420 cubic feet per second. The peak flow determined at Gage station 16701300 for this storm was 5,760 cubic feet per second. The flood peak attenuation from this storm was an approximate reduction of 0.03 cubic feet per second per linear foot, slightly higher for this higher peak flow event.

The USGS operates a crest-stage gage on Palai Stream at Highway 11, Kanoelehua Avenue, (USGS Gage station number 16701400). This gage records only peak water level stage and flow. This type of data is used for flood-frequency analysis. During storms much of the runoff enter into lava tubes and reappear as springs in the downstream area. In most cases these springs develop 2-3 days after the heaviest rainfall and do not have a significant impact on peak flows. Flood flows in Palai Stream are characterized by sharp rises of relatively short duration from intense rainfall over the watershed, followed by sharp recessions. Peak discharges typically occur within 2 hours after the end of the heavy rainfall. The flash flood characteristics of Palai Stream result in inadequate flood warning for the lower floodplain downtown Hilo area.

Table 3. U.S. Geological Survey Streamflow Data collected on Waiakea and Palai Streams, Hilo, Hawaii

Gage Location, Elevation, or Period of Record	**Stream Gage station Number**				
	16700000	**16700600**	**16701200**	**16701300**	**16701400**
Gage Location, lat.	19º38'30"	19º39'40"	19º41'42"	19º42'38"	19º40'56"
Gage Location, long.	155º10'28"	155º07'20"	155º05'51"	155º05'02"	155º04'04"
Gage Elevation	1,934 ft	860 ft	369 ft	80 ft	160 ft
Drainage Area (mi^2)	17.4	31.92	33.6	35.8	5.06
Period of Continuous Record	Oct 1930 to Sep 1991	Oct 2003 to Sep 2005	June 1957 to June 1967	Oct 2003 to Sep 2005	N/A
Period of Peak Flow Record Only	-----	-----	-----	1967 to 2003, 2006-present	1965-present with gaps
Number of Annual Peak Flows available for analysis	61	2	10	20	23

1.5.2 Climate Change Impact

The current inland hydrology civil works regulation requires that Waiakea incorporate design change to sustain climate induced vulnerabilities. USACE Climate Assessment Tool can be used to develop qualitative analysis of the climate impact analysis on Waiakea project areas. This program tool is unavailable at this time to perform a typical assessment of climate vulnerabilities in the region.

However, climate influenced water resources impact is well documented in the Hawaiian climate literature. Rainfall trended downward, so is the base flow of streams in Hawaiian Islands (Center for climate adaptation policy - 2012). Heavy rainfall and drought events become more common (Honolulu County 2018) Temperature is rising and sea level is expected to rise as much as 3.2 ft, El Nino would be dominant precipitation pattern (EPA 2016). The climate related information pointed to common direction that Hawaiian climate is changing and change in temperature, wind speed, wind pattern, sea level increase and ecosystem changes collectively influencing floods, droughts and depletes drinking water resources. Even without such climate induced issues, increased population and land degradation will exacerbate current conditions with increased runoff, particularly impacting communities which live near water courses in lower land areas.

Temperature influenced sea level rise will have no significant impact on Waiakea project area as most of the flooding occurs in sloping terrain away from ocean. However, changes in precipitation intensity and frequency may pose significant impact. The preliminary review of climate influence on water resources indicates that it is important to conduct sensitivity analysis of the Waiakea-Palai watershed and project measures to understand the resiliency and vulnerabilities posed by potential climatic and hydrologic changes. Since hydrology and hydraulic analyses will be revisited during next phase of design development, the climate induced impact analysis can be conducted at that same time.

1.6 Flood Problems. In general, flood problems in the Waiakea, Palai, and Four Mile study areas are attributed to poorly defined channels. In areas where the channel is more defined, the channel capacity is inadequate to convey excess runoff. The streams can be classified as perched or partially perched, having variable stream slopes ranging from 2 to 6 percent and severe bends. The accumulation of debris and vegetation in and near the channels, especially vegetation growth in the channels during the dry season, along with poor drainage facilities to convey storm runoff from streets and open areas contribute to the problem. High intensity rainfalls of short duration along with steep terrain, cause rapid flood flows. Deposits of sediment and other debris aggravate flood damages to agricultural land, residential and commercial properties, and public roads. These deposits cause changes in the flow directions making other areas prone to flooding. Inadequate drainage facilities to convey storm water runoff from streets and open lots cause repetitive problems in the south Hilo area.

1.6.1 Storms and Floods of Record**.** Historical accounts, although not well documented, indicate that the study area is flood prone. The following is a brief description of major storms and their accompanying floods.

2 March 1939. Torrential rainfall from this storm brought 19.2 inches of rain over 24 hours recorded at the Hilo Post Office and 18.8 inches in 24 hours at Waiakea Mill. Portions of the lower Waiakea area in Hilo were flooded up to 5 feet deep with 1 to 2 feet of water flowing along many streets (U.S. Army Engineer District, 1962). For Palai Stream, the peak flow was about 920 cubic feet per second and 1,180 cubic feet per second for Four Mile Creek. These discharges were estimated at sites located at Highway 11. Both sites were mostly undeveloped at this time.

9-10 March 1953. Thunderstorm showers produced 10 to 13 inches of rain in 24 hours in the Hilo Area. Rainfall totals of 3.91 inches on the 9th and 13.62 inches on the 10th were recorded at the Waiakea Gage (U.S. Army Engineer District, 1962).

25 July 1966. This storm brought 17 inches of rain over 24 hours according to Wilson Okamoto and Associates (1967). A peak discharge of 1080 cubic feet per second was recorded at USGS station 16701200, a gage which was located upstream of Komohana Street from 1957-66. A peak discharge of 1,000 cubic feet per second was recorded on Palai Stream. Residential damages were reported along Haihai and Kawailani Streets on Waiakea Stream and residential damages occurred along Four Mile Creek, but no discharge information is available.

20 February 1979. From this storm, 16.87 inches of rainfall was recorded at Hilo airport according to the NWS (National Weather Service). A maximum 22.3 inches of rainfall was recorded at the same rain gage over a 24-hour period according to the U.S. Army Corps of Engineers (1990). Damages totaled $6 million in the urban Hilo area along Waiakea Stream and $300,000 in the Palai Stream/Four Mile Creek area. The urban Hilo area was also evacuated during this storm. Station 16701300 on Waiakea Stream recorded a peak flow of 2,590 cubic feet per second, while the Palai stream gage recorded a peak flow of 1,260 cubic feet per second.

17 March 1980 - March 1980: Approximately 25 inches of rain was recorded in a 72-hour period with damages estimated at $3.8 million. The Palai stream gage recorded a peak flow of 1,070 cubic feet per second.

August 1994: Approximately 4 inches of rain was recorded with damages estimated at $1 million. A USGS stream gauge on Waiakea stream recorded a peak flow of 3670 cfs, estimated at a 10-15 year discharge recurrence interval. The Palai stream gage recorded a peak flow of 575 cubic feet per second.

November 2000: Approximately 29 inches of rain was recorded in a 24-hour period and rainfall intensities of 2.57-3.24 inches per hour were recorded over a four-hour period. A U.S. Geological Survey (USGS) stream gauge on Waiakea Stream recorded a peak flow of 5760 cfs, estimated at a 70-year discharge recurrence interval. In the Waiakea Stream area, bridge crossings at Kawailani Street and

Kupulau Road were washed away. Entire neighborhoods were isolated and cut off from the rest of Hilo for several days. The Palai stream gage recorded a peak flow of 1,580 cubic feet per second.

29 January 2002. This storm recorded 12.20 inches of rainfall at Hilo airport on that day according to the NWS. The USGS has no data for this storm event.

August 2018: Approximately 43 inches of rain was recorded in a 4-day period resulting from Hurricane Lane. The storm caused widespread damage to the properties (CBCNews, Aug 26, 2018)

February 2008: Approximately 16 inches of rain was recorded in a 24-hour period. Approximately 150 homes were damaged by floodwaters rising up to 4 feet deep in Hilo.

1.6.2 Flood Protection Measures. Downstream in the lower reaches of Waiakea Stream from near The University of Hawaii at Hilo campus to Wailoa Pond (also called Waiakea Pond) (Figure 3) the U.S. Army Corps of Engineers built a flood control project in 1965 consisting of channel improvements and levees to protect that portion of Hilo. This project was designed for a flood event of 6,500 cubic feet per second which was determined to have a recurrence interval of 125 years (U.S. Army Engineer District, 1962). Upstream, in the detailed study area, The County of Hawaii constructed the Waiakea Uka channel improvements in 1984. This project consists of 3,460 feet of concrete lined and unlined trapezoidal channel modifications from Komohana Street to near Apono Place (Figure 3d). These improvements were designed for a discharge of 4,460 cubic feet per second and were damaged in the November 1-2, 2000 flood. Although not a flood control improvement for Waiakea Stream, The Kupulau Ditch was constructed in 1971 to diverted runoff from the Palai Stream drainage basin to Waiakea Stream upstream of the Kupulau Road Bridge. No site-specific flood warning system exists for the Waiakea Stream area. Special storm warnings for the Island of Hawaii are broadcast over local radio and television. These warnings are made for broad, extensive areas of the island because of the “flashy” nature of floods and the unpredictability of the precise location of intense storm cells in Hawaii.

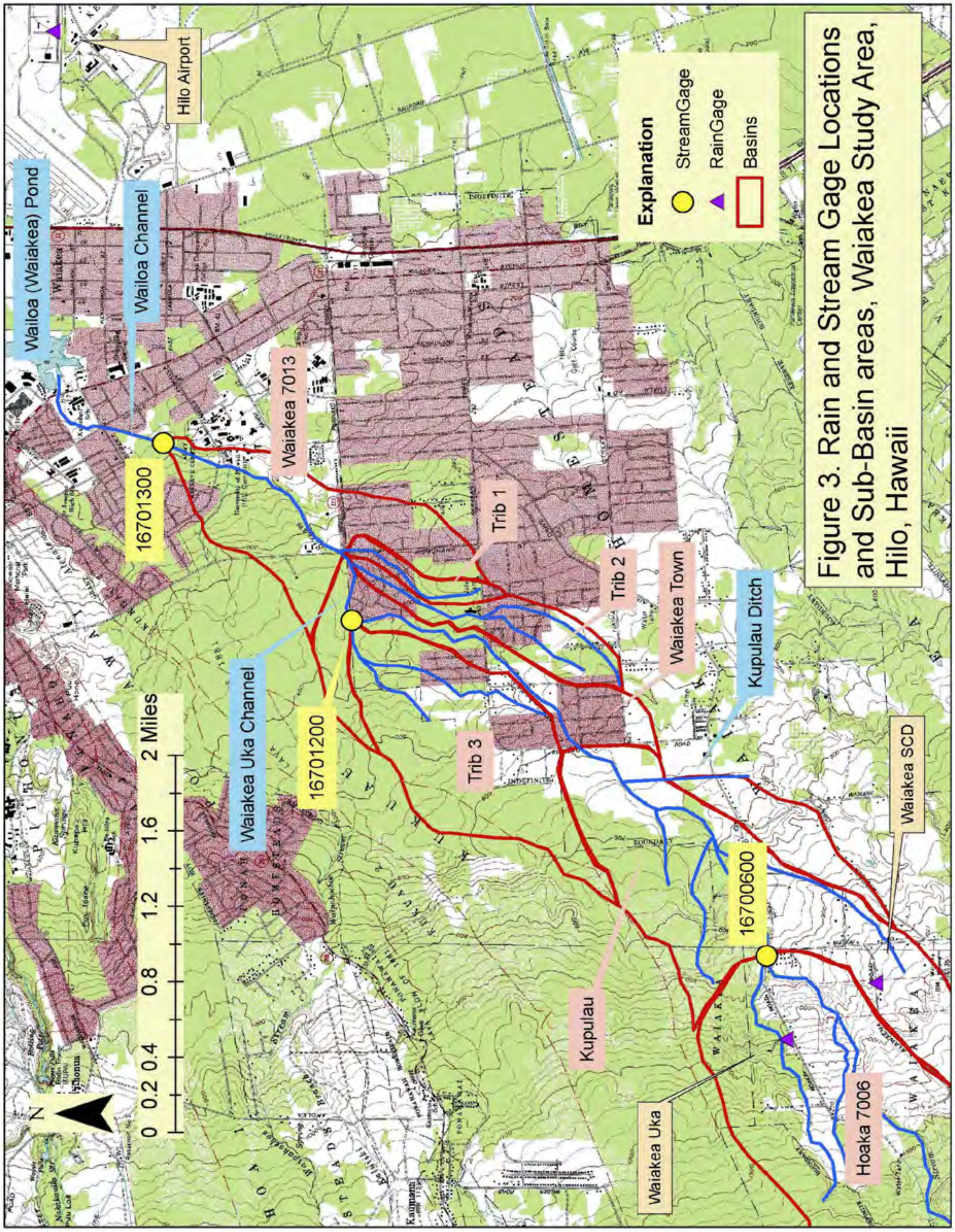


Figure 2d –Channel Modification Locations

1.6.3 Previous Flood Studies. A number of previous studies have looked at the flood problems in the upper Waiakea and Palai Stream areas and provide various suggested improvements. The Wilson, Okamoto, and Associates (1967) study titled *Hilo Drainage and Flood Control*, used streamflow data from storms in 1957, 1965, and 1966 from the USGS gage station 16701200 on Waiakea Stream to create synthetic hydrographs used to create design hydrographs for a number of streams and tributaries in the Hilo area. For Waiakea Stream at Kupulau Road a design hydrograph was created using the Soil Conservation Service (SCS) curve number method. This hydrograph used a 24 hour storm of 17 inches, a curve number of 37, and a time to peak of 1.03 hours to create a peak discharge of 3,210 cubic feet per second. From rainfall frequency analysis in this report, a 17 inch 24 hour rainfall event has a recurrence interval of about 50 years. The suggested improvements for the study area was to construct a trapezoidal channel with 30 feet bottom width and 2 to 1 side slopes in Waiakea Stream from Kawailani to Puainako Streets and 3 foot wide drainage ditch along Komohana Street which would discharge into Waiakea Stream at the Komohana Street Bridge.

A flood control reconnaissance study for Palai Stream in 1979 (Department of the Army, 1979) documented the construction by local interest of the Four Mile Creek channel downstream of Kanoelehua Highway in 1976 and the desire to provide flood mitigation for Palai Stream by diversion into Four Mile Creek. The 1981 study (Department of the Army, 1981) follows up on the reconnaissance study looking at structural and non-structural alternatives with computations of benefits and costs and determining a lack of economic justification for federal interest with a benefit cost ratio less than one.

A flood control reconnaissance study for Waiakea Stream in 1982 (Department of the Army, 1982) analyzed a trapezoidal concrete channel improvement extending from Kupulau Road to Komohana Street, about 9,800 feet long. This channel would have a bottom width of 35 feet with 2 to 1 side slopes and a channel design capacity of 6,200 cubic feet per second, about a 125-year recurrence interval. This study introduced the idea of a perched channel, where the out of bank ground elevation is lower then the stream elevation and thus creates a myriad of flooding issues once the streamflow leaves the bank. Perched channels were identified by the Kawailani Street Bridge area. This study did not recommend a further study due to a benefit cost ratio less than one.

Another flood control reconnaissance study was conducted in 1995 (Department of the Army, 1995) due to a significant storm damage in 1994. Hydrologic data form USGS gage stations 16700000 and 16701300 were used to create a regional curve which determined the 100-year discharge of Waiakea Stream at Kupulau Road to be 3,280 cubic feet per second. The proposed improvement was a detention pond design near Kupulau Road to contain either the 50- or 100-year flows. This study did not recommend a further study due to a benefit cost ratio less than one.

Also in response to the 1994 flood, the Natural Resources Conservation Service (NRCS) conducted a preliminary investigation into the Waiakea flooding problems under the PL83-566 Small Watershed Program (Natural Resources Conservation Service, 1999). This study looked at bridge replacements, levees, channel modifications, and detention basins as possible mitigation measures. This study did not recommend a further study due to a benefit cost ratio less than one.

The large flooding event of November 2000 resulted in another flood control reconnaissance study in 2001 (U.S. Army Corps of Engineers, 2001). The hydrologic analysis in this study determined a 1% Annual Exceedance Probability (AEP) design discharge of 5,724 cubic feet per second. Potential flood mitigation measures studied included channel and levee improvements, a detention pond, and extended the Kupulau Ditch to carry floodwaters around the community and return the runoff to Waiakea Stream by Komohana and Puainako Street Extension Bridges. This study did recommend further study since the benefit cost ratio was greater than one.

Dewberry and Davis (2001) computed updated hydrologic discharges and hydraulic flood elevation profiles on Waiakea Stream for the Federal Emergency Management Agency (FEMA) Flood Insurance Study as a result of the November 2000 storm. The revised 100-year discharge for Waiakea Stream is 6,230 cubic feet per second (ft^3/s), previously it was 3,750 cubic feet per second. Discharges were also updated for the three tributaries of Waiakea Stream originally mapped in 1981. These tributaries were mapped from Kawailani Street to Puainako Street. The detailed study area for the flood mapping covered the area of Waiakea Stream from Kupulau Ditch to Wailoa Pond. Flood elevation profiles were updated for certain reaches of Waiakea Stream from the previous 1995 HEC-2 model data computations. Flood Insurance Rate Maps (FIRM) for the Waiakea area are covered in panel numbers 1551660880C and 1551660890C, both last revised September 16, 1988.

URS Corporation, formerly United Research Services, (2003) conducted a study to update the Flood Insurance Rate Maps (FIRM) for Palai Stream Tributaries A, B, and C. As part of this study, flows and floodplains in the area by Kupulau Ditch and portions of Waiakea Stream near Kupulau Ditch were determined. Peak flow values were determined from USGS data on Palai Stream and existing FEMA values. The 100-year flow for Waiakea Stream that was used was 6,230 ft^3/s and 2,144 ft^3/s was used at Kupulau Ditch. The floodplain mapping was done using steady-flow split flow analysis in this area, as flow is known to leave Waiakea Stream and flow into Kupulau Ditch and then some flow leaves the Ditch as opposed to returning to Waiakea Stream to flow down Palai Stream C. The area of Palai Stream C is included as a tributary to Waiakea Stream in this study since the flow path downstream of Palai Stream C is not well defined and can be interpreted to enter Waiakea Stream as opposed to just ending at Kawailani Street.

2.0 HYDROLOGIC ANALYSIS

2.1 Hydrology. The main objective of this hydrologic analysis was to determine the “best” estimates of the 50%, 20%, 10%, 4%, 2%, 1%, 0.5%, 0.2% AEP flood events. Discharge-frequency values in this report will be referred to as the [x] percent flood which is defined as a discharge magnitude having a one chance in [100/x] of being exceeded in any given year. To determine the “best” estimate of the discharge-frequency curve three methods were applied: HEC-HMS rainfall-runoff modeling (version 3.0; U.S. Army Corps of Engineers, 2000, 2002, and 2005), Flood frequency analysis using recorded peak flow data from Waiakea and Palai Streams, and Plate 6 (County of Hawaii Storm Drainage Standards, 1970). The selection of the "best" estimate was done by comparing the various derived discharge-frequency curves graphically and by the accuracy or uncertainty of each method. The existing condition hydrologic analysis models the condition where the Waiakea and Palai Stream Basins drain into Waiakea Pond in Hilo Town, and the Four Mile Creek Basin drains into an old quarry.

2.2 Uncertainty Analysis. Department of the Army (1996) guidelines on risk-based analysis for flood damage reduction studies presents guidelines on assigning accuracies to flood frequency estimates determined by various methods in terms of equivalent years of record. Those estimates with the higher equivalent years of record are assumed to be more reliable than those with lower values. Each method used was assigned an accuracy value.

2.3 Data Availability. The USGS 1:24,000 scale topographic maps and Geographic Information System (GIS) tools were used to determine the layout and physical sub-basin characteristics for the HEC-HMS model (Figures 3 and 4). Also detailed topographic data at 4 foot contour intervals collected in 2005 for Waiakea Stream in an area between Kupulau Road and Komohana Street was also used, especially in the determination of the area and flow paths of tributaries 1, 2, and 3 of Waiakea Stream (Figure 3). Rainfall data from the NWS Waiakea-Uka, Waiakea Summary Climate Data (SCD), and Hilo Airport gages were used for calibration along with USGS stream flow data from Gage stations 167006000, 16701200, 16701300, and 16701400 (Table 3). The Waiakea-Uka gage is part of the NWS Hydronet system in Hawaii, so data is primarily used for flood forecasting and is not quality assured, start from 1995 and can only be found at website http://www.prh.noaa.gov/hnl/pages/hydrology.php (last accessed on September 12, 2006) (Kevin Kodama, Senior Staff Hydrologist, NWS, oral communication, 2004). Data from the Waiakea SCD and Hilo Airport gages are collected under other NWS programs. Data from these rain gages can be found at the National Climatic Data Center (NCDC) website http://www.ncdc.noaa.gov/oa/ncdc.html (last accessed on September 12, 2006). Data from the Waiakea Uka rain gage and the USGS stream gages are available in 15 minute intervals; the Waiakea SCD data is based on a daily read can and the Hilo Airport Data is hourly. The rainfall frequency intensity was determined from the National Oceanic and Atmospheric Administration Atlas 14 website; see Section 2.7.2 for information about this data set.

2.4 Waiakea Stream HEC-HMS Rainfall-Runoff Model. A lumped basin watershed model was constructed using the HEC-HMS software program. The HEC-HMS model has three components a basin model, a meteorological model, and a control model. The basin model divided the Waiakea Stream Watershed into a number of smaller sub-basins and used the initial and constant loss rate method and the Snyder Unit Hydrograph Method for creating peak flows. Flow routing through reaches was done by the Muskingham-Cunge method to account for peak flow attenuation. The baseflow recession method was used for the baseflow portion of the basin model. The meteorological model used both storm hydrographs for calibration and frequency based rainfall after calibration to compute synthetic flood events. The control model sets the computation parameters. A 5 minute computation interval was used for calibration and frequency storm computations. Discharge determinations were conducted at the gage station locations for Gage stations 16700600 and 16701300 and at locations in the detailed study area, most notably at the Kupulau Road and Komohana Street bridges (Figure 3).

Figure 3- Gage Locations Map

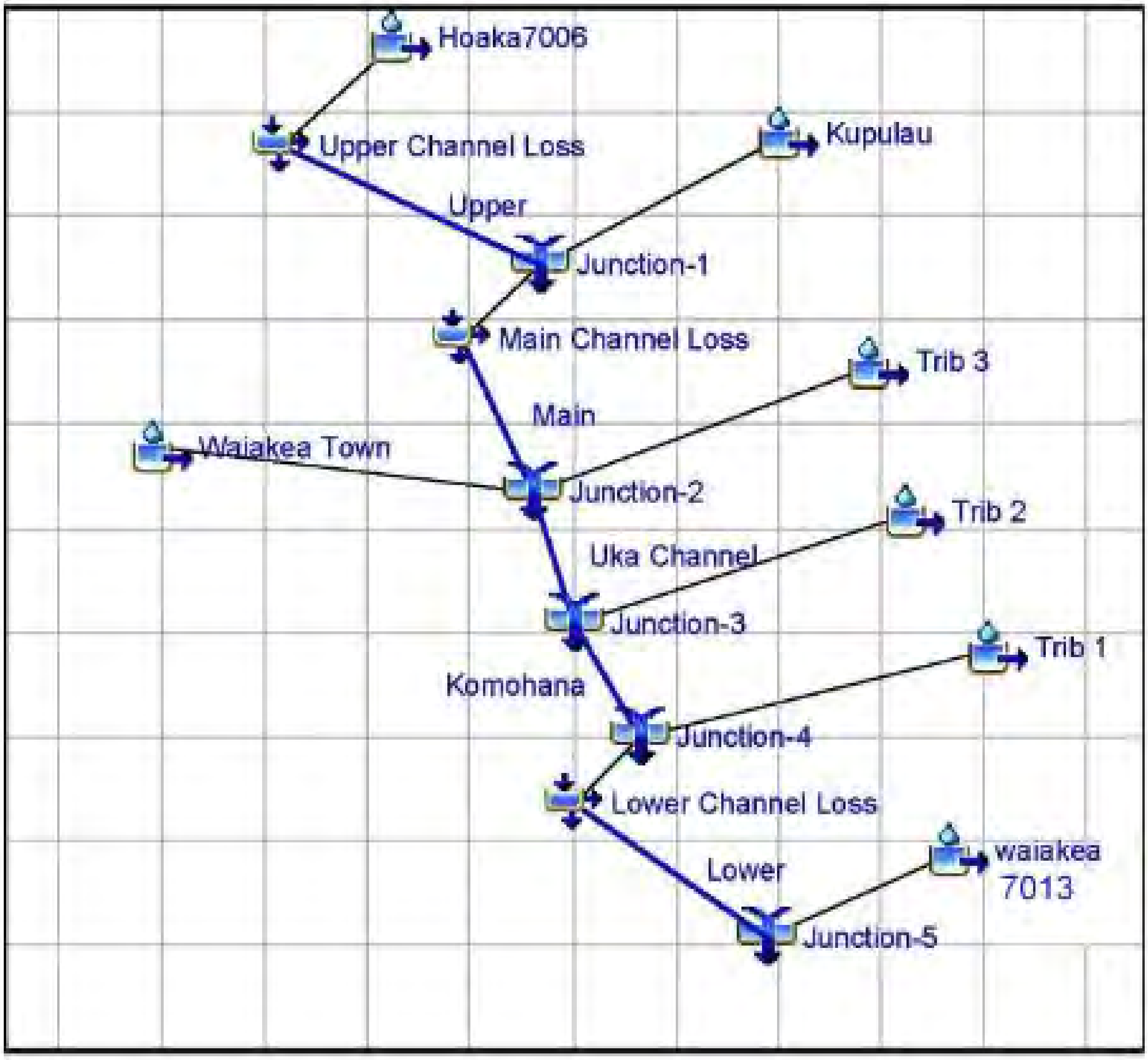


Figure . Waiakea Stream HEC-HMS Model Layout

The concept of “effective” drainage area was employed to determine the drainage areas used for the upper sub-basin area at Gage station 16700600. The topographic drainage area of Gage station 16700600 is 31.5 square miles. The use of this entire area in rainfall-runoff modeling would result in large peak flow values or the use of large soil loss coefficients to replicate observed data, therefore, only the drainage area below the 3,000 foot elevation was used to compute the sub-basin area of gage station 16700600, which is 12.2 square miles (Figure 2). Long term streamflow data from 1931-91 collected at USGS gage station 16700000 which is upstream of gage station 16700600 at elevation 1,934 feet (Figure 2) does not indicate very high rates of runoff from the upper elevations of this watershed. Topographic area of gage station 16700000 is 17.4 square miles, yet maximum recorded peak flow is only 310 ft^3/s recorded on August 26,

1970. The November 1-2, 2000 storm resulted in a higher peak stage at this site, but peak flow was not determined (Fontaine and Hill, 2002).

The HEC-HMS program allows the analyst to estimate runoff parameters automatically using the optimization manager. Observed discharge must be available for at least one element before optimization can begin. Sub-basin parameters at any element upstream of the observed flow can be estimated. The program makes an estimate of the required parameters, computes the resulting runoff, and compares the goodness of fit. The optimization manger was just one tool used in the model calibration process. The rainfall runoff models used in the Alenaio and Palai Stream studies also provided guidance (U.S. Army Corps of Engineers, 1990). The Manning's n value and channel sizes for the Muskingham-Cunge routing method were determined from a site visit in February 2006 and guidebooks such as Arcement and Schneider (1989).

The Alenaio and Palai Stream studies (U.S. Army Corps of Engineers, 1990; Section 2.6) used basin parameters calibrated from past storms on August 26, 1970 and January 23, 1979 at the USGS Wailuku River gage, station 16701800, because these records contain complete rainfall and runoff data. The Wailuku calibrated basin parameters were 0.45 as an average Snyder Peaking Coefficient, Cp, value, lag values of 1.3 to 2.4 hours, Initial soil losses ranging from 1.10 to 5.4 inches and constant soil losses of 0.47 to 0.65 inches. The Wailuku storm parameters showed higher initial and constant soil losses for larger peak flow events even in the lower permeability rocks of the Moana Kea with Pahala Ash area of the Wailuku River basin. The Palai model calibration results also resulted in higher soil losses for storms of higher magnitudes.

Between October 2003 and September 2005, two continuous streamgages have been operated by the USGS on Waiakea Stream, Station 16700600 in the upper basin above the urbanization and station 16701300 at the lower end of Waiakea Stream (Figure 3). Data from two storms, April 10-13, 2004 and November 1-2, 2000 were used for HEC-HMS model calibration. Complete rainfall and runoff data were available for the April 10-13, 2004 event while only complete rainfall was available for the November 1-2, 2000 storm. At that time, Station 16701300 was operated as a crest-stage gage so only peak flow data was collected. For that storm a peak flow calculation was also made at Waiakea Stream near Hoaka Road (Fontaine and Hill, 2002) which is near the Station 16700600 site. Rainfall data was missing at the Waiakea Uka gage for two other storms, January 25-26, 2004 and August 7-8, 2005, so these storms were not used for calibration purposes since the Waiakea Uka data is very important to proper model calibration due to its location (Table 4).

Table 4. Rainfall and Streamflow Data in and near the Waiakea Stream Study Area, Hilo, Hawaii

	Rain Gage Daily Total Data Rain fall values in inches			**Stream Gage Peak Flow Data**		
Gage Location, Elevation, or Storm Date	**Waiakea Uka 85.2 (15 min)**	**Waiakea SCD 88.2 (Daily)**	**Hilo Airport (Hourly)**	**Waiakea 16700600 (ft^3/s)**	**Waiakea 16701300 (ft^3/s)**	**Peak Flow Difference, percent of 16701300 value**
Gage Location, lat.	19º40'N	19º40'N	19º43'N	19º39'40"	19º42'38"	----
Gage Location, long.	155º08'W	155º08'W	155º03'W	155º07'20"	155º05'02"	----
Gage Elevation	1,000 ft	1,050 ft	38 ft	860 ft	80 ft	----
November 1, 2000	14.09	0.11	12.64	6,420	5,760	-11%
November 2, 2000	16.12	26.33	16.64	----	----	----
January 25, 2004	Missing	0.15	4.07	1,330	725	-83%
January 26,2004	Missing	8.82	1.24	----	----	----
April 10, 2004	2.20	0.65	1.67	----	----	----
April 11, 2004	5.67	3.62	4.65	----	----	----
April 12, 2004	6.47	9.06	7.82	1,000	701	-43%
April 13, 2004	2.07	6.28	1.25	----	----	----
August 7, 2005	Missing	3.81	2.00	990	455	-118%
August 8, 2005	Missing	3.17	0.42	----	----	----

The recorded runoff data from gage stations 16700600 and 16701300 indicate a peak flow attenuation of 11 to 118 percent between the two measuring locations (Table 2). The April 10-13, 2004 hydrographs (Figure 5) of gage stations 16700600 and 16701300 show an approximate lag of 45 minutes and a distinct flow attenuation. This flow attenuation is attributed to the highly permeable lava rocks that make up the stream channels and was modeled in HEC-HMS by removing a fixed percentage of channel flow in the three main reaches in the model (Figure 4).

The April 10-13, 2004 storm was used in the initial model calibration with the Snyder's Cp and lag, soil loss, and baseflow recession values determined at the HEC-HMS Hoaka7006 sub-basin from the gage station 16700600 data. These values were then applied to the remaining sub-basins and further adjusted to represent the flow hydrograph at the Station 16701300 location, Junction 5 in the model. Graphical results in Figures 6 and 7 show that while the peak values at Hoaka7006 have a lag compared to the observed, the fit is better downstream at Junction 5. The initial and constant soil loss method is not fully capable of capturing all the multiple peaks observed during the April 10-13, 2004 event. Other methods such as Green-Ampt and exponential were used (U.S. Army Corps of Engineers, 2005) but did not significantly improve the fit. This was not considered a major problem with the calibration as the goal was to model events of higher magnitude. Calibrated basin parameters and rain gage weights are shown in Table 3. For the rainfall inputs, the Waiakea Uka gage represented the upper basin and the Hilo Airport gage the lower basin areas. For the sub-basins in the middle, a 50/50 split was used. The daily read data from Waiakea SCD was used only slightly to adjust the Waiakea Uka values (Table 5).

The April 10-13, 2004 calibrated model was then calibrated to the November 1-2, 2000 storm data. To replicate the observed peak flows, the constant soil losses had to be increased. This was also done in the Palai model (Section 2.6). One possible reason for having higher constant soil losses for higher magnitude events could be that the larger rainfall events cover a greater surface area of permeable soil and rocks which allow a greater capture of the rainfall and overland flow before it enters the stream channels. Other basin parameters remained the same between the two storms except that the lower channel losses were decreased to better replicate the peak at Station 16701300, Junction 5 in the model (Figure 8; Table 3). This calibrated model was then used for synthetic flow frequency analysis. Tables 6 and 7 summarize the initial and constant loss rates determined for the Waiakea Stream watershed, while Tables 8 and 9 summarize the Snyder Unit Hydrograph and Muskingum-Cunge routing parameters respectively.

Table 5. HEC-HMS Model Basin and Reach Calibrated Storm Parameters for Waiakea Stream, Hilo, Hawaii

Basin or Reach Characteristics		Soil Loss Data for Calibration Storms				Snyder's Unit Hydrograph Parameters	
Sub-Basin	**Drainage Area (mi^2)**	**Percent Impervious**	**Initial Loss (inches)**	**April 2004 Storm Constant Loss (inches)**	**November 2000 Storm Constant Loss (inches)**	**Lag (hour)**	**Peaking Coefficient Cp**
Hoaka 7006	12.2 [a]	0 %	4.1	0.26	2.4	0.25	0.21
Kupulau	1.63 [b]	0 %	4.2	0.27	2.2	0.3	0.21
Waiakea Town	0.47	5 %	4.4	0.29	2.2	0.3	0.21
Tributary 3	0.93	3 %	4.4	0.29	2.2	0.5	0.21
Tributary 2	0.28	5 %	4.4	0.29	2.2	0.3	0.21
Tributary 1	0.09	5 %	4.4	0.29	2.2	0.3	0.21
Waiakea 7013	0.68	3 %	4.5	0.32	2.2	1.0	0.21

	Muskingham-Cunge Routing Parameters						Percent Channel Flow Loss [c]
Reach	**Length (feet)**	**Slope (feet/feet)**	**Manning's n**	**Shape**	**Width (feet)**	**Side Slopes**	
Upper	2600	0.028	0.045	Trapezoid	30	1H:1V	15
Main	8000	0.036	0.04	Trapezoid	35	1H:1V	20
Uka Channel	1700	0.015	0.04	Trapezoid	35	1H:1V	0
Komohana	500	0.03	0.03	Trapezoid	35	1H:1V	0
Lower	6000	0.04	0.045	Trapezoid	35	1H:1V	30/15 [d]

	Baseflow Recession Parameters			Rain Gage Weight for Calibration Storms		
Sub-Basin	**Initial Discharge**	**Recession Constant**	**Ratio to Peak**	**Waiakea Uka 85.2**	**Waiakea SCD 88.2**	**Hilo Airport**
Hoaka 7006	10	0.30	0.35	0.80	0.20	----
Kupulau	1	0.30	0.35	0.80	0.20	----
Waiakea Town	0.01	0.20	0.25	0.50	----	0.50
Tributary 3	0.01	0.20	0.25	0.50	----	0.50
Tributary 2	0.01	0.20	0.25	0.50	----	0.50
Tributary 1	0.01	0.20	0.25	0.50	----	0.50
Waiakea 7013	0.01	0.20	0.35	----	----	1.0

[a] Effective drainage area for runoff computations, topographic drainage area is 31.5 mi^2.
[b] A drainage area of 1.87 mi^2 was used for calibrating the November 2000 storm and for the frequency storm calculations of the 2%, 1%, 0.5%, and 0.2% storms. This additional area represents potential in-flow from the Kupulau Ditch from area outside the topographic drainage area for this sub-basin. The 1.63 mi^2 drainage area was used in the April 2004 storm calibration and in the frequency storm computations for the 50%, 20%, 10%, and 4% storms.
[c] Diversions of channel flows to represent losses due to the high permeability of the volcanic rocks in the stream channels.
[d] The lower channel loss of 15% was used for the November 2000 storm calibration and for the frequency storm calculations of the 2%, 1%, 0.5%, and 0.2% storms. The higher 30% loss was used in the April 2004 storm calibration and in the frequency storm computations for the 50%, 20%, 10%, and 4% storms.

Table 6. HEC-HMS Frequency Storm Initial Loss Rates for Waiakea Stream Sub-Basins

Basin Characteristics			Initial Loss Rate (in.)							
Sub-basin	**Drainage Area (sq mi)**	**Imperv-iousness (%)**	**50%**	**20%**	**10%**	**4%**	**2%**	**1%**	**0.2%**	**0.5%**
Hoaka 7006	12.2[a]	0 %	4.6	4.6	4.6	4.6	4.1	4.4	4.1	4.1
Kupulau Ditch	1.63[b]	0 %	4.6	4.6	4.6	4.6	4.2	4.4	4.2	4.2
Waiakea Town	0.47	5 %	4.6	4.6	4.6	4.6	4.4	4.4	4.4	4.4
Tributary 3	0.93	3 %	4.6	4.6	4.6	4.6	4.4	4.4	4.4	4.4
Tributary 2	0.28	5 %	4.6	4.6	4.6	4.6	4.4	4.4	4.4	4.4
Tributary 1	0.09	5 %	4.6	4.6	4.6	4.6	4.4	4.4	4.4	4.4
Waiakea 7013	0.68	3 %	4.6	4.6	4.6	4.6	4.5	4.4	4.5	4.5

a Effective drainage area for runoff computations, topographic drainage area is 31.5 mi^2.
b A drainage area of 1.87 mi^2 was used for calibrating the November 2000 storm and for the frequency storm calculations of the 2%, 1%, 0.5%, and 0.2% storms. This additional area represents potential in-flow from the Kupulau Ditch from area outside the topographic drainage area for this sub-basin. The 1.63 mi^2 drainage area was used in the April 2004 storm calibration and in the frequency storm computations for the 50%, 20%, 10%, and 4% storms.

Table 7. HEC-HMS Frequency Storm Constant Loss Rates for Waiakea Stream Sub-Basins

Basin Characteristics			Constant Loss Rate (in/hr)							
Sub-basin	**Drainage Area (sq mi)**	**Imperv-iousness (%)**	**50%**	**20%**	**10%**	**4%**	**2%**	**1%**	**0.2%**	**0.5%**
Hoaka 7006	12.2[a]	0 %	2.4	2.4	2.4	2.4	2.4	2.3	2.4	2.4
Kupulau Ditch	1.63[b]	0 %	2.4	2.4	2.4	2.4	2.2	2.3	2.2	2.2
Waiakea Town	0.47	5 %	2.4	2.4	2.4	2.4	2.2	2.3	2.2	2.2
Tributary 3	0.93	3 %	2.4	2.4	2.4	2.4	2.2	2.3	2.2	2.2
Tributary 2	0.28	5 %	2.4	2.4	2.4	2.4	2.2	2.3	2.2	2.2
Tributary 1	0.09	5 %	2.4	2.4	2.4	2.4	2.2	2.3	2.2	2.2
Waiakea 7013	0.68	3 %	2.4	2.4	2.4	2.4	2.2	2.4	2.2	2.2

a Effective drainage area for runoff computations, topographic drainage area is 31.5 mi^2.
b A drainage area of 1.87 mi^2 was used for calibrating the November 2000 storm and for the frequency storm calculations of the 2%, 1%, 0.5%, and 0.2% storms. This additional area represents potential in-flow from the Kupulau Ditch from area outside the topographic drainage area for this sub-basin. The 1.63 mi^2 drainage area was used in the April 2004 storm calibration and in the frequency storm computations for the 50%, 20%, 10%, and 4% storms.

Table 8. HEC-HMS Frequency Storm Snyder Unit Hydrograph Parameters for Waiakea Stream Sub-Basins

Basin Characteristics		**Snyder's Unit Hydrograph Parameters**	
Sub-Basin	**Drainage Area (mi²)**	**Lag (hour)**	**Peaking Coefficient Cp**
Hoaka 7006	12.2 [a]	0.25	0.21
Kupulau	1.63 [b]	0.3	0.21
Waiakea Town	0.47	0.3	0.21
Tributary 3	0.93	0.5	0.21
Tributary 2	0.28	0.3	0.21
Tributary 1	0.09	0.3	0.21
Waiakea 7013	0.68	1.0	0.21

Table 9. HEC-HMS Frequency Storm Muskingum-Cunge Routing Parameters for Waiakea Stream Reaches

	Muskingham-Cunge Routing Parameters						**Percent Channel Flow Loss [c]**
Reach	**Length (feet)**	**Slope (feet/feet)**	**Manning's n**	**Shape**	**Width (feet)**	**Side Slopes**	
Upper	2600	0.028	0.045	Trapezoid	30	1H:1V	15
Main	8000	0.036	0.04	Trapezoid	35	1H:1V	20
Uka Channel	1700	0.015	0.04	Trapezoid	35	1H:1V	0
Komohana	500	0.03	0.03	Trapezoid	35	1H:1V	0
Lower	6000	0.04	0.045	Trapezoid	35	1H:1V	30/15 [d]

[c] Diversions of channel flows to represent losses due to the high permeability of the volcanic rocks in the stream channels.

[d] The lower channel loss of 15% was used for the November 2000 storm calibration and for the frequency storm calculations of the 2%, 1%, 0.5%, and 0.2% storms. The higher 30% loss was used in the April 2004 storm calibration and in the frequency storm computations for the 50%, 20%, 10%, and 4% storms

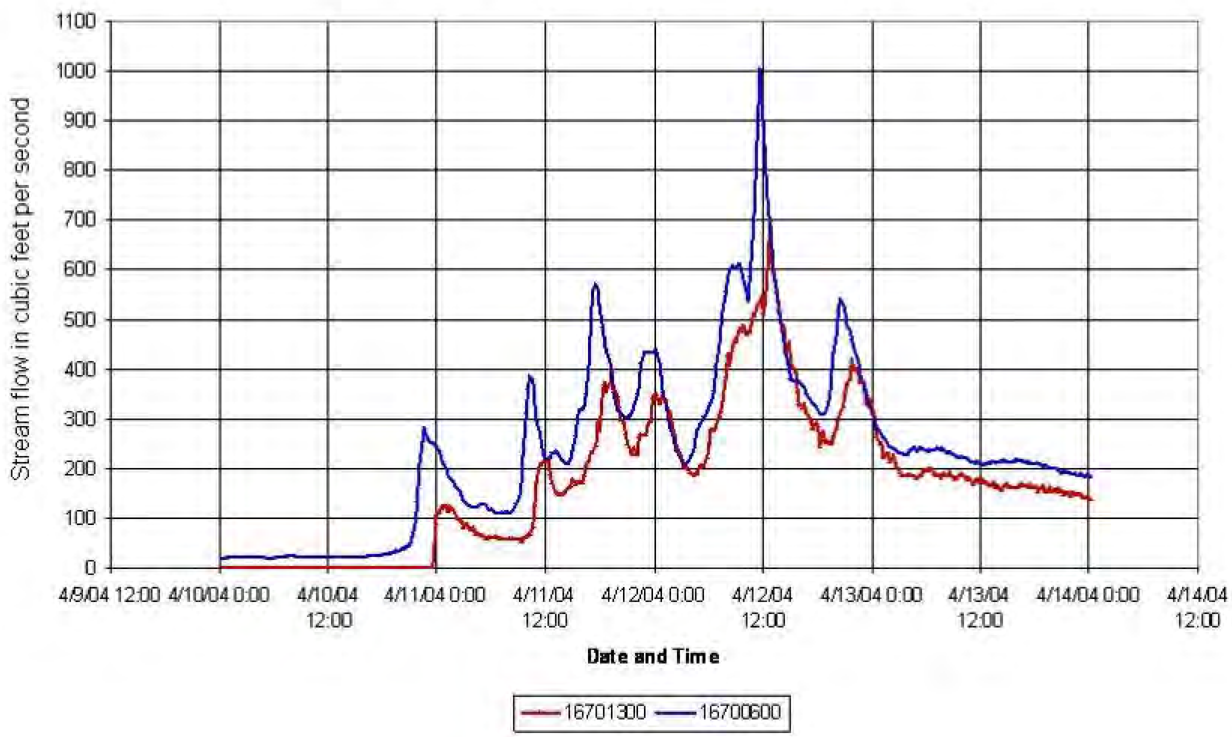


Figure 5. – Stream Flow Hydrographs, April 10-13, 2004, at USGS Stations 16700600 and 16701300 on Waiakea Stream

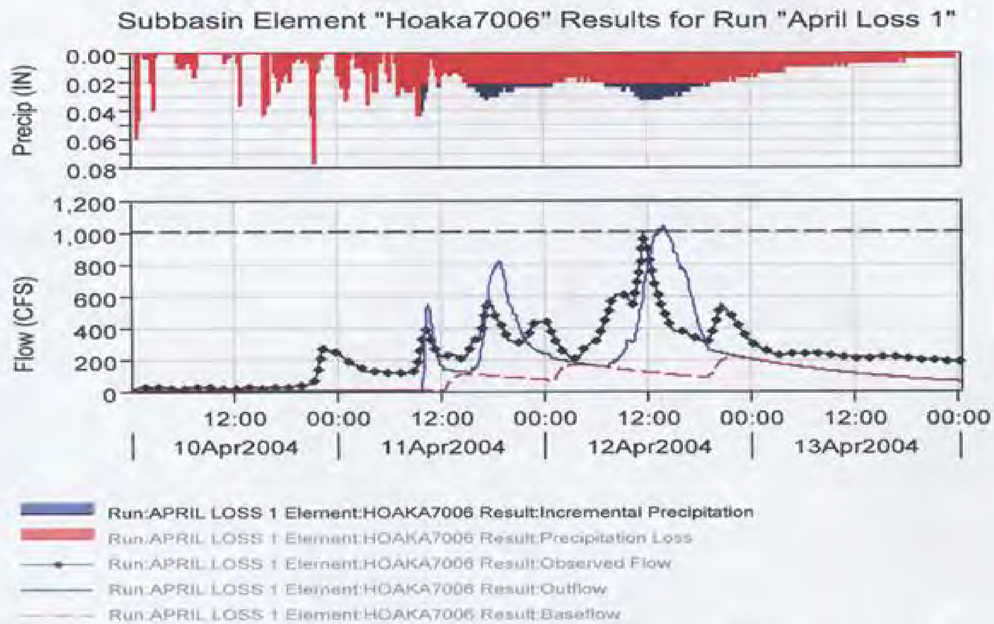


Figure 6. HEC-HMS Model Results versus Observed Data at USGS Station 16700600, Waiakea Stream near Hoaka Road, upstream end of Waiakea Stream Study Area, Hilo, Hawaii

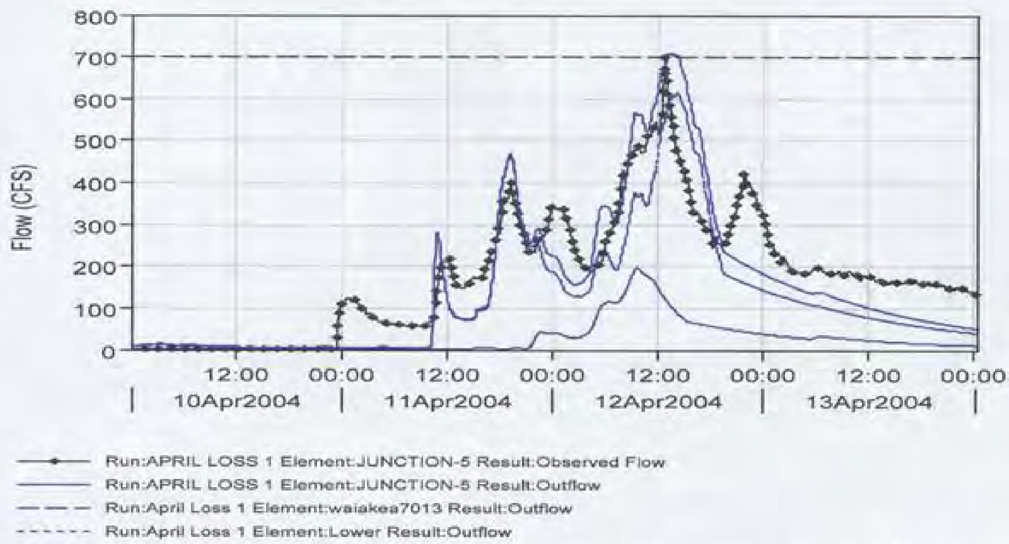


Figure 7. HEC-HMS Model Results versus Observed Data at USGS Station 16701300, Waiakea Stream near Hilo, downstream end of Waiakea Stream Study Area, Hilo, Hawaii

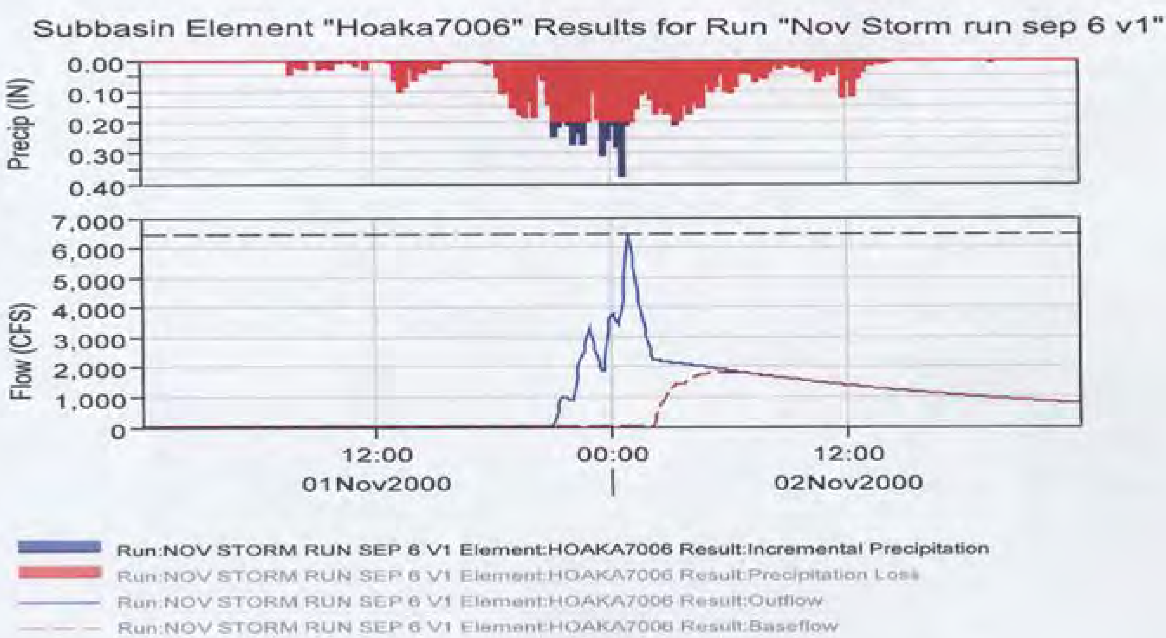


Figure 8. HEC-HMS Model Results at USGS Station 16700600, Waiakea Stream near Hoaka Road, upstream end of Waiakea Stream Study Area, Hilo, Hawaii for November 1-2, 2000 Storm Event

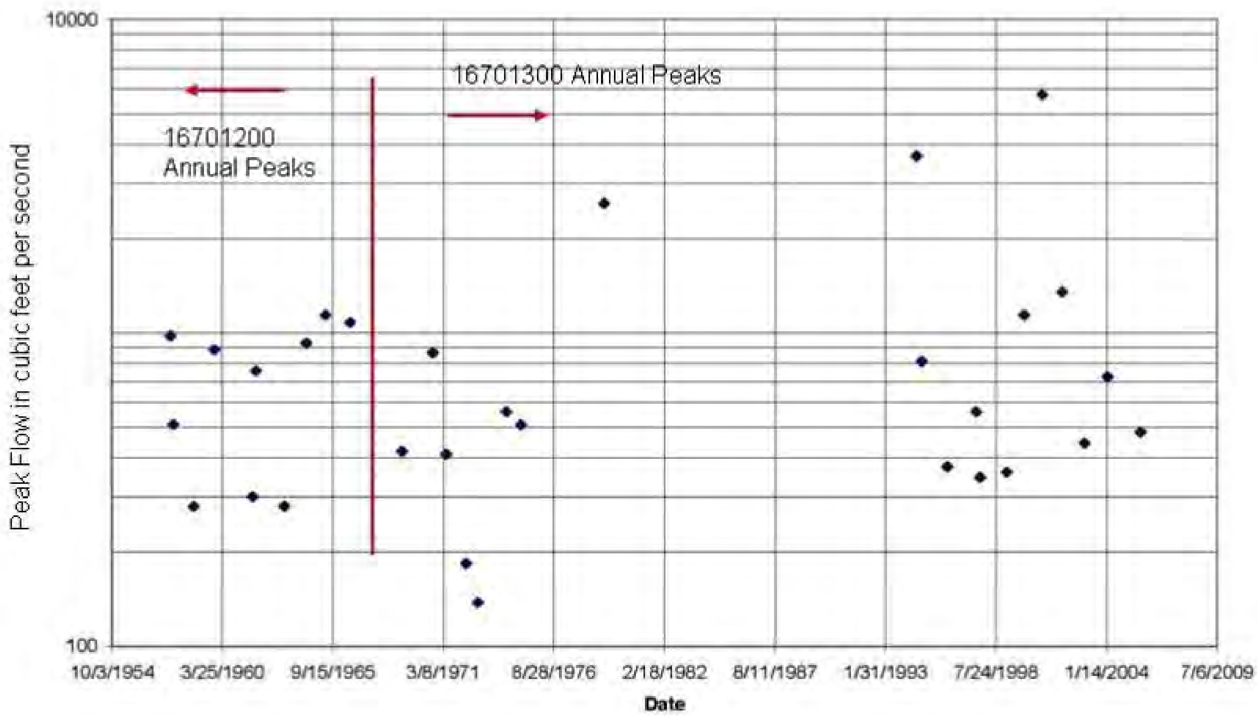


Figure 9. Annual Peak Flow Data at USGS Gage Stations 16701200 and 16701300, Waiakea Stream

2.5 Palai Stream and Four Mile Creek HEC-HMS Rainfall-Runoff Model. Similar to Waiakea Stream, a lumped basin watershed model was constructed using the HEC-HMS software program. Calibration of this model involves reconstituting basin parameters from past storms at Wailuku River because these records contain the closest continuous stream gage information to Palai Stream with complete rainfall and runoff data. These basin parameters are used in running a separate model with hypothetical storm rainfall to match the USGS gage station 16701400 statistics as described in Section 1.5.1, Runoff Characteristics. Further discussion on the USGS gage 16701400 gage statistics can be found in Section 2.7, Frequency Analysis. These basin parameters will then be compared to the historical peak, November 2000 storm within Palai Basin and Four Mile Creek for model continuity.

For this model, the hydrograph parameters selected are initial constant loss for rainfall runoff loss rates, Snyder's unit hydrograph for unit hydrograph determination, and lag time used for routing hydrographs from higher elevation watersheds through lower elevation watersheds with a slightly defined channel.

Snyder's peaking coefficient was estimated from the reconstitution of the Wailuku River for two storms, 26 August 1970 and 23 January 1979, using HEC-HMS. Values for Snyder lag in hours and the unit-less peaking coefficient were taken from the Alenaio Stream study (U.S. Army Corps of Engineers, 1990). The rainfall runoff loss method used was the initial constant method because it provided a fairly simple and straight-forward approach. The Alenaio Stream study (U.S. Army Corps of Engineers, 1990) used a former version of HEC-HMS, HEC-1, which contained a different method for the rainfall runoff loss function which is unavailable in HEC-HMS. The selection of the initial constant loss values for the reconstitution of the two storms used a "best-fit" or "optimized" value for each storm in generating the outputs for peak flow and discharge volume. Baseflow was considered negligible as runoff occurs only as a direct response to high intensity rainfall. The input and output values for the reconstitution of the two storms are shown in Table 10 and Table 11 respectively.

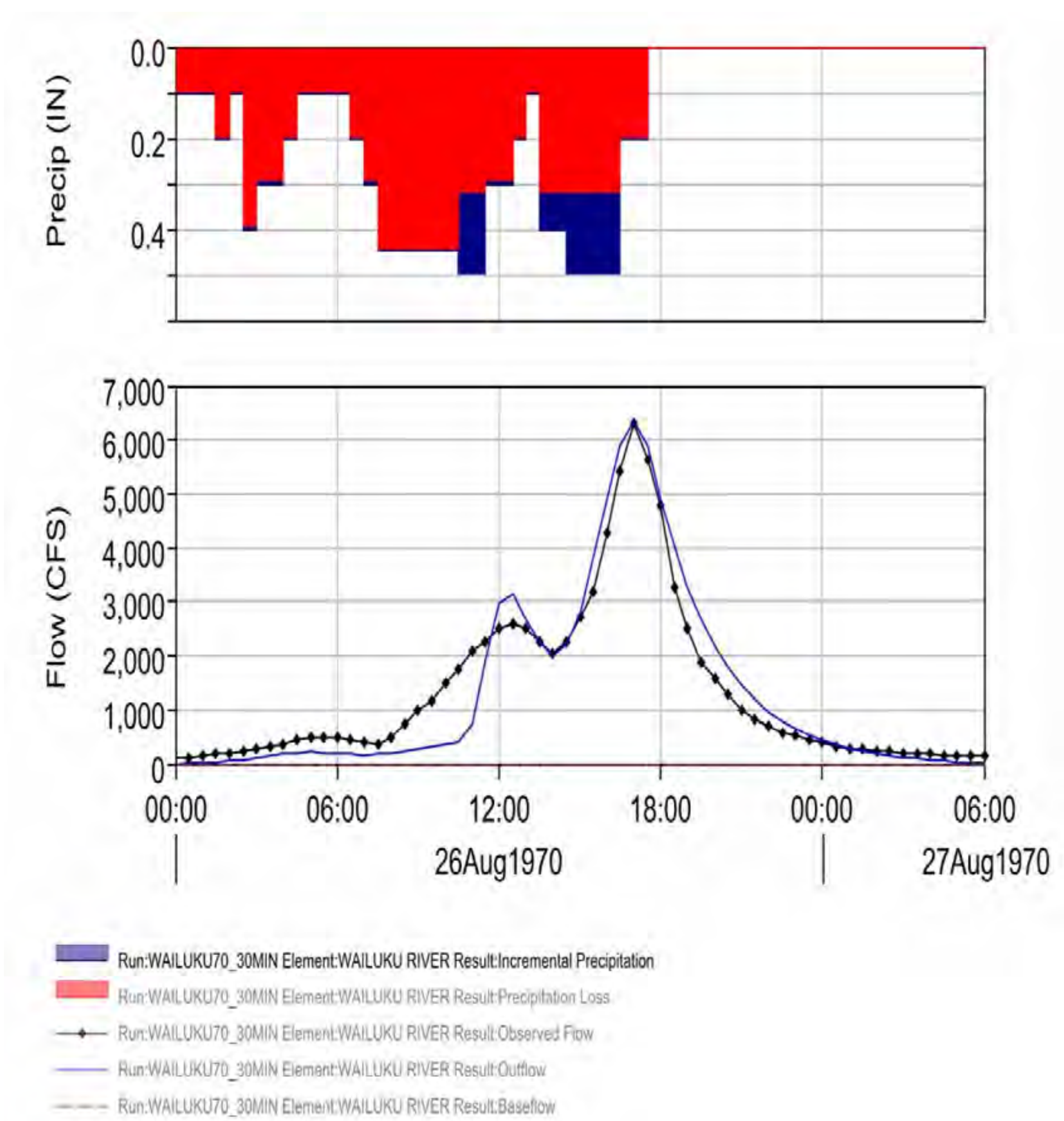
Table 10. Wailuku River Reconstitution: Input for 1970 and 1979 Storms

			Rainfall Runoff Parameters			Snyder Hydrograph Parameters from Alenaio Report March 1990	
Gage	**Date**	**Area (Sq mi)**	**Initial Loss (in)**	**Constant Loss (in)**	**% Imper-vious**	**Lag (hrs)**	**Cp, Peaking Coeff.**
Wailuku River near Kaumana (7018)	26Aug70	43.4	5.40 in	0.65 in	2%	1.30 hrs	0.41
	23Jan79	43.4	1.10 in	0.47 in	2%	2.40 hrs	0.49

Table 11. Wailuku River Reconstitution: Output for 1970 and 1979 Storms

		Qp, Peak Flow Output (ft^3/s; cfs)		Volume of Discharge (in)	
Gage	**Date**	**HMS Model Calc**	**Observed**	**HMS Model Calc**	**Observed**
Wailuku River near Kaumana (7018)	26Aug70	6,340	6,325	1.39 in	1.43 in
	23Jan79	5,630	5,690	1.75 in	1.75 in

Graphical output hydrographs and rainfall hyetographs for the reconstitution of these two storms are shown in Figure 10 and 11. From the reconstitution of the two storms for Wailuku River, the Snyder Peaking Coefficient, Cp, is assumed constant throughout the northeast windward territory of Hawaii which includes the Hilo District area. An average value of 0.45 for the Snyder Peaking Coefficient, Cp, will be used and applied to both Palai Stream and Four Mile Creek.

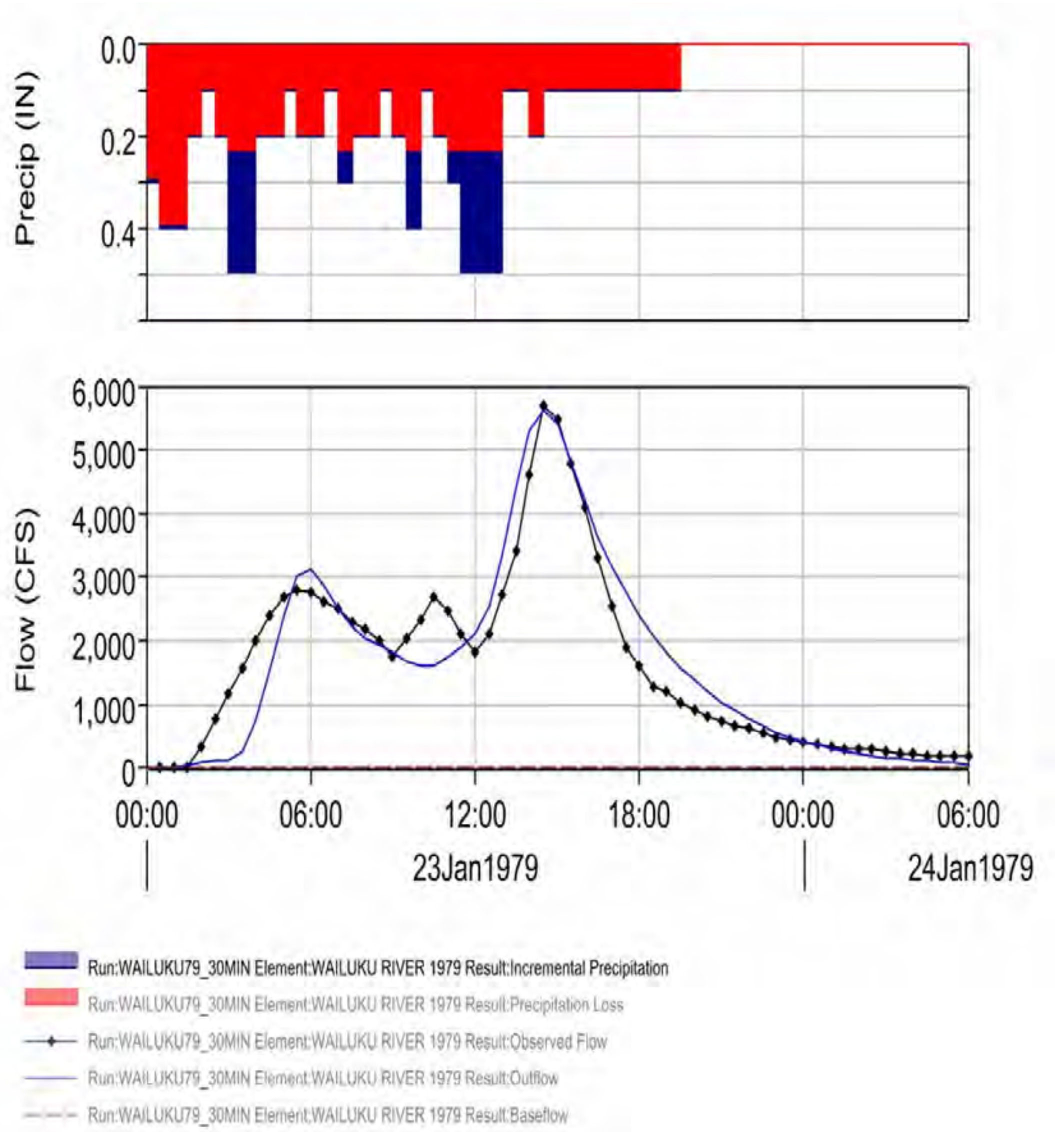


PALAI STREAM HILO, HAWAII

WAILUKU RIVER RECONSTITUITION FROM 1970 STORM

U.S. ARMY ENGINEER DISTRICT, HONOLULU

FIGURE 10. Flow Hydrograph Wailuku River from 1970 Storm



PALAI STREAM HILO, HAWAII

WAILUKU RIVER RECONSTITUITION FROM 1979 STORM

U.S. ARMY ENGINEER DISTRICT, HONOLULU

FIGURE 11. Flow Hydrograph Wailuku River from 1979 Storm

The initial constant loss rate for the HEC-HMS model is determined by a "best fit" method in achieving the peak flow rate from the USGS gage station 16701400 statistics. The frequencies used in the HEC-HMS model are from the statistical analysis of the gage station 16701400. The frequencies are the 50-, 10-, 4-, 2-, and 1- % ACP floods with peak flows of 565, 1,070, 1,360, 1,600, and 1,860 ft^3/s (from computation done in 2004), respectively. Based on information from Rick Fontaine (Hydrologist, U.S. Geological Survey, Oral Comm., 2002), and the Soil Survey (Sato and others, 1973), states that soil permeabilities in this region are between 2.0 to 6.0 in/hr aided in refining the rainfall loss amount. Rainfall losses are shown in Tables 12 to 15 with increasing constant loss rainfall from 50- to 1- % flood. The percentage impervious is measured and approximated from various maps.

Table 12. HEC-HMS Frequency Storm Initial Loss Rates for Palai Stream Sub-Basins

Basin Characteristics			Initial Loss Rate (in.)							
Sub-basin	**Drainage Area (sq mi)**	**Imperv-iousness (%)**	**50%**	**25%**	**10%**	**4%**	**2%**	**1%**	**0.2%**	**0.5%**
Upcountry P1	3.27	0 %	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
d/s Maunakai St P2	0.49	2 %	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
d/s Maunakai St P3	0.67	5 %	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Hilo Golf Course P4	0.47	3 %	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Kanoelehua Ave P5	0.26	2 %	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Puainako St P6	1.65	10 %	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Waiakea Pond P7	0.85	10 %	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0

Table 13. HEC-HMS Frequency Storm Constant Loss Rates for Palai Stream Sub-Basins

Basin Characteristics			Constant Loss Rate (in/hr)							
Sub-basin	**Drainage Area (sq mi)**	**Imperv-iousness (%)**	**50%**	**20%**	**10%**	**4%**	**2%**	**1%**	**0.2%**	**0.5%**
Upcountry P1	12.2[a]	0 %	3.28	4.0	4.45	4.64	4.96	5.14	5.35	5.6
d/s Maunakai St P2	1.63[b]	0 %	3.28	4.0	4.45	4.64	4.96	5.14	5.35	5.6
d/s Maunakai St P3	0.47	5 %	3.28	4.0	4.45	4.64	4.96	5.14	5.35	5.6
Hilo Golf Course P4	0.93	3 %	3.28	4.0	4.45	4.64	4.96	5.14	5.35	5.6
Kanoelehua Ave P5	0.28	5 %	3.28	4.0	4.45	4.64	4.96	5.14	5.35	5.6
Puainako St P6	0.09	5 %	3.28	4.0	4.45	4.64	4.96	5.14	5.35	5.6
Waiakea Pond P7	0.68	3 %	3.28	2.4	4.45	4.64	4.96	5.14	5.35	5.6

Table 14. HEC-HMS Frequency Storm Initial Loss Rates for Four Mile Creek Sub-Basins

Basin Characteristics			Initial Loss Rate (in.)							
Sub-basin	**Drainage Area (sq mi)**	**Imperv-iousness (%)**	**50%**	**20%**	**10%**	**4%**	**2%**	**1%**	**0.2%**	**0.5%**
Upcountry F1	2.41	0 %	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Tributary 2 F2	0.74	0 %	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Tributary3 F3	1.23	0 %	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
FourMile & Tributary 2 F4	0.39	1 %	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Tributary 1 F5	1.17	0 %	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Kilauea Ave F6	0.29	2 %	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Kanoelehua Ave F7	0.06	1 %	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Near quarry F8	0.92	1 %	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0

Table 15. HEC-HMS Frequency Storm Constant Loss Rates for Four Mile Creek Sub-Basins

Basin Characteristics			Constant Loss Rate (in/hr)							
Sub-basin	**Drainage Area (sq mi)**	**Imperv-iousness (%)**	**50%**	**20%**	**10%**	**4%**	**2%**	**1%**	**0.2%**	**0.5%**
Upcountry F1	2.41	0 %	3.28	4.0	4.45	4.64	4.96	5.14	5.35	5.6
Tributary 2 F2	0.74	0 %	3.28	4.0	4.45	4.64	4.96	5.14	5.35	5.6
Tributary3 F3	1.23	0 %	3.28	4.0	4.45	4.64	4.96	5.14	5.35	5.6
Four Mile & Tributary 2 F4	0.39	1 %	3.28	4.0	4.45	4.64	4.96	5.14	5.35	5.6
Tributary 1 F5	1.17	0 %	3.28	4.0	4.45	4.64	4.96	5.14	5.35	5.6
Kilauea Ave F6	0.29	2 %	3.28	4.0	4.45	4.64	4.96	5.14	5.35	5.6
Kanoelehua Ave F7	0.06	1 %	3.28	2.4	4.45	4.64	4.96	5.14	5.35	5.6
Near quarry F8	0.92	1 %	3.28	4.0	4.45	4.64	4.96	5.14	5.35	5.6

Using HEC-HMS, the hypothetical storms were modeled with the Snyder Peaking Coefficient value from the reconstitution of the Wailuku River storms as described. The Snyder Lag is approximated to be 60% of the time of concentration, Tc. The time of concentration is calculated from the travel time via sheet flow, shallow flow, and channel flow. Time of concentration and the time to peak, Snyder's Lag, are usually close in value to each other because storms on the Big Island tend to form hydrographs with sharp peaks with an immediate recession limb due to the steep slopes of the upper watershed areas; neither Tc nor Snyder's Lag duration are more than several hours apart. Snyder coefficients are found in Table 16 and 17.

The hydrograph routing method used is Lag time in minutes due to the lack of detailed information on the channel terrain. This Lag time is approximated by the time of travel within the channel from the start to exit points. This information can be found in Tables 16 and 17. See Figure 12 for the HEC-HMS Model setup.

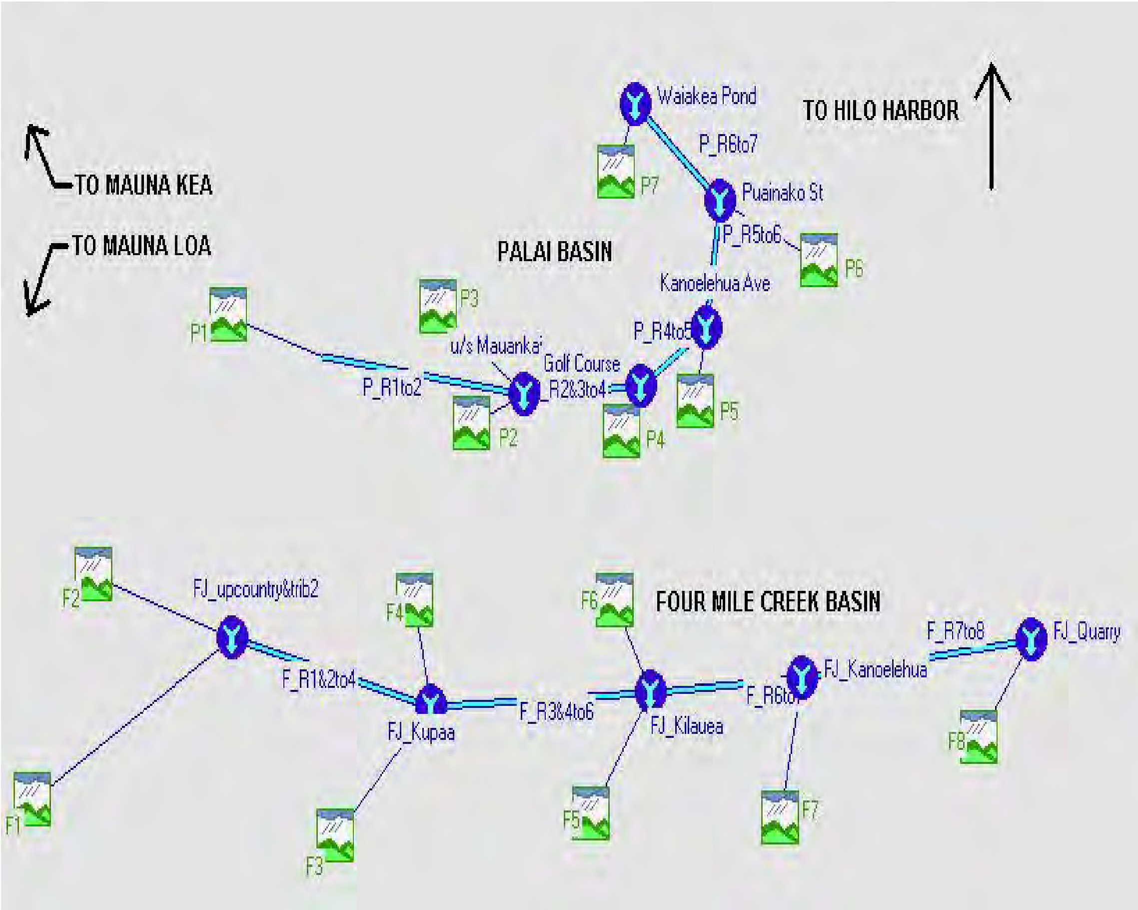
Once the Palai Basin (summation of P1 to P7) input matches output values for the USGS gage station 16701400, the same initial and constant loss rates are applied to Four Mile Creek. Baseflow is considered negligible as runoff occurs only as a direct response to high intensity rainfall. See Table 19 and 20, HEC-HMS output Model for Hypothetical Storms.

Table 16. HEC-HMS Input Model for Palai Stream Sub-Areas (Runoff Transform and Routing)

Palai Sub-Area	**Drainage Area (sq mi)**	**Snyder Lag, Tp (hrs)**	**Snyder Peaking Coefficient, Cp**	**Reach, Lag Method (min)**
P1 Upcountry Palai	3.27 sq mi	1.61 hrs	0.45	
P_R1to2				32.00 min
P2 d/s Maunakai Street	0.49 sq mi	0.32 hrs	0.45	
P3 d/s Maunakai Street	0.67 sq mi	0.17 hrs	0.45	
J_d/s Maunakai Street	**4.43 sq mi**			
P_R2&3to4				4.00 min
P4 Hilo Golf Course	0.47 sq mi	0.10 hrs	0.45	
J_Hilo Golf Course	**4.90 sq mi**			
P_R4to5				3.00 min
P5 Kanoelehua Ave	0.26 sq mi	0.10 hrs	0.45	
J_Kanoelehua Ave	**5.16 sq mi**			
P_R5to6				11.00 min
P6 Puainako Street	1.65 sq mi	0.11 hrs	0.45	
J_Puainako Street	**6.81 sq mi**			
P_R6to7				16.00 min
P7 Waiakea Pond	0.85 sq mi	0.15 hrs	0.45	
J_Waiakea Pond	**7.66 sq mi**			

Table 17. HEC-HMS Input Model for Four Mile Creek Sub-Areas (Runoff Transform and Routing)

Four Mile Creek Sub-Area	Drainage Area (sq mi)	Snyder Lag, Tp (hrs)	Snyder Peaking Coefficient, Cp	Reach, Lag Method (min)
F1 Upcountry 4Mi	2.41 sq mi	0.99 hrs	0.45	
F2 Trib2	0.74 sq mi	0.44 hrs	0.45	
F_R1&2to4				7.00 min
F3 Trib3	1.23 sq mi	1.03 hrs	0.45	
F4 4Mi&Trib2	0.39 sq mi	0.10 hrs	0.45	
FJ_Kupaa Street	**4.77 sq mi**			
F_R3&4to6				7.00 min
F5 Trib1	1.17 sq mi	0.84 hrs	0.45	
F6 Kilauea Ave	0.29 sq mi	0.10 hrs	0.45	
FJ_Kilauea Ave	**6.23 sq mi**			
F_R6to7				0.00 min
F7 Kanoelehua Ave	0.06 sq mi	0.10 hrs	0.45	
FJ_Kanoelehua Ave	**6.29 sq mi**			
F8 Near Quarry	0.92 sq mi	0.10 hrs	0.45	
F_R7to8				7.00 min
FJ_Near Quarry	**7.21 sq mi**			



EXISTING CONDITION: HEC-HMS PALAI AND FOUR MILE CREEK BASIN MODEL

PALAI STREAM HILO, HAWAII

EXISTING CONDITION:
HEC-HMS MODEL
Palai Stream and Four Mile Creek

U.S. ARMY ENGINEER DISTRICT, HONOLULU

FIGURE 12. HEC-HMS Model Schematic Palai Stream and Four Mile Creek

The November 1-2, 2000 storm resulted in a peak flow of 1,580 ft^3/s at USGS gage station 16701400 which is about a 2% AEP flood according to the gage statistics. This gage location corresponds to Palai Basin (summation of P1 to P5) junction at Kanoelehua Avenue in Figure 12. The 1,580 ft^3/s peak is the highest recorded at this location since data collection began in 1965. The previous peak of record was 1,260 ft^3/s from the 1979 storm. Figure 13 shows the observed precipitation data for the meteorological and control model received from the Waiakea Uka rain gage on November 1-2, 2000 located at latitude 19 degrees, 40 minutes north, and longitude 155 degrees, 8 minutes west. The input for the 1-2 November 2000 storm over the Palai Basin in HEC-HMS is the same as in Tables 12 to 15 except for the constant loss rate. A constant loss rate of 2.36 inches per hour was used for the November 2000 storm to produce a peak flow of 1,580 ft^3/s at the USGS gage station 16701400 location. Table 18 compares the hypothetical storms with the November 2000 storm. From Table 18, the constant loss rate of 2.36 inches per hour for the November 2000 storm shows that the rainfall frequency is less than the 50-percent hypothetical storm constant loss rate. However, when comparing peak flows at the USGS gage station 16701400, the November 2000 storm is about a 2% AEP flood. One other point of notice is the volume of 725 acre-feet for the November 2000 storm which is larger than the volume of the 1% hypothetical storm. The conclusion from this is that the November 2000 storm had a different storm pattern than the hypothetical storms. However, the model still was able to portray the hypothetical and November 2000 storm patterns by varying the constant loss rates. The output for the 1-2 November 2000 storm over Palai Basin and Four Mile Creek Basin in HEC-HMS is shown in Tables 19 and 20 respectively.

Table 18. HEC-HMS Model: Comparison of Hypothetical vs November 2000 Storm

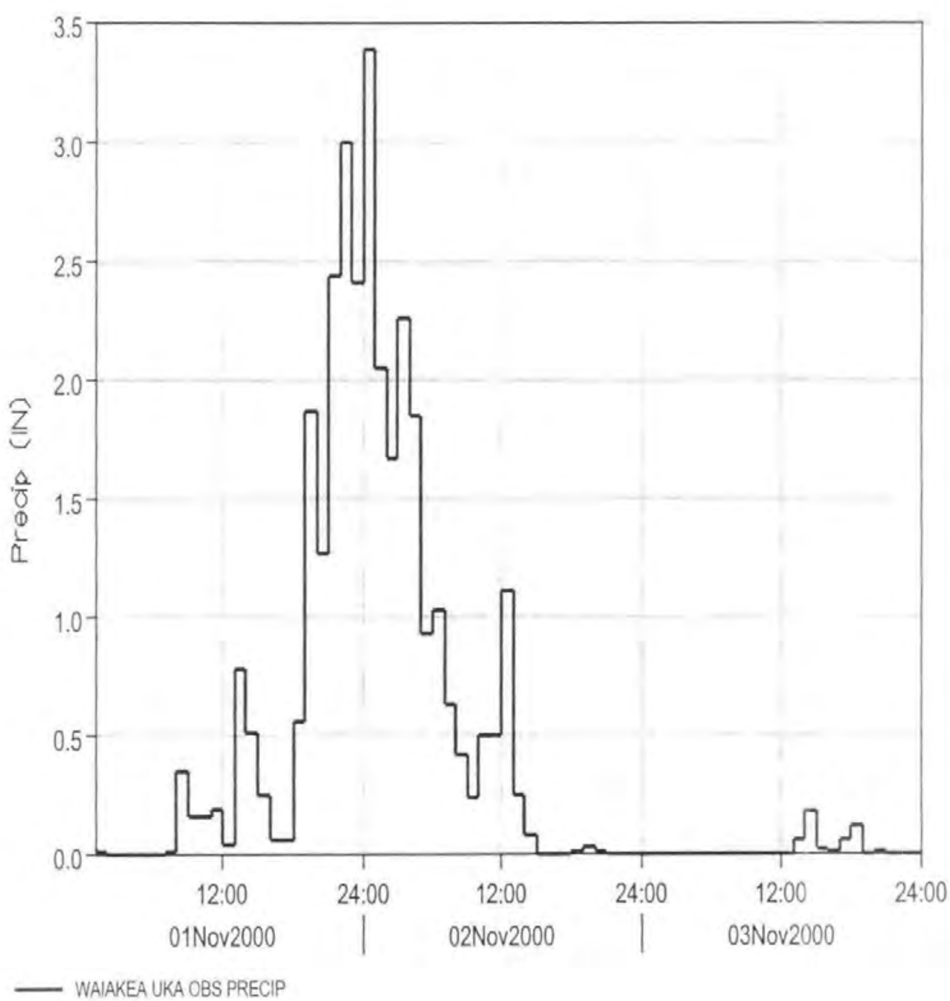
Description	Hypothetical Storm Frequency Flood					Nov 2000 Flood
	1%	2%	4%	10%	50%	
All Palai Sub-Areas Constant Loss Rate (in/hr)	5.14 in/hr	4.96 in/hr	4.64 in/hr	4.45 in/hr	3.28 in/hr	2.36 in/hr
J_Kanoelehua Ave Peak Flows (ft^3/s) DA=5.16 sq. mi.	1,860 ft^3/s	1,600 ft^3/s	1,360 ft^3/s	1,070 ft^3/s	565 ft^3/s	1,580 ft^3/s
J_Kanoelehua Ave Volume (ac-ft) DA=5.16 sq. mi.	690 ac-ft	595 ac-ft	505 ac-ft	400 ac-ft	210 ac-ft	725 ac-ft

Table 19. HEC-HMS Output Model for 1-2 November 2000 Storm at Palai Basin

Description	Drainage Area (sq mi)	Discharge Peak (ft3/s)	Volume (ac-ft)
J_ u/s Maunakai	4.43	1,290	605
J_Golf Course	4.90	1,480	685
J_Kanoelehua Ave	5.16	1,580	725
J_Puainako Street	6.81	2,450	1,180
J_Waiakea Pond	7.66	2,840	1,410

Table 20. HEC-HMS Output Model for 1-2 November 2000 Storm at Four Mile Creek

Description	Drainage Area (sq mi)	Discharge Peak (ft3/s)	Volume (ac-ft)
FJ_Upcountry&Trib2	3.15	1,240	385
FJ_Kupaa	4.77	1,860	585
FJ_Kilauea	6.23	2,420	770
FJ_Kanoelehua	6.29	2,450	780
FJ_Quarry	7.21	2,790	905



DATA USED IN METEOROLOGIC AND CONTROL MODEL

PALAI STREAM HILO, HAWAII

WAIAKEA UKA RAIN GAGE OBSERVED PRECIPITATION, 1-2 NOVEMBER 2000

U.S. ARMY ENGINEER DISTRICT, HONOLULU

FIGURE 13. November 2000 Storm Observed Precipitation Waiakea Uka Rain Gage

2.6 Frequency Analysis.

2.6.1 Recorded Data. The statistical frequency analysis was conducted following Bulletin 17B guidelines which use the Log-Pearson Type III method to compute frequency flows (Interagency Committee on Water Data, 1982). Annual flood peaks from Waiakea Stream at USGS gage stations 16701200 and 16701300 were combined to compute a single frequency curve which was assigned to the station 16701300 site for "best estimate" comparison purposes. This was done based on fact that the drainage area differences between the two stations is less than 10 percent (Thomas, 2001) and a comparison of flood peaks from these two stations over time (Figure 9) showed that the two annual series of peaks are not disparate. Frequency analysis on data from USGS gage station 16700000 was not done since such data are not representative of the flood frequency near the detailed study area. Frequency analysis on data from USGS gage station 16701400 was done for Palai Stream. There are no stream gages located on Four Mile Creek. The program HEC-SSP which follows the Bulletin 17B guidelines was used to conduct the frequency calculations. Results are shown in Tables 21 and 22.

A comparison of flood peaks on the same date between USGS gage stations 16700600 and 16701300 indicated that flood peaks were about 11 to 118 percent greater on average at USGS gage station 16700600 due to peak flow attenuation with a higher percentage loss at lower peak flows (Table 4). Therefore, an adjustment of adding 11 percent to the flood frequency values at USGS gage station 16701300 were assigned as the flood frequency values at Station USGS gage station 16700600, based on the peak flow of November 1-2, 2000. By a simple drainage area ratio adjustment, the values at USGS gage station 16700600 would be increased by about 13 percent, a similar amount. Flood frequency estimates were not transferred to other locations in the detailed study area due to the inability to properly account for tributary inflow and stream channel losses in those areas by frequency analysis.

Table 21. Peak Flow Frequency Values computed at Station 16701300 and estimated at Station 16700600 Waiakea Stream, Hilo, Hawaii

Percent Chance Exceedance	Recurrence Interval (years)	Station 16701300 Peak Flow Computation (ft^3/s)	95% Confidence Limits for Peak Flow Estimate at Station 16701300		Adjusted Peak Flow Estimate for Station 16700600 (ft^3/s)
			Lower (ft^3/s)	Upper (ft^3/s)	
50%	2	645	510	816	716
20%	5	1,400	1,070	1,850	1,550
10%	10	2,130	1,550	2,960	2,370
5%	25	3,070	2,110	4,440	3,410
2%	50	4,720	2,970	7,090	5,240
1%	100	6,370	3,740	9,760	7,070
0.5%	200	8,470	4,630	13,100	9,400
0.2%	500	12,100	6,000	19,000	13,500
Peak flow values at Station 16701300 computed by procedures in Bulletin 17B using 39 events between					

1964 and 2013 from Stations 16701200 and 16701300, mean=2.819, standard deviation=0.381, and adjusted skew=0.150. Values at Station 16700600 were estimated by increasing the Station 16701300 values by 11 percent.

Annual flood peaks from Palai Stream were recorded from a peak-stage stream gage, USGS gage station 16701400. The analysis uses 23 events between 1965 and 2013 to determine the peak frequency flows. Table 22 below summarizes the annual exceedance probability flows using an adopted skew of -0.499, a standard deviation of 0.392, and a mean of 2.645. The analysis results in Table 22 are more recent and differ from that presented in Table 18 due to additional peak flow data. It does not change the calibration results in Section 2.6.

Table 22. Peak Frequency Values computed at Station 16701400, Palai Stream, Hilo, Hawaii (computation conducted in 2014)

Percent Chance Exceedance	Recurrence Interval (years)	Station 16701400 Peak Flow Computation (ft^3/s)	95% Confidence Limits for Peak Flow Estimate at Station 16701400	
			Lower (ft^3/s)	Upper (ft^3/s)
50%	2	476	347	658
20%	5	981	688	1,470
10%	10	1,385	923	2,190
5%	25	1,820	1,150	2,980
2%	50	2,430	1,430	4,140
1%	100	2,940	1,640	9,760
0.5%	200	3,470	1,850	6,080
0.2%	500	4,210	2,110	7,450

The Flood frequency Analysis information provided in this section will be updated with new data available. The brief review of current data indicates that some gages may have been relocated and missing data exists in the interim years. A new Bulletin 17C analysis will be performed with quality assurance check of available data during design stage to make sure that the model reflects the current realities on the watershed.

2.6.2 Synthetic Event Analysis. Rainfall intensity frequency data for the study area was obtained by the use of the National Oceanic and Atmospheric Administration Atlas 14 entitled "Precipitation-Frequency Atlas of the United States" (NOAA Atlas 14). Volume 4, Version 3 of this atlas, first published in 2009 and revised in 2011 contains precipitation frequency estimates for the Hawaiian Islands. These estimates for selected durations and frequencies with 90% confidence intervals and supplementary information on temporal distribution of annual maxima, analysis of seasonality, and trends in maximum series data. The results are published through the Precipitation Frequency Data Server which can be accessed at: http://hdsc.nws.noaa.gov/hdsc/pfds.

An interactive web page for the Hawaiian Islands is available from the PFDS web page - http://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_hi.html. Several options are available to obtain the precipitation information. For this study, the centroidal point of the combined

Waiakea-Palai-Four Mile watersheds was manually entered. This point, in decimal latitude and longitude is: N19.6088 and W-155.2197. The interactive web page then returns the precipitation frequency data for this point. Table 23 below shows the selected rainfall frequency intensity data used in this study.

Table 23. Rainfall Intensity Frequency Data for the Waiakea-Palai Study Area, Area Averaged between Elevations 0 to 4,000 feet, Hilo, Hawaii

	Depth (inches) for specified percent chance exceedance flood rainfall								
	100%	**50%**	**20%**	**10%**	**4%**	**2%**	**1%**	**0.5%**	**0.2%**
Duration	**1 year**	**2**	**5**	**10**	**25**	**50**	**100**	**200**	**500**
5 min	0.68	0.82	1.01	1.14	1.31	1.43	1.55	1.67	1.83
10 min	1.01	1.22	1.49	1.69	1.94	2.13	2.30	2.48	2.71
15 min	1.27	1.53	1.87	2.12	2.44	2.67	2.89	3.12	3.40
30 min	1.78	2.15	2.64	2.99	3.43	3.76	4.07	4.39	4.79
1 hour	2.34	2.83	3.47	3.93	4.51	4.94	5.35	5.77	6.30
2 hour	3.26	4.02	5.01	5.75	6.69	7.40	8.09	8.79	9.71
3 hours	3.85	4.85	6.08	7.00	8.19	9.08	9.96	10.80	12.00
6 hours	5.22	6.49	8.24	9.56	11.3	12.6	13.9	15.2	17.0
12 hours	6.92	8.70	11.1	13.0	15.5	17.4	19.4	21.4	24.1
24 hours	8.99	11.5	14.8	17.4	20.9	23.6	26.4	29.3	33.3

Rainfall frequency estimates in this table are based on frequency analysis of partial duration series. NOAA Atlas 14 Volume 4 Version 3 Precipitation-Frequency Atlas of the United States, Hawaiian Islands. NOAA, National Weather Service, Silver Spring, MD (2011). NOAA Atlas 14 provides precipitation frequency estimates for 5-minute through 60-day durations at average recurrence intervals of 1-year through 1000-year.

Flood estimates for the 50%, 20%, 10%, 4%, 2%, 1%, 0.5%, 0.2% AEP (the 2-, 5-, 10-, 25-, 50-, 100-, 200-, and 500-year floods) flood events were determined by using the calibrated HEC-HMS models. A comparison of the recorded data from the April 10-13, 2004 and November 1-2, 2000 storm events with rainfall and peak flow frequency values (discussed in detail below) indicated that the April 10-13, 2004 event was about a 99% AEP (1-year) event in rainfall magnitude and about a 50% AEP (2-year) storm in peak flow magnitude at USGS gage station 16701300 (Tables 23 and 24). The November 1-2, 2000 event was closer to a 1% AEP (100-year) event for both the rainfall and peak flow frequencies (Tables 4 and 21). Therefore, to better represent the assumption that the resulting peak flow has the same frequency as the rainfall input, the November 1-2, 2000 calibrated basin values for Waiakea Stream were used, with one exception, for the frequency storm computations.

The exception was determined by comparing the rainfall intensity values of the November 1-2, 2000 storms to the intensity-frequency rainfall (Tables 23 to 25). Rainfall values for the 50%, 20%, 10%, and 4% AEP storms tend to have higher intensities for the 15 minute, 30 minute, 1-, 2-, 3-hour rainfall depths than were recorded for the November 1-2, 2000 storm. Therefore, the calibrated model would overestimate storms with lower recurrence intervals (50%, 20%, 10%, and 4%) due to higher rainfall inputs then actually observed. To correct this problem, the 50%, 20%, 10%, and 4% AEP peak flow computations were done using the November 1-2, 2000 model parameters with the initial and constant soil losses increased to 4.6 and 2.4 inches for all sub-basins.

The 2%, 1%, 0.5%, and 0.2% AEP peak flow computations were done with the November 1-2, 2000 basin parameters as shown in Table 5. The frequency storm method was used with a 50% storm centering and a 150 square mile storm area. This area was chosen based on the area of high intensity rainfall from the November 1-2, 2000 storm (Fontaine and Hill, 2002). Results of the HEC-HMS frequency storm computations at various flow junctions for Waiakea Stream are shown in Table 26. An accuracy value of about 25 equivalent years of record was assigned to these values.

Table 24. Rainfall intensity duration data from recorded rainfall data at Waiakea Uka and Hilo Airport Raingages, Hilo, Hawaii

	November 1-2, 2000 Storm		April 10-12, 2004 Storm	
Duration	**Waiakea Uka**	**Hilo Airport**	**Waiakea Uka**	**Hilo Airport**
15 min	1.13	----	0.13	----
30 min	1.98	----	0.36	----
1 hour	3.38	4.49	0.48	1.23
2 hour	5.81	7.87	0.77	2.16
3 hours	8.78	9.86	1.14	2.70
6 hours	14.8	15.69	2.15	4.89
12 hours	23.78	22.47	3.82	7.04
24 hours	29.38	27.24	7.01	10.82

On Palai Stream, the November 2000 rainfall amounts are less than the 100% (1-year) flood for the 15-min duration. The November 2000 rainfall amounts are about equal to the 100% flood for the 30-min duration, 10% flood for the 2-hour duration, and slightly greater at the 4% flood for a 3-hour duration. The November 2000 rainfall amounts are greater than the 1% flood for durations of 6-, 12-, and 24-hours.

Table 25. Depth (in) for Specified Percent Chance Exceedance Flood Rainfall Compared to Storm of November 1, 2000

Duration	Depth (in) for specified percent chance exceedance flood rainfall						
	100%	**50%**	**20%**	**10%**	**4%**	**2%**	**1%**	**Nov 2000**
15 min	1.27	1.53	1.87	2.12	2.44	2.67	2.89	1.1
30 min	1.78	2.15	2.64	2.99	3.43	3.76	4.07	1.8
1 hour	2.34	2.83	3.47	3.93	4.51	4.94	5.35	3.2
2 hour	3.26	4.02	5.01	5.75	6.69	7.40	8.09	5.8
3 hours	3.85	4.85	6.08	7.00	8.19	9.08	9.96	8.8
6 hours	5.22	6.49	8.24	9.56	11.3	12.6	13.9	15
12 hours	6.92	8.70	11.1	13.0	15.5	17.4	19.4	24.3
24 hours	8.99	11.5	14.8	17.4	20.9	23.6	26.4	29.7

Synthetic storm discharges for the selected frequencies were developed using calibrated HEC-HMS basin models and the NOAA Atlas 14 rainfall estimates. The peak center of the storms was set at 50%. A 24-hour storm period was selected with a rainfall intensity of 5 minutes. The storm area for Waiakea Stream was 150 square miles, while Palai Stream and Four Mile Creek were combined for a storm area of 11.56 square miles. The control model uses a 5 minute time step on Waiakea Stream and a 15 minute time step on Palai Stream/Four Mile Creek to simulate the hypothetical rainfall for a storm duration of 24 hours. Tables 26 to 28 summarize the annual exceedance probability peak flows using the HEC-HMS model for hypothetical events for Waiakea Stream, Palai Stream, and Four Mile Creek.

Table 26. Peak Flow Discharge Frequency Values (cubic feet per second) determined by HEC-HMS Model, Waiakea Stream, Hilo, Hawaii

Flow Concentration Location	Percent Chance Exceedance							
	50	**20**	**10**	**4**	**2**	**1**	**0.5**	**0.2**
Hoaka Road, 7006	1,950	2,960	3,840	5,080	6,170	8,070	9,230	11,400
Kupulau Road, J1	1,880	2,840	3,680	4,860	6,090	7,710	9,100	11,200
Waikaea Town, J2	1,630	2,470	3,220	4,260	5,340	6,790	8,090	9,940
Uka Channel, J3	1,660	2,510	3,250	4,280	5,440	6,920	8,240	10,200
Komohana Street, J4	1,660	2,520	3,270	4,310	5,490	6,960	8,300	10,200
Station 7013, J5	1,170	1,790	2,310	3,050	4,710	4,950	7,150	8,830

Table 27. Peak Flow Discharge Frequency Values (cubic feet per second) determined by HEC-HMS Model, Palai Stream, Hilo, Hawaii

Flow Concentration Location	Percent Chance Exceedance							
	50	**20**	**10**	**4**	**2**	**1**	**0.5**	**0.2**
u/s Mauankai	421	641	797	1,040	1,160	1,310	1,450	1,630
Golf Course	548	833	1,040	1,350	1,510	1,700	1,890	2,120
Kanoelehua Ave	590	898	1,120	1,460	1,630	1,830	2,040	2,290
Puainako St	1,110	1,660	2,050	2,630	2,940	3,290	3,640	4,080
Waiakea Pond	1,350	2,000	2,470	3,160	3,520	3,940	4,370	4,890

Table 28. Peak Flow Discharge Frequency Values (cubic feet per second) determined by HEC-HMS Model, Four Mile Creek Stream, Hilo, Hawaii

Flow Concentration Location	Percent Chance Exceedance							
	50	**20**	**10**	**4**	**2**	**1**	**0.5**	**0.2**
Upcountry & Trib2	410	637	799	1,060	1,190	1,340	1,490	1,680
Kupaa	597	927	1,160	1,540	1,720	1,950	2,170	2,450
Kilauea	781	1,210	1,520	2,010	2,250	2,540	2,840	3,200
Kanoelehua Ave	790	1,230	1,540	2,030	2,280	2,570	2,870	3,230
Quarry	880	1,360	1,710	2,260	2,530	2,860	3,180	3,590

2.6.3 Regional Data. Two sets of regional regression equations to estimate peak flows based on drainage basin characteristics were created for the Island of Hawaii. One set published by the FEMA for the flood insurance study (Federal Emergency Management Agency, 2004), covered the windward or northeast side of Hawaii. Peak flows with recurrence intervals of 50% to 1% AEP (2 to 100 years) were related to two independent variables, drainage area in square miles and mean annual precipitation in hundreds of inches. These equations were first created in 1977 and have standard errors of 102 to 106 percent and coefficient of determinations of 0.79 to 0.80 (Ewart, C.J., Hydrologist, U.S. Geological Survey, written communication, 1977). The second set was published by the U.S. Army Corps of Engineers for the Alenaio Flood Control Project (U.S. Army Corps of Engineers, 1990). These equations relate the 50%, 10%, 2%, 1%, and 0.2% chance exceedance floods for 23 various streams of data along the windward northeast portion of the Island of Hawaii to drainage area in square miles. The standard errors for these equations ranged from 0.425 to 0.590 log units with coefficient of determinations of 0.50 to 0.69. Both sets of equations are considered outdated based on the revision of peak flow records for the Island of Hawaii conducted by the USGS in the 1990s which discredited some peak flow data used to create the two sets of regression equations and also by the fact that neither set of equations account for the extreme runoff event of November 2000. Therefore, neither set of equations was deemed worthwhile to use in this analysis. A newer set of regional regression equations was published by the USGS in 2010 (Oki and others, 2010). This study created new regional peak-flow regression equations for the State of Hawaii using updated peak flow data frequency analysis. The equations covering this study area, called Hawaii, Southern, had standard errors for these equations ranging from 140 to 150 percent with coefficient of determinations of 0.17 to 0.38 and used the maximum 48-hour precipitation that occurs on average once in 5 years as an independent variable. Based upon the large error in these equations and the fact that the HEC-HMS modeling was considered more accurate, no peak flow estimates were made using the latest regional regression equations for this study.

2.7 County of Hawaii Storm Drainage Standards. The County of Hawaii (1970) storm drainage standards specify the use of the Rational Method for areas of 100 acres (0.16 square miles) and less and the Plate 6 design curve for areas greater than 100 acres. The Rational Method was not applied even though Tributary One to Waiakea Stream had a drainage area of 0.09 square miles, since the interest of this computation was in the larger flow concentration areas. There were no areas in Palai Stream or Four Mile Creek that met this criteria. The Zone C Plate 6 design curve was used. This curve approximates only the 1% AEP flood and is related to drainage area (The County of Hawaii, 1970). Results are shown in Tables 29 to 31 and show that using a strict topographic drainage area results in very high values of peak flows. The use of “effective” drainage area in the Waiakea Basin, in this case, computing drainage area only below the 3,000 foot elevation, results in more reasonable estimates when compared to the other methods (Tables 21 and 26). No accuracy is provided with Plate 6 but it is assumed to be equivalent to 10 years of record (Interagency Committee on Water Data, 1982, p.21).

Table 29. Peak Flow Discharge Values determined by Plate 6 in County of Hawaii Storm Drainage Standards, Waiakea Stream, Hilo, Hawaii

Flow Concentration Location and Junction Number	Topographic Drainage Area (mi²)	Topographic Drainage Area (in 100 acres)	Plate 6 Discharge (ft³/s)	Effective Drainage Area (mi²)	Effective Drainage Area (in 100 acres)	Plate 6 Discharge (ft³/s)
Hoaka Road	31.5	202	10,500	12.2	77.8	6,500
Kupulau Road, J1	33.16	212	10,500	13.78	88.2	7,000
Waikaea Town, J2	34.56	221	10,700	15.18	97.2	7,500
Uka Channel, J3	34.84	223	10,700	15.46	98.9	7,500
Komohana Street, J4	34.93	224	10,800	15.55	99.5	7,600
Station 7013, J5	35.61	228	11,000	16.23	104	7,600

Table 30. Peak Flow Discharge Values determined by Plate 6 in County of Hawaii Storm Drainage Standards, Palai Stream, Hilo, Hawaii

Flow Concentration Location and Junction Number	Topographic Drainage Area (mi²)	Topographic Drainage Area (in 100 acres)	Plate 6 Discharge (ft³/s)
J_ u/s Maunakai	4.43	28.4	3,900
J_Golf Course	4.90	31.4	4,200
J_Kanoelehua Ave	5.16	33.0	4,400
J_Puainako Street	6.81	43.6	8,150
J_Waiakea Pond	7.66	49.0	11,000

Table 31. Peak Flow Discharge Values determined by Plate 6 in County of Hawaii Storm Drainage Standards, Four Mile Creek, Hilo, Hawaii

Flow Concentration Location and Junction Number	Topographic Drainage Area (mi²)	Topographic Drainage Area (in 100 acres)	Plate 6 Discharge (ft³/s)
FJ_Upcountry&Trib2	3.15	20.2	3,100
FJ_Kupaa	4.77	30.5	4,100
FJ_Kilauea	6.23	39.9	4,700
FJ_Kanoelehua	6.29	40.3	4,750
FJ_Quarry	7.21	46.1	5,100

2.8 Comparison of Methods and Selection of Best Estimates. The selection of the “best” estimate was done by comparing the various derived discharge-frequency curves graphically and by the accuracy or uncertainty of each method along with engineering judgment. On Waiakea Stream, comparisons of the peak flow determinations were done for the upstream end (sub-basin Hoaka7006) and the downstream end at USGS gage station 16701300, (Junction 5) in the model. Based on the comparison at the upstream end, the HEC-HMS derived values were higher for the lower recurrence intervals and lower for the higher recurrence intervals. At USGS gage station 16701300, the HEC-HMS derived values were higher for the lower recurrence intervals (50%, 20%, and 10% AEP) but fit well with the 4% and 2% AEP events, and underestimated the other methods for the higher recurrence intervals. However, with the exception of the 50% AEP recurrence interval, the HEC-HMS derived values were within the lower and upper bounds of the frequency curve. The discharge values for the lower and higher recurrence interval events were adjusted using the differences in discharge as a percent to obtain a better fit. Tables 32 and 33 show the comparison between the gage statistics and the HEC-HMS output. There is a significant interbasin flow exchange between Waiakea Stream and Palai Stream during storm events when flow exceeds the capacity of Waiakea Stream and flows into Palai Stream after overtopping the Kupulau Ditch. This interbasin transfer is not accounted for in the HEC-HMS model but has been modeled in the HEC-RAS hydraulics model for this study (see Hydraulic Appendix). For this reason, the adjusted HEC-HMS discharge values were adopted for use in this study. The final selected “best” estimates of peak flows in the Waiakea study area are shown in Table 34 and assigned an equivalent years of record (EYOR) of 25 years based on engineering judgment following guidance in Department of the Army (1996). The EYOR value is used as part of the economic analysis in the HEC-FDA program, see Economic Appendix for more details.

Table 32. Peak Flow Frequency comparison between Bulletin 17B analysis and HEC-HMS model at Station 16700600 Waiakea Stream, Hilo, Hawaii

Percent Chance Exceedence	Recurrence Interval (years)	Station 16700600 Adjusted Estimate Peak Flow (ft^3/s)	HMS Model Result Hoaka 7006
50%	2	720	1,950
20%	5	1,550	2,960
10%	10	2,370	3,840
4%	25	3,410	5,080
2%	50	5,240	6,170
1%	100	7,070	8,070
0.5%	200	9,400	9,230
0.2%	500	13,500	11,400

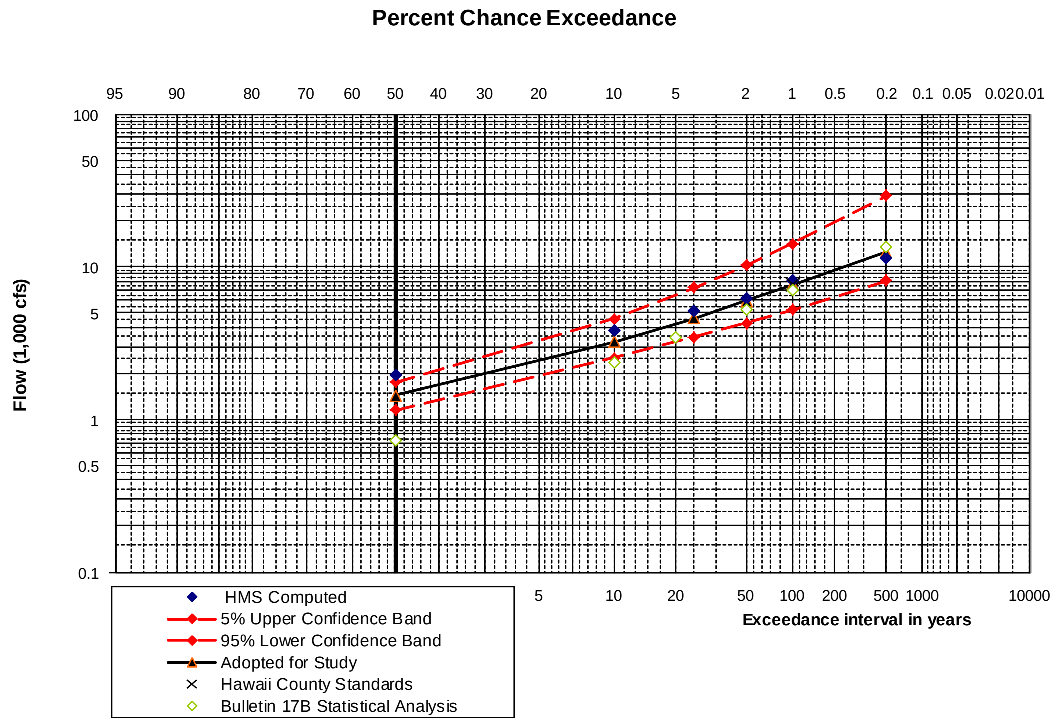
Table 33. Peak Flow Frequency comparison between Bulletin 17B analysis and HEC-HMS model at Station 16701300 Waiakea Stream, Hilo, Hawaii

Percent Chance Exceedence	Recurrence Interval (years)	Station 16701300 Peak Flow Computation (ft^3/s)	HMS Model Result Station 7013 J5
50%	2	645	1,170
20%	5	1,400	1,790
10%	10	2,130	2,310
4%	25	3,070	3,050
2%	50	4,720	4,710
1%	100	6,370	4,950
0.5%	200	8,470	7,150
0.2%	500	12,100	8,830

Table 34. Final Adjusted Peak Flow Frequency Values (cubic feet per second), Waiakea Stream, Hilo, Hawaii

Sub-Basin or Junction Number	Percent Chance Exceedance							
	50	**20**	**10**	**4**	**2**	**1**	**0.5**	**0.2**
Hoaka 7006	1,480	2,370	3,350	4,930	5,980	7,990	9,970	11,400
Kupulau	219	331	430	567	894	904	1,340	1,630
Kupulau Road, J1	1,430	2,270	3,680	4,710	5,965	7,630	9,830	11,230
Waiakea Town	81	117	148	190	252	290	365	440
Tributary 3	95	139	177	231	321	375	488	606
Waikaea Town, J2	1,240	1,980	2,800	4,310	5,230	6,790	8,730	9,940
Tributary 2	49	70	88	114	150	173	217	262
Uka Channel, J3	1,260	2,010	3,250	4,150	5,334	6,920	8,900	10,160
Tributary 1	16	23	29	37	48	56	70	84
Komohana Street, J4	1,660	2,020	2,840	4,180	5,375	6,960	8,970	10,240
Waiakea 7013	39	57	72	93	133	138	215	273
Station 7013, J5	761	1,430	2,110	2,840	4,430	5,600	7,940	9,540

On Palai Stream, the comparison between USGS gage station 16701400 and the HEC-HMS derived values shows that the model overestimated the peak flow for the 50% AEP flood and underestimated flows for the remainder of the frequency events (Table 35). The difference in flow values may be attributed to the interbasin transfer of flow between Waiakea Stream and Palai Stream as mentioned previously. Additionally, the USGS values and the historical storm of November 2000 are based on 23 useable years of data Therefore, accuracy of these values alone is 23 years. However, with the model calibrated to the November 2000 extreme event flood, the accuracy in equivalent years of record is about 25 years which is the highest among all options as interpreted from Department of the Army (1996).



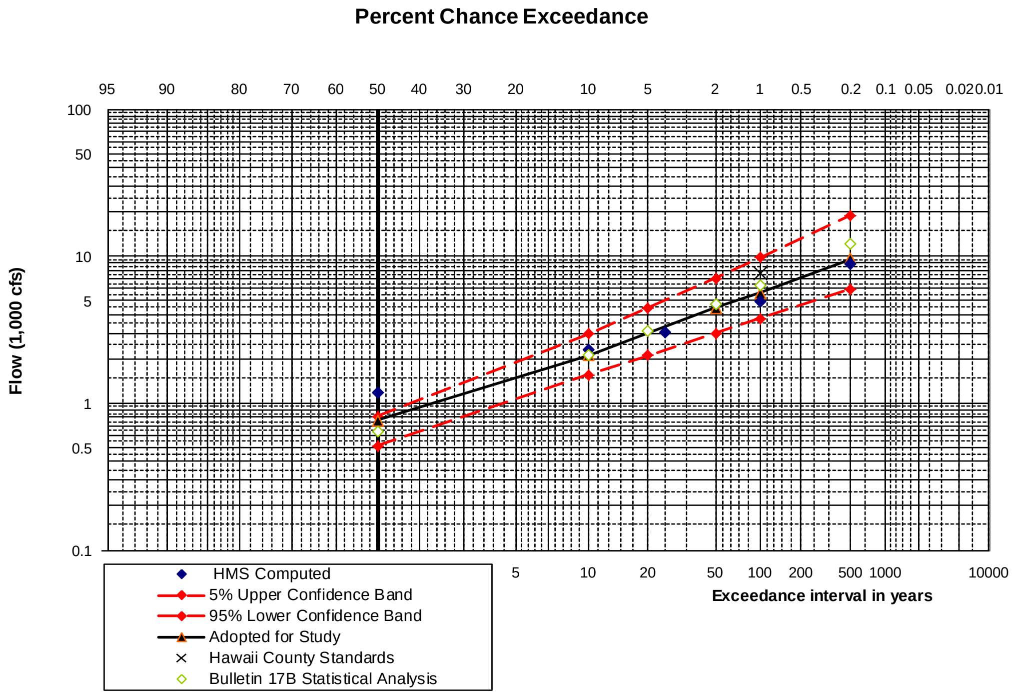
HEC-HMS Conditional Probability Statistics
logMean: 3.187
Skew: 0.839
log Std Dev: 0.238
HEC-HMS 90% confidence band statistics
computed with equations in Appendix 5, Bulletin 17B
(Interagency Committee on Water Data, 1982)

WAIAKEA-PALAI STREAM FLOOD RISK MANAGEMENT
H&H STUDY, HAWAII, HAWAII

COMPARISON OF DISCHARGE
FREQUENCY CURVES FOR EXISTING CONDITION
USGS STATION 16700600

U.S ARMY CORPS OF ENGINEERS
HAWAII ENGINEER DISTRICT

Figure 14. Waiakea Stream USGS Gage Station 16700600 Discharge Frequency Curve Comparison



HEC-HMS Conditional Probability Statistics
logMean: 2.645
Skew: -0.499
log Std Dev: 0.392
HEC-HMS 90% confidence band statistics
computed with equations in Appendix 5, Bulletin 17B
(Interagency Committee on Water Data, 1982)

WAIAKEA-PALAI STREAM FLOOD RISK MANAGEMENT
H&H STUDY, HAWAII, HAWAII

COMPARISON OF DISCHARGE
FREQUENCY CURVES FOR EXISTING CONDITION
USGS STATION 16701300

U.S ARMY CORPS OF ENGINEERS
HAWAII ENGINEER DISTRICT

Figure 15. Waiakea Stream USGS Gage Station 16701300 Discharge Frequency Curve Comparison

Table 35. Peak Flow Frequency comparison between Bulletin 17B analysis and HEC-HMS model at Station 16701400 Palai Stream, Hilo, Hawaii

Percent Chance Exceedence	Recurrence Interval (years)	Station 16701400 Peak Flow Computation (ft^3/s)	HMS Model Result J_Kanoelehua Ave
50%	2	476	590
20%	5	981	898
10%	10	1,385	1,120
4%	25	1,820	1,460
2%	50	2,430	1,630
1%	100	2,940	1,830
0.5%	200	3,470	2,040
0.2%	500	4,210	2,290

The Hawaii County Standards (Plate 6) yields one point, a roughly 1-percent AEP flood peak, at each of the concentration points. The peak flows determined from this method tend to be on the higher end when compared with the other methods at all locations. For these reasons the HEC-HMS hypothetical model is the chosen option for the percent chance exceedance flood flows for most of the junction concentration points on Palai Stream and Four Mile Creek (except Palai junction at Puainako and Waikea Pond as will be discussed) because it is based on the study area attributes, calibrated to storm events, and although lower than the USGS stream gage 16701400 peak flow values, they are within the confidence limits of the stream gage statistics (Figure 16).

2.8.1 Linear Decreasing of Hydrologic Flows for Palai Stream and Four Mile Creek. An exception to the chosen HEC-HMS values are concentration points downstream of the USGS gage at Kanoelehua on Palai Stream, Puainako and Waikea Pond. Based on a survey of the households and businesses downstream of the USGS gage along Palai Stream, there had been little to no flooding in the past few decades. Also from this survey, the November 2000 flood did little flooding too many of the downstream areas. An explanation for this may be underground lava tubes throughout the downstream portion of Palai Stream. Based on data from an adjacent intermittent watershed, Waiakea Stream, shown in Figure 1, there is a linear decrease of flow from upstream to downstream even though there is a larger drainage area downstream. There were two USGS gages that were operational at the same time during 2003 to present on Waiakea Stream, which are about 4.2 miles apart from each other. The upstream gage station number is 16700600 and the downstream gage is 16701300 as shown in Figure 10. Based on data from these gages, there were two peaks that occurred on 25 January 2004 and 12 April 2004. Both these peaks showed that there was a linear decrease in flow between the two gages. See Tables 36 and 27 for a summary of the linear peak flow reduction. Based on the data from these tables, the average linear reduction is 0.02 cubic feet per second per linear foot (cfs/lf) in distance. However, the actual flow loss reduction is greater than 0.02 cfs/lf distance because of losses from downstream drainage areas that need to be factored in.

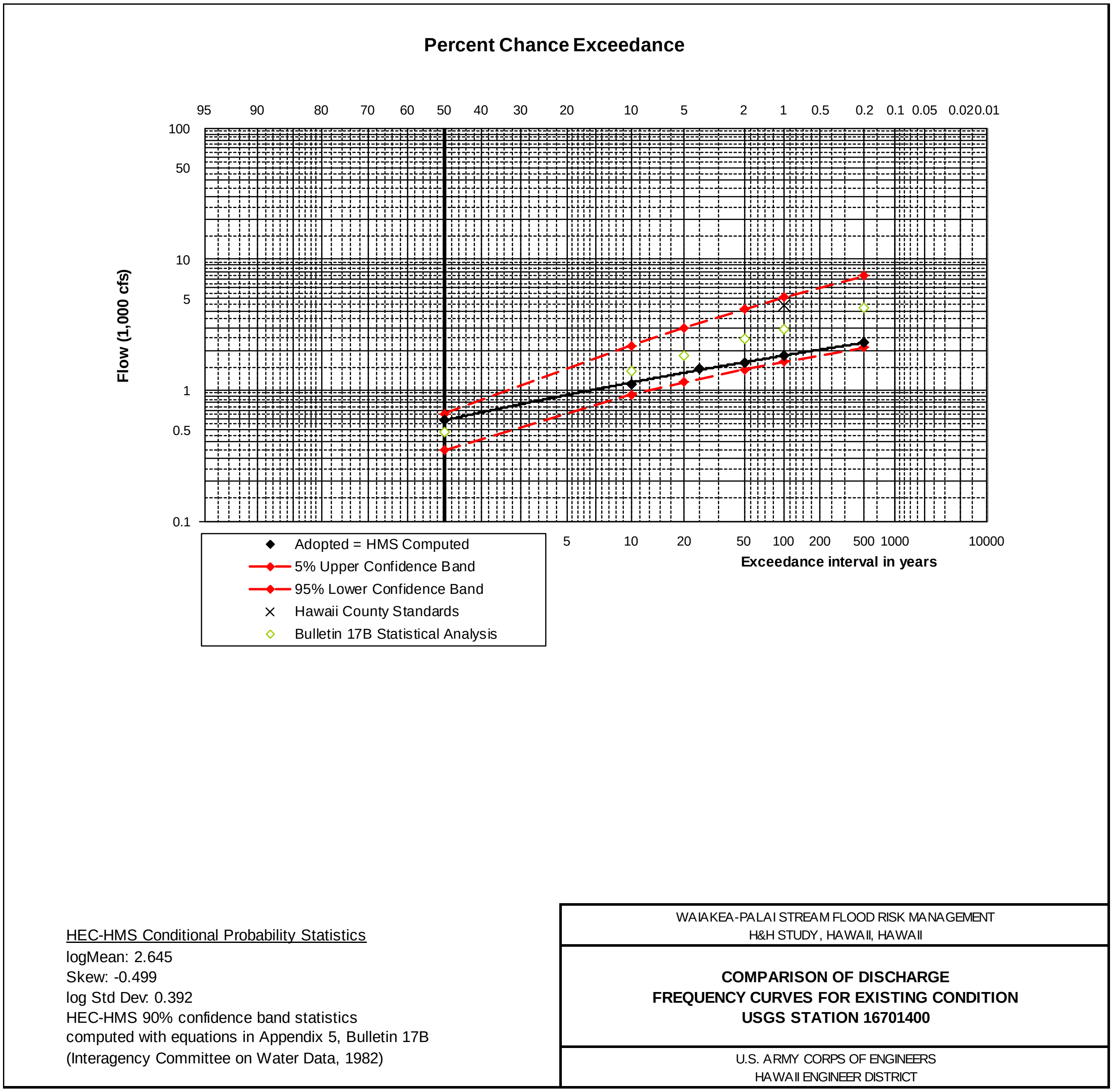


Figure 16. Palai Stream USGS Gage station 16701400 Discharge Frequency Curve Comparison

For example if the upstream flow rate is 1,000 ft^3/s (cfs) then 500 feet downstream the flow rate should be 1,200 ft^3/s without any 0.02 cfs/lf distance linear reduction because an additional 200 ft^3/s has been added from the downstream drainage areas. Now using 0.02 cfs/lf distance loss for 500 feet, the upstream flow is still 1,000 ft^3/s, but a reduction in 10 ft^3/s results in a downstream flow of 990 ft^3/s. The difference between 1,200 ft^3/s without linear reduction less the linear reduction factor flow of 990 ft^3/s is 210 ft^3/s. Taking 210 ft^3/s and dividing this by 500 linear feet, then the actual loss factor from upstream to downstream including all downstream drainage areas then becomes 0.42 cfs/lf.

The 25 January 2004 event had a larger reduction than the 12 April 2004 event because the 12 April 2004 event had greater soil saturation from previous rainfall events than the 25 January 2004 event. Statistical data from 19 years of peak flow data suggests that USGS gage station 16701300 peaks for both events is about a 50-percent flood. Similar statistical data for the USGS gage station 16700600 is not computed because it has only been in existence for about 3 years. Despite the peak event being only a 50-percent flood, a linear reduction amount greater than 0.02 cfs/lf distance can be expected for larger events. Without further data, a linear decrease larger than 0.02 cfs/lf of distance cannot be used for larger events. At a minimum, a linear reduction of 0.02 cfs/lf distance along the stream will be applied to Palai Stream, downstream of USGS gage station 16701400 for all events due to a survey of households in this area which claimed little to no flooding during the November 2000 event, past historical events, and the adjacent Waiakea Stream flood reduction analysis. Similarly, a reduction in peak flows will be applied to Four Mile Creek downstream of Kupaa Street which has a similar drainage ratio area to total watershed area as Palai Stream at USGS gage station16701400; 66 percent total drainage area at Kupaa on Four Mile Creek and 67 percent total drainage area at USGS gage station 16701400 on Palai Stream, respectively. See Table 38 for Palai Stream and Four Mile Creek linear rates of flow reduction for a given frequency flood. Slight differences in the linear flow reduction between Palai Stream and Four Mile Creek can be attributed to the longer path of travel for Palai Stream and larger drainage flows for the developed downstream Palai drainage areas.

Table 36. Linear Peak Flow Reduction 25 January 2004

		25-Jan-04		
Gage	**DA (sq. mi.)**	**Peak discharge (cfs)**	**Peak discharge/DA (cfs/sq. mi)**	**Reduction (cfs/lf)**
16700600	31.9	1,330	41.67	na
16701300	35.8	725	20.25	0.027

Table 37. Linear Peak Flow Reduction 12 April 2004

		12-Apr-04		
Gage	**DA (sq. mi.)**	**Peak discharge (cfs)**	**Peak discharge/DA (cfs/sq. mi)**	**Reduction (cfs/lf)**
16700600	31.9	1,000	31.33	na
16701300	35.8	701	19.58	0.013

Table 38. Linear Flow Reduction for Palai Stream and Four Mile Creek

Percent Chance Exceedence	**Linear Reduction in Flow (cfs/lf)**	
	Palai Stream	**Four Mile Creek**
0.20%	0.18 cfs/lf	0.16 cfs/lf
0.40%	0.16 cfs/lf	0.13 cfs/lf
1%	0.14 cfs/lf	0.12 cfs/lf
2%	0.12 cfs/lf	0.11 cfs/lf
4%	0.11 cfs/lf	0.09 cfs/lf
10%	0.09 cfs/lf	0.08 cfs/lf
20%	0.08 cfs/lf	0.07 cfs/lf
50%	0.06 cfs/lf	0.05 cfs/lf

2.8.2 Adopted Flows for Palai Stream and Four Mile Creek. See Tables 39 and 40 for the adopted peak percentage floods for the floodplain study for the existing Palai Basin and Four Mile Creek, respectively, based on HEC-HMS modeling and linear decreasing application as described in the above paragraph. The two adopted discharge values on Palai Stream, J_Puainako Street and J_Waiakea Pond; which have linear decreasing peak flows, are based on the discussions in the paragraphs above. Note that the adopted flows are the best estimate of the flows in the Palai Stream and Four Mile Creek watersheds based on the available information. However, it should also be noted that lava tubes in the area may not be reliable sources of infiltration as the effect is estimated in the model while in actuality; the effect on peak flow reduction will be variable depending on flood event and location

Table 39. *Final Adjusted Peak Flow Frequency Values (cubic feet per second), Palai Stream, Hilo, Hawaii*

Sub-Basin or Junction	Percent Chance Exceedence							
	50	**20**	**10**	**4**	**2**	**1**	**0.5**	**0.2**
J_Golf Course	548	833	1,040	1,350	1,510	1,700	1,890	2,120
J_Kanoelehua Avenue*	590	897	1,120	1,460	1,630	1,830	2,040	2,290
J_Puainako Street	1,110	1,660	2,050	2,630	2,940	3,290	3,640	4,080
J_Waiakea Pond	1,350	2,000	2,470	3,160	3,520	3,940	4,370	4,890
u/s HaiHai St	250	389	488	646	725	818	913	1,030
Palai C	254	384	476	617	689	774	859	965

* Represents the location of USGS gage 16701400 location

Table 40. *Final Adjusted Peak Flow Frequency Values (cubic feet per second), Four Mile Creek, Hilo, Hawaii*

Sub-Basin or Junction	Percent Chance Exceedence							
	50	20	10	4	2	1	0.5	0.2
F_U/S Tributary 2	294	457	574	760	852	962	1,070	1,210
F_U/S Tributary 1	403	626	799	1,060	1,190	1,340	1,490	1,680
FJ_Kilauea	781	1,210	1,520	2,010	2,250	2,540	2,840	3,200
FJ_Kanoelehua	790	1,230	1,540	2,030	2,280	2,570	2,870	3,230
FJ_Quarry	880	1,360	1,710	2,260	2,530	2,860	3,180	3,590
F_Tributary 1	167	260	326	431	484	546	609	686
F_Tributary 2	188	293	367	490	545	616	687	774

3.0 CONCLUSION

A hydrologic analysis was conducted to determine the “best” estimates of the 50%, 20%, 10%, 4%, 2%, 1%, 0.5%, 0.2% AEP (the 2-, 5-, 10-, 25-, 50-, 100-, 200-, and 500-year floods) flood events for the Waiakea-Palai Stream study area as part of the Waiakea-Palai Stream Flood Damage Reduction Study. The “best” estimate of the discharge-frequency curves were determined by adjusting peak flow values computed by a HEC-HMS model with peak flows computed by frequency analysis of data from USGS gaging stations. The HEC-HMS rainfall-runoff model was calibrated using storm data from two events, April 10-13, 2004 and November 1-2, 2000. The County of Hawaii Storm Drainage Standards while useful for comparison purposes was not used in determining the “best” estimate. Regional regression peak flow equations were not considered sufficient in accuracy due to limitations of the data for South Hawaii and were not used in this analysis. The adopted flows are the best estimates of the flows in the Waiakea Stream, Palai Stream, and Four Mile Creek watersheds based on the available information and were used in the companion HEC-RAS hydraulic model. An equivalent years of record of 25 years accuracy was assigned for risk and uncertainty analysis in the companion HEC-FDA model. In this analysis future without project and future with project modeling parameters and resulting flow frequency estimates are assumed to be identical except where influenced by proposed flood damage reduction measures.

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WAIAKEA-PALAI STREAMS
Hilo, Island of Hawaii, Hawaii

CONTINUING AUTHORITIES PROGRAM SECTION 205
FLOOD RISK MANAGEMENT

Appendix B-2: Hydraulics

MAY 2020

US Army Corps of Engineers
Honolulu District

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Appendix B2 – Hydraulic Analysis

WAIAKEA-PALAI FLOOD RISK MANAGEMENT
FLOOD DAMAGE REDUCTION PROJECT, HILO, HAWAII
MAY 2019

Executive Summary

The Hydraulic Appendix provides details of the hydraulic analysis performed for Waiakea, Palai and portion of Four Mile streams in Wailoa watershed. The report summarizes previous studies conducted for the project area, as well as updated data, information, and modeling used for the tentatively selected plan (TSP). Since 1984, various channel and conveyance improvements have been done to alleviate acute flooding problems in the project area. Similarly, hydrology and hydraulic modeling has been conducted by the Corps of Engineers with partner organizations.

The modeling is based on HEC-RAS model version 5.0.6. Model simulations were done for eight frequency events including the 50%, 20%, 10%, 4%, 2%, 1%, 0.5%, and 0.2% Annual Chance Exceedance (AEP). Inflow hydrographs for the each event were obtained from the Hydrology analysis (Appendix A2) and some based on the field observations.

As a part of the study, nine different alternatives including future without project were assessed to identify the most beneficial alternative for reducing flooding problems in the Waiakea Hilo project area. As indicated in the main report, TSP alternative is a combination of two measures (Kupulau Ditch and Golf Course projects) that produce the most benefits. The TSP simulation is based on the 2% AEP (50-year), as required by plan formulation guidance based on project life. But this report is supplemented with results from all flow events for the purpose of information and future use.

The final intent of the hydraulic analysis is to provide comprehensive floodplain maps, inundation extents, and water elevation profiles in the project area. The project development team will use the hydraulic results to perform the flood damage assessment, risk assessment, and benefit cost analysis.

Consistent with Corps risk informed decision making policy, this report is based on best available information developed over several years by the Corps and its partner agencies. Data sets that underpin the modeling and results have significant uncertainties that cannot be resolved until new terrain data (LiDAR) becomes available. LiDAR data will be available during the design phase of the project and the hydrologic and hydraulic modeling will be updated at that time. The accuracy of the updated modeling is expected to be significantly greater than that used for feasibility level analysis. Model hydraulic output data (flow rates, elevations, depths, inundation) could differ enough from the values presented in this report that modification to the project measures may still be necessary to maintain the same or higher economic benefits of the selected plan.

1. INTRODUCTION

1.1 PURPOSE AND SCOPE. This hydraulic appendix documents the hydraulic modeling, assumptions, analyses, and results used to determine the extent and amount of flood damage resulting from the 50%, 20%, 10%, 4%, 2%, 1%, 0.5%, and 0.2% Annual Chance Exceedence (AEP) storm events in the Waiakea and Palai Streams, and Four Mile Creek drainage areas. This hydraulic analysis is part of Flood Risk Management (FRM) study for the Waiakea-Palai Stream system in Hilo, Hawaii. Results of the hydraulic modeling are presented as water surface elevation profiles and inundation maps for the various stream reaches used in this analysis.

1.2. STUDY AUTHORITY. The Waiakea-Palai Streams Flood Risk Management (FRM) Project investigation is authorized under Section 205 of the Rivers and Harbors Act of 1962, Public Law 87-874, as amended (76 U.S.C. 1197s; hereinafter Section 205). Section 205 is an authority allowing the Secretary of the Army to initiate surveys for flood control and allied purposes.

1.3 STUDY AREA LOCATION AND DESCRIPTION. Waiakea and Palai Streams, and Four Mile Creek, located in Hilo, Hawaii, are part of the Waiakea-Uka district and extend upstream southwest of Hilo Harbor. The island of Hawaii is also known as the Big Island. Waiakea Stream originates in the upper watershed along the slopes of Mauna Loa (elevation 13,653 feet) volcano and flows through the residential community of upper Waiakea-Uka Homesteads before entering the business district in Hilo town in the lower portion of the watershed (Figure 1). Palai Stream and Four Mile Creek originate down slope on Mauna Loa and while Palai stream flows thru the City of Hilo, Four Mile Creek flows away from Hilo through a constructed channel. The other volcanic masses on the island are Mauna Kea Volcano, Kohala Mountains, Hualalai Volcano, and Kilauea Volcano. Mauna Loa and Kilauea Volcano located in the southern half of the island are the only remaining active volcanoes on the island. See Figure 1, the Location Map. A complete description of the study area can be found in the Hydrology Appendix.

1.4 FLOOD PROBLEMS. Stream flow within the Waiakea-Palai Stream and its tributaries is intermittent with flooding occurring during heavy rainfall events. The flood problems within the study area can be attributed to primarily poorly defined channels with inadequate capacity and secondarily to accumulation of debris and vegetation in the channels which cause blockages within the channels and at stream crossings (Figure 2). The channels when crossing perpendicular to the slope are classed as perched or partially perched and when overtopped can cause severe flooding to the surrounding areas. Severe flooding has occurred within the study area in March 1939, March 1953, July 1966, February 1979, March 1980, August 1994, November 2000, January 2002, and February 2008. A complete description of the prior flood events and previous flood studies can be found in the Hydrology Appendix.

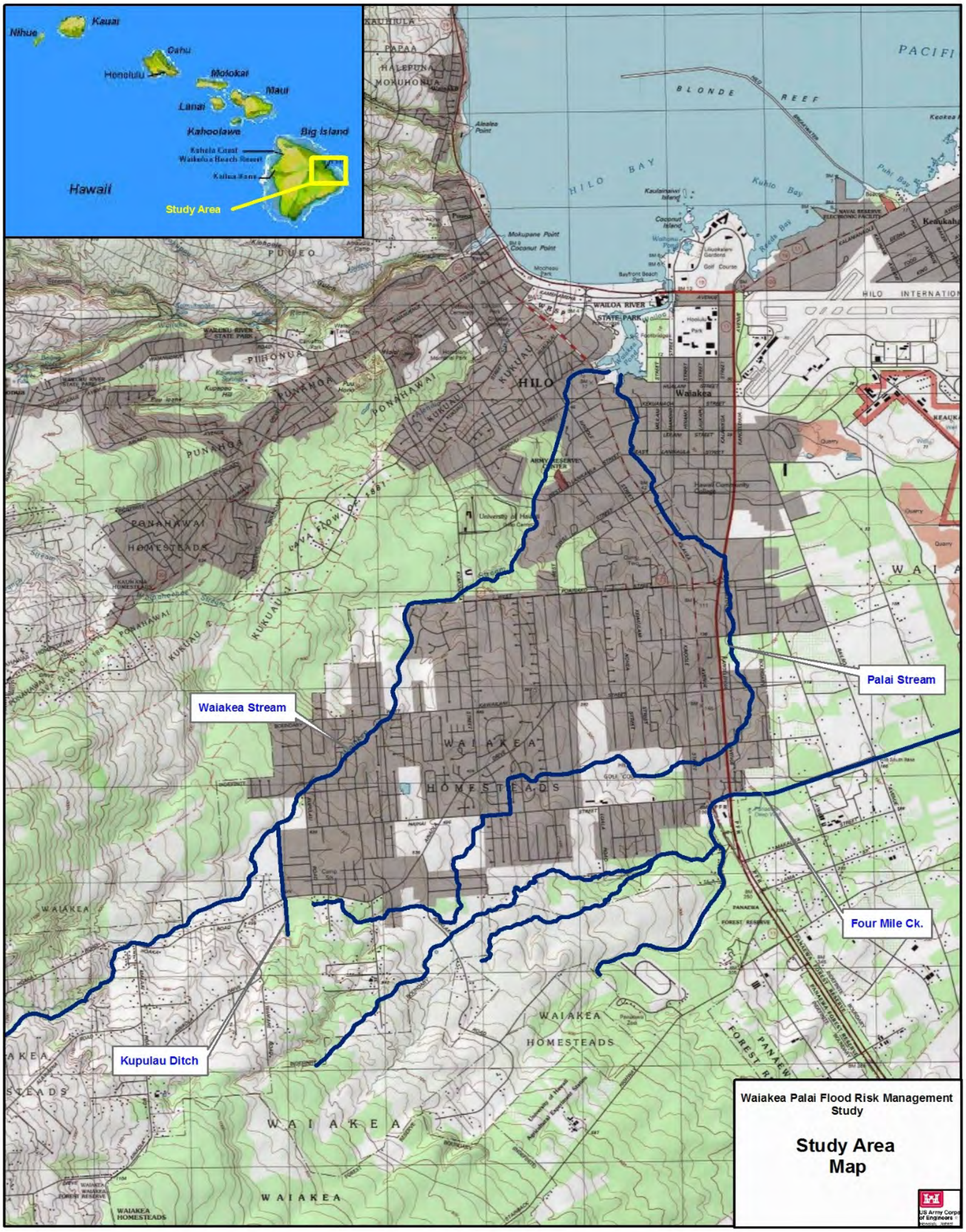

Figure 1. Study Area/Location Map

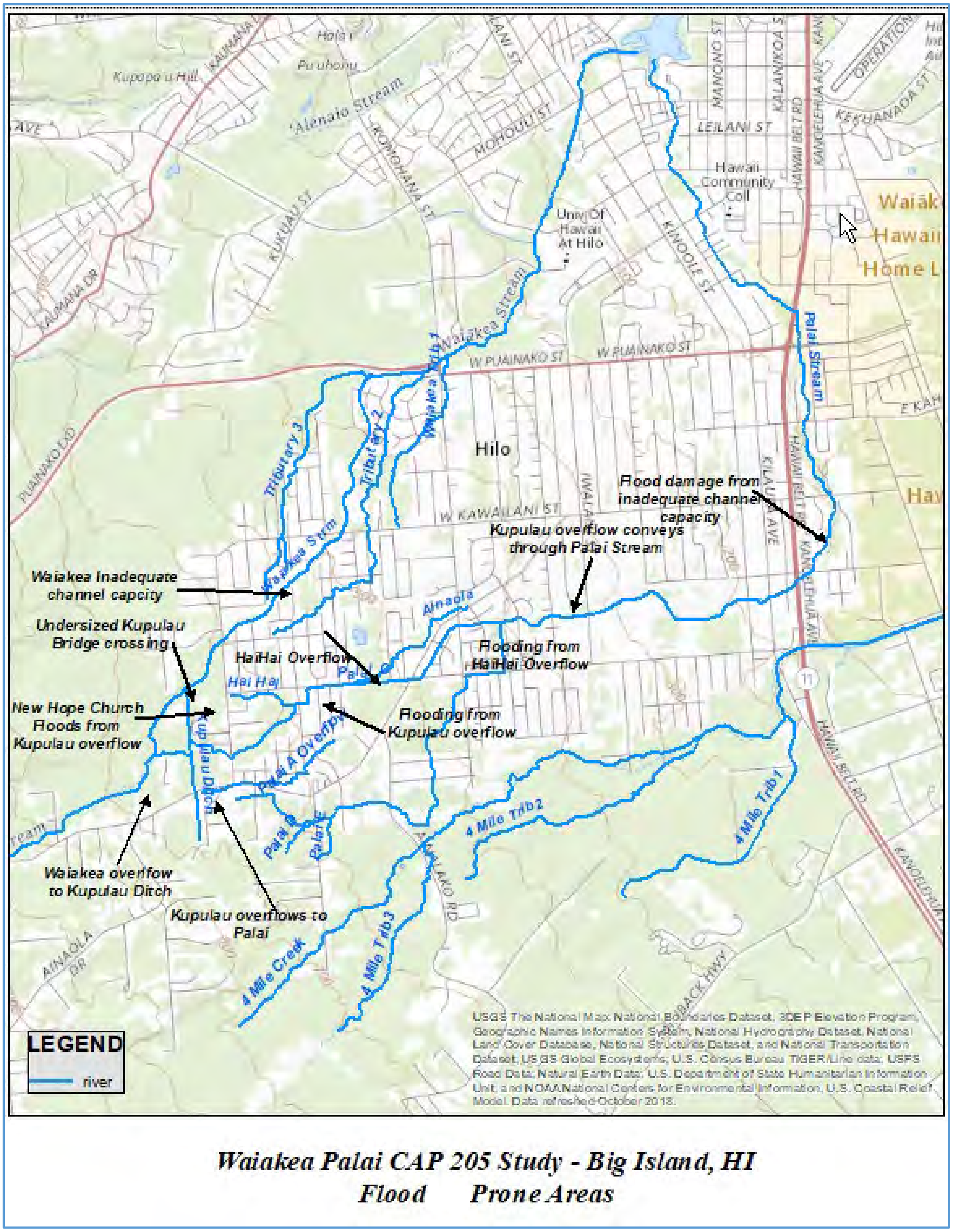

Figure 2. Flood Prone Areas

1.5 FLOOD PROTECTION MEASURES. Downstream in the lower reaches of Waiakea Stream from near The University of Hawaii at Hilo campus to Wailoa Pond (also called Waiakea Pond) at Hilo Bay (Figure 1) the U.S. Army Corps of Engineers (USCAE) built a flood control project in 1965 consisting of channel improvements and levees to protect that portion of Hilo. This project was designed for a flood event of 6,500 cubic feet per second (cfs; ft^3/s) which was determined to have a recurrence interval of 125 years (U.S. Army Engineer District, 1962). Upstream, in the detailed study area, The County of Hawaii constructed the Waiakea Uka channel improvements in 1984. This project consists of 3,460 feet of concrete lined and unlined trapezoidal channel modifications from Komohana Street to near Apono Place. These improvements were designed for a discharge of 4,460 cubic feet per second and were damaged in the November 1-2, 2000 flood. Although not a flood control improvement for Waiakea Stream, The Kupulau Ditch was constructed in 1971 to divert runoff from the Palai Stream drainage basin to Waiakea Stream upstream of the Kupulau Road Bridge. In 2001, after the November 2000 flood, the Kawailani Street Bridge was rebuilt with a new larger clear span structure that to reduce the chance of debris buildup during a rainfall event and repairs were made to the Kupulau Rd. Bridge. No site-specific flood warning system exists for the Waiakea Stream area. Special storm warnings for the Island of Hawaii are broadcast over local radio and television. These warnings are made for broad, extensive areas of the island because of the “flashy” nature of floods and the unpredictability of the precise location of intense storm cells in Hawaii.

1.6 PREVIOUS STUDIES. There have been a number of prior hydraulic studies conducted primarily for the determination of flood insurance rate maps. The Hydrology Appendix describes in greater detail the previous studies undertaken in the Waiakea-Palai watershed. In 2001, in response to the November 2000 flood, POH prepared reconnaissance reports for both Waiakea and Palai Streams under Section 205 of the Flood Control Act of 1946. These reports recommend further studies to identify solutions to the flooding problems.

2. HYDRAULIC ANALYSIS

This section discusses the creation of the hydraulic model, modeling assumptions and limitations, and results.

2.1 TOPOGRAPHIC DATA SOURCES. The topographic data used in this study was obtained from several sources. The base topography was obtained by RM Towill Corporation in 2003 via aerial photogrammetric methods (First Palai Stream and Four Mile Creek; then Waiakea Stream through two separate contacts). This basic topographic data has 4-foot contour intervals with 0.1 ft spot elevations accuracy, and a digital elevation model (DEM). The base topo is supplemented by three other sources: 1) LIDAR data from Hawaii County at the Kaumana Road project, covering lower reaches of Waiakea stream; 2) survey data at Ainalako Road diversion area; and, 3) Kapulau Ditch flood insurance study (by Dewberry 2002). The remaining gaps were filled with USGS 10m digital elevation data. Channel, road, bridge, and culvert geometry data was obtained from field measurements, Hawaii State and County Department of Transportation plans, and existing HEC-RAS models created for Flood Insurance Studies.

2.2 MODELING LIMITS. The HEC-RAS modeling limits in this study mirror those of previous studies and are based on flood prone areas. The primary stream network comprises of the channel centerline and stream bank locations of Waiakea and Palai Streams and those tributaries studied in detail. The detailed modeling limits are as follows:

Waiakea Stream was modeled from Waiakea Pond in Hilo, upstream to a point approximately 3,400 feet upstream of its confluence with the Kupulau Flood Ditch for a total distance of about 4.8 miles. Palai Stream was modeled from Waiakea Pond in Hilo, upstream to a point shortly upstream of Ainalako Rd, for a distance of about 6.1 miles. Four Mile Creek was modeled from its mouth at an old quarry upstream to Ainalako Rd for a distance of about 4.4 miles. The Kupulau Ditch was modeled form its confluence with Waiakea Stream upstream to a point just above Ainaola (Hoaka) Road for a distance of about 0.5 miles. Included in the modeling were tributaries to the main study streams. Along Waiakea Stream, tributaries 1, 2, and 3 were modeled for distances of 0.9, 1.8, and 1.2 miles respectively. Along Palai Stream, several of its tributaries were modeled (called A. B. and C which follows the prior FEMA designations). The Palai Stream C stream was modeled from the point where the stream enters the underground storm system at Haihai Street upstream to the point near the New Hope Chapel for a total distance of about 0.8 miles. An overflow reach was labeled as a continuation of Palai Stream from a point where it enters the Kupulau Ditch upstream to a point where it diverts from the Waiakea Stream for a distance of about 0.2 miles.

Additional overland reaches were modeled to convey overflow leaving the main stream channels. The reach designated as Ainaola runs on the north side of HaiHai St and west side of Ainaola Dr. This reach was modeled from a point about 150 feet downstream of Komohana St to just east of Lei Luaha St for a distance of about 0.5 miles. The reach designated as HaiHai runs along HaiHai St. on its south side. The HaiHai reach runs from Kupulau Rd to just upstream of Hoolaulea St. for a distance of about 0.3 miles. The reach designated as Palai overflow runs from a point just east of Kupulau Road south of Ainaola (Hoaka) Rd downstream to a point just south of Nou Street for a distance of about 0.75 miles. The Puhau St reach runs from the south end of Puhau St downstream to Kawailani St for a distance of about 0.3 miles.

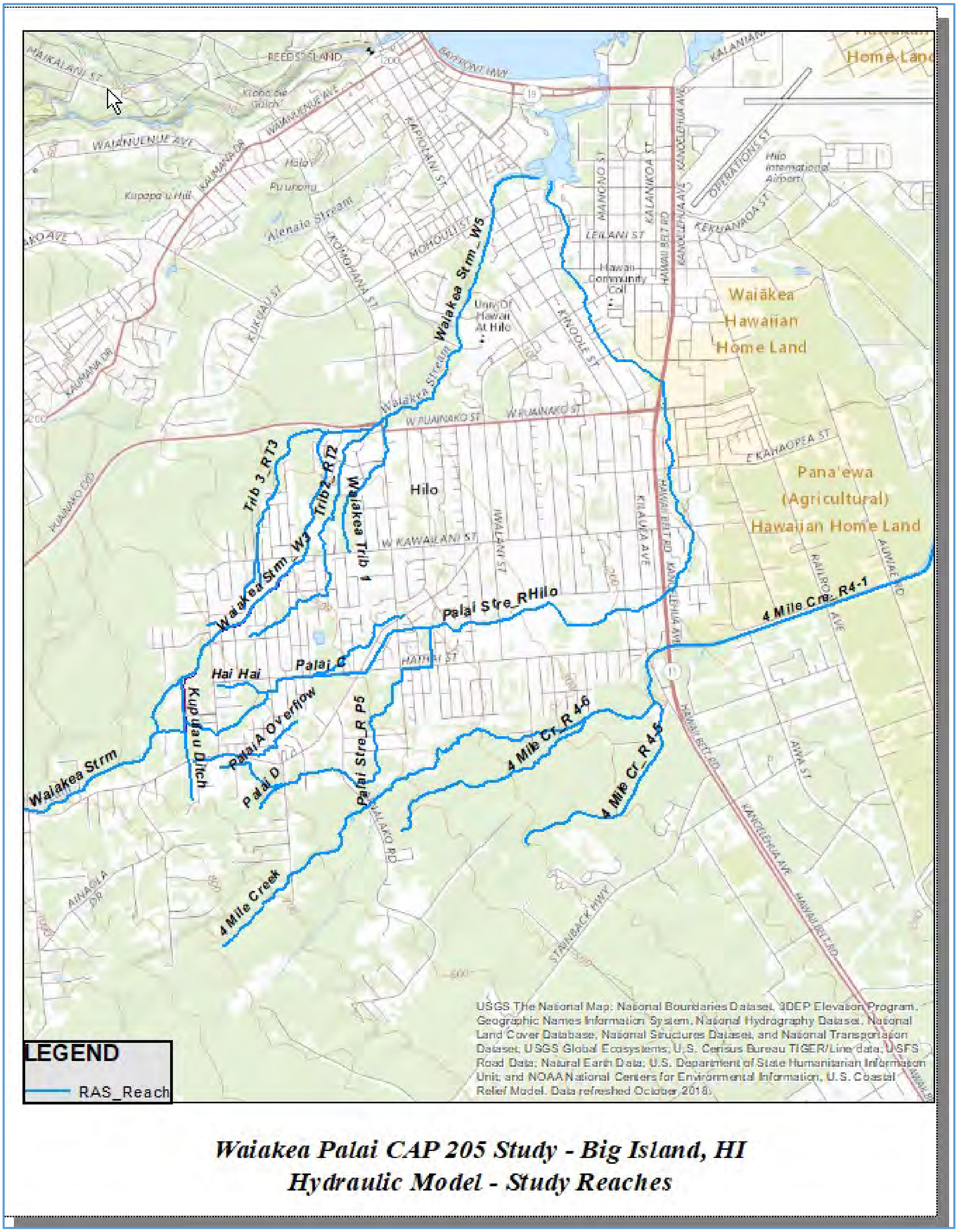

Figure 3. Hydraulic Model Boundaries and Reaches

2.3 GIS METHODOLOGY. GIS (Geographic Information System) tools and datasets were used to develop the hydraulic model. These datasets came from various sources. The basic source of elevation data came from a Triangulated Irregular Network (TIN) created from the various elevation sources described in Section 2.1. This dataset was created from Microstation 3D CADD files as part of the aerial photogrammetric data collection. The Microstation files also included a series of 3D "dgn" files. These files contained both topographic and planimetric features. Contour information at 4 foot intervals was provided along with roads, building footprints, bridge and culvert locations, and other ancillary data. Aerial imagery was used in the background to provide location information.

These datasets were used with the Environmental Systems Research Institute (ESRI) software product ArcGIS version 10.1 for processing and data extraction. Upon adding the data layers into ArcGIS, hand-digitizing of the stream centerlines, cross sections, bank locations, flow path lines, and bridge locations was performed.

2.4 INTIAL HEC-RAS MODEL DEVELOPMENT. The Waiakea Palai Stream and Four Mile Creek HEC-RAS hydraulic model was developed to achieve the highest accuracy possible within the limitations of topographic data accuracy, the HEC-RAS model limitations, and the modeling assumptions used. The following sections describe the procedures used to develop the model.

2.4.1 Terrain Data. HEC-GeoRAS (GeoRAS) is a software extension to ArcGIS created by the U.S. Army Corps of Engineers Hydrologic Engineering Center (HEC) in conjunction with ESRI. GeoRAS runs within ArcGIS to prepare an ASCII text file that can be directly imported into HEC-RAS. GeoRAS was used to develop preliminary data that creates a HEC-RAS geometry file that is further processed within the HEC-RAS software.

Input parameters created in GeoRAS for the HEC-RAS model include the primary stream network, channel bank locations, flowpath lengths, and cross section locations. After the HEC-RAS model is created, manual editing is required to input expansion and contraction coefficients, boundary conditions, ineffective flow areas, levees, weirs, roughness coefficients, and stream crossing data to the HEC-RAS model.

All GIS data was projected to a common projection, Hawaii State Plane. The projection parameters are as follows:

Projection:	Hawaii State Plane
Zone:	1
Units:	Feet
Horiz. Datum:	NAD83
Vert. Datum	Mean Sea Level
Spheroid:	GRS80
ZUnits:	Feet
Xshift;	0.0
YShift:	0.0

2.4.2 Detail Study Streams

The primary stream network comprises of the channel centerline and stream bank locations of Waiakea and Palai Streams and those tributaries studied in detail. The stream centerlines and stream banks were hand digitized in GeoRAS using the contour maps and orthophotos as background imagery. The resulting GIS shapefiles are processed in GeoRAS for conversion to HEC-RAS.

The flowpath locations are a measure of the path taken by the flow as it moves across the terrain. It is comprised of three parts; the centerline, left overbank, and right overbank. The overbank flowpaths are typically located at the “center of mass” of the overbank flow. GeoRAS uses this dataset to compute the overbank reach lengths and distance between cross sections.

2.4.3 Cross Section Modeling. Cross sections are oriented from left to right in the downstream direction. For this study, initial cross sections were created at an interval of 200 feet for all streams. Elevation data for the cross sections are extracted from the TIN dataset by GeoRAS.

Stream junctions are used to model where streams join or diverge. Preliminary junction names and lengths in HEC-RAS were created using GeoRAS. The actual distance across the junction was measured along the stream channel from the cross section immediately upstream of the junction to the cross section immediately downstream of the junction. For the tributaries, the distance from the junction to the first upstream cross section was measured and input into the model.

2.4.4 Geometry Update. During the TSP modeling process, a new version of HEC RAS software was used to run the model. RAS Mapper, a new utility within HEC RAS, eliminates the need to use GeoRAS for pre- or post-processing of RAS data and maps. In addition, one can use RAS Mapper and some Geo-processing to recreate the channel geometry based on surveyed cross sections. The recreated channel can be used to compare the terrain and corresponding depth grids. The Mapper utility has been used in the TSP modeling phase to manage DEM inconsistencies and improve inundation accuracies. Potential terrain concerns and a path forward to alleviate them are summarized in the Executive Summary.

The HEC RAS model has been updated using terrain data identified as “applebanana.tif”. Previous modeling efforts have used the best available data from state and FEMA. However, it is important to note that the combined data set may have inherent data accuracy issues that may compromise the validity of the hydraulic results but given the circumstances this data would be adequate for ATR.

2.4.4 Bridge and Culvert Modeling. There are 59 bridges and culverts that were modeled in this study. They ranged from small pipe culverts to large bridge structures. The geometry of these hydraulic structures were obtained from field investigations and as-built drawings. The height, width, deck thickness, and pier type and sizes were gathered and input into the model. The bridge modeling approach is decided based on modelers knowledge of the conditions on the ground or what is appropriate based on the model geometry data. In most of the cases, the energy method is used but in some locations it is expanded to include momentum and Yarnell methods to optimize results

2.5 MODEL REFINEMENT. Once processing of the GIS data was accomplished, the resulting ASCII text file was input into HEC-RAS. Further processing of the geometry file was required in order to complete the data that will allow the model to run. Items such as boundary conditions, Manning’s “n-values", expansion and contraction coefficients, bridge and culvert geometry, weirs, etc. were incorporated. These additional parameters are described in the following sections.

2.5.1 Stream Roughness. Manning's n-values are a measure of the roughness characteristics of the channel and floodplain and are a very important parameter in open channel flow modeling. High water marks from previous flood events were not available to calibrate the model, therefore the selection of n-values was based on observations from the site visit, theoretical literature, and engineering judgment. Initial estimates of the roughness coefficients were obtained using Jarrett's equation. This equation is applicable due to the steep slopes of the channel bed for the streams in question. Jarrett's equation was developed in 1984 by performing a regression analysis on 75 datasets that were surveyed from 21 different high gradient mountain streams. Jarrett's equation for predicting channel Manning's n-values is as follows:

$$n = 0.39 \times S^{0.38} \times R^{0.16}$$

where:

S = the friction slope of the stream. The average channel invert Slope can be used in place of the actual friction slope

R = the hydraulic radius (area/wetted perimeter) of the flow

The Jarrett equation was used to predict base n-values for the streams along their entire length with the hydraulic radius determined from the 1% AEP (100-yr.) event. Adjustments to the channel n-values were required to account for meandering, irregularity, variation in cross sections, obstructions, and vegetation. These factors are explained in Acrement and Schneider (1989).

Overbank n-values varied along the streams due to several factors. Areas of residential housing show a mix of low resistance (streets) to areas of no flow (buildings). Areas of vacant land are shown to be pastures or fields with scrub brush or heavily wooded areas. During the development of the model, a decision was made to use averaged "n" values between effective and ineffective flow areas. An n-value table is shown below.

Table 1. Range of Manning's n-Values used in the HEC-RAS Model

Stream Reach	Manning's n-Value Channel	Manning's n-Value Overbank
Waiakea Stream	0.016 - 0.048	0.040 - 0.100
Palai Stream	0.035 - 0.048	0.055 - 0.100
Four Mile Creek	0.042	0.050 - 0.080
Kupulau Ditch	0.041	0.048 - 0.100
Tributary 1	0.035 - 0.070	0.050 - 0.080
Tributary 2	0.035 - 0.010	0.056 - 0.100
Tributary 3	0.048 - 0.053	0.056 - 0.080

Stream Reach	Manning's n-Value Channel	Manning's n-Value Overbank
Palai B	0.048	0.056
Palai C	0.048	0.048 - 0.080
Palai D	0.040	0.080
Palai Overflow	0.048 - 0.052	0.080
Ainaola	0.040 - 0.072	0.050 - 0.080
HaiHai	0.040 - 0.060	0.056 - 0.080
Puhau	0.035	0.090
Four Mile Trib 1	0.042	0.080
Four Mile Trib 2	0.042	0.080

Several channel observations were made during site visits. Waiakea Stream and Kupulau Ditch channel beds are comprised mainly of volcanic rock. While some areas lined up with concrete, other segments of the channels are heavily vegetated, and consist of channel boulders. All of these add complexity and variability of channel friction that change flow regime in the stream. In order to accommodate these variations, a range of n values are selected for a range of flow conditions. On the upper reaches of Waiakea Stream, "n" values were increased by as much as 50% for low flows, 40% on Kupulau Ditch, and as channel fills up "n" value reaches to the normal base.

<u>2.5.2 Expansion and Contraction coefficients.</u> Expansion and contraction coefficients are used to measure the losses in stream energy due to the expansion or contraction of flow. These coefficients are multiplied by the change in velocity head to determine the energy loss. Initial contraction and expansion coefficients were set at 0.1 and 0.3 respectively for the channel sections and 0.3 and 0.5 for the hydraulic structures to account for those losses. During the development of the model, instabilities were encountered due to steep slopes that forced the model to reach critical depth. In order to dampen these instabilities, the expansion and contraction coefficients were reduced to 0.06 and 0.15 in areas where critical depth was attained over several sections. On Waiakea Stream, the Kupulau Road Bridge was assigned values of 0.1 and 0.2, as an example.

<u>2.5.3 Boundary Conditions</u>. Initial model runs were done assuming sub critical flow conditions. Normal depth was used as the boundary condition at the downstream end and is based on a channel bed slope of 0.007 ft/ft for Waiakea stream, 0.0073 ft/ft for Palai Stream, 0.0039 ft/ft for Four Mile Creek, 0.0125 ft/ft for Ainaola reach, and 0.0124 ft/ft for Palai outflow reach. The downstream boundary for the reach named "Debris" was set at critical depth. For the remaining reaches, the downstream boundary was determined by the program at junctions.

In the original modeling for large storm events, flow regime was assumed to be subcritical despite the steepness of some segments. Steep supercritical reaches warrant mixed flow modeling. Some changes were incorporated in the TSP model runs after further examination of the channel conditions and flow patterns.

2.5.4 Lateral Weirs. During the November 2000 flood, it was observed Waiakea stream overtop at upstream and overflow reached Kupulau ditch, then overflow of Kupulau ditch flow travel overland and subsequently reached Palai Stream C. The overflow conditions were modelled using lateral structures feature in the RAS model. The alignment of the lateral structures were determined from digitizing the ground elevation along the overflow path and setting elevation profile

Lateral weirs were incorporated into the model on Waiakea Stream upstream of Kupulau Ditch Reach W2, and at several locations from Kupulau Rd. to Kawailani St. (Reach W3). These weirs control the flow leaving Waiakea Stream and entering Kupulau Ditch, Tributary 2, or Tributary 3. A lateral weir was added along a portion of the right overbank of Kupulau Ditch to allow flow to pass over the bank and eventually into the main stem of the Palai stream in Hilo, passing over HaiHai St. (or Palai C. On Palai C, lateral weirs were inserted on a segment between Waiakea Stream and Kupulau Ditch (Reach P1) and along HaiHai St. where flow overtops the street and enters what was called the Ainaola area (Reach A1).

Weir coefficients were changed to stabilize the water elevation across the structure and Table 2 below shows the final range applicable to each weir.

Table 2.
Final Lateral Weir Coefficients Used in HEC-RAS Model

Reach	Weir Coefficient Range
W2	2.11
W3 (Trib 3)	1.0 - 2.0
W3 (Trib 2)	2.5 - 3.0
KD2 (Palai C)	2.41 - 2.5
KD2 (HaiHai)	1.0 - 1.45
P1	2.0
P3	2.5

There are two stream gage locations in the modeling limits. One is located on Waiakea Stream (USGS 16701300) and the other on Palai Stream (USGS 16701400). USGS Stream gage 16701300 is located approximately 1,580 feet upstream of the Kinoole St Bridge in Reach W5 of the model. USGS Stream gage 16701400 is located approximately 160 feet upstream of Olu St, which is in the Hilo Reach of the model. These two gage stations used to compare model results to observed records for various weir coefficients. The table 3 and Table 4 shows the results of model and observed flows. As can be seen from the tables, at Palai stream gage observed and model flows are fairly lined up but Waiakea gage shows inconsistent results.

Adjustments to the weir coefficients did not improve the results on Waiakea Stream without adversely impacting the results on Palai Stream. Since reach W5 on Waiakea Stream was significantly downstream of the study and anticipated work area, while the Hilo reach on Palai was an integral part of the study objectives, it was decided to use the set of weir coefficients that compared Palai stream favorably. All the subsequent modeling was done using these conclusions and corresponding numerical values.

Table 3.
Flow Comparison at USGS Stream gage 16701400

Event	Model Results		Adopted Flows from Hydrologic Analysis
AEP	Flow (cfs)	Elev. (feet)	Flow (cfs)
50%	497	168.6	476
20%	902	169.3	
10%	1,404	169.9	1,385
4%	1,958	170.3	1,819
2%	2,526	170.7	2,433
1%	2,685	170.8	2,936
0.5%	3,426	171.1	
0.2%	3,928	171.4	4,209

AEP=Annual Exceedance Probability
Elev. = elevation
cfs = cubic feet per second

Table 4.
Flow Comparison at USGS Stream gage 16701300

Event	Model Results		Adopted Flows from Hydrologic Analysis
AEP	Flow (cfs)	Elev. (feet)	Flow (cfs)
50%	1,185	64.2	761
20%	1,702	64.7	
10%	2,102	65.1	2,106
4%	3,114	65.9	
2%	3,820	66.5	4,427
1%	5,271	67.3	5,600
0.5%	6,601	67.8	
0.2%	7,438	68.2	9,535

AEP=Annual Exceedance Probability
Elev. = elevation
cfs = cubic feet per second

2.5.5 Cross Section Modeling. During the original modeling process, it was observed more cross sections were needed to rectify instabilities in steep stream segments. Therefore, more sections were added at 50ft intervals using the cross section interpolation feature in RAS.

2.5.6 Blocked Obstructions and Debris. Blocked obstructions were used to model large objects that disrupt the flow of water. On Kupulau Ditch reach, the New Hope Church complex was inserted into the model as a blocked obstruction. At certain bridge locations, partial blockage was used to represent the accumulation of stream bed material under bridges that were observed during the site visits. Clear water flow was assumed in the model, no floating debris functions at bridge locations were used as not many bridge locations had mid-stream piers.

Although it was known that debris played a part in the damage to the Kupulau Road Bridge in November 2000, no debris analysis was conducted, as it was not part of the scope due to the difficulty of accounting for debris impacts on flow conditions. However, in order to accommodate debris effects, manning n value was used as a surrogate with subcritical flow conditions.

3. WITHOUT PROJECT HYDRAULIC ANALYSIS

3.1 Model Calibration and Verification. High water marks from previous flood events were not available to calibrate the model. Model coefficients were adjusted to produce relatively smooth profiles and increase model stability. Floodplains resulting from the original model runs were delineated and were reviewed by other district personnel and Hawaii county representatives for reasonableness and accuracy. The resulting floodplains were judged to be consistent with observations in the field and therefore were considered valid.

3.2 Sensitivity Analysis. Sensitivity analysis was conducted on the lateral weir coefficients since some of the chosen values seemed higher than would be expected for natural ground. Model runs were made with the lateral weir coefficients set lower to 1.0 and 1.5. These runs were compared with the current HEC-RAS model to track the difference in flow. The practical effect of reducing the lateral weir coefficients is to increase flow along Waiakea Stream while decreasing flow in Palai Stream. Reducing the coefficients reduces the amount of flow overtopping Waikea Stream into Kupulau Ditch, and overtopping Kupulau Ditch and entering the Palai Stream system.

On Palai Stream, at USGS Streamgage 16701400, flows are reduced from the current model between 4.7 and 22.7 percent with the average being 15.7 percent when the weir coefficient is reduced to 1.0. When the weir coefficient is set to 1.5, flows are reduced between 1.1 and 10.4 percent with the average being 4.3 percent. Table 5 below shows the comparison at the gage location. The table also contains the water surface elevation at this location. These differences are much closer. The difference in elevation when compared from all runs ranges between 0 and 0.6 feet.

Table 5.
Comparison of Weir Coefficient Runs (Palai Stream)

Recurrence Interval	Weir Coefficient = 1		Weir Coefficient = 1.5		Current Model		Adopted Flows from Hydrologic Analysis
AEP	Flow (cfs)	Elev. (feet)	Flow (cfs)	Elev. (feet)	Flow (cfs)	Elev. (feet)	Flow (cfs)
50%	473	168.6	491	168.6	497	168.6	476
20%	819	169.2	877	169.3	902	169.3	
10%	1,155	169.6	1,312	169.8	1,404	169.9	1,385
4%	1,703	170.1	1,867	170.2	1,958	170.3	1,819
2%	1,974	170.3	2,263	170.5	2,526	170.7	2,433
1%	2,280	170.5	2,620	170.7	2,685	170.8	2,936
0.5%	2,648	170.7	3,270	171.1	3,426	171.1	
0.2%	3,082	171.0	3,855	171.3	3,928	171.4	4,209

AEP=Annual Exceedance Probability
Elev. = elevation
cfs = cubic feet per second

On Waiakea Stream, at USGS Stream gage 16701300, flows are increased from the current model between 2.7 and 17.6 percent with the average being 10.6 percent when the weir coefficient is reduced to 1.0. When the weir coefficient is set to 1.5, flows are reduced between -0.3 and 7.2 percent with the average being 2.6 percent. At the 500yr event, the flow is slightly reduced, which resulted in the negative percentage. Table 6 below shows the comparison at the gage location. The table also contains the water surface elevation at this location. These differences are much closer. The difference in elevation when compared from all runs ranges between 0 and 0.7 feet.

Table 6.
Comparison of Weir Coefficient Runs (Waiakea Stream)

Recurrence Interval	Weir Coefficient = 1		Weir Coefficient = 1.5		Current Model		Adopted Flows from Hydrologic Analysis
AEP	Flow (cfs)	Elev. (feet)	Flow (cfs)	Elev. (feet)	Flow (cfs)	Elev. (feet)	Flow (cfs)
2	1,216	64.2	1,192	64.2	1,185	64.2	761
5	1,833	64.8	1,736	64.7	1,702	64.7	
10	2,431	65.4	2,222	65.2	2,102	65.1	2,106
25	3,444	66.1	3,247	66.0	3,114	65.9	
50	4,491	66.9	4,116	66.7	3,820	66.5	4,427
100	5,770	67.5	5,297	67.3	5,271	67.3	5,600
200	7,333	68.1	6,664	67.9	6,601	67.8	
500	8,198	68.9	7,413	68.1	7,438	68.2	9,535

APE=Annual Exceedance Probability
Elev. = elevation
cfs = cubic feet per second

Comparing the results of the sensitivity runs shows there is a difference in flows between weir coefficients. However, the difference in water surface elevation appears to be relatively minor. The largest difference occurs at the 0.5% and 0.2% ACE events, and when considering annual flood damages, the difference would have a small effect on the overall damage calculation.

Sensitivity analysis was also done by varying the estimated Manning "n-values" by +/- 20%. This process was used in determining the stage uncertainty values for use in HEC-FDA. See Section 5.3 on risk and uncertainty for more information.

4. Without Project Conditions (Existing Conditions)

This section provides a description and an analysis of the HEC-RAS model results for the various steam reaches in the HEC-RAS model.

4.1 Waiakea Stream. Waiakea Stream above Kupulau Ditch is characterized by poorly-defined channels. It has a nominal slope of 0.01479 ft/ft (1.48%). It has a channel capacity of less than 1,020 cfs, which is comparable to a 50% AEP storm event. The channel bed is a mix of earth and volcanic rock. Excess water leaves the Waiakea Stream by overtopping the right bank at the 50% AEP event and flows overland eastward toward Kupulau Ditch.

Between Kupulau Ditch and the Kupulau Rd Bridge, Waiakea Stream has a nominal slope of 0.02249 ft/ft (2.25%). It has an average channel capacity of about 1,630 cfs, which is comparable to a 20% AEP storm event. Flows greater than the 20% AEP event flood the right and left overbanks, but due to the surrounding topography this flow ultimately makes its way downstream to the bridge.

The Waiakea Stream reach between Kupulau Rd and Kawailani St drops in elevation about 129 feet over a 4,000 foot length for a nominal slope of 0.03242 ft/ft (3.24%). It has a minimum channel capacity of about 2,400 cfs which is comparable to a 10% AEP storm with some areas capable of containing a 4% AEP event. The channel bed is primarily volcanic rock and at its upstream and downstream ends incorporates improvements due to bridge construction as a result of the November 2000 flood. Flows in excess of the channel capacities leave the channel and flood the residential properties along Hookano St, Hoaloha St, Kuleana Loop, Kuleana Place, among others on the right overbank. On the left overbank, water leaves the channel and floods residential properties along Puhau St, Auahi Place where the flow enters the drainage area of Tributary 3. Downstream of Tributary 3 floodwaters impact properties south of Kawailani St before it is eventually contained in the improved channel upstream of the new Kawailani St Bridge.

Downstream of Kawailani St, the stream is characterized by the Waiakea-Uka Flood Control channel. The channel was constructed in 1984 by the County of Hawaii. It consists of a concrete lined and unlined trapezoidal channel and has a design discharge of 4,460 cfs. The channel bed is primarily grouted lava rock. It begins at the Komahana St Bridge and continues upstream to a point parallel to Apono St for a distance of about 3,460 feet. Figures 3 to 20 illustrate the channel conditions of Waiakea Stream.

Figure 3.
Waiakea Stream looking upstream from its confluence with Kupulau Flood Ditch

Figure 4.
Waiakea Stream looking downstream from just downstream of the confluence with Kupulau Flood Ditch

Figure 5.
Waiakea Stream looking upstream from Kupulau Rd Bridge

Figure 6.
Waiakea Stream looking downstream from Kupulau Rd Bridge

Figure 7.
Waiakea Stream looking downstream from Kupulau Rd Bridge at Station 20+219.90

Figure 8.
Waiakea Stream looking upstream from rock outcropping Approximate Stream Station 17+001.00

Figure 9.
Waiakea Stream looking downstream from rock outcropping
Approximate Stream Station 17+001.00

Figure 10.
Waiakea Stream looking upstream from the end of the channel lining near Kawailani St

Figure 11.
Waiakea Stream looking downstream from the end of the channel lining towards Kawailani St

Figure 12.
Waiakea Stream looking upstream at Station 14+592.73

Figure 13.
Waiakea Stream looking downstream at the upstream end of the Waiakea-Uka Channel

Figure 14.
Waiakea Stream looking upstream from the upstream end of Waiakea-Uka channel

Figure 15.
Waiakea Stream looking at the upstream end of Waiakea-Uka Channel

Figure 16.
Waiakea Stream looking downstream at the upstream face of the T. Shiroma Bridge (Note channel restriction)

Figure 17.
Waiakea Stream looking downstream from the T. Shiroma Bridge

Figure 18.
Waiakea Stream looking upstream at Waiakea-Uka channel from Station 18+00
Note scour damage repair on right bank.

Figure 19.
Waiakea Stream looking downstream at upstream face of Puainako St Bridge

Figure 20.
Waiakea Stream looking at downstream face of Komohana St Bridge

4.2 Kupulau Flood Ditch. Kupulau Ditch is a non-federal channel constructed in 1971 to divert runoff from the Palai Stream drainage basin into Waiakea Stream. It consists of an unlined trapezoidal channel with an upstream bottom width of about 8 ft, and widening to a bottom width of 15 feet for the lower 1,600 feet until it meets Waiakea Stream. The channel begins at the Waiakea Stream and ends just upstream of Ainaola Street for a total distance of about 2,710 feet. It has a channel capacity of about 1,000 cfs which is comparable to a 2% AEP storm event. However, the ditch is subject to significant backwater from Waiakea Stream which reduces the effective channel capacity to approximately a 20% AEP event.

Water overtopping the right bank of Waiakea Stream is received by Kupulau Ditch in the vicinity of the New Hope Church. The flow quickly exceeds the capacity of the ditch and overtops the banks where it again flows to the east overtopping Kupulau Rd and flows overland in two pathways; along the south side of HaiHai St and the Palai Stream C tributary south of the New Hope Church. These two paths merge at Hoolaulea St and eventually enter Palai Stream.

Figure 21.
Kupulau Ditch looking upstream at downstream face of Ainaola Dr.

Figure 22.
Kupulau Ditch looking downstream from point approx. 500 ft downstream of Ainaola Dr.

Figure 23.
Kupulau Ditch looking downstream from Pedestrian Bridge at park

4.3 HaiHai Street Reach. Floodwaters that overtop Kupulau Road flow overland along the south side of HaiHai St. This area does not contain a defined channel which causes damage to the residential structures located along the street. Water flows eastward following the topography until it joins with the second pathway from Kupulau Ditch and enters a 4 ft diameter culvert on the south side of HaiHai St.

4.4 Palai Stream C. The Palai Stream C drainage receives excess water from Kupulau Ditch that overtops Kupulau Rd and routes it downstream through a swale where it joins with the flow from the HaiHai St Reach and enters a 4 ft diameter culvert. This culvert, about 320 ft in length, conveys flow through the residential structures along Hoolaulea St where it then enters an open ditch that collects local drainage from the subdivision. This flow enters another 4 foot diameter conduit about 1,060 feet in length along the south side of HaiHai St, and discharges into a concrete lined open channel flowing east until it reaches Ainaola Dr. At Ainaola Dr, the channel transitions into a series of 5 ft diameter conduits that travel through the development and exits to an open channel east of Keone St. Finally, Palai Stream C joins the main stem of Palai Stream at the Hilo Municipal Golf Course.

Figure 24.
Palai Stream C looking upstream at drainage ditch

Figure 25.
Palai Stream C looking upstream at stormwater ditch on HaiHai St.

Figure 26.
Palai Stream C looking at stormwater ditch inlet along HaiHai St.

4.5 Ainaola Reach. This reach begins on the north side of HaiHai Street just east of Lei Lehua St. where it receives floodwaters from Palai C which overtop HaiHai St. These waters flow overland and follow the topography impacting residential structures along Hoomalu St., Ahe St., and Ainaola Dr. At Ainaola Dr., flow overtops the street and enters the Palai C reach drainage impacting the structures there.

4.6 Waiakea Tributary 2 Reach. The Waiakea Tributary 2 stream flows primarily east of Waiakea Stream beginning just upstream of Komohana St and ends just upstream of Kawailani St for a distance of about 5,890 feet. It has a nominal slope of 0.02491 ft/ft (2.49%). The lower end of the stream forms a defined channel for about 2,800 feet, and flows through a residential subdivision. Upstream of the subdivision the stream transitions to overland flow and continues upstream to Kawailani St. Floodwaters overtop the Waiakea Stream channel and enter the tributary flooding residential structures along its length until it joins with Waiakea Stream upstream of Puainako St.

Figure 27.
Waiakea Tributary 2 Stream looking at the tributary outlet to Waiakea Stream

4.7 Waiakea Tributary 3. Waiakea Tributary 3 stream begins at an open channel collecting drainage from residential structures located along both Puhau and Auahi Streets. The stream crosses Kawailani St and transitions to overland flow following the topography to the west of Launa St, continuing downstream west of Olhana St. impacting pockets of residential structures. The stream continues overland where it finally joins the Waiakea Stream approximately 2,000 ft upstream of Puainako St. The total length of the stream is about 6,230 feet and has a nominal slope of 0.02330 ft/ft (2.33%). The channelized portion of the stream has a capacity of about 230 cfs, which is comparable to a 10% AEP storm. The overland portion of the stream results in flood depths of 1 to 4 feet.

4.8 Palai Stream A (Overflow). Palai Stream A begins just east of Kupulau Ditch south of Ainaola Drive. It does not have a well-defined channel and travels overland where it crosses Ainaola Dr in the vicinity of Kupulau Rd. It continues eastward where, after crossing Kaulike St it turns northeast and continues overland following the topography. The modeling of this stream ends at a point south of Nou St for a total distance of about 4,020 feet. The modeled portion of the stream has a nominal slope of 0.01763 ft/ft (1.76%). The stream is dry up to the 0.2% AEP event where it receives flow that overtops the right bank of Kupulau Ditch. At the 0.2% AEP event flood depths are 1-2 feet.

4.9 Palai Stream. Palai Stream is characterized by poorly defined channels. In Hilo Town, the stream has a nominal slope of about 0.00727 ft/ft (0.73%) between Waiakea Pond and Kawailani St. Upstream of Kawailani St, the stream slope increases to 0.02624 ft/ft (2.62%) through the Hilo Municipal Golf Course. The stream mainly travels overland through the city with pockets of flooding occurring at numerous locations. Upstream of the Hilo Municipal Golf Course the stream begins to split into several tributaries. The main stem of the stream turns south and flows towards a residential area near HaiHai St. Between HaiHai St and Ainalako Rd, the stream has a nominal slope of about 0.01831 ft/ft (1.83%), and crosses residential properties at Leimamo and Malia Streets. Above Ainalako Rd the stream flows through mainly open land.

Figure 28.
Palai Stream looking downstream through Hilo Municipal Golf Course

Figure 29.
Palai stream looking at HaiHai St culvert

Figure 30.
Palai Stream looking downstream from Heahea St Bridge

Figure 31.
Palai stream looking downstream from Kinoole Ave Bridge

Figure 32.
Palai Stream looking downstream from Kilauea Ave Bridge

Figure 33.
Palai Stream looking upstream from Palai St

Figure 34.
Palai Stream looking downstream on Kawili St, stream crosses road here and flow around to right of building

4.10 Four Mile Creek. Four Mile Creek empties into an old quarry on the east side of Hilo (Figures 35 to 37). Leading into the quarry is an unlined flood control channel constructed by the Hawaii County.

This channel begins at the Kanoelehua St Bridge and is about 10,000 feet in length. The nominal slope of the channel is about 0.00764 ft/ft (0.76%). Upstream of this point the stream flows mainly through open land with some scattered pocket of mixed residential structures and farmland.

Figure 35.
Four Mile Creek looking downstream from Ainalako Rd

Figure 36.
Four Mile Creek looking downstream from Awa St Bridge

Figure 37.
Four Mile Creek looking upstream from Railroad Ave Bridge

5. WITHOUT PROJECT MODEL RESULTS

5.1 Flood Inundation Maps. Figures 38 and 39 show the computed 1% and 0.2% AEP flood inundation areas for the Waiakea-Palai Study without project conditions. The maps are created by plotting the water surface elevations onto a digital elevation model. The areas where the water surface elevations are greater than the ground elevations are shown as flooded.

5.2 Without Project Water Surface Profiles. The without project water surface for the 0.5%, and 0.2% AEP events are shown in figures 40-42.

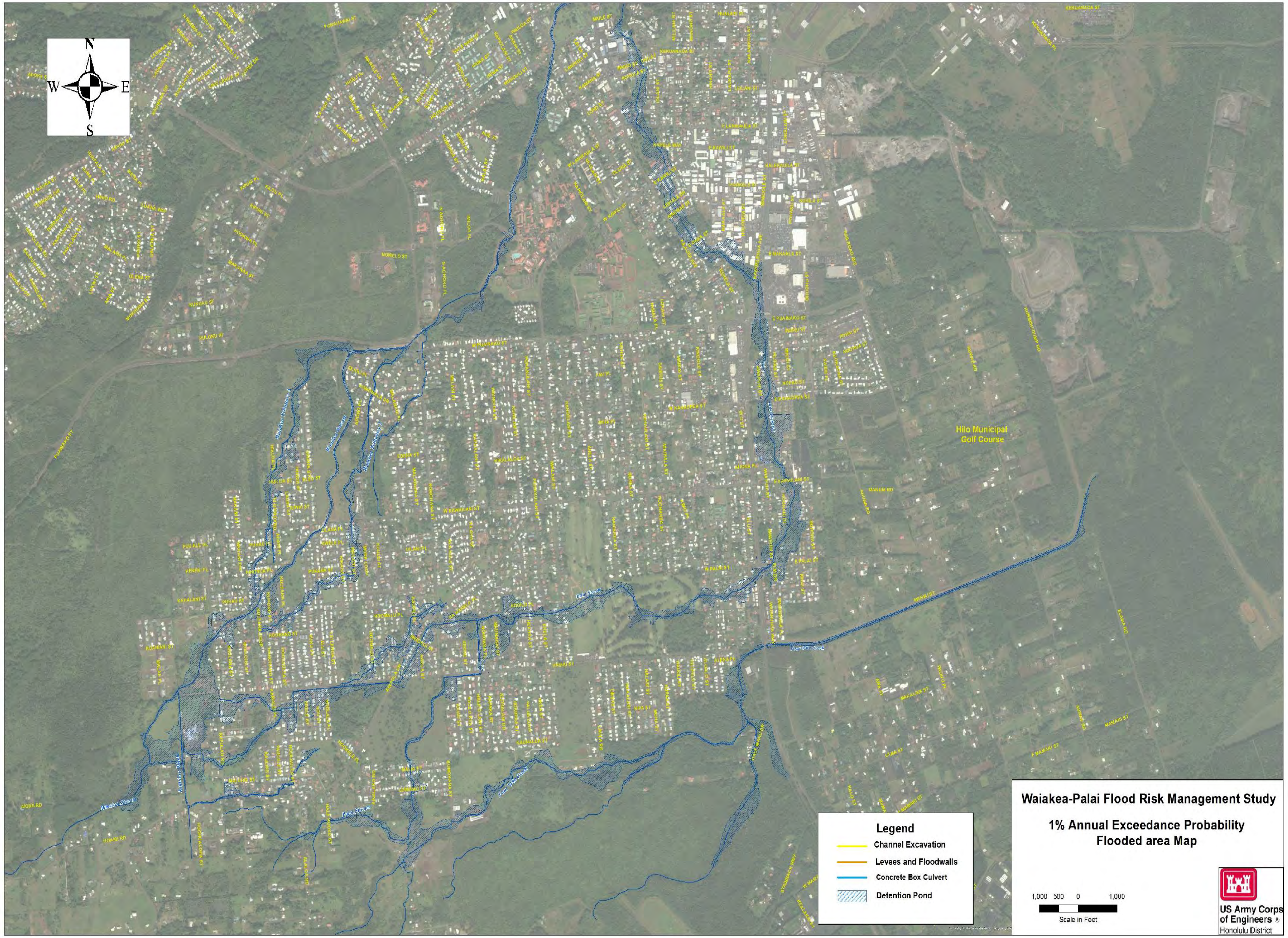

Figure 38. 1% AEP Without Project Flooded Area Map

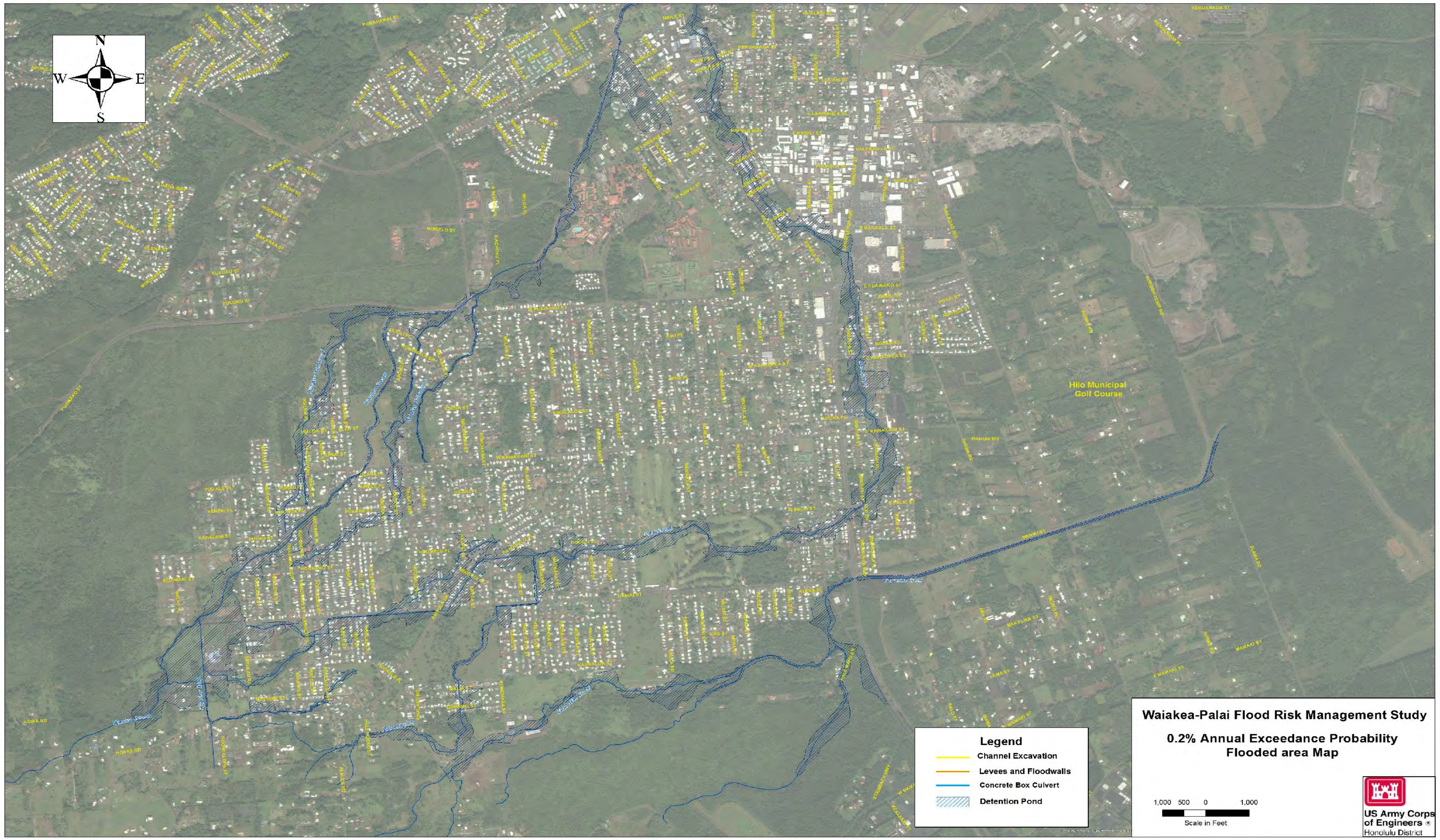

Figure 39. 0.2% AEP Without Project Flooded Area Map

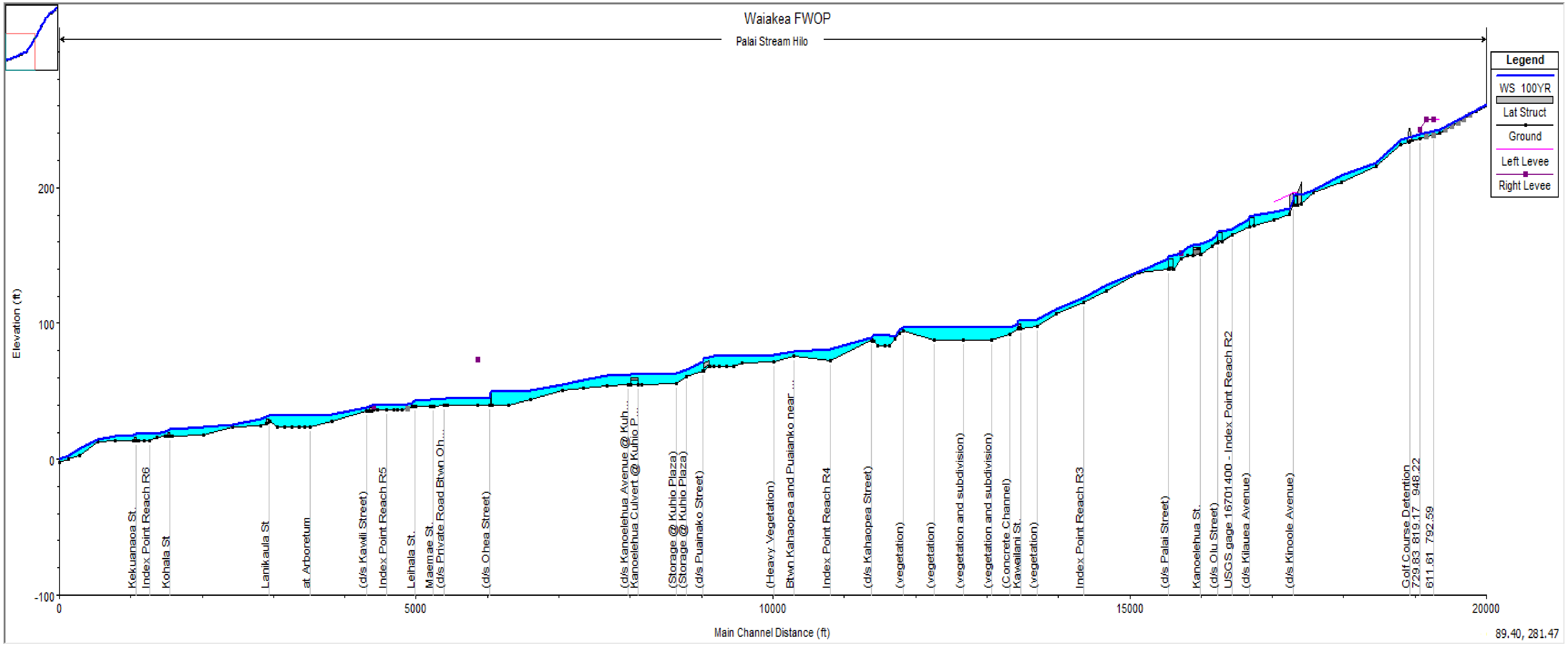

Figure 40A. Waiakea Stream Without Project Profile (Strem Distance up to 20000)

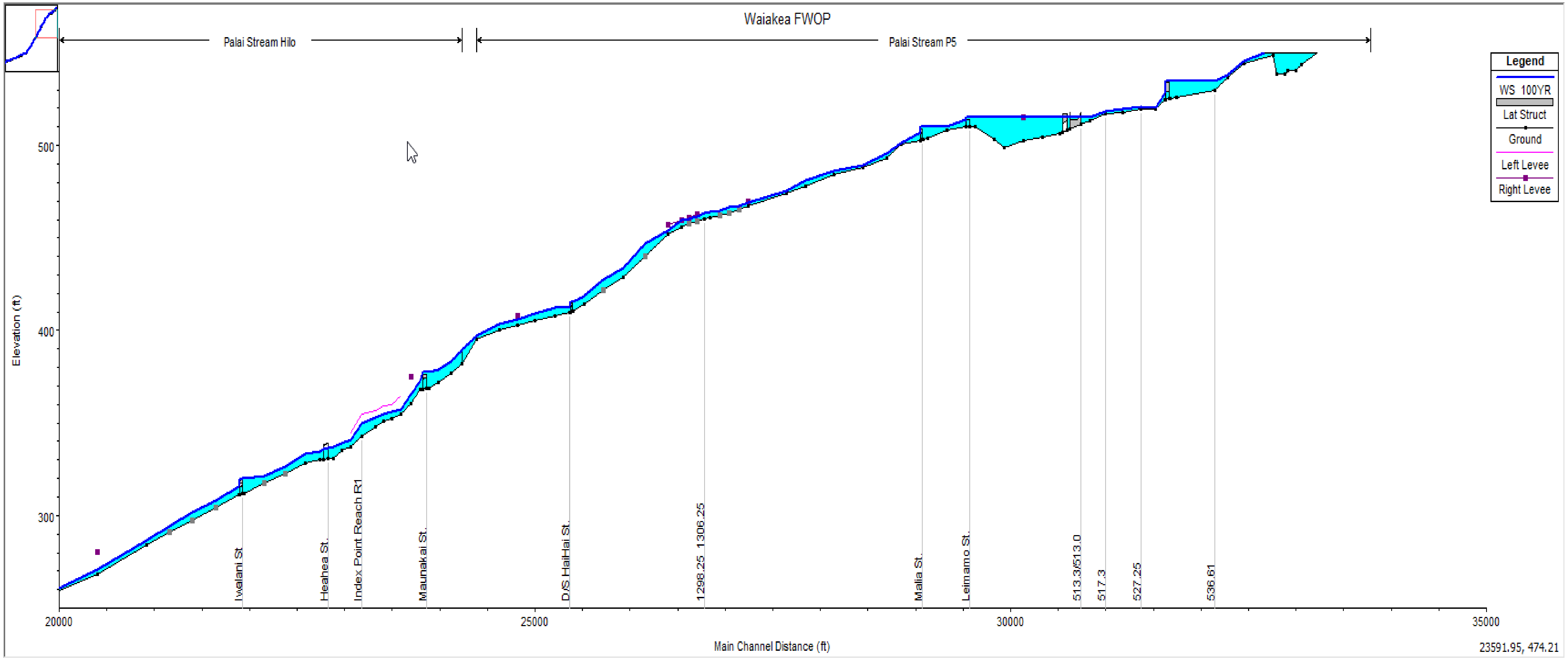

Figure 40B. Waiakea Stream Without Project Profile (Stream Distance from 20000 to 35000

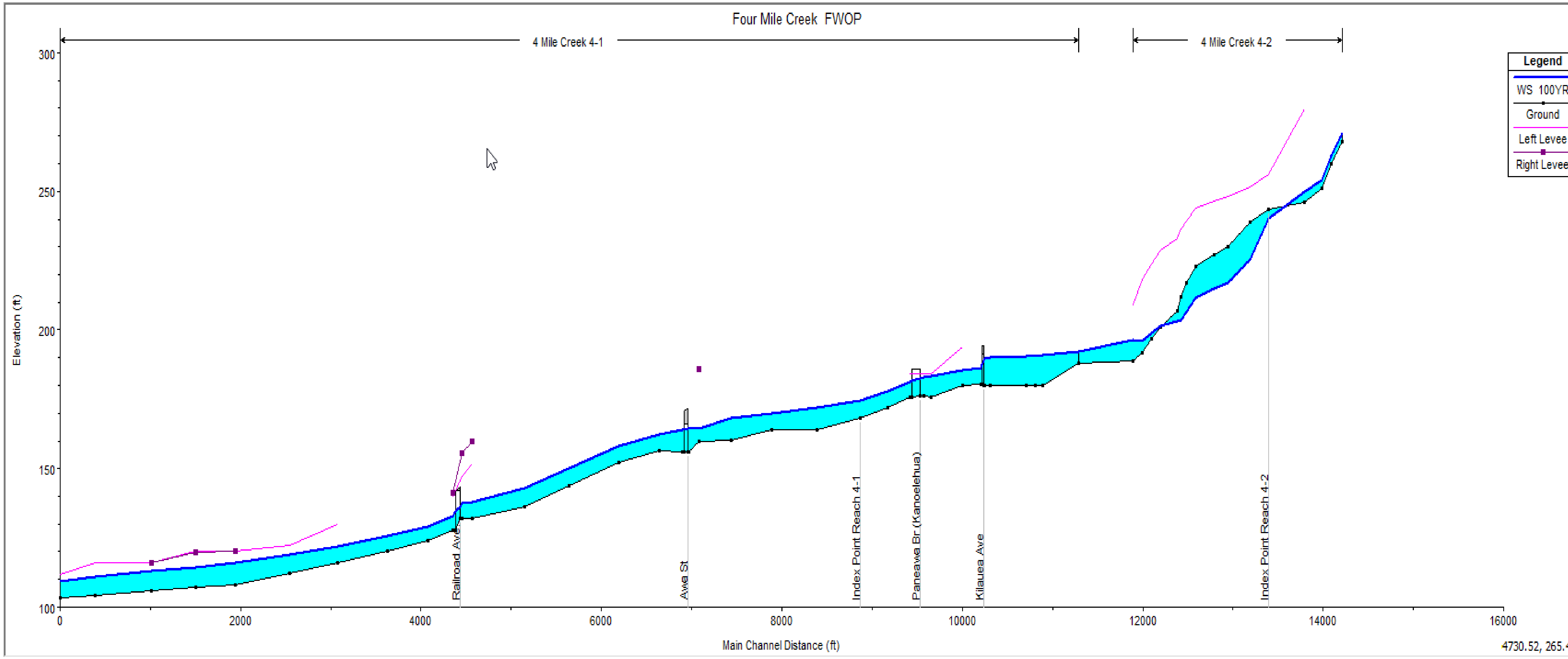

Figure 42A. Four Mile Creek Without Project Profile (Reach 1 and 2)

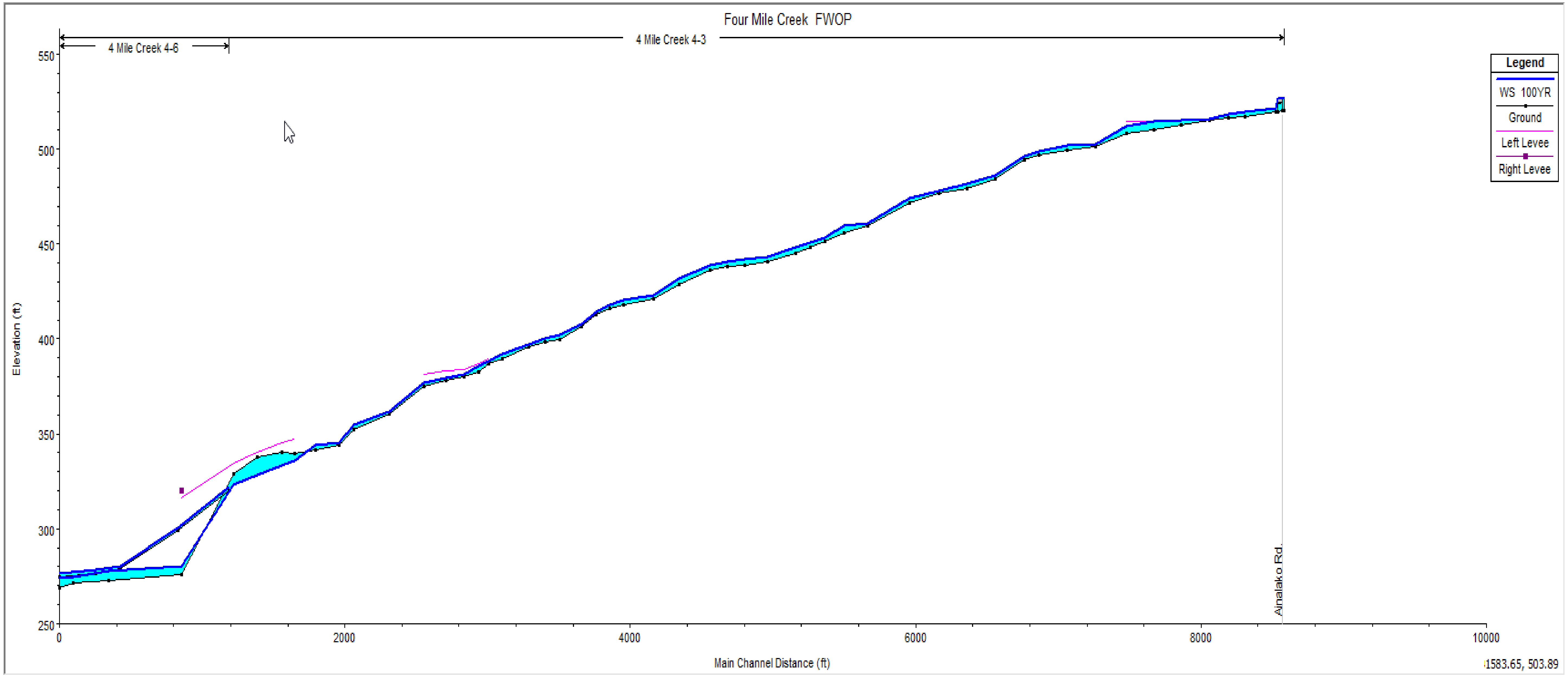

Figure 42B. Four Mile Creek Without Project Profile (Reach 3 and 6)

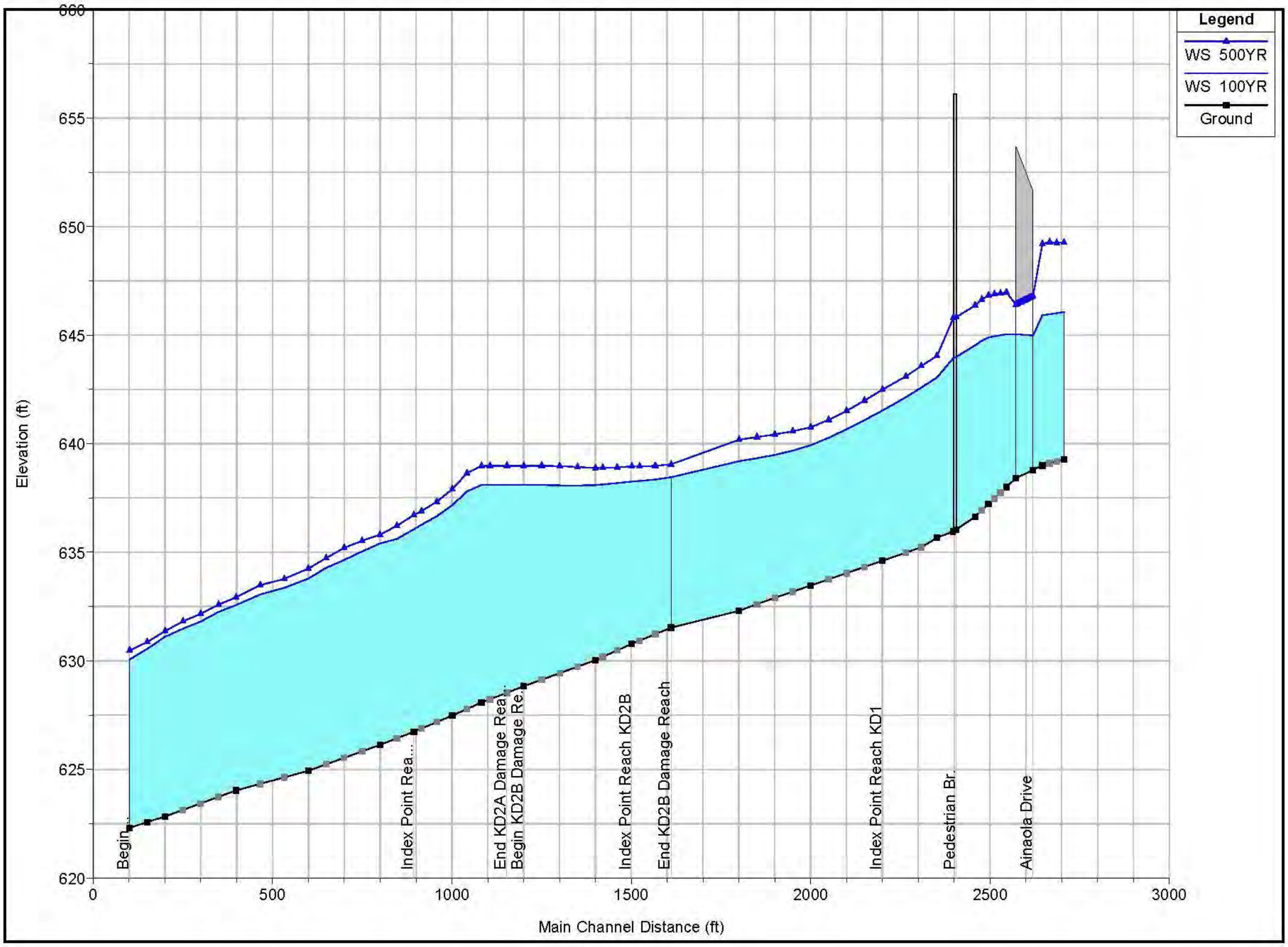

Figure 41. Kupulau Ditch Without Project Profile

5.3 Risk and Uncertainty. The determination of uncertainty in stage-discharge relationships depends on many factors. These factors include bed-forms, debris and/or suspended sediment, variation in channel shape, variations in hydraulic roughness, and channel scour or deposition. Engineer Manual 1110-2-1619, Risk-Based Analysis for Flood Damage Reduction Studies, (EM 1110-2-1619) provides guidance in determining risk and uncertainty. Stage-discharge relationships, or rating curves, were developed for the selected index stations along the streams studied.

Water surface profiles were computed for the without-project condition using the estimated values for Manning's Roughness coefficient. Sensitivity runs were made by varying the estimated "n-values" by +/- 20%. The standard deviation was estimated by using the following equation:

$$S = E_{mean} / 4$$

Using the above equation as a guide, the standard deviation was calculated. Table A7 shows an example of the computed values for stage uncertainty under without project conditions for Reach W3C. Each reach had a similar table computed for use in HEC-FDA.

Table A7. Stage-Discharge Uncertainty

	Waiakea Stream - Reach W3C					
	Index Station 21818.65					
AEP	FREQ. (%)	MIN. ELEV.	BASE ELEV.	MAX. ELEV.	FLOW	STANDARD DEVIATION
	-	618.5	618.5	618.5	0.00	0.000
	0.990	618.90	618.95	619.00	8.01	0.025
50%	0.500	625.38	625.56	625.67	1351.69	0.072
20%	0.200	625.79	625.96	626.08	1955.15	0.073
10%	0.100	626.05	626.25	626.38	2596.77	0.083
4%	0.040	626.32	626.58	626.80	3588.95	0.120
%	0.020	626.57	626.81	627.00	4438.59	0.107
1%	0.010	626.81	627.04	627.28	5669.63	0.118
0.5%	0.005	627.01	627.36	627.63	7494.06	0.155
0.2%	0.002	627.20	627.57	627.85	8474.66	0.162

6 WITH PROJECT HYDRAULIC ANALYSIS

6.1 METHODOLOGY. This section describes the methodology used in evaluating alternatives to reduce the flood potential in the Waiakea-Palai study area. A general assumption in the design process was that any alternative would provide maximum net benefits. Other design objectives included:

- avoid environmental impacts to the maximum extent possible
- minimize initial construction cost and long term maintenance
- minimize project-induced damages, both within the project area and downstream
- incorporate environmental friendly design opportunities where possible
- provide for a minimum 50 year project life

Flood damage reduction measures considered centered around two principles. These were to either reduce the volume of flow moving downstream, or to control the existing flow volume. The 2001 Reconnaissance Report identified four alternatives to reduce the flood potential. These alternatives were the construction of levees/floodwalls, channel modifications to the stream, construction of a diversion channel, and construction of a detention basin. One additional alternative was requested by the local sponsor. This alternative was to evaluate the impacts of improving the Kupulau Ditch alone without any additional work in the project area. As the study progressed additional measures were also analyzed.

6.2 STRUCTURAL MEASURES FOR WAIAKEA STREAM. This section discusses all the measures analyzed for flood risk management. For all figures illustrating the measures in this section, the north direction is toward the top of page and all figures are considered not to scale unless otherwise noted.

6.2.1 Upper Waiakea Stream Reservoirs. This measure consists of two detention basins constructed in the upper reach of Waiakea Steam above the Waiakea Homesteads to attenuate flood flows. The basins would be located upstream of the Waiakea Homesteads residential community at the edge of the Waiakea-Uka Forest Preserve. Upstream of this point the landscape rises sharply up the mountainside limiting the storage potential. The basins would be formed by creating an embankment across the landscape to form a basin with sufficient storage to reduce downstream flood damage. Figure 8 shows the location of the detention basins.

Upstream of the Waiakea Homesteads community, Waiakea Stream splits into three branches. Detention basins would be constructed on the two largest branches while the third would remain in its natural state. The detention basins would be sized to reduce the 1% chance recurrence interval peak flow down to a level so that when combined with the contribution from Kupulau Ditch, the combined flow would approach the channel capacity for Waiakea Stream downstream of Kupulau Ditch.

Preliminary analysis shows that the detention basins require the following parameters, where ac-ft is acre-feet and cfs = cubic feet per second:

Table A8. Detention Storage

	Peak Storage (ac-ft)	Peak Outflow (cfs)	Peak Stage (ft)
Reservoir1	225	1,490	1,482
Reservoir 2	250	1,800	1,452

Reservoir 1 would require construction of an embankment approximately 3,500 ft in length and ranging from 0 to 30 feet in height, while Reservoir2 would require an embankment about 3,600 feet in length and range from 0 to 40 feet in height. The side slopes of the embankment would be a minimum of 3:1 horizontal to vertical, resulting in a base footprint of about 200 to 250 feet. The outlet works would be constructed of reinforced concrete pipe (RCP).

Construction of these detention basins would occur in the Waiakea Forest Preserve, which is a pristine, environmentally sensitive area. Immediately downstream of the detention basins is the Waiakea Homesteads residential community consisting of many single family homes.

Due to their size, the detention basins would be regulated by the State of Hawaii and as such, they which would require additional analysis and design considerations in order to satisfy the state Dam Safety Regulations.

Due to the magnitude of construction for these detention basins, it is doubtful that this measure could be cost-effective. Construction of the impoundment would require large areas of pristine forest removal which would not be environmentally acceptable. The Waiakea Homesteads community would be living literally in the shadow of these basins, placing at risk a portion of the population where there is now minimal risk. It is for these reasons that this measure was not considered feasible and will not be analyzed further.

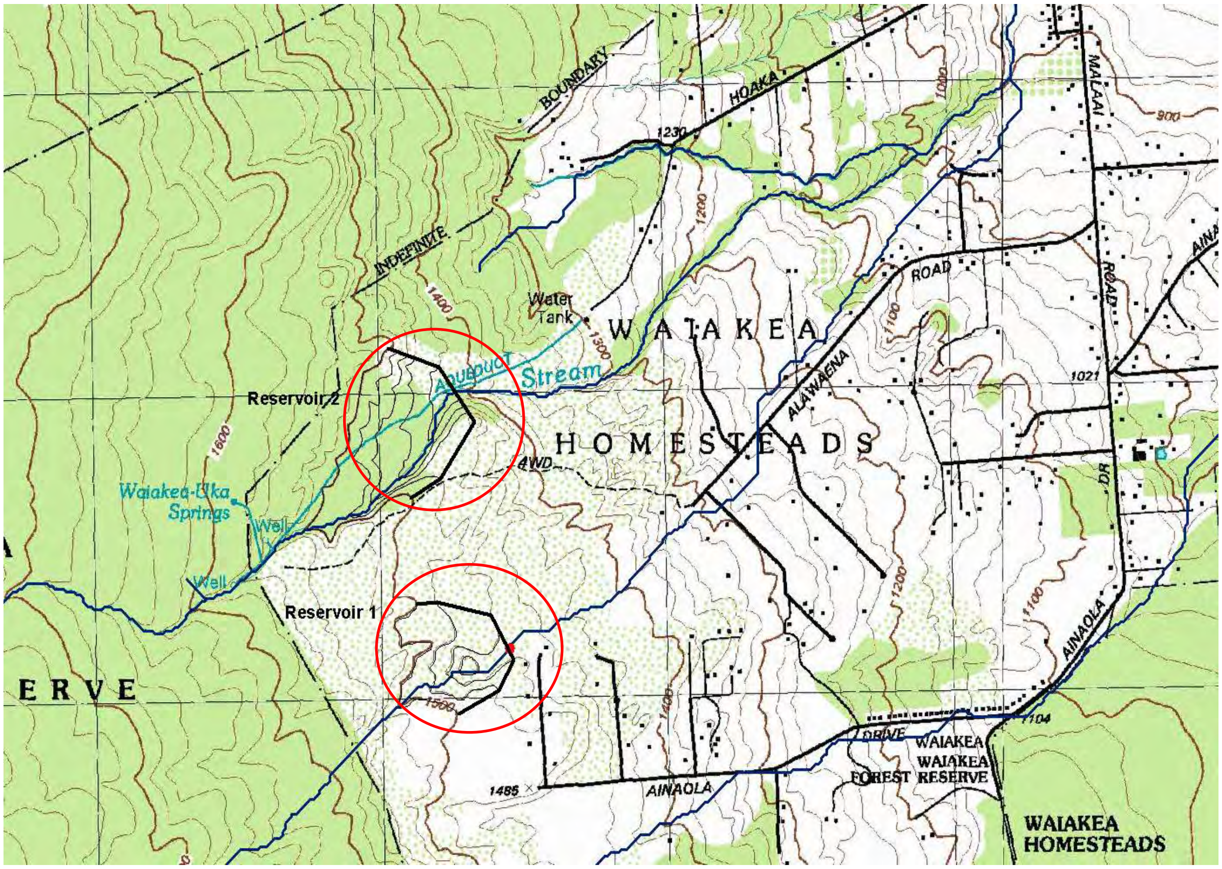

Figure 43. Upper Waiakea Basin Detention Basins Location

<u>6.2.2 Upper Waiakea Stream Levee #1</u>. This measure consists of a levee constructed along the right bank of Waiakea Stream above the confluence with Kupulau Ditch to prevent flows from leaving Waiakea and entering Kupulau Ditch. This levee would be approximately 2,000 ft in length and have an average height of about 15 ft at the 1% AEP event. While the levee prevented flow from entering Kupulau Ditch it also increased the amount of flow at the confluence of Waiakea Stream and Kupulau Ditch thereby increasing the tailwater condition for the ditch to a point where the ditch was not able to contain its own flow. Overtopping of the ditch still occurred and additional measures were required to contain the flow within the ditch. Thus, this measure was not analyzed any further. Figure 44 shows the location of the Upper Waiakea Levee #1.

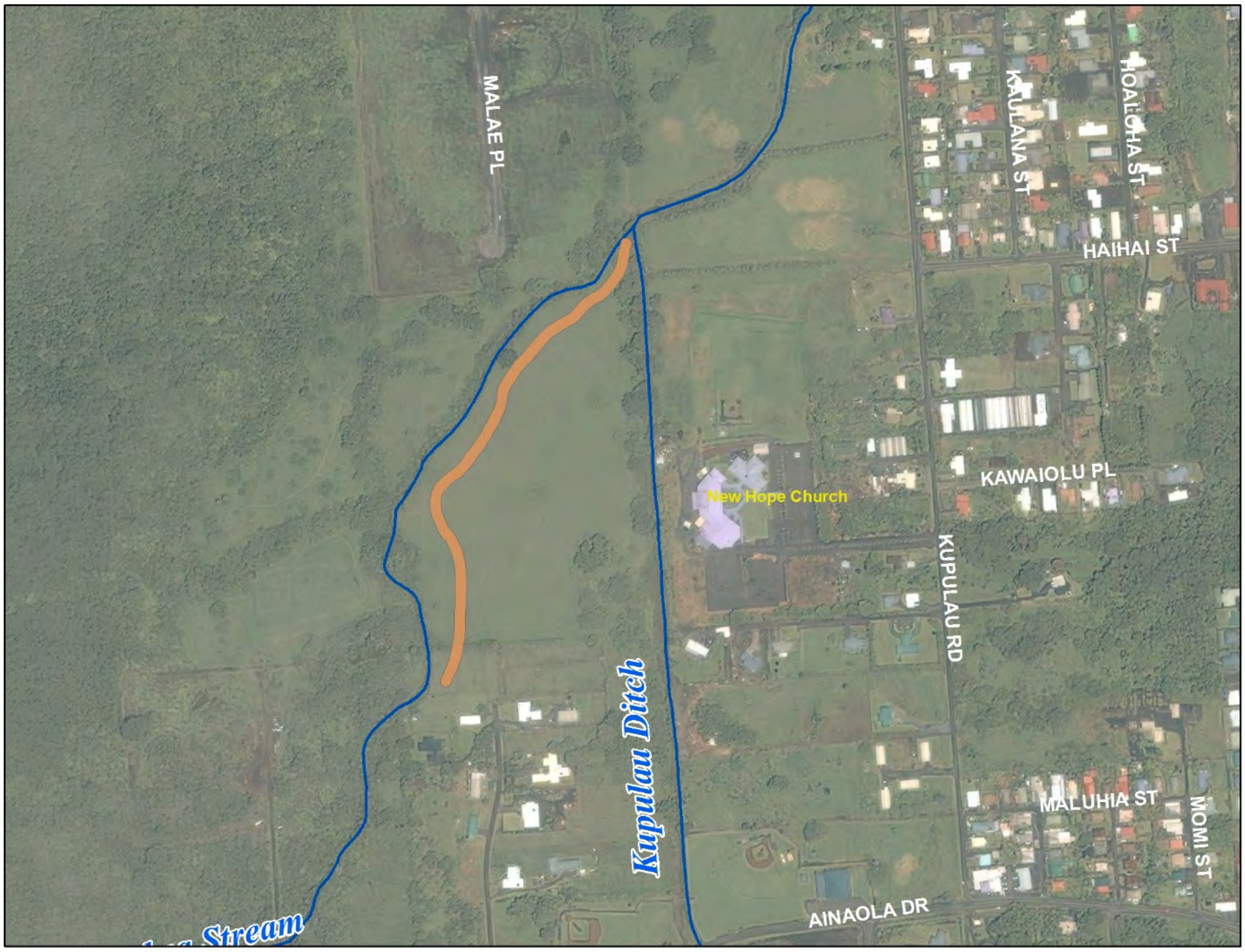

Figure 44. Location of Upper Waiakea Levee #1

<u>6.2.3 Upper Waiakea Stream Levee #2</u>. This measure consists of constructing a levee on land between Waiakea Stream and Kupulau Ditch, upstream of its confluence. This levee forms a detention area to hold excess flow in times of extreme rain events. The levee begins at Waiakea Stream and travels east to the left bank of Kupulau Ditch where it turns south and generally follows the 636 foot elevation contour. It ties into a small hill and then continues in a southwesterly direction and ties into high ground along the right bank of Waiakea Stream. This levee has a total length of about 1,810 ft and a maximum height of 6.8 ft. Figure 45 shows the location of the Upper Waiakea Stream Levee #2.

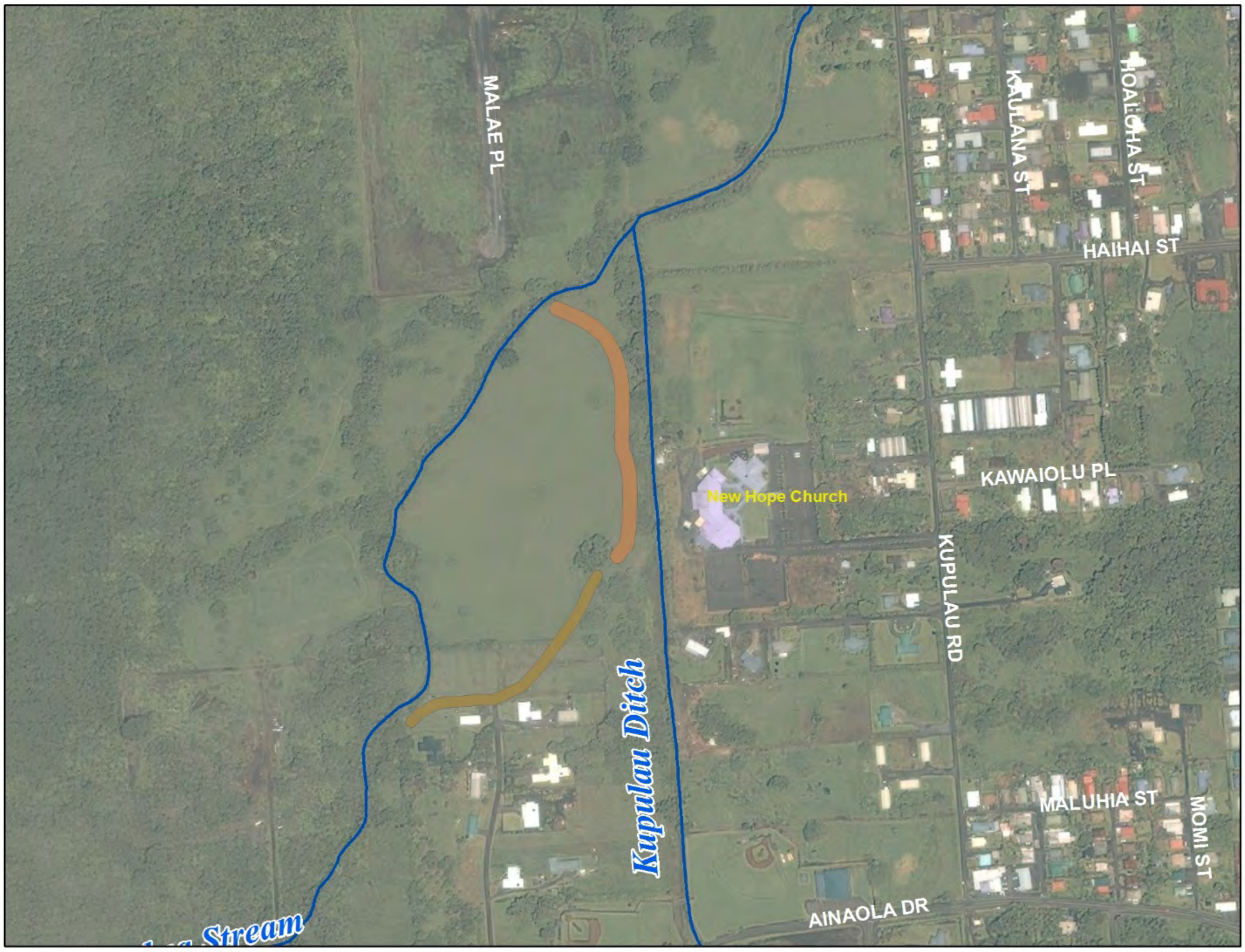

Figure 45. Location of upper Waiakea Levee #2

6.2.4 Kupulau Ditch Channel Enlargement. This measure consists of enlarging the Kupulau Ditch channel from its mouth upstream to the pedestrian bridge for a distance of about 2,400 ft. This channel excavation would be designed to contain its own flow plus the overflow from Waiakea Stream. The existing Kupulau Ditch contains a channel having a 12 foot bottom width with 2:1 side slopes. Various channel configurations ranging from a 15 foot bottom width to a 30 foot bottom width were analyzed to determine their impact on the water surface elevation of the 1% AEP flood event. Excavation of the channel could only occur along the left bank as the existing ground elevations begin to become lower along the right bank as the distance from the ditch increases. In each case the excavation was not sufficient to contain the flood profile due to the excessive tailwater condition at the confluence of the ditch with Waiakea Stream. For each configuration, additional measures were required to completely contain flow to the ditch. This effort was terminated after testing the 30 foot bottom width as excavation quantities became sufficiently too large to render this measure economically infeasible. Thus, this measure was not considered any further. Figure 46 shows the location of the Kupulau Ditch Channel Enlargement.

Figure 46. Location of Kupulau Ditch Channel Enlargement

6.2.5 Kupulau Ditch Detention I. The main component of this measure is the construction of a detention area to store excess runoff which now enters Kupulau Ditch. The improvements include levee and floodwall construction on Kupulau Ditch, and for Waiakea Stream, the improvements include the construction of both levees and floodwalls, along with channel deepening or improvements to Waiakea stream. Additional measures on Waiakea Stream consist of the construction of a debris control structure, grade control measures, and the removal of a privately owned bridge.

Kupulau Ditch Detention I will also require the construction of the Kupulau Ditch Levee Floodwall measure to address flooding due to the backwater effect at the confluence of Kupulau Ditch and Waiakea Stream. This will result in levees/floodwalls on both sides of Kupulau Ditch. The natural topography of the site location for the detention area will require levee heights in excess of 11 ft to contain a 0.2% AEP flood. The detention area will have a positive impact in shaving off the peak flows but improvements to Waiakea Stream downstream of Kupulau Road Bridge will still be required. The construction of levees/floodwalls on both sides of Kupulau Ditch will result in a potentially a higher overall implementation cost than Detention Area II which will not require improvements to Waiakea Stream downstream of Kupulau Road Bridge.

For Kupulau Detention I, the improvements to Waiakea Stream begin with the construction of a series of levees on the land between Waiakea Stream and Kupulau Ditch, upstream of its confluence. These levees are connected to form a storage area to hold excess flow in times of extreme rain events. The first levee is to be constructed along the right overbank of Waiakea Stream, for a length of about 795 feet. The levee ranges from elevation 644.6 to 646.0 ft, and has a maximum height of about 8.6 feet at its downstream end. The second levee for the storage area connects to the Waiakea levee and travels west across the landscape to the left bank of Kupulau Ditch where it turns south and generally follows the 636 ft contour, and ties into a small hill at approximate elevation 646.2 ft. The levee begins again on the back side of the hill and travels in a southwesterly direction and ties into high ground along the right bank of Waiakea Stream at elevation 648.0 ft. The total length of this levee is approximately 1,907 ft and has a maximum height of 11.5 ft. Construction of these levees will store water up to and including the 0.2% AEP event storm.

This levee configuration will create a storage area of about 16.7 acres and a volume of about 66.3 acre-ft at the 1% AEP event. According to the State of Hawaii Revised Statute 179 D3, the dam safety threshold of storing more 50 acre-ft of water will be triggered with this alternative, requiring additional regulatory considerations to be considered for the implementation of this measure. Water will enter the storage area by overflowing the natural bank upstream of the Waiakea levee where the overflow occurs under without project conditions. Water will re-enter Waiakea Stream by means of two (2) 36 in RCP culverts. Under high flows the outlet of these culverts will be submerged, however the head inside of the storage area will still allow some flow to be released. As the water surface in the stream recedes, the flow from the culverts will increase. It is estimated that the storage area will empty within 24 hours after the rain stops.

Continuing downstream to the confluence with Kupulau Ditch, the channel here is improved. Currently, the ditch empties into Waiakea Stream at essentially a right angle. This confluence is improved by widening Waiakea Stream from the confluence downstream to station 216+19, a distance of about 600 ft. At the confluence the channel bottom is widened to a 55 foot width to span both the outflows from Kupulau Ditch and Waiakea Stream. This bottom width is reduced to 25 feet at station 220+20, and continues at this width until the end of the improvement at 216+19. At this point, Waiakea Stream begins to increase its channel slope as it travels to the Kupulau Rd Bridge.

This improvement is continued on Kupulau Ditch from the confluence upstream for about 200 feet. At station 1+01.5 on Kupulau Ditch the channel bottom is widened to 35 feet, and the right bank transitions to meet the bank on Waiakea Stream . At station 1+50.4 the channel width reduces to 25 feet and this is continued to station 2+00.4, where it then transitions to the existing bottom width.

In the vicinity of Kupulau Road, channel modifications to Waiakea Stream consists of channel excavation beginning approximately 500 feet upstream of the Kupulau Rd bridge at approximate station 211+74, to remove a large rock outcropping and provide a smoother transition into the bridge opening. Channel excavation consists of widening the present stream to a 25 foot bottom width, with 2:1 side slopes. The stream is improved along its present alignment; however, its bed slope is modified. The excavation ends at the Kupulau Road Bridge.

Floodwalls along both the right and left banks of Waiakea Stream from the Kupulau Road Bridge downstream to the upstream end of the Kawailani St Bridge will be constructed to prevent flow from leaving the stream and inundating the surrounding property. These floodwalls will consist of a CRM (Concrete Rubble Masonry) design, and were held to a maximum height of 5 feet along the banks. They are located along the path of the top of bank, and where existing topography permits the floodwall will merge with the surrounding land. It is estimated that there will be a total floodwall length of about 3,350 ft on the right bank and 3,330 ft along the left bank.

Excavation of the Waiakea Stream channel bed will increase the capacity of the stream to carry the 1% AEP event while maintaining the 5 feet height limit of the floodwalls requested by the County of Hawaii for maintaining homeowner sight lines and floodwall maintenance purposes. Channel modifications begin at Waiakea Stream station 174+18 and end at station 202+17. Channel excavation consists of widening the present stream to a 25 foot bottom width with 1:1 side slopes. The stream will be improved along its present alignment and its bed slope will be modified. From station 174+18 to station 192+14, the channel slope is 0.03286 ft/ft, at station 192+14 the channel slope changes to 0.02262 ft/ft to station 196+85, where the slope again changes to 0.03256 ft/ft to station 202+17 where the channel bed meets its existing slope. The total length of this excavation is about 2,800 ft.

Additional measures along Waiakea Stream include the construction of a debris control structure located at approximate station 10+801.33, which is just upstream of the end of the channel excavation. This structure will consist of a concrete pad containing 8 in. steel pipes filled with concrete rising from the ground an average of about 4 feet. The pipes will be spaced 4 feet apart. This will trap debris before it reaches the Kupulau Rd Bridge. An access road will be constructed to provide access for maintenance. The road will be about 300 ft in length. This structure is similar to the debris structure described in previous measures. Also, three grade control measures will be installed along Waiakea Stream where changes in slope occur. These measures consist of a concrete pad placed across the bottom of the channel to prevent erosion. This pad will be 2' wide by 25' long (going across the channel) by 4' deep (7.5 CY)

Levee/floodwall construction along the right bank of Kupulau Ditch consists of an earthen levee/floodwall combination. The CRM floodwall begins on Kupulau Ditch at approximate Kupulau Ditch station 17+85 where it ties into high ground at elevation 643.0 ft. The floodwall continues downstream to station 13+00 where it transitions to an earthen levee. This transition is due to the height of the floodwall increasing to 5 feet, a maximum height desired by the local sponsor due to maintenance concerns. This elevation is approximately 640.1 ft at this transition. The levee continues downstream past the confluence with Waiakea Stream for about 860 feet and ends on Waiakea Stream at approximate station 213+70. The downstream end of the levee is open-ended as the existing topography begins at a downward slope towards Kupulau Road. The top of levee elevation here is approximately 629.1 ft.

The levee is approximately 1,824 ft long. The levee toe is setback from the right bank a minimum of 5 feet. The proposed CRM floodwall is about 358 feet long. It is constructed with an estimated 2 foot of buried depth. This detention basin idea was considered for further analysis. Figure 47 shows the location of the Kupulau Ditch Detention I measure.

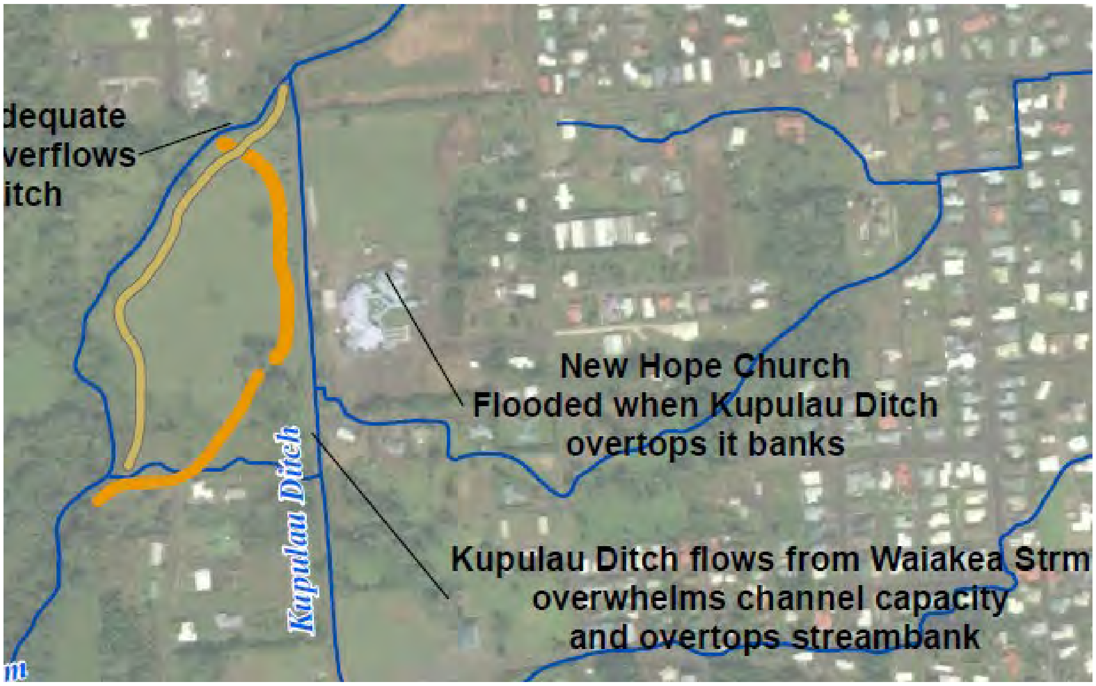

Figure 47. Location of Kupulau Ditch Detention I

6.2.6 Kupulau Ditch Detention II. The main component of this plan is the construction of a detention basin on property located to the north of the New Hope Church and adjacent to the right bank of Kupulau Ditch. Impounding of the runoff is accomplished by constructing a series of three levees to enclose the landscape and uses the natural topography of the area. The levees are described in the following paragraphs and a map is shown in Figure 48.

The Waiakea Stream or north levee is constructed along Waiakea Stream which separates the basin from the stream. This levee begins at approximate stream station 213+70, which is about 860 feet downstream of the confluence with Kupulau Ditch. The levee continues upstream along the right bank to approximate Kupulau Ditch station 2+00 for a length of about 970 feet. The downstream end of the levee is open-ended as the existing topography begins a downward slope towards Kupulau Rd. The top of levee elevation ranges from 624.7 to 636.4 ft with an average height of 5.7 ft.

The second levee referred to as the East Containment Levee is constructed to create the eastern boundary of the basin. This levee intersects the Waiakea Levee described above and travels in a generally southern direction for a distance of about 900 feet. The top of levee elevation ranges from 632.3 to 634.4 with an average height of 6.7 ft.

The third levee referred to as the South Containment Levee is constructed to create the southern boundary of the basin. This levee intersects the East Containment Levee and travels in a westerly direction for a distance of about 532 ft where it ends back at Kupulau Ditch. This levee has an average height of about 2.8 ft.

To protect the New Hope Church and properties to the east, a CRM floodwall is constructed along the right bank of Kupulau Ditch from the detention basin upstream for a distance of about 912 ft. The floodwall has an average height of about 5.6 ft.

Water enters the basin by overtopping the existing right bank of Kupulau Ditch between ditch stations 2+00 and 8+00 for a length of about 600 ft. To "encourage" flow into the basin, a culvert is installed at the downstream end of Kupulau ditch to limit the amount of water leaving the ditch. This culvert consists of a 12' wide x 8' high concrete box about 92 ft in length. The invert of this culvert is set at the existing channel bottom. The culvert embankment is protected by grouted rip-rap at both the downstream and upstream ends. The top of the culvert embankment is set at 3 ft above the top of the culvert to create an overflow weir for large events. This weir is protected by grouted rip-rap.

The detention basin is emptied by use of four (4) corrugated metal pipe culverts (4 ft in diameter) located at the northwest corner of the basin. The culverts will be installed through the Waiakea Levee and enters Waiakea Stream at approximate stream station 217+44, about 480 ft downstream of the confluence with Kupulau Ditch. The culvert is approximately 61 ft. long. The culvert inverts are all set at elevation 624 ft.

Figure 48. Kupulau Ditch Detention II

6.2.7 Kupulau Ditch Levee/Floodwall. This measure consists of a levee/floodwall constructed along the right bank of Kupulau Ditch to prevent floodwaters that are in excess of the channel capacity of the ditch from overtopping the ditch and flowing to the east causing damage to properties along HaiHai St. and eventually entering the Palai Stream basin. Due to space restrictions the upper portion of this measure is a CRM floodwall about 485 ft in length and a maximum of 5 feet in height. At this point the New Hope Church structure ends and the land opens up to a broad field. The floodwall then transitions to an earthen levee ranging from 5 to 8 feet in height with 3: 1 side slopes. This levee extends for about 1,225 ft in length along the ditch, and then continues for about 600 feet along the right bank of Waiakea Stream. The Kupulau Ditch levee/floodwall measure will prevent flow from leaving Kupulau Ditch and flooding properties to the east. However, as a result of this, there will be an increase in flow and damage to properties located on Waiakea Stream downstream of Kupulau Ditch. Therefore, this measure cannot stand alone as a flood damage reduction plan, but can be included as part of any overall alternative. Figure 49 shows the location of the Kupulau Ditch Levee/Floodwall measure.

Figure 49. Location of Kupulau Ditch Levee/Floodwall

To reduce the flood problem along Waiakea Stream, four measures were considered. They are: the Waiakea Diversion channel, channelization of the stream, construction of floodwalls, and a combination of channelization and floodwalls. These measures are described as follows. Parts of the last three Waiakea Stream measures were included in the Kupulau Detention I measure as necessary improvements to Waiakea stream to make the Kupulau Detention I measure work.

6.2.8 Waiakea Stream Diversion Channel. This measure consist of constructing a diversion channel from the junction of Kupulau Ditch and Waiakea Stream downstream to a point where it re-enters Waiakea Stream upstream of Komohana St for a distance of about 10,400 ft. It also requires construction of a new bridge crossing the channel on Puainako St. Construction of this measure would be through largely undeveloped land and would potentially cause significant environmental impacts. However, there has been recent residential development along the proposed channel alignment. It would not be feasible to change the alignment as it would add significant excavation to the construction increasing an already high cost. This measure will not be considered any further. Figure 50 shows the location of the Waiakea Diversion Channel.

Figure 50. Location of Waiakea Stream Diversion Channel

6.2.9 Waiakea Stream Channelization. This measure consists of excavating a channel along the Waiakea Stream to contain the flood flows, from upstream of Kupulau Rd to upstream of Kawalani St. The channel excavation consists of a rectangular channel having a 50 ft bottom width for a distance of about 2,155 ft long between Kupulau Road and Kawailani St. Upstream of Kupulau Rd the channel cut has a 25 ft bottom width for a distance of about 500 ft. This measure also constructs a debris trap composed of concrete filled steel pipes designed to reduce debris transport into Waiakea Stream and subsequent flood damage due to debris dams. This trap would be installed upstream of the channel improvements and would trap large woody vegetation and rocks while allowing water to flow around the structure and continue downstream. It also improves the Kupulau Rd Bridge by raising and extending the upstream bridge guard wall to elevation 604 ft in order to prevent floodwaters from overtopping the bridge. Grade control structures consisting of concrete filled trenches will be installed at changes in channel slope to control bed erosion. Figure 51 shows the location of the Waiakea Channelization measure.

Figure 51. Location of Waiakea Stream Channelization

6.2.10 Waiakea Stream Floodwalls. This measure consists of two CRM floodwalls constructed along both the left and right banks of the stream from Kupulau Rd downstream to approximately Kawalani St. This prevents floodwaters from causing flood damage to properties along each side of Waiakea Stream. The floodwalls are 3,530 ft each in length and range from 3 to 9 ft in height. Upstream of Kupulau Rd. the channel will be excavated to a 25 ft. bottom width for a distance of about 500 ft. This measure also constructs a debris trap composed of concrete filled steel pipes designed to reduce debris transport into Waiakea Stream and subsequent flood damage due to debris dams. This trap would be installed upstream of the channel improvement and would trap large woody material and rocks while allowing water to flow around the structure and continue downstream. It also improves the Kupulau Rd. Bridge by raising and extending the upstream bridge guardwall to elevation 604 ft in order to prevent floodwaters from overtopping the bridge. Figure 52 shows the location of the Waiakea Stream Floodwalls measure.

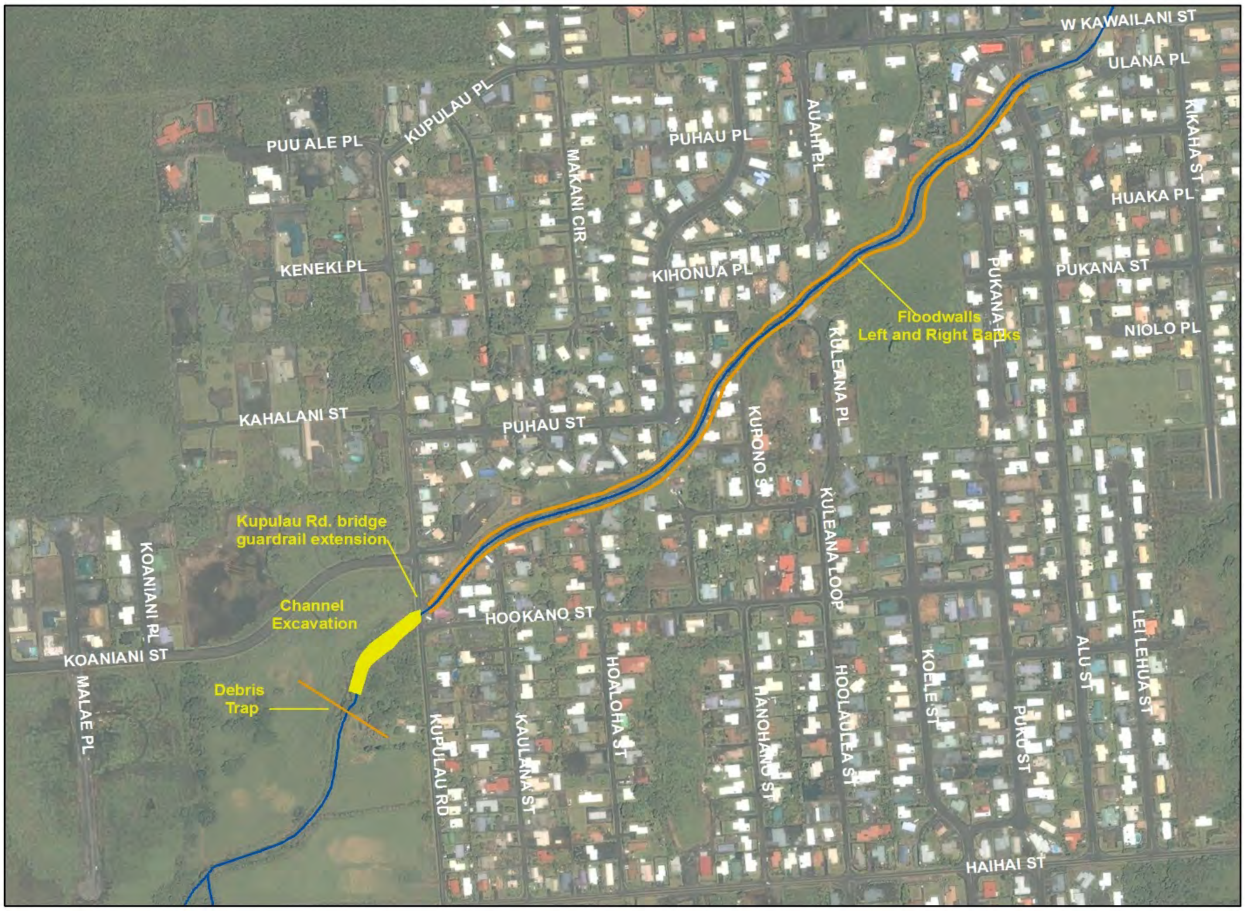

Figure 52. Location of Waiakea Stream Floodwalls

<u>6.2.11 Combination of Waiakea Steam Floodwalls and Channelization</u>. This measure consists of the construction of floodwalls and channelization of Waiakea Stream from Kupulau Rd to Kawalani St. This measure reduces the height of the floodwalls from Waiakea Stream Floodwalls measure previously discussed and reduces the excavation from the Waiakea Stream Channelization measure described above. The floodwalls are reduced to a maximum height of 5 ft, and the channel excavation consists of a 25 ft bottom width upstream of Kupulau Rd for a distance of about 500 ft. Downstream of Kupulau Rd the excavation consists of a rectangular channel having a 30 ft. bottom width for a distance of about 2,155 ft. This measure also constructs a debris trap composed of concrete filled steel pipes designed to reduce debris transport into Waiakea Stream and subsequent flood damage due to debris dams. This trap would be installed upstream of the channel improvements. It also improves the Kupulau Rd. Bridge by raising and extending the upstream bridge guard wall to elevation 604 ft in order to prevent floodwaters from overtopping the bridge. Grade control structures consisting of concrete filled trenches will be installed at changes in channel slope to control

bed erosion. Figure 53 shows the location of the Waiakea combination floodwalls and channelization measure.

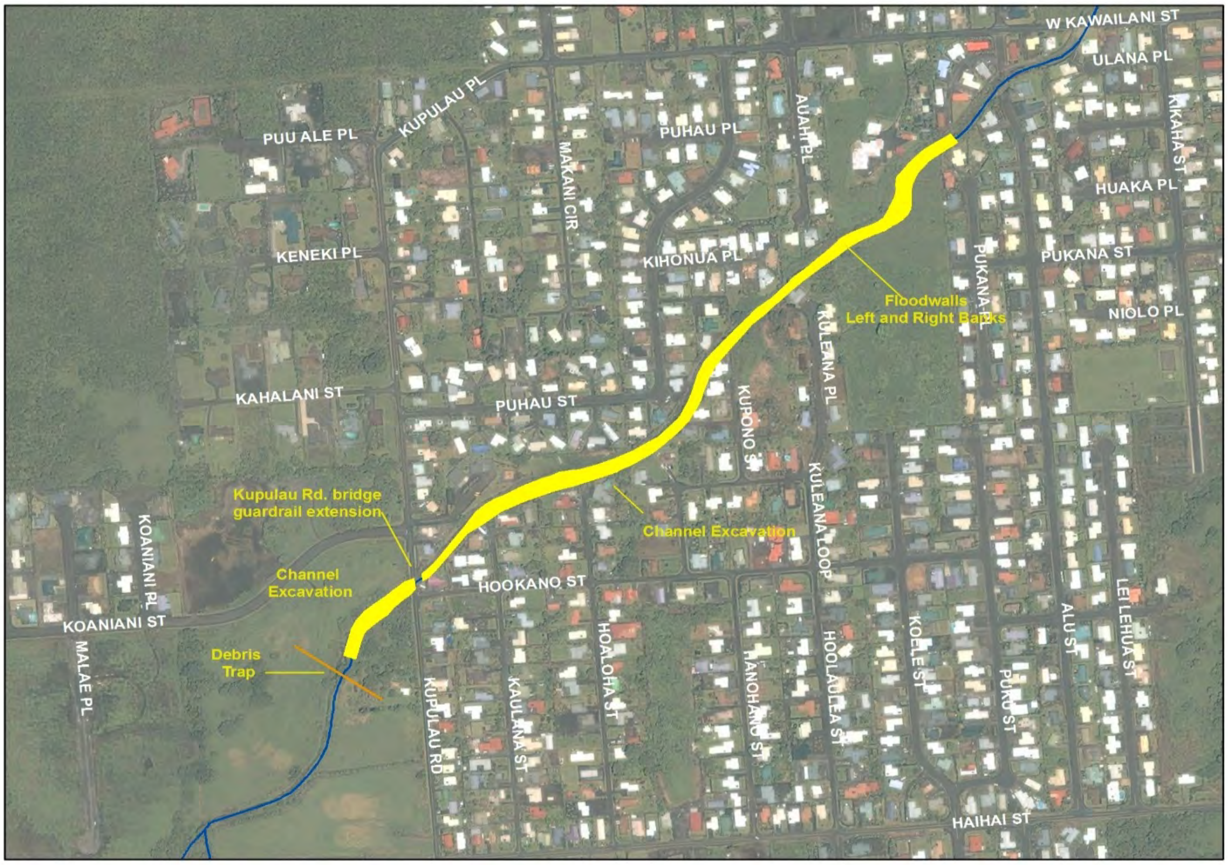

Figure 53. Location of Waiakea Stream Combination of Floodwalls and Channelization

6.3 STRUCTURAL MEASURES FOR PALAI STREAM. Intense urbanization of Palai Stream watershed downstream of the Hilo Municipal Golf Course poses significant challenges to creating flood risk management measures in the areas where the flooding occurs, because many residential, commercial, and industrial properties are located in the stream channel or in very close proximity to the stream banks. Therefore, no structural measures in this area were considered to address the flood risk.

The remaining Palai Stream flood problem results from the generation of runoff within the watershed, this was analyzed by considering the following measures: the Hilo Municipal Golf Course Diversion, Hilo Municipal Golf Course Detention Basin, HaiHai St. Detention, and Ainalako Diversion. These measures are described in the following paragraphs.

<u>6.3.1 Hilo Municipal Golf Course Diversion</u>. This measure consists of constructing a new diversion channel beginning in the Hilo Municipal Golf Course and traveling around the perimeter of the Palai Church property down to HaiHai St., where it enters an underground conduit before emptying into Four Mile Creek.

This measure would include a 2.5 acre-ft. detention pond in the golf course to attenuate flow, leading to approximately 1,000 ft. of open channel transitioning to about 1,840 ft. of two 10' wide by 9' tall underground box culverts running under HaiHai St. to the Panaewa Bridge at Kanoelehua St. where they will enter the existing Four Mile Creek county flood control channel. This measure will reduce flood damage to properties in the downstream areas of Hilo. Due to the high cost, this measure will not be considered further. Figure 54 shows the location of the Hilo Municipal Golf Course Diversion measure.

6.3.2 Hilo Municipal Golf Course Detention Basin. This measure consists of constructing a 21 acre-ft detention basin in the Hilo Municipal Golf Course to attenuate flow and reduce damage to properties in the downstream reaches of Palai Stream. The basin is formed by constructing an in-channel structure across Palai Stream creating a dam embankment having an expected maximum height of 20 ft from the existing channel invert, designed to hold the 1% AEP event. The total length of the embankment is about 1,374 ft. The top of the embankment is set at elevation 250.0 ft.

A 60 foot wide overflow spillway allows flow in excess of the 1% AEP event to exit the basin. The spillway elevation is set to 247.0 ft, which is about 0.4 feet above the 1% ACE water surface elevation inside the basin. The spillway is constructed of concrete and is 29 ft in length and has vertical side walls rising to the top of the embankment. The weir is protected by grouted rip-rap on both the upstream and downstream face. The outlet itself will consist of two (2) 6 foot diameter Aluminized Steel pipes.

Figure 54. Location of Hilo Municipal Golf Course Diversion

At the 1% AEP event, the detention basin has a storage volume of 16.7 Acre-ft. and at the 0.2% ACE event the storage volume is about 20.2 Acre-ft. Maximum water depth at the 1% Event is about 12.7 feet and about 13.9 feet at the 0.2% event. Since the estimated peak storage is less than 50 acre-ft, the detention basin would not be categorized as a regulated dam by the State of Hawaii. It is estimated that the basin will empty in less than 24 hours for all events.

The detention basin is located entirely within the golf course property which is owned by the county of Hawaii. The location of the impoundment incorporates the existing terrain in developing the necessary storage. There would be some modifications to the golf course configuration required for this impoundment, but it would not be extreme. Figure 55 shows the location of the Hilo Municipal Golf Course Detention Basin.

Figure 55. Location of Hilo Municipal Golf Course Detention Basin

<u>6.3.3 HaiHai St Detention</u>. This measure consists of constructing a 28 acre-ft detention basin on Palai Stream upstream of HaiHai St on a 69 acre parcel of state-owned land. It is located on the southeast corner of the intersection of HaiHai St and Ainaola Rd.

The impoundment is created by constructing an in-channel barrier with an uncontrolled outlet in the shape of a flow restricting flume. The flume has a throat width of 4.5 feet and is 34 feet in length. It has an invert elevation of 461.0 ft. The upstream approach section of the flume is 40 ft wide and reduces to the throat width at a 45 degree angle. The exit section of the flume is similar. The top of the flume is set at an elevation of 474.0 ft where an overflow weir is constructed. This weir is 40 ft wide and will allow flows in excess of the 1% AEP event to pass over the structure. The top of the weir sidewalls are set at elevation 478.0 ft. This outlet configuration is preferred over a culvert outlet in that with the flume the upstream head of the structure is reduced resulting in a lower upstream water surface elevation.

On the north side of the structure and running parallel to HaiHai St will be an earthen levee embankment having a total length of about 138 ft and will have an average height of about 7.2 ft. South of the outlet structure and running parallel to the east property line a second earthen levee embankment will be constructed. This embankment will have a total length of about 782 ft and have an average height of 9.2 ft.

At the 1% AEP event, the detention basin has a storage volume of 21.4 Acre-ft. and at the 0.2% AEP event the storage volume is about 27.9 Acre-ft. Maximum water depth at the 1% ACE event is about 13 ft and about 13.9 ft at the 0.2% AEP event. The detention basin will be located entirely within state owned land. Figure 56 shows the location of the HaiHai St. Detention measure.

Figure 56. Location of HaiHai St Detention

6.3.4 Ainalako Rd Diversion. The main component of this measure is the construction of a diversion structure to divert excess flows into Four Mile Creek. This diversion structure will be located just downstream of Ainalako Rd on Palai Stream. It takes advantage of the natural topography along the right overbank of Palai Stream and the natural drainage pattern of the immediate area. The location of this area is shown on Figure 57.

Along the right overbank of Palai Stream there exists a natural depression between two small mounds, creating what can be referred to as a “saddle” effect. Under without project conditions water overtops the saddle and enters Four Mile Creek. The difference in elevation between the Palai Stream channel bottom and the saddle is about 3 feet.

To “encourage” flow to enter the diversion structure an in-channel barrier with an uncontrolled outlet consisting of two (2) 5 foot diameter pipes will be constructed. The invert of the pipe is set at elevation 507.6 ft, which results in a pipe about 72 feet long. The total length of the in-channel barrier is about 500 ft. The top of the embankment is set at elevation 518.0 ft.

The “saddle” has a minimum elevation of 514.0 ft. At that elevation, the diversion weir is 200 ft in length. Under without project conditions, the overflow is covered with scrub brush and tall grasses. Improvements to the overflow weir will increase its efficiency and allow an increase in flow over the diversion weir. These improvements will consist of clearing the weir section of grass and brush, stripping of the top layer of soil, and placing a cap of grouted rip-rap on the crest to prevent erosion.

A grassed swale will be constructed to direct the overflow from the weir into Four Mile Creek. This swale will utilize the natural topography of the land. It is estimated that this swale will be about 276 ft in length and an average width of about 182 ft.

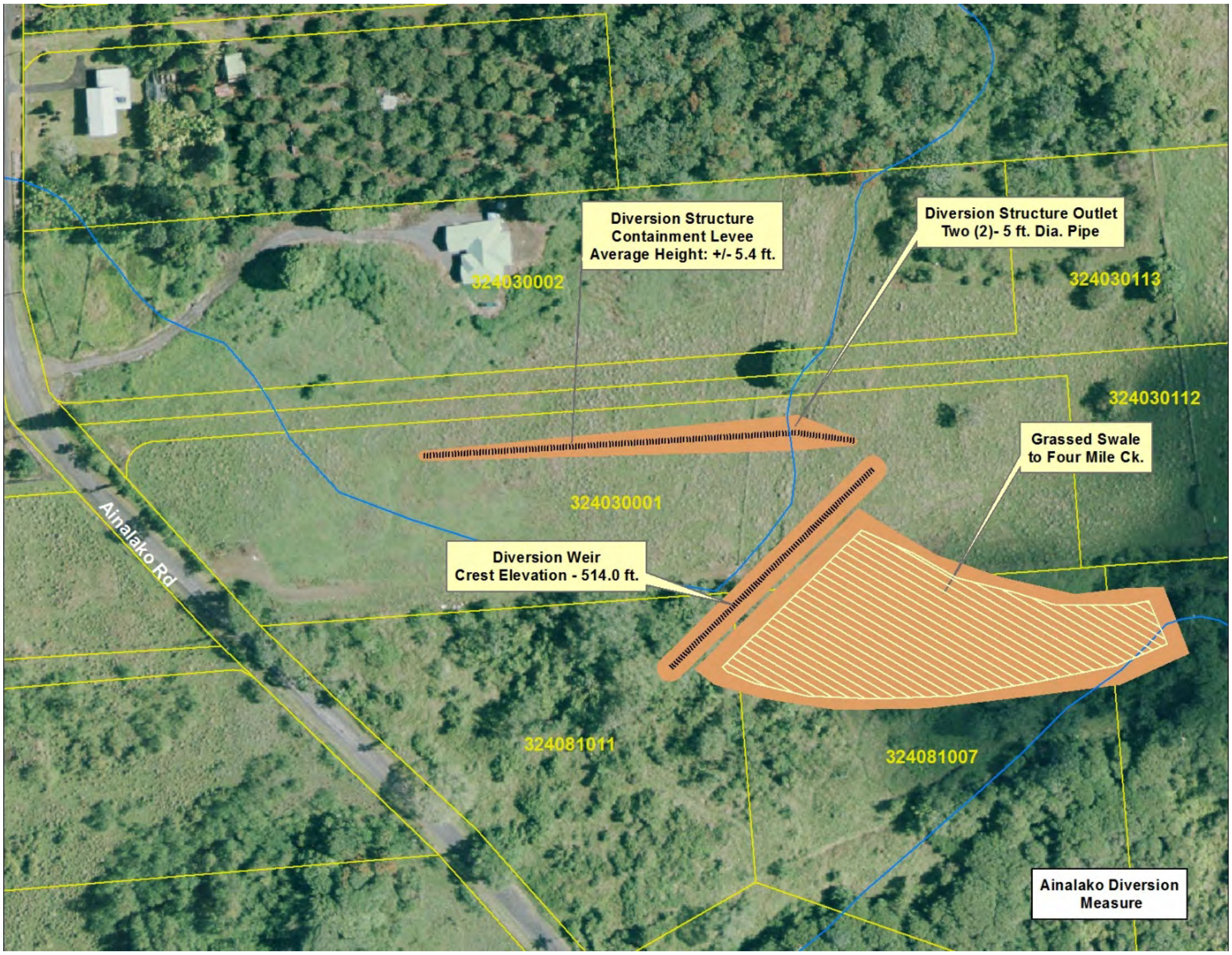

Figure 57. Location of Ainalako Rd Diversion

<u>6.3.5 Tandem Alternative.</u> This plan combines the Ainalako Rd Diversion measure with a reconfigured Hilo Municipal Golf Course Detention Basin measure. Peak flows on Palai Stream will be reduced when the Ainalako Rd Diversion Plan is implemented. This allows for a smaller detention basin in the Hilo Municipal Golf Course.

The smaller Hilo Municipal Golf Course Detention basin is created by constructing an in-channel barrier with an uncontrolled outlet consisting of three (3) 4 ft. diameter aluminized steel pipes. The design of this structure has a crest width of 10 ft with side slopes of 3:1 and a total length of about 823 ft. Side embankments located on the north and south side of Palai Stream prevent flow from escaping the stream. The levee embankment will require about 652 CY of material. The top of the embankment is set at elevation 244.0 ft. The in-channel embankment has a height of about 10 ft. The north side embankment has an average height of about 2.4 ft, while the south embankment has an average height of about 2.1 ft.

Grouted riprap on both the upstream and downstream face of the in-channel embankment is required to protect it from erosion. The grouted rip-rap on both the upstream and downstream slopes of the outlet will require approximately 2,682 SF of coverage, and at a thickness of 1 ft., it will require about 100 CY of material.

The outlet of basin is comprised of three (3) 4 ft diameter pipes. Analysis of this structure has a storage volume of about 7 acre-ft. at the 1% AEP event and about 12 acre-ft. at the 0.2% chance event. Maximum water height at the 1% event is about 7.3 ft and about 9.2 ft. at the 0.2% event. Figure 55 shows the alignment of the impoundment; the actual dimension as explain are smaller than shown on Figure 55. This outlet configuration approaches the existing downstream channel capacity of Palai Stream.

7. PREFERRED ALTERNATIVE FOR FLOOD RISK MANAGEMENT

A combination of measures were selected to provide a complete solution to managing the flood risk to the Waiakea-Palai study area. These alternatives are discussed in the main report under the plan formulation and alternatives analysis section. The preferred measure selected include Kupulau Ditch Detention II (Figure 45) andthe Tandem Plan including both the Ainalako Road Diversion (Figure 53) and the re-configured Hilo Municipal Golf Course Detention Basin (Figure 55).

7.1 Kupulau Ditch Detention Storage

The proposed Kupulau Ditch detention plan provides protection from excess runoff of the 1% AEP event for properties east of Kupulau Ditch and areas along Waiakea Stream downstream. The main component of this plan is the construction of a detention basin on property located to the north of the New Hope Church, adjacent to the right bank of Kupulau Ditch. Impounding of the runoff is accomplished by constructing three levees to enclose the storage landscape.

Waiakea Stream Levee (Figure 48) serves as a barrier between storage basin from the Waiakea stream. This levee begins at approximate stream station 213+70, which is about 860 feet downstream of the confluence, and continues upstream along the right bank to station 2+00 approximate for a length of about 970 feet. The downstream end of the levee is open-ended as the existing topography begins a downward slope towards Kupulau Road. The top width of the of levee is 10 ft, side slopes 3:1 and top elevation ranges from 624.7 to 636.4 with an average height of 5.7 feet. This levee requires 6078 CY of material to build.

East Containment Levee forms the eastern boundary of the basin. This levee travels in a southerly direction about 900 ft and intersects the Waiakea Levee. The top width of the levee is 10 ft, side slopes 3:1, top elevation range from 632.3 -634.4 ft with average height of 6.7 ft. This levee requires 6997 CY of material to build

South Containment Levee forms the southern boundary of the basin. This levee is located a short distance north of the New Hope Church structure. This levee segment is 532 ft long and connects Kupulau Ditch Levee and East Containment Levee. The top width of the levee is 10 ft, side slopes 3:1, top elevation is 634.5 ft with average height of 2.8 ft. This levee requires 1041 CY of material to build.

Water enters the basin by overtopping the existing right bank of Kupulau Ditch between stations 2+00 and 8+00 for a length of about 600 feet. To “encourage” flow into the basin, a culvert is installed at the downstream end of Kupulau ditch to limit the amount of water leaving the ditch. This culvert consists of a 12’ wide x 8' high concrete box about 92 feet in length. The end sections of the culvert are mitered to conform with the embankment side slopes. The invert of this culvert is set at the existing channel bottom. The culvert embankment is protected by grouted rip-rap at both the downstream and upstream ends. The top of the culvert embankment is set at 3 feet above the top of the culvert to create an overflow weir for large events. This weir is protected by grouted rip-rap.

Restricting the outflow of the ditch causes a surcharge upstream of the culvert. The ditch overtops into the detention basin starting at the 50% AEP event. At the 1% AEP event the basin overtops through spillway to Waiakea stream. The calculated depth of water over the spill way is 0.3 ft and 1.2 ft for 1% and 0.2% AEP respectively. The outlet of the detention basin consists of four 4-ft diameter, 60-ft long corrugated metal pipes. The invert of the detention basin culvert is at elevation 624 ft, and is located approximately 480 ft downstream from Kupulau Ditch outlet. The top of the 50-ft long spillway is set at an elevation of 630.5 ft, which is 0.5 ft above the 1% AEP water surface. The calculated depth of water – for the 1% AEP – at the culvert is 6 ft and the velocity of flow ranges from 1.3 fps at the upstream end of the basin to 4.5 fps at the culvert outlet.

A flood wall along the right bank of the Kupulau Ditch has a top width 2.5 ft, 1:4 side slopes, is 912 ft long, and has a top elevation range between 634.5 -642.7 ft with average height of 5.6 ft. This floodwall requires 1425 CY of material to build. Once completed, the proposed flood wall will protect New Home Church and other properties to the east.

Basin Storage_- The detention basin was designed to comply with the Hawaii Dam Safety Regulations._The table A9 below illustrates the results of the hydraulic modeling of the detention basin.

Table A9 - Kupulau Detention Basin Storage Calculation

Event		Q (cfs)	Max. Depth (ft.)	Storage (Ac-ft)	Area (Ac)	Outflow (cfs)	Est. Time to Empty (hrs)
AEP (%)	Frequency						
50	2	387	1.7	2.9	4.7	39.2	0.9
20	5	996	2.5	6.5	6.6	78.5	1.5
10	10	1672	3	9.8	7.5	113.8	1.9
4	25	2803	3.8	14.7	8.3	162.1	2.3
2	50	3881	4.4	19.23	8.8	194.3	2.6
1	100	4848	4.9	23.4	9.4	216.5	2.8
0.5	200	6717	5.8	31.9	10	470.7	3
0.2	500	7468	6.2	35.3	10.1	681.8	3.1

Downstream Impacts – The analysis of the impacts of the detention basin confirms that 0.5% AEP flow stays within channel and the 0.2% AEP flow becomes bankfull with minor spillovers. Table A10 below shows the with project and without project discharge and corresponding water elevations.

Table A10. - Comparison of without project and Kupulau Detention

Waiakea Stream					
Index Station 19776.7					
Event		Without Project		Kupulau Detention	
AEP (%)	Freq	Flow	Stage	Flow	Stage
50	2	1352	564.89	972	564.21
20	5	1955	565.84	1071	564.40
10	10	2597	566.68	1240	564.70
4	25	3589	567.85	1463	565.09
2	50	4439	568.88	1507	565.16
1	100	5659	569.96	2013	565.94
0.5	200	7459	572.25	2353	566.38
0.2	500	8424	572.71	2708	566.81

Real Estate Requirements - Some real estate properties will be impacted by construction of detention basin. Table A11 below shows land ownership and areas affected.

Table A11. - Real Estate Impacts

Kupulau Ditch Detention Real Estate Requirements		
TMK	Ownership	Area (Acres)
324036001	Church	6.6
324065036	Private	3.83
324036999	Public	0.63
324076044	Private	0.18
324065035	Private	0.44
324036001	Church	1
324035003	Private	0.22
324035032	Private	0.16

7.2 Golf Course Storage

The Golf Course detention basin provides flood risk reduction to the properties in City of Hilo for flows that exceed 1% AEP in Palai Stream. The Golf Course detention basin works in conjunction with Analako Diversion, which will provide additional flood risk reduction to the area downstream of Golf Course. The detention basin is built in within the golf course boundary, taking advantage of natural topography and drainage conditions (Figure 55).

The impoundment is created by constructing a barrier across the Palai stream and installing a 3-ft diameter aluminum culvert outlet. The top elevation of the 823ft long earth barrier structure is 244 ft. It has a top width

10 ft, side slopes at 3:4, and the average height is 10 ft. This barrier requires 652 CY of material to build. The facility includes side embankments to prevent water from escaping on sides. Both north and south embankments are extended to a natural ground elevation of 244 ft, and corresponding average heights are 2.4 and 2.1, respectively.

The golf course outlet structure, which consists of three 4-ft diameter pipes, is configured to allow flow leaving the facility equal to that of the capacity of the Palai stream downstream. The detention basin can store 7-ac-ft of water in the 1% AEP, 12 ac-ft in 0.2 AEP, and 7.3 ft and 9.2 ft of water at corresponding events.

The detention area is located entirely within the golf course property which is publicly owned. Construction of the stream crossing would not be unduly complex. The location of the impoundment incorporates the existing terrain in developing the necessary storage. There would be some modifications to the golf course configuration required for this impoundment, but they do not appear to be extreme.

7.3 Ainalako Diversion

Ainalako Diversion provides flood risk reduction to properties along Palai Stream down to City of Hilo from excess runoff of the 1% AEP event. The main feature of the proposal is the diversion structure which diverts excess flow over a weir to Four Mile Creek, thus reducing flow in the Palai stream.

Along the right overbank of Palai Stream, there exists a natural depression between two small mounds, referred to as a "saddle" effect. Under general conditions, water passes this saddle and enters the Four Mile Creek. The proposed diversion takes advantage of this natural ground and drainage patterns on right side of Palai Stream to direct floodwater to Four Mile Creek, just downstream of Ainalako Road (Figure 57). The difference in elevation between the Palai Stream channel bottom and the saddle is about 3 feet.

In order to facilitate flow through the saddle, a diversion containment levee and outlet structure are proposed. The outlet structure consists of two 5-ft diameter, 72-ft long, aluminum steel pipes with an invert at elevation 507.6 ft. The diversion containment levee begins from the right bank of the Palai Stream, runs across the stream and meets natural ground on the left side. This structural feature facilitates additional flow over the saddle. The diversion levee is 500-ft long, with a top width is10 ft, side slopes at 3:1, and a top elevation is 518.0 ft. This levee requires 465 CY of material to build.

The saddle is at elevation 541 ft, is 200 ft long, and covered with grass and brush thus reducing the natural carrying capacity of flow compared to clean conditions. Once cleared and capped with rip-rap and grout, the new diversion weir on the saddle will be 220 ft long with side slopes at 3:1. The area of clearing, stripping and riprap is 2200 sq ft. Down from the diversion weir, the channel flow follows the natural drainage path until it reached Four Mile creek about 272 ft away. The proposed actions will affect 6 real estate properties in the area.

<u>Four Mile Creek Impacts</u>

Based on current findings, there are a couple of properties adjacent to Four Mile Creek that may be affected by increased flow. Some of these properties are already in flood prone areas without project conditions. The proposed action intend to reduce flood risks. Any induced flooding as a result of the proposed measure will be addressed during design phase with updated surveys, updated modeling and consideration of structural and non-structural measures to address the induced flooding concerns.

7.4 Feature Optimization

Risk analysis was performed on the Kupulau Ditch Detention II measure to determine the optimum levee heights that would maximize the net benefits. The Ainalako R. Diversion measure is based on existing topography, and in its present form, provides an efficient optimal design not subject to scaling. The re-configured Hilo Municipal Golf Course Detention Basin measure is reduced in size from the original configuration (Figure 55). Therefore, it is felt that this measure has been optimized to its ideal design based on net benefits and site constraints. The preferred alternative with-project flood inundation map is shown in Figure 58.

The PDT (Project Development Team) feels that a 4.3-foot average floodwall/levee height is the preferred alternative for Kupulau Ditch Detention II (KD) and, along with the logically sized Ainalako Rd. Diversion and smaller Hilo Municipal Golf Course Detention, most reasonably comprises the NED (National Economic Development) Plan. Not only is this the height that maximizes net benefits, but in terms of the residual risk and resiliency perspective, the 4.3 ft average height at KD provides a performance CNP (Conditional Non-Exceedance Probability) of 96% for the 1% AEP flood. The average height of 4.3 feet for the Kupulau Ditch Levee/Floodwalls includes about +2.5 feet of height to achieve greater than 95 percent assurance so the measure will safely convey a 1% AEP event. Sensitivity modeling was performed that showed with less than +2.5 feet, the conditional non-exceedance probability dropped below 95% to about 76%, at less than 90% CNP, this was an unacceptable level of confidence.

In developing the final performance table, several iterations involving changing standard deviations of the stages in the stage-discharge relationship and adding large floods of 0.01 frequency and greater were run through the HEC-FDA model. These sensitivity runs had a minimum effect on the bottom line expected annual damages and benefits results (generally less than $10,000 annually, or less than 1%) and, in no case, indicated that the optimal levee/floodwall height would be anything other than 4.3 feet, which includes +2.5 feet of overbuild.

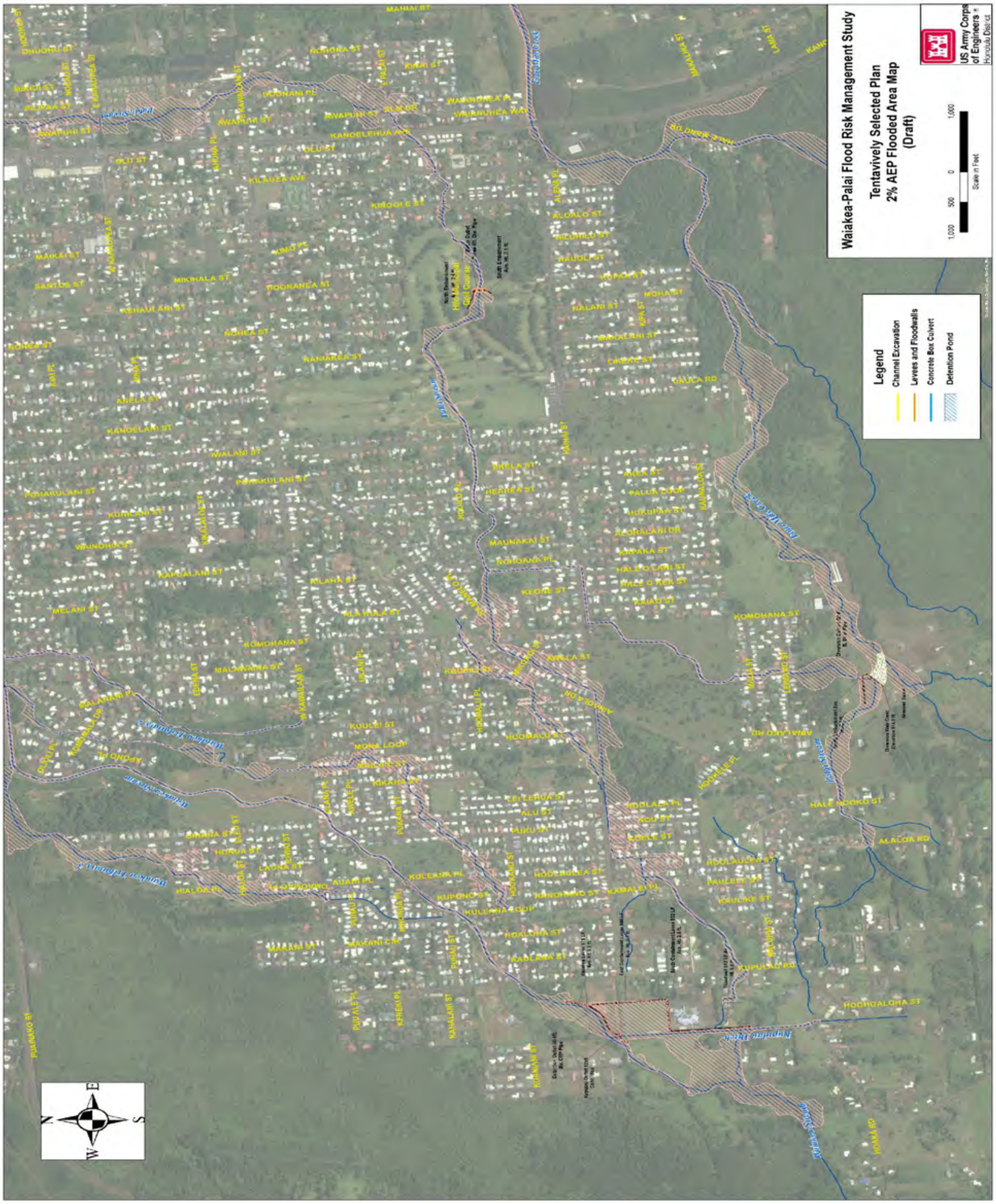

Figure 58. With Project Flooded Area Map (Draft)

7.5 WITH PROJECT WATER SURFACE PROFILES (Preferred Alternative)

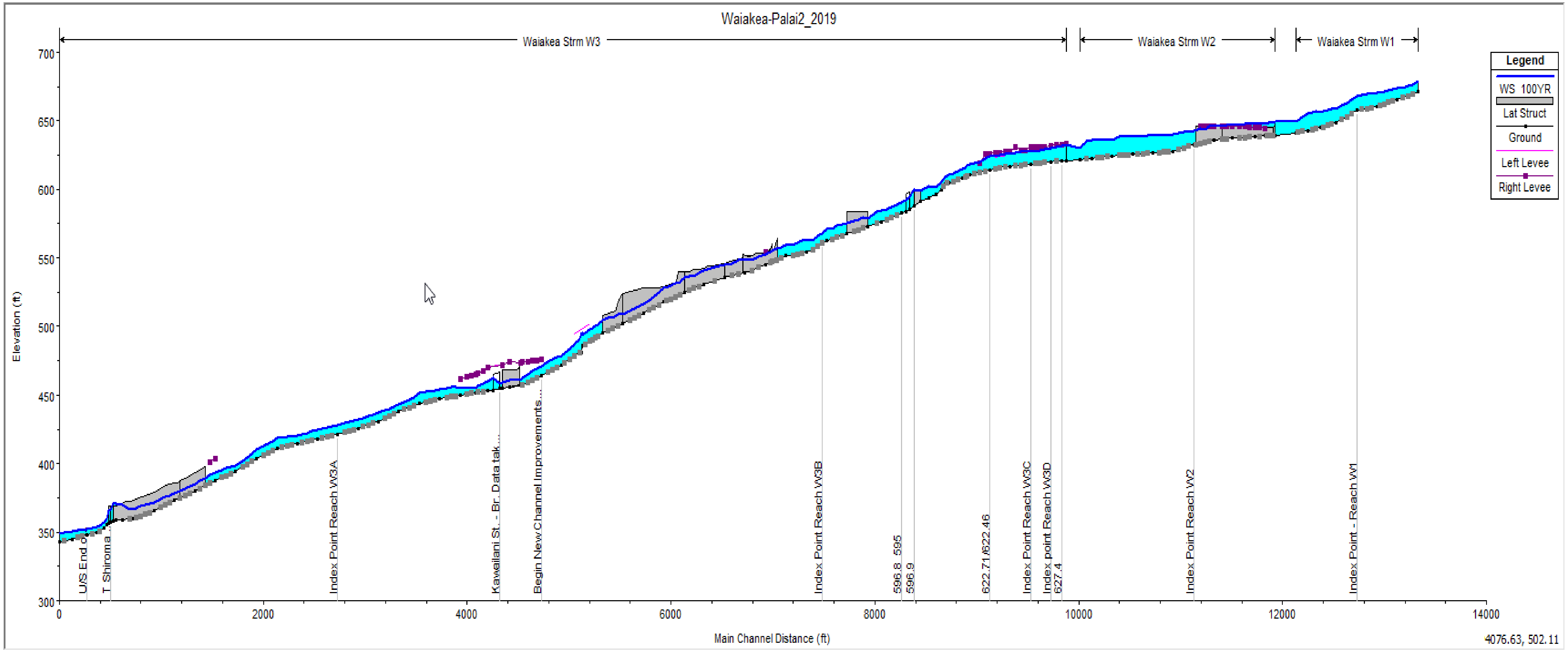

Figure 59A. With Project Waiakea Stream Water Surface Profiles (Reach W1-W3)

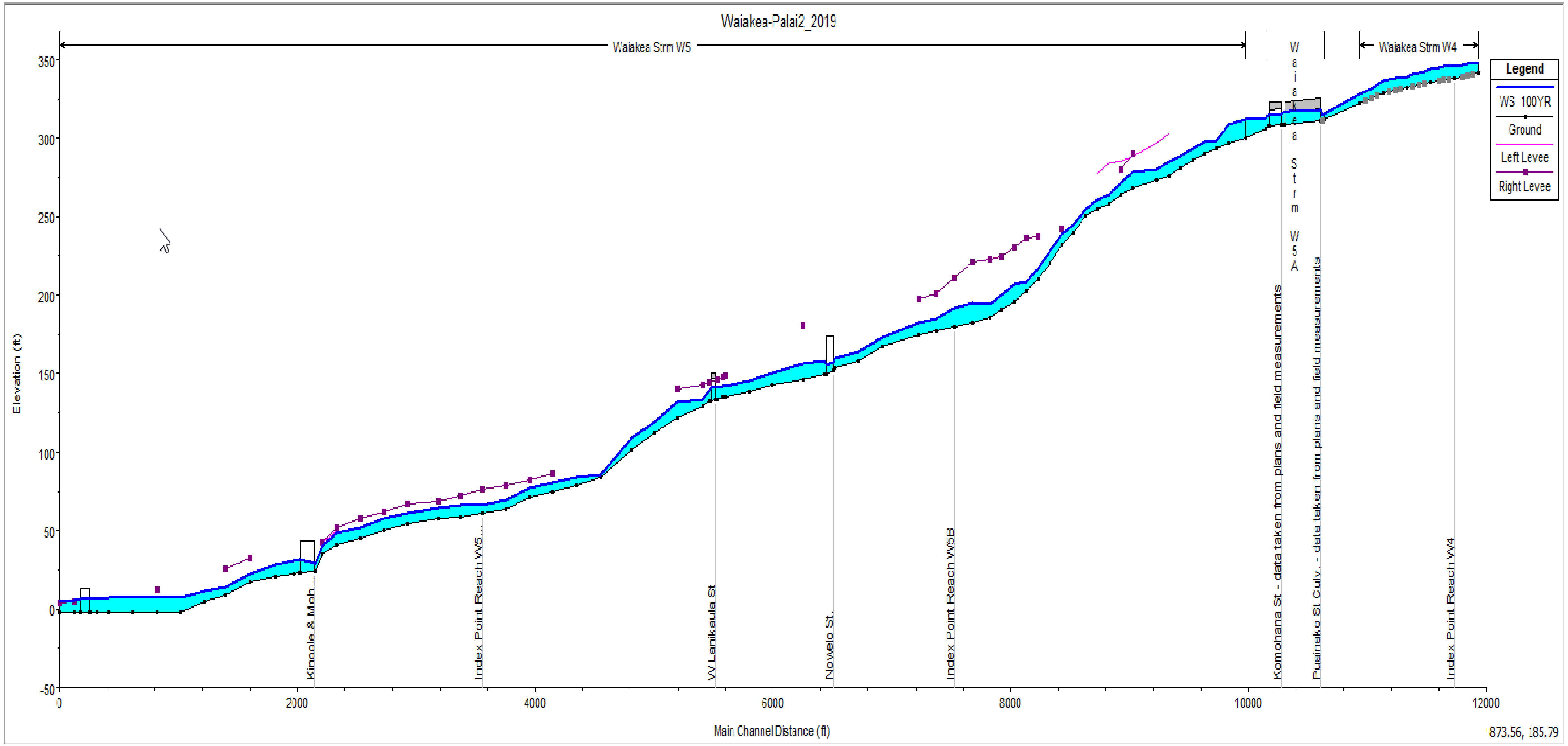

Figure 59B. With Project Waiakea Stream Water Surface Profiles (Reach W4-W5A)

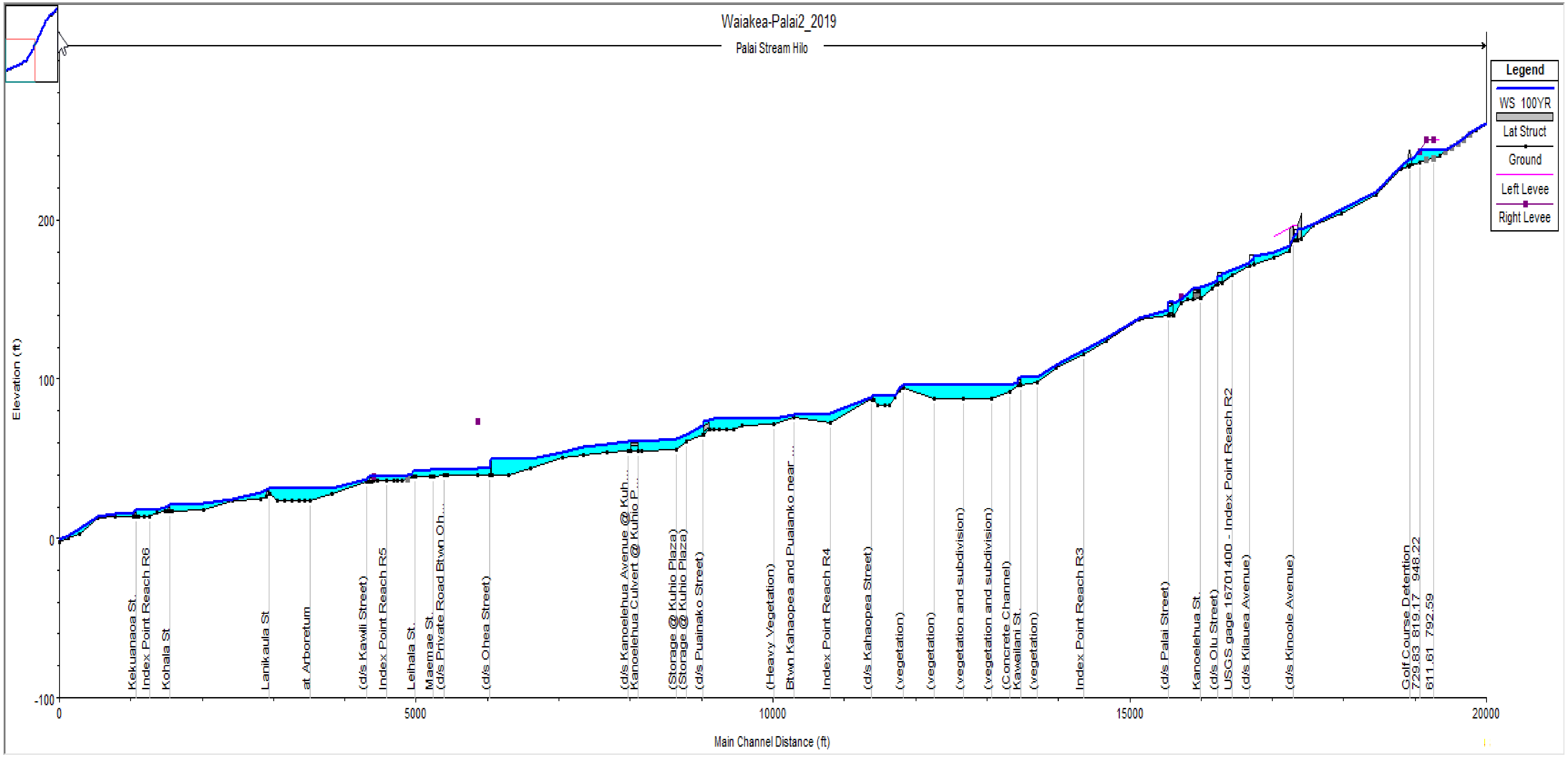

Figure 60A. With Project Palai Stream Water Surface Profiles (Reach Hilo)

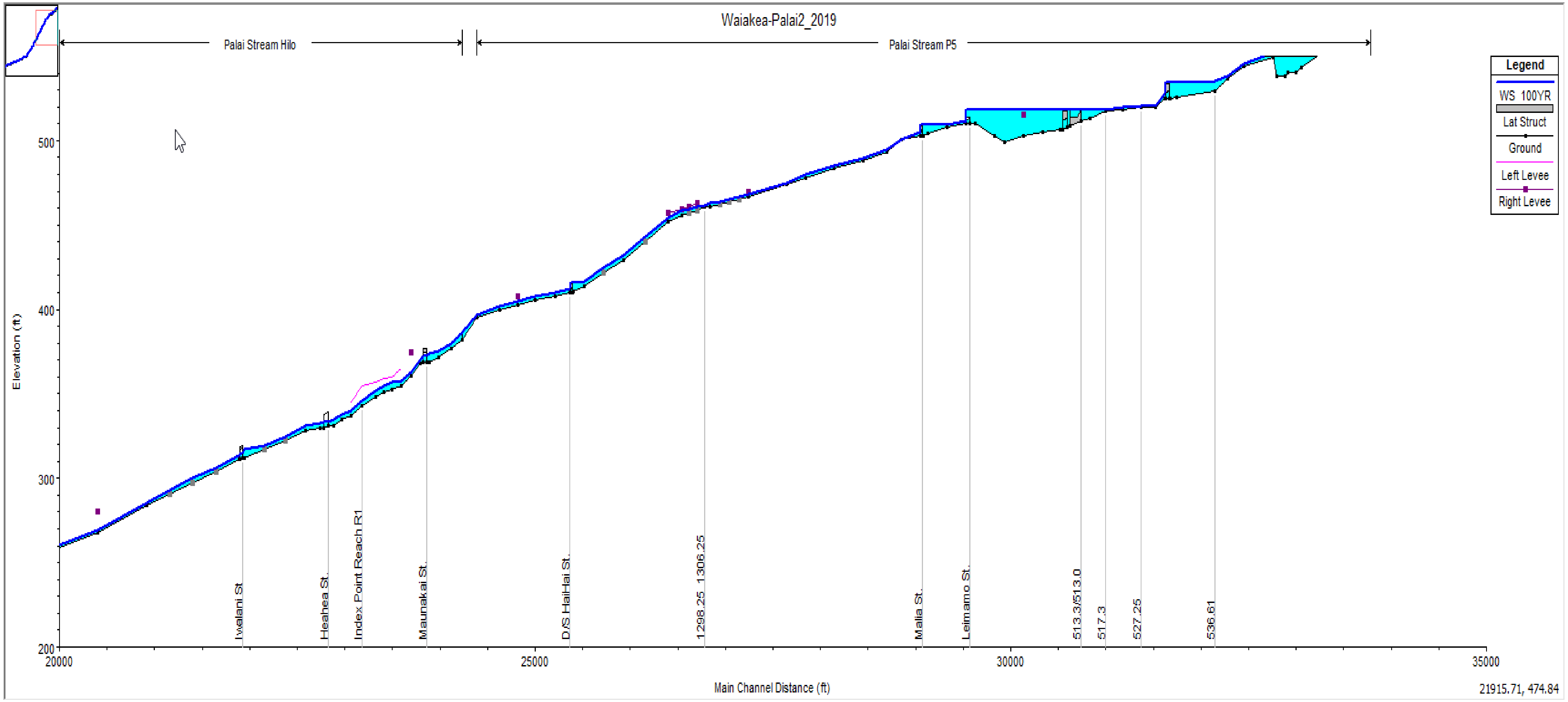

Figure 60B. With Project Palai Stream Water Surface Profiles (Reach Hilo and P5)

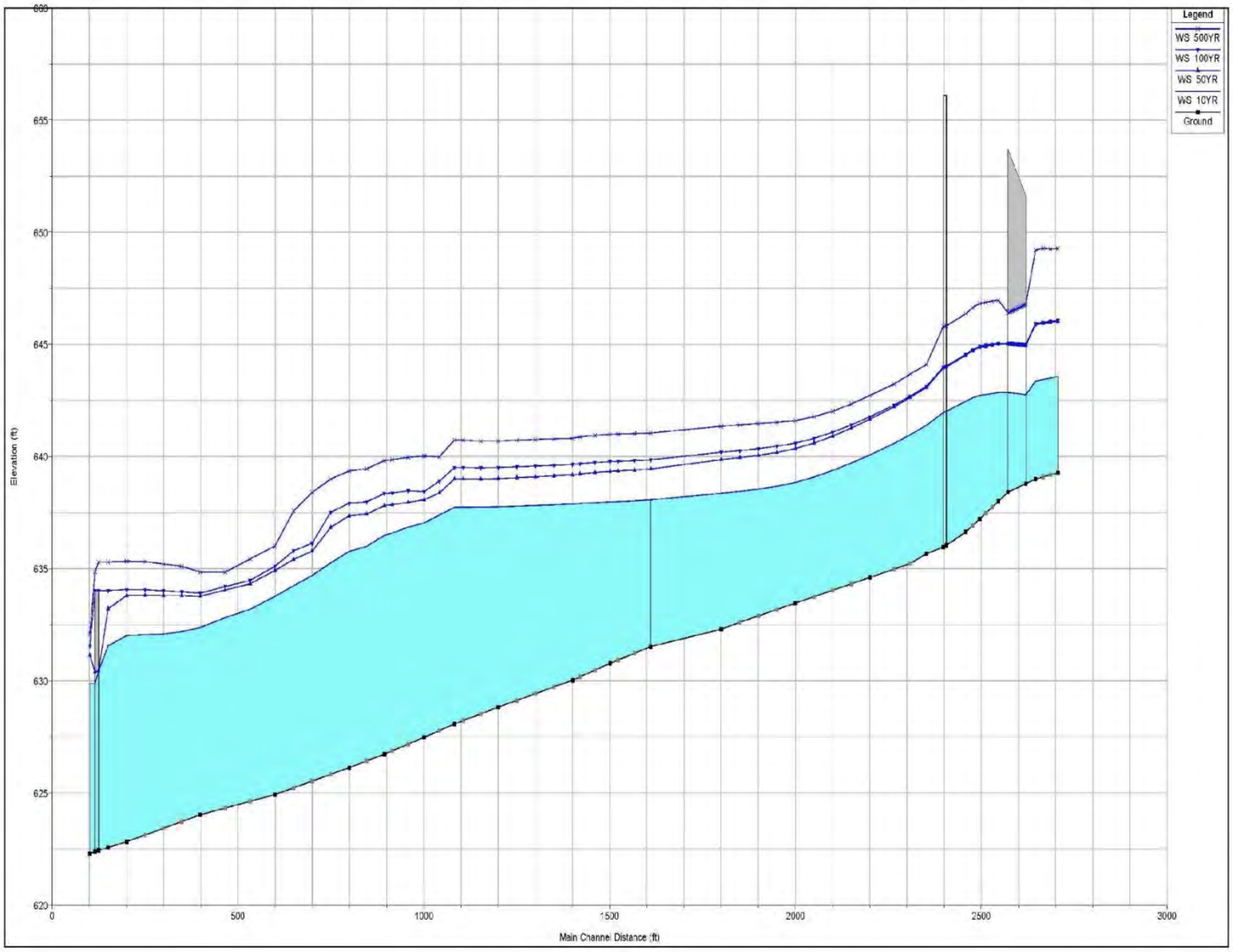

Figure 61. With Project Kupulau Ditch Water Surface Profile

8. SUMMARY

This appendix presented a discussion on creating a HEC-RAS model for Waiakea drainage basin area to simulate the flood problems in Waiakea Palai, Four Mile Streams and their tributary areas. Model results show the impact of flooding on the channel and overland areas of Waiakea and Palai Streams and their tributaries, from

Discharge estimates from eight frequency storms (50%, 20%, 10%, 4%, 2%, 1%, 0.5%, and 0.2% AEP) events were analyzed with HEC-RAS. Input discharge data for the model was obtained from the results of the Hydrologic Appendix B1 and field observations. Flood inundation boundary for 2% AEP was provided alone with 10%, 2%, 1% and 0.5% profiles. The results were compared with field observations during past flood events for reasonableness and accuracy. The model provides reasonable estimates of the flood magnitudes, depths and damages.

A number of flood risk management measures were created and analyzed with the HEC-RAS model. Then, combinations of measures (or alternatives) were analyzed to optimize outcome. The model was fine tuned to adjust the performance of the proposed measures to justify the preferred alternative in terms of technical feasibility and economic viability.

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Appendix C: Environmental Appendix

Waiakea-Palai Flood Risk Management, Hilo, Island of Hawaii, Hawaii

Table of Contents

LIST OF ACRONYMS

ACE	Annual Chance Exceedance
ASYA	Aquifer System Area
BMP	Best Management Practice
CEQ	Council on Environmental Quality
CERCLIS	Comprehensive Emergency Response, Compensation, and Liability Information System
cfs	cubic feet per second
CORRACTS	Corrective Action Reports
CWA	Clean Water Act
CZMA	Coastal Zone Management Act
CZMP	Coastal Zone Management Program
dB	Decibels
dBA	A-weighted sound level
DFIRM	Digital Flood Insurance Rate Map
DNL	Day-night Sound Level
DLNR	Department of Land and Natural resources
EA	Environmental Assessment
EFH	Essential Fish Habitat
EIS	Environmental Impact Statement
EO	Executive Order
EPA	Environmental Protection Agency
ERNS	Emergency Response Notification System
FEMA	Federal Emergency Management Agency
FPPA	Farmland Protection Policy Act
FRM	Flood Risk Management
FWCA	Fish and Wildlife Coordination Act
FWP	Future with Project
FWOP	Future without Project
ft	foot or feet
GHG	Greenhouse Gas
HCCS	Hawaiʻi Comprehensive Conservation Strategy
HRS	Hawaiʻi Revised Statute
HSDOH	Hawaiʻi State Department of Health
HTRW	Hazardous, Toxic, and Radioactive Waste
HUD	Housing and Urban Development
IFR/EA	Integrated Feasibility Report/Environmental Assessment
LUST	Leaking Underground Storage Tank
MBTA	Migratory Bird Treaty Act
mgd	million gallons per day
MMPA	Marine Mammal Protection Act
MSFCMA	Magnuson-Stevens Fisheries Conservation and Management Act
NAAQS	National Ambient Air Quality Standards

NEPA	National Environmental Policy Act
NHPA	National Historic Preservation Act
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NRCS	Natural Resources Conservation Service
NWI	National Wetlands Inventory
OEQC	Office of Environmental Quality Control
OHWM	Ordinary High Water Mark
ORMP	Ocean Resource Management Plan
OSHA	Occupational Safety and Health Administration
RCRA	Resource Conservation and Recovery Act
RCRIS	Resource Conservation and Recovery Information System
RSLR	Relative Sea Level Rise
SHPO	State Historic Preservation Officer
SLR	Sea Level Rise
SWPPP	Storm Water Pollution Prevention Plan
TMDL	Total Maximum Daily Load
TSD	Treatment, Storage, or Disposal
USDA	U.S. Department of Agriculture
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
UST	Underground Storage Tank
WOTUS	Waters of the U.S.

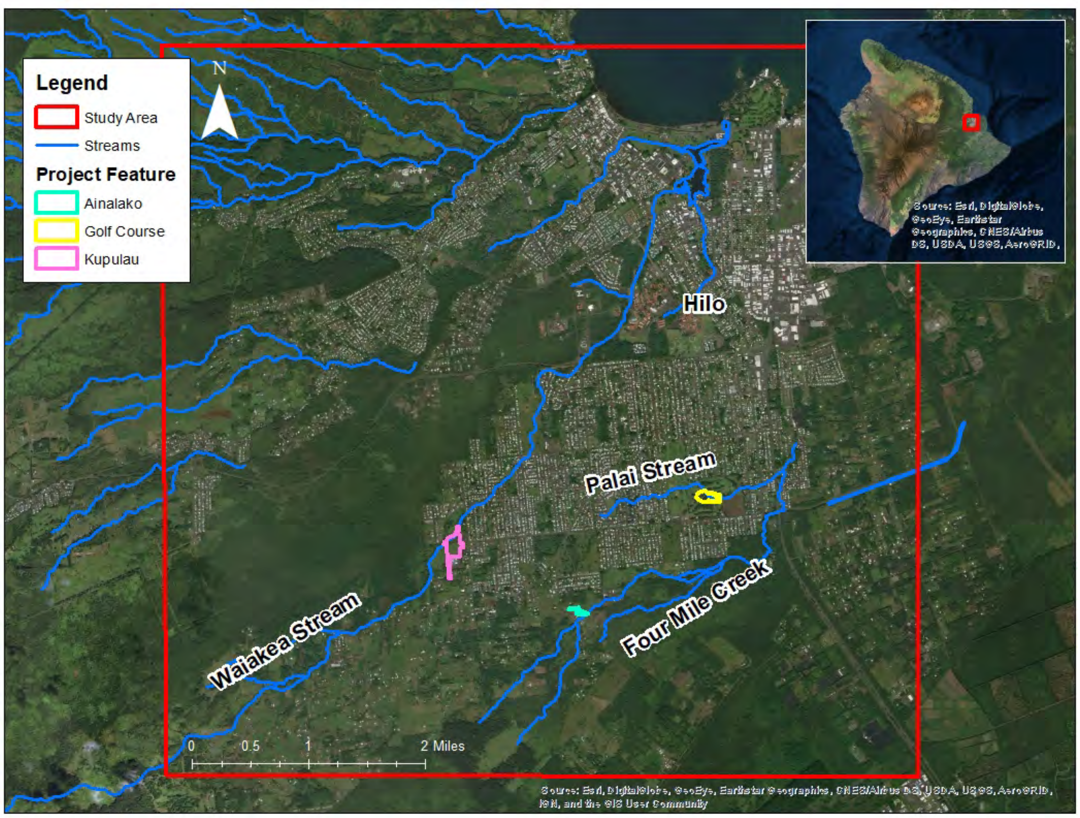
1 INTRODUCTION

The U.S. Army Corps of Engineers, Honolulu District (USACE), in partnership with the County of Hawaiʻi Department of Public Works, is assessing the reduction of flood risk in the Waiakea and Palai Streams near Hilo, Hawaiʻi. The study is authorized under Section 205 of the Flood Control Act of 1948, as amended (33 U.S.C. 701s; Public Law 93-251, as amended; Public Laws 97-140 and 99-662). This environmental appendix supplements the Waiakea-Palai Integrated Feasibility Report/Environmental Assessment (IFR/EA) in compliance with the National Environmental Policy Act (NEPA) of 1969, the Council of Environmental Quality (CEQ) regulations 40 CFR 1500-1508 and incorporates the requirements of the Hawaiʻi Revised Statutes (HRS) and the Hawaiʻi State Office of Environmental Quality Control (OEQC). This Integrated Feasibility Report and Environmental Assessment was developed under the NEPA rules of 1978. All analysis, coordination, consultations, as well as outreach was complete prior to the implementation of the new NEPA rules effective September 14, 2020. The IFR/EA meets the appropriate State filing and notification requirements, as applicable.

2 STUDY AREA

The study area encompasses the Waiakea and Palai watersheds near the town of Hilo, Hawaiʻi, located on the northeastern coast of the island of Hawaiʻi (***Figure 1***). The Waiakea Stream, Palai Stream, and Four Mile Creek are three of the five tributaries within the principal Wailoa River System, which drains a total of 178 square miles and empties into Hilo Bay.

Figure 1: Waiakea-Palai Stream Study Area



3 FLOOD RISK MANAGEMENT ALTERNATIVES

The objective of the feasibility study is to identify measures to reduce the flood risk associated with the Waiakea and Palai Streams in the City of Hilo. The proposed final array of alternatives consist of two stand-alone alternative measures (Kupulau Ditch Levee/Floodwall andHilo Municipal Golf Course Detention) and an alternative combining both of these FRM features. The location of the each of the FRM project areas is provided in ***Figure 1***.

3.1 KUPULAU DITCH

The Kupulau Ditch Alternative includes the construction of a detention basin on property located to the north of the New Hope Church and adjacent to the right bank of Kupulau Ditch (located east of the confluence of Kupulau Ditch and Waiakea Stream)(**Figure *2***). Impounding the runoff would be accomplished by constructing a series of three levees and one floodwall to enclose the landscape by utilizing the natural topography of the area.

Figure 2: Kupulau Ditch Alternative

3.2 HILO MUNICIPAL GOLF COURSE DETENTION

The golf course alternative includes the construction of a detention basin in the Hilo Municipal Golf Course to attenuate flow and reduce damage to properties in the downstream reaches of Palai Stream (**Figure *3***). A 21 acre-foot detention pond would be constructed at the Hilo Municipal Golf Course to capture flood flows with an outlet structure designed to release flow to minimize flood damage to downstream property.

Figure 3: Hilo Municipal Golf Course Detention

This environmental appendix addresses the natural and social resources in the study area and the impacts to these resources resulting in the construction and operation of the flood risk management alternatives.

4 EXISTING CONDITIONS

The following section describes the existing conditions of the study area. This analysis established a baseline, or existing condition, to provide a frame of reference to evaluate the performance of alternative plans.

4.1 LAND USE

The upper reaches of the Waiakea and Palai Stream watershed consist of pastoral land uses such as cropland, pastures, shrub rangeland, and evergreen forest. Continuing into the Hilo town limits, residential land uses increase in density and generally transition into commercial and industrial uses towards the coastline.

4.2 CLIMATE

The region has a tropical climate with mild temperatures throughout the year, moderate humidity, persistent northeasterly trade winds, significant differences in rainfall within short distances, and infrequent severe storms. The climate is dominated by the northeast trade winds blowing against the slopes of Mauna Loa. Orographic rainfall caused by lifting and cooling of moisture-laden air masses, is highest in a north-south trending zone on the eastern slope of Mauna Loa between altitudes of 2,000 and 4,000 feet. The annual temperature within the study area averages 72 °F with little variation in summer and winter air temperatures. The annual rainfall in the study area ranges from 143 inches a year in the town of Hilo and up to 200 inches a year in the upper reaches of the watershed (University of Hawaiʻi at Mānoa, 2019). Peak rainfall events occur in the spring and early winter. The monthly average high precipitation in the town of Hilo is 17 inches in November and the monthly average low occurs in June with 2 inches of precipitation. In the upper reaches of the watershed, winter also results in higher precipitation with a monthly high in March of 22 inches and a low of 13 inches in February.

4.3 WATER RESOURCES

Water resources include both surface water and groundwater resources, associated water quality, and floodplains. Surface water includes all lakes, ponds, rivers, streams, impoundments, wetlands and estuaries within the watershed. Subsurface water, commonly referred to as ground water, is typically found in certain areas known as aquifers. Aquifers are areas with high porosity rock where water can be stored within pore spaces. Water quality describes the chemical and physical composition of water affected by natural conditions and human activities.

4.3.1 HYDROLOGY AND HYDRAULICS

Waiakea Stream, Palai Stream, and Four Mile Creek are tributaries of the Wailoa River system. The Waiakea and Palai Streams drain into the Waiakea Pond, which is contiguous with Hilo Bay and the Pacific Ocean.

At the upstream end of the study area, Waiakea Stream contains a poorly defined channel. When the stream overflows, floodwaters travel east to enter the Kupalau Ditch. The channel bed is composed of lava rock and the overbanks are highly vegetated. The high velocities dislodge rock and vegetation and transport the material downstream.

Kupulau Ditch was built in 1971 to divert water from the Palai watershed into the Waiakea Stream in order to reduce flood problems. The ditch is approximately 3,500 in length, has an average depth of seven feet, has a bed slope of 0.006 foot per foot (ft/ft), and is composed of lava rock. The 10 percent annual chance exceedance (ACE) flows for Kupulau Ditch is 430 cubic feet per second (cfs) and the ditch conveys 904 cfs during a one-percent event. Kupulau Ditch receives overflow from Waikea Stream and quickly reaches its capacity. The ditch begins to overflow over its right bank and flood the New Hope Church, which is located adjacent to the ditch. The water then backs up across Kupulau Road and flows overland in an eastward direction flooding structures along HaiHai Street and Ainalako Road.

Floodwater from the overtopping Kupulau Ditch enters the Palai Stream at the Hilo Municipal Golf Course before continuing downstream to industrial, commercial, and residential areas within the Town of Hilo. The channel capacity of Palai Stream is about 1,000 cfs, equivalent to a 20 percent ACE flood from the Hilo Municipal Golf Course downstream to Kawailani Street. The bed slope of this reach of Palai Stream is 0.026 ft/ft and flattens to a slope of 0.006 ft/ft downstream of Kawailani Street. Downstream of Kawailani Street the channel capacity reduces to approximately 800 cfs which is the equivalent of a 50 percent ACE flood. Once leaving the banks, floodwaters in this reach of the Palai Stream are conveyed by overland flow. Stream channels in this area are poorly defined with low lying areas serving as pockets of storage areas.

4.3.2 FLOODPLAINS

Federal Emergency Management Agency (FEMA) National Flood Insurance Maps were used to delineate the 100-year floodplains for the study area (FEMA, 2019). Additional Hydrology and Hydraulic models further refined the areas inundated at various ACEs, including the 0.01 ACE. The FEMA Flood Maps delineate the watershed using different zone designations associated with the probability of flooding frequency for that area. The study area contains six different zone designations:

- A and AE – Areas subject to inundation by the one percent ACE,
- AO – Areas subject to inundation by the one percent ACE shallow flooding, usually sheet flow on sloping terrain) where average depths are between one and three feet,
- AH – Areas subject to inundation by the one percent ACE shallow flooding, usually areas of ponding) where average depths are between one and three feet,
- VE – Areas subject to inundation by the one percent ACE with additional hazards due to storm-induced velocity wave action
- X – Areas outside of the 0.2 percent floodplain
- NP – Areas not mapped by the FEMA National Flood Insurance Program.

The floodplains associated with Waiakea Stream, Palai Strean, and Four Mile Creek follow the stream course in a relatively narrow corridor, with areas of shallow sheet flow flooding (AO and AH) extending the floodplain out into the adjacent areas. FEMA has designated the Waiakea floodplains as A, AE, AH, and AO indicating the Waiakea widens out of its banks during the one percent ACE and the storm also induces shallow sheet flow inundation into areas outside of the channel. Similarly, FEMA has designated the Palai floodplain as AE and AO. However, FEMA designates the Four Mile Creek floodplain as AH indicating that much of the one percent flooding along the Creek is due to sheet flow. Finally, areas along the coastline of the study area have been designated as VE zones transitioning into AE farther inland.

4.4 WETLANDS

Wetlands are often defined as areas where the frequent and prolonged presence of water at or near the soil surface drives the natural system. Wetland areas require specific hydrology, soil types (i.e. hydric soils), and plant species that are characterized as requiring wetland habitats.

The U.S. Fish and Wildlife Service (USFWS)(2019) has mapped wetlands within the study area as part of the National Wetlands Inventory (NWI). Although the USFWS have identified several errors in the national NWI, the database provides a good baseline prior to field identification.

Within the Waiakea-Palai watershed, the NWI identifies five freshwater ponds (three PUBHh, one PUBH, and one PUBHx); however, these ponds are 1,600 to 5,700 feet from the floodplains of the streams. The first letter of the NWI designation refers to the Palustrine hydrology of the wetland. The rest of the designation refers to an unconsolidated bottom (UB), permanently flooded (H), diked or impounded (h), or excavated (x). The NWI characterizes Waiakea Pond as an Estuary (E1UBL). For estuarine systems, the first letter of the wetland designation refers subtidal estuarine (E1) hydrology of the wetland. Waiakea pond has an unconsolidated bottom (UB) and is subtidal (L). According to the NWI, no riverine or palustrine wetlands occur along the streams.

4.5 SURFACE WATERS

The Clean Water Act (CWA)(33 U.S.C §§1251 *et seq*.) establishes the basic structure for regulating discharges of pollutants into the waters of the United States and regulating quality standards for surface waters. For the purposes of Clean Water Act regulatory jurisdiction, the term Waters of the U.S. is defined at 33 CFR 328.3(a). Waters of the U.S. include all tributaries to those waters currently or previously used or susceptible for interstate of foreign commerce, including all waters which are subject to the ebb and flow of the tide. Three main waterways occur within the project areas, the Waiakea Stream, Kupulau Ditch and Palai Stream. Both Waiakea and Palai streams feature intermittent flow while the Kupulau Ditch conveys ephemeral flow.

The Waiakea Stream is a tributary to a navigable water, conveying continuous surface connectivity to Hilo Bay and as such, is a water of the U.S. The Waiakea Stream flows intermittently in the project area and perennially downstream prior to confluence with a navigable water.

The Kupulau Ditch was artificially-constructed in uplands to convey stormwater flows to the downstream Waiakea Stream, flowing only in response to precipitation events,. The Kupulau Ditch conveys ephemeral flow downstream to the Waiakea Stream and features a trapezoidal channel constructed of earthen bed and banks. Under the Navigable Waters Protection Rule, the Kupulau Ditch is not a water of the U.S. e.g. "non-jurisdictional".

The Palai Stream bifurcates the Hilo Municipal Golf Course. The Palai Stream channel and banks are defined within the project areas. However, based on a site visit attended by USFWS in February 2019, the Corps confirmed that flow within the Palai Stream, downstream of the Golf Course at the intersection of Mamalahoa Highway and Puainako Street, eventually vanishes into swales and storm water conduits. The tributary lacks continuous surface connectivity to a navigable water and according to the Navigable Waters Protection Rule, is not a water of the U.S. e.g. "non-jurisdictional".

During storms, storm water runoff from the steep watershed of the streams results in high energy flows by the time it reaches the study area. Some runoff may quickly seep into the ground depending on subsurface permeability where flows continue subsurfacely. Storm water runoff can also disappear into lave tubes and reappear as surface flow downstream. The movement of subsurface flow is unknown and may or may not affect peak storm water flows (USDA, 2009).

4.5.1 WAIAKEA STREAM

Waiakea Stream originates along the northeastern slopes of Mauna Loa volcano (elevation 13,653 feet) and has a drainage area of 35.6 square miles. Waiakea Stream flows northeast through the residential community of upper Waiakea-Uka Homesteads before entering the town of Hilo and ultimately emptying into Waiakea Pond and Hilo Bay. The stream is intermittent due to the highly permeable volcanic substrate. During storms, storm water runoff returns flow to the streams. Due to the steep nature of the watershed, the stream flow has high energy and is turbulent. Some of the stormwater runoff eventually seeps in to the ground, continues as subsurface flow, or flows into lava tubes and reappears as springs.

Portions of the Waiakea Stream within the study area have been previously altered to reduce flood risk in the Hilo area. In 1965, USACE built a flood control project that extends from the lower reaches of Waiakea Stream to Waiakea Pond. This project, called the Wailoa Stream Flood Control Project, consists of channel improvements and levees to provide flood protection for an area of Hilo downstream of the University of Hawaiʻi at Hilo. The project was designed for a discharge of 6,500 cubic feet per second (cfs) and at the date of completion provided a 0.008% ACE.

In 1971, the County of Hawaiʻi constructed Kupulau Ditch. This ditch diverted storm water runoff from to the Waiakea Stream upstream of Kupulau Road. The ditch consists of a trapezoidal channel about 3,500 linear feet long with a 12-foot bottom width and 2:1 slopes.

Upstream, the County of Hawaiʻi constructed the Waiakea-Uka channel in 1984. This channel consists of 3,460 linear feet of concrete lined and unlined trapezoidal channel improvements from Kawailani Street to the intersection of Komohana and Puainako Streets. These improvements were designed for a discharge of 4,460 cfs. Farther upstream, the County of Hawaiʻi replaced the Kawailani Street Bridge with a new bridge having a larger opening and improved the channel upstream and downstream of the bridge. These bridge and channel improvements were completed in November 2000.

4.5.2 PALAI STREAM

Palai Stream has a drainage area of about 7.7 square miles and is classified as an intermittent stream. Its watershed is linearly shaped and approximately 11 miles in length and about 2 miles in width at its widest point. Palai Stream originates down slope of the broad saddle formed between Mauna Loa and Mauna Kea volcanos and flows for about 7 miles through the Waiakea Forest Reserve with elevations ranging from 2,100 to 1,500 feet. The watershed is largely developed below the 1,500-foot elevation. It flows an additional four miles through the Town of Hilo before emptying into Waiakea Pond and Hilo Bay. There are no federal flood risk management (FRM) projects located in the Palai watershed.

4.6 GROUND WATER

The study area is underlain with the Hilo and Keaau Aquifer System Area (ASYA) of the Northeast Mauna Loa Aquifer Sector Area. Water in the study area aquifer occurs as a lens of basal water floating on saline groundwater (Takasaki, 1993). The aquifer is unconfined and occurs in basalt originating from flank lava flows. The aquifer is designated as a drinking water source, is irreplaceable, and is highly vulnerable to contamination (Mink and Lau, 1990). Wells in the study area indicate that the depth to groundwater is estimated to be greater than 100 feet. The sustainable yield of the Hilo ASYA is 347 million gallons per day (mgd) and the Keaau ASYA provides a yield of 393 mgd. The combined ASYAs provide the highest yield of all the sector areas on the island. The watersheds associated with Mauna Loa slope contributes 50 to 100 inches per year of groundwater recharge. The aquifer provides water resources for municipal, agricultural, and industrial uses in the Hilo area.

4.7 COASTAL ZONE MANAGEMENT RESOURCES

In 1972, Congress passed the Coastal Zone Management Act (CZMA), which established the federal Coastal Zone Management Program (CZMP; Public Law 92-583 Stat.1280, 16 §§ 1451-1464, Chapter 33). The CZMP is a federal-state partnership that provides a basis for protecting, restoring, and responsibly developing coastal resources. The CZMA defines coastal zones wherein development must be managed to protect areas of natural resources unique to coastal regions. Hawaiʻi has developed and enacted the Hawaiʻi Ocean Resources Management Plan (ORMP), in which any federal and local actions must be determined to be consistent with the management plan. The State of Hawaiʻi Office of Planning enforces consistency of the plan for Hawaiʻi.

States are required to define the area that will comprise their coastal zone and develop management plans that protect the unique resources through enforceable policies of the State ORMP. Hawaiʻi defines its coastal zone as all lands of the state and the area extending seaward from the shoreline to the limit of the State's police power and management authority, including the U.S. territorial sea. Therefore, the study area lies within the coastal zone as defined by the State.

The ORMP goals and policies focus management efforts on 11 management priority groups:

- Appropriate Coastal Development
- Management of Coastal Hazards
- Watershed Management
- Marine Resources
- Coral Reef
- Ocean Economy
- Cultural Heritage of the Ocean
- Training, Education, and Awareness
- Collaboration and Conflict Resolution
- Community and Place-based Ocean Management Projects
- National Ocean Policy and Pacific Regional Objectives

4.8 AIR QUALITY

The U.S. Environmental Protection Agency (EPA) has the primary responsibility for regulating air quality nationwide. The Clean Air Act (42 U.S.C. 7401 *et seq*.), as amended, requires the EPA to set National Ambient Air Quality Standards (NAAQS) for wide-spread pollutants from numerous and diverse sources considered harmful to public health and the environment.

EPA has set NAAQS for six principal pollutants, which are called "criteria" pollutants. These criteria pollutants include carbon monoxide (CO), nitrogen dioxide (NO_2), ozone (O_3), particulate matter less than 10 microns (PM_{10}), particulate matter less than 2.5 microns ($PM_{2.5}$), sulfur dioxide (SO_2), and lead (Pb). If the concentration of one or more criteria pollutants in a geographic area is found to exceed the regulated "threshold" level, the area may be classified as a non-attainment area. Areas with concentrations of criteria pollutants that are below the levels established by the NAAQS are considered in attainment.

There are no non-attainment areas within the State of Hawaiʻi (EPA, 2019a).

An air quality monitoring station is located within the study area at 1099 Waianuenue Avenue near the Hilo Medical Center. The prevailing trade winds on Hawaiʻi Island are from the east-northeast, with a mean wind speed of 10.6 miles per hour. The trade winds persist approximately nine months out of the year. Trade winds blow vog from Hawaiʻi Island's volcanoes (e.g., Kilauea volcano), as well as other air contaminants, to the southwest. During the winter months, winds tend to be less predictable; there are longer periods of light and variable winds. Strong southerly, or "Kona", winds occur and are associated with weather fronts and storms. When these conditions occur, much of the vog stays on the eastern side of the island, where it affects Hilo and the study area. In addition, when trade winds are absent for prolonged periods of time, vog travels up the island chain and can affect air health by increasing levels of SO_2 and $PM_{2.5}$. Although both of these pollutants are regulated by the EPA, Hawaiʻi's advisories for volcanic SO_2 and $PM_{2.5}$ have been customized for local conditions. Air monitoring stations in communities near the volcano record regular exceedances of the NAAQS for SO_2 and occasional exceedances of the NAQQS for $PM_{2.5}$. The EPA considers the volcano a natural, uncontrollable event, and therefore the state requests exclusion from these NAAQS exceedances for attainment/non-attainment determination (DOH, 2015). Shorter exposure time intervals have also been adopted due to variable wind conditions, which can cause volcanic gas concentrations to change rapidly (USGS, 2017).

4.9 WATER QUALITY

Section 305(b) of the CWA requires states to assess the water quality of the waters of the state and prepare a comprehensive report documenting the water quality. The report is to be submitted to the EPA every two years. In addition, Section 303(d) of the CWA requires states to prepare a list of impaired waters on which total maximum daily loads (TMDLs) where corrective actions must be implemented. The EPA has delegated the Hawaiʻi State Department of Health (HSDOH), Clean Water Branch as the agency in Hawaiʻi responsible for enforcing the water quality standards and preparing the comprehensive report for submittal to the EPA.

Surface water quality in the study area is influenced by agricultural practices and residential, commercial, and industrial areas associated with urban development. Palai Stream is not include the 2018 Section 303(d) list of impaired waters (HSDOH, 2018). Therefore, the water quality of the stream has not been assessed. Waiakea Stream (Water Body ID 8-2-61) has been classified as an impaired waterbody due to elevated Total Nitrogen (TN), nitrite ($NO_{2)}$ and nitrate (NO_3), and total phosphorous (TP). The HSDOH categorizes the priority for establishing TMDLs for streams as high, medium, or low. Waiakea Stream has been assigned as a medium TMDL priority category.

The specific water quality impairments of Waiakea Stream are typical of streams that bisect agricultural areas as TN, nitrate, nitrite, and TP are common constituents of fertilizers used in cultivation. The agricultural areas within the study area are located in the upstream portions of the watershed; therefore, these pollutants are carried downstream into the urban areas and ultimately into Hilo Bay.

4.10 GEOLOGIC RESOURCES

Geologic resources are defined as the topography, geology, soils, and mining of a given area. The existing physiography, soils, and geomorphology of the study area is a result of complex interactions of geological, hydrological, and meteorological processes that occurred during the Holocene epoch of the Quaternary period. The primary driver behind these processes are eruptions of the island's five coalesced shield volcanos: Kahala, Mauna Kea, Hualalai, Mauna Loa, and Kilauea. Mauna Loa is an active volcano which last erupted in 1984. USGS has mapped potential lava flow inundation zones which include most of the southern half of the Hilo watershed and most of the City of Hilo. The study area is located in a lava flow hazard zone 3, which is defined as an area where one to five percent of the area has been covered with lava since 1800 and 15 to 75 percent of the area has been covered within the last 750 years (Wright et al., 1992).

The underlying geology of the study area resulted from the lava flows of the Mauna Loa Volcano. The lave flow consists of Kau Basalt that was laid down approximately 5,000 to 10,000 years ago. Younger Kau Basalt lava flows border the northern (deposited 200 to 750 years ago) and southern (deposited 750 to 1,500 years ago) of the study area. These features are associated with the Mauno Loa southwest rift zone transitional unit.

The geology of the study area includes lava flows from Mauna Loa with volcanic rock close to the surface creating a hard surface layer that limits infiltration in some locations. Existing lava tubes in the area may route water underground where it reappears elsewhere as springs or seeps.

Earthquakes are often associated with volcanic activity and occur thousands of times annually; most of which are at a very small magnitude. Hilo, and the study area, is located in areas designated as an area designated seismic design code Dclassified as occurring in seismD1 and D2. These zones have a two percent chance for peak ground acceleration to exceed 67-percent amd 83-percent gravity, respectively, over a 50 year exposure time (USGS, 2019).

A tsunami is a series of great waves, typically the result of a violent displacement of the seafloor. Tsunamis are characterized by high speeds (up to 560 miles per hour), long wave lengths (up to 120 miles), and long periods between successive wave crests (up to several hours). Tsunamis have the potential to inundate the coastline, causing severe property damage and/or loss of life. Located in the middle of the Pacific Ocean, Hawaii is susceptible to tsunamis from earthquakes and tsunamis generated by the Pacific Rim. The downstream portion of Waiakea Stream is within the tsunami evacuation zones (Hawaii County Civil Defense, 2019).

4.11 SOILS

The soils found in the study area is consistent with the Akaka-Honokaa-Kaiwiki soil association. Soils within this association are deep, gently sloping to steep, and moderately well drained. The soils are moderately fine textured soils formed from volcanic ash, are high in organic material, are very porous, and are continuously wet (USDA, 1973). **Table *1*** lists the soil types and their extent within the study area.

Table 1: Extent of Soil Types within the Study Area

Soil Map Unit	Soil Name	Acres in Study Area	Percent of Soil in Study Area	Prime Farmland Soil	Hydric Soils
614	Waiakea hydrous loam, 2-20% slopes	515	2.0%	No	Yes
624	Kopua-Ihope complex, 3-10% slopes	1,124	4.4%	No	Yes
628	Papai extremely cobbly highly decomposed plant material, 2-10% slopes	4,117	16.2%	No	No
629	Panaewa very cobbly hydrous loam, 2-10% slopes	3,158	12.5%	No	Yes
637	Papai-Urban land complex, 2-10% slopes	1,940	7.7%	No	No
638	Panaewa-Urban land complex, 2-10% slopes	3,182	12.6%	No	No
639	Keaukaha-Urban land complex, 2-10% slopes	866	3.4%	No	Yes
640	Opihikao-Urban land complex, 2-20% slopes	1,438	5.7%	No	No
653	Keaukaha highly decomposed plant material, 2-10% slopes	2,344	9.3%	No	Yes
660	Olaa cobbly hydrous loam, 2-10% slopes	588	2.3%	No	No
662	Hakuma highly organic hydrous loam, 2-10% slopes	2,116	8.4%	No	Yes
664	Opihikao highly decomposed plant material, 2-20% slopes	34	0.1%	No	No
900	Kaiwiki hydrous silty clay loam, 0-10 % slopes	190	0.7%	Yes	Yes
901	Hilo[1] hydrous silty clay loam, 0-10%	2,069	8.2%	Yes	No
902	Hilo[1] hydrous silty clay loam, 20-35% slopes	67	0.3%	No	No

903	Hilo[1] hydrous silty clay loam, 10-20% slopes	1122	4.4%	No	No
906	Kaiwiki hydrous silty clay loam, 10-20% slopes	116	0.5%	No	Yes
909	Hilo-Rock outcrop complex, 35-100%	350	1.4%	No	No
	Total	25,336	100%	-	

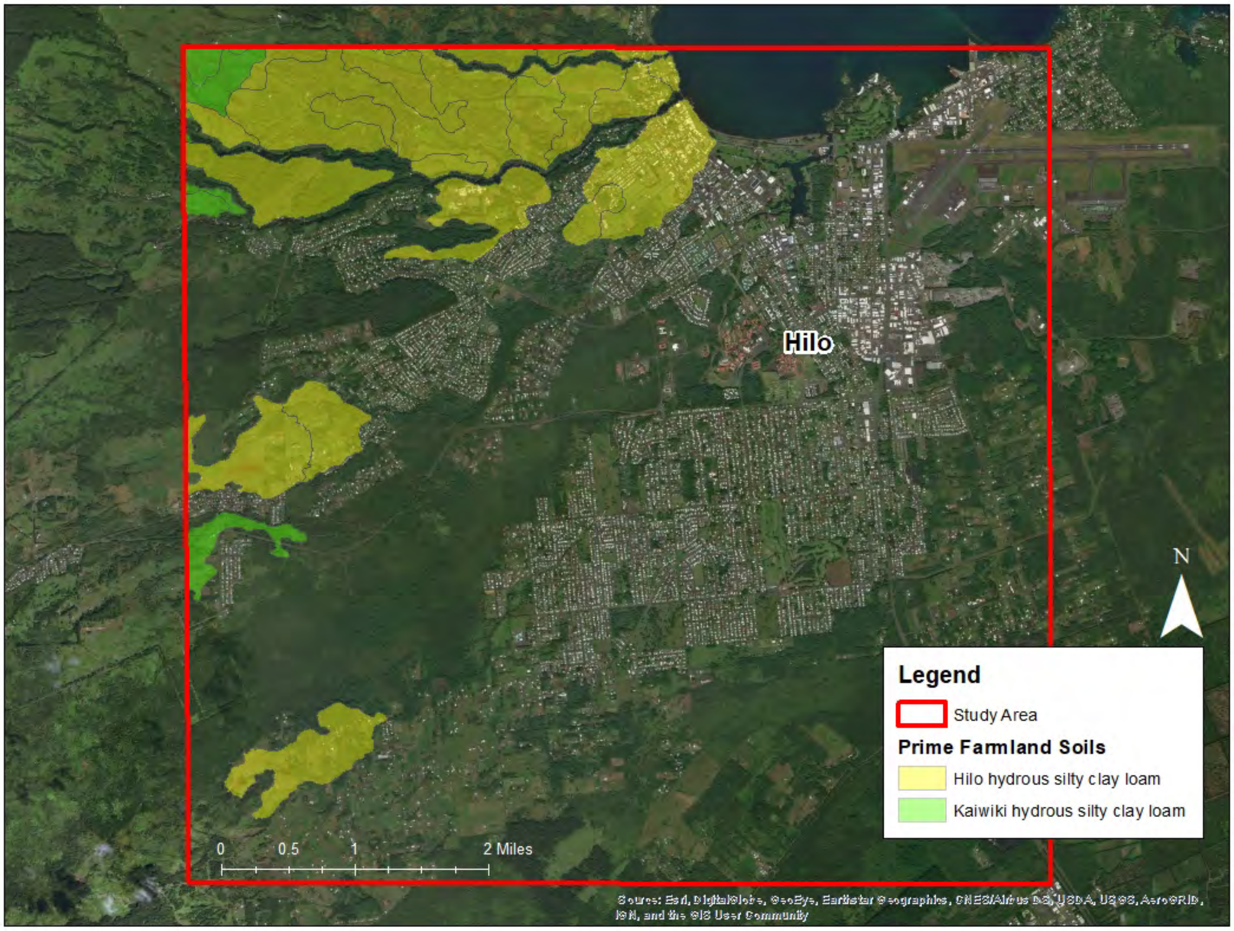
Source: NRCS Soil Data Mart (2019)

The Farmland Protection Policy Act of 1981 (FPPA)(P.L. 97-98) is intended to minimize the impact of Federal actions on the conversion of prime farmland, unique farmland, or land of statewide or local importance to non-agricultural uses. Farmland consists of cropland, forest land, rangeland, and pastures. Urban lands containing prime farmland soils are not covered under the FPPA.

Prime farmland is land that has the best combination of physical and chemical properties for producing food, feed, forage, fiber, and oilseed crops. In general, prime farmland has an adequate and dependable supply of moisture from precipitation or irrigation. Unique farmland is land other than prime farmland that is used for the production of specific high-value food and fiber crops, such as citrus, tree nuts, olives, cranberries, and other fruits and vegetables. Nearness to markets is also a consideration. Unique farmland is not based on national criteria. Farmland of statewide importance do not meet the qualifications of prime or unique farmland.

The study area includes two prime farmland soil types: Kaiwiki hydrous silty clay loam with 0- to 10-percent slopes and Hilo hydrous silty clay loam with 0- to 10-percent slopes. In addition, the Hilo soils have been designated as the State soil of Hawaiʻi due to its value for the production of sugarcane, ginger, taro, orchard crops, and forestry. The two prime farmland soils, concentrated in the northwestern quadrant of the study area, comprise 2,259 acres or 8.9-percent of land within the study area (**Figure *4***).

Figure 4: Prime Farmland Soils within the Waiakea-Palai Stream Study Area



4.12 BIOLOGICAL COMMUNITIES

Biological communities include plants and animals and the habitats in which they occur. They are important because they influence ecosystem functions and values, have intrinsic value, contribute to the human environment, and are the subject of a variety of statutory and regulatory requirements.

The study area is located in the Lowland Wet ecological system of the Tropical Moist Forest ecoregion. The Lowland Wet ecological system consists of natural communities below 3,000 feet in elevation and receiving greater than 75 inches of annual precipitation. Vegetative communities associated with this system include wet grasslands, shrublands, and forests. Biodiversity in the Lowland Wet system is high and supports specialized plants and animals.

Three separate biological surveys were conducted to assess the existing conditions within the project area, as well as the projected impacts on biological resources from the Proposed Action (USACE, 2005; USACE, 2010a; and USACE, 2010b). The results of these surveys, and information from additional research were used to characterize and assess the biological resources within the project area.

4.12.1 VEGETATION

The vegetative community within the study area has been altered as native habitats have been converted to agriculture and urbanization has introduced ornamental plant species. In addition, non-native invasive species have become established throughout much of the study area. Non-native species within the study area include strawberry guava (*Psidium cattleianum*), gunpowder (*Trema orientalis*), African tulip (*Spathodea campanulata*), common guava (*Psidium guajava*), albizia (*Falcateria moluccana*), melochia (*Melochia umbellata*), and kukui (*Aleurites moluccana*). Native vegetation extends upslope of the study area and is dominated by ʻōhiʻa (*Metrosideros polymorpha*) trees and dense patches of ʻuluhe (*Metrosidero polymorpha*). A full list of plant species observed in the study area is described in USACE (2005, 2010a, 2010b).

4.12.2 AQUATIC WILDLIFE

Biota occurring in the isolated pools associated with the streams in the study area include swordtails (*Xiphophorus helleri*) and marine toad tadpoles (*Bufo marianus*), which are abundant throughout the study area. Dragonfly and damselfly naiads (Odonata) and red swamp crayfish (*Procambarus clarkii*) are common. Guppies (*Poecila reticulata*) are occasionally encountered schooling with swordtails. Mosquitofish (*Gambusia affinis*), bullfrogs (*Rana catesbeiana*), and adult marine toads are uncommon. A full list of aquatic fauna observed in the study area is described in USACE (2005, 2010a, 2010b).

4.12.3 TERRESTRIAL SPECIES

Avian species identified within the project area were dominated by non-native species. The only native species identified was the Pacific-golden Plover (*Pluvialis fulva*). Similarly, no native mammals were identified within the study area; non-native species included the Indian mongoose (*Herpestes auropunctatus*), dogs (*Canis familiaris*), and pigs (*Sus scrofa*). A full list of terrestrial wildlife species observed in the study area is described in USACE (2005, 2010a, 2010b).

4.13 BIOLOGICAL COMMUNITIES

Three separate biological surveys were conducted to assess the existing conditions within the project area, as well as the projected impacts on biological resources from the Proposed Action (USACE, 2005; USACE, 2010a; and USACE, 2010b). The results of these surveys, and information from additional research were used to characterize and assess the biological resources within the project area, as well as any anticipated effects on biological resources within the project area from the Proposed Action.

4.13.1 THREATENED AND ENDANGERED SPECIES

Wildlife and plant species may be classified as threatened or endangered under the Endangered Species Act (ESA) of 1973. Protection of non-marine protected species is overseen by the USFWS and NMFS is responsible for protected marine species. The purpose of the ESA is to establish and maintain a list of threatened and endangered species and establish protections for their continued survival. Section 7 of the ESA requires federal agencies to coordinate with USFWS and NMFS to ensure that any federal action is complaint with the ESA and that the action will not jeopardize the continued existence of threatened or endangered species or result in the destruction or adverse modification to their critical habitat. The State of Hawaiʻi has also developed a State list of threatened and endangered species and incorporated it in the Hawaiʻi Comprehensive Conservation Strategy (HCCS)(Mitchell et al., 2005).

Three ESA-listed species were identified in an 8 June 2018 informal consultation letter from the USFWS (**Attachment *1***). Habitat and life requisites for these species are provided below. No critical habitat for any listed species is designated within the study area. Habitat suitable for the Hawaiian coot and Hawaiian hawk are also absent within the study area. During field investigations, no threatened or endangered species were observed within the study area (USACE 2005, 2010a, 2010b).

4.13.1.1 HAWAIIAN HOARY BAT

The ʻŌeʻapeʻa or Hawaiian hoary bat (*Lasiurus cinereus semotus*) is Hawaiʻi's only native terrestrial mammal (Mitchell et al., 2005). The bats roost in 3- to 29-foot tall native and non-native vegetation. Key plant species used for roosting include ʻōhiʻa, pu hala (*Pandanus tectorius*), coconut palms (*Cocos nucifera*), kukui (*Aleurites moluccana*), kiawe (*Proscopis pallida*), avocado (*Persea americana*), shower trees (*Cassie javanica*), pūkiawe (*Styphelia tameiameiae*), and fern clump. They may also roost in stands of eucalyptus (*Eucalyptus* spp.) and Sugi pine (*Cyrptomeria japonica*). The bats feed on a variety of native and non-native night-flying insects, including moths, beetles, crickets, mosquitoes, and termites. The hoary bat mates between September and December and gives birth in May and June. Because bat reproductive success is highly correlated to warm temperatures, it is likely that key breeding habitat for bats on the island of Hawaiʻi would occur below 4,200 feet elevations.

4.13.1.2 HAWAIIAN HAWK

The ʻio, or Hawaiian Hawk, is the only broad-winged hawk known to have colonized Hawaiʻi (Mitchell et al., 2005). The hawks feed on insects, birds, and rodents. The hawks inhabit lowland non-native forests, urban areas, agricultural lands, pasturelands, and high elevation native forests from sea level to elevations of 5,600 feet. Although hawk nests have been found in non-native trees, most nests are constructed in ʻōhiʻa trees. The hawks may seasonally occupy different habitats as they have been found to winter in subalpine māmane /naio forests.

4.13.2 HAWAIIAN COOT

The ʻAlae keʻokeʻo, or Hawaiian Coot is an endemic waterbird in Hawaiʻi (Mitchell et al., 2005). The Hawaiian Coot is a generalist with a diet ranging from seeds and leaves, snails, crustaceans, insects, tadpoles, and small fish. The coots typically forage in water less than 12-inches deep. The coots create floating nests in open water, constructed of aquatic vegetation, and anchored to emergent vegetation. Open water nests are typically composed of water hyssop (*Bacopa monnier*) and Hilo grass (*Paspalum conjugatum*) while platform nests in emergent vegetation are comprised from buoyant stems of bulrushes (*Scirpus* spp.). The coot inhabits lowland wetland habitats with suitable emergent plant growth interspersed with open water. These habitats include freshwater wetlands, taro fields, freshwater reservoirs, canefield reservoirs, sewage treatment ponds, brackish wetlands, and rarely saltwater habitats. Hawaiian coots inhabit Waiākea and Loko ponds on the island of Hawaiʻi.

4.14 SPECIAL STATUS SPECIES AND PROTECTED HABITAT

4.14.1 MIGRATORY BIRDS

The Migratory Bird Treaty Act (MBTA)(16 U.S.C. 703-712) prohibits the take of migratory birds resulting from activities unless authorized by the USFWS. Take includes pursuing, hunting, capturing, and killing of migratory birds or any part of their nests or eggs. The Act also prohibits the sale, purchase, or shipment of migratory birds, nests, or eggs. The MBTA is an international treaty with the U.S., Canada, Mexico, Japan and Russia. Non-native bird species are not protected under the MBTA.

4.14.2 MARINE MAMMALS

The Marine Mammal Protection Act of 1972 (MMPA)(16 U.S.C. 1361-1407) prohibits the take of marine mammals in U.S. waters and the importation of marine mammals and marine mammal products into the U.S. Take incudes the harassment, feeding, hunting, capture, collection, or killing of any marine mammal or part of a marine mammal. All cetaceans, (whales, dolphins, porpoises), sirenians (manatees and dugongs) and several marine carnivores (seals, sea lions, otters, walrus, and polar bears) are protected under the MMPA. The Act also established the Marine Mammal Commission, the International Dolphin Conservation Program, and the Marine Mammal Health and Stranding Response Program.

There are a total of 26 marine mammals documented in the Hawaiian Islands:

- Bottlenose dolphin (*Tursiops truncatus*)
- Pacific white-sided dolphin (*Lagenorhynchus obliquidens*)
- Pan-tropical spotted dolphin (*Stenella attenuata*)
- Risso's dolphin (*Grampus griseus*)
- Rough toothed Dolphin (*Steno bredanensis*)
- Spinner Dolphin (*Stenella longirostris*)
- Striped Dolphin (*Stenella coeruleoalba*)
- Hawaiian monk seal (*Monachus schauinslandi*)
- Northern fur seal (*Callorhinus ursinus*)
- Northern elephant seal (*Mirounga angustirostris*)
- Blainsville's beaked whale (*Mesoplodon densirostris*)
- Blue whale (*Balaenoptera musculus*)
- Bryde's whale (*Balaenoptera edeni*)
- Cuvier's beaked whale (*Ziphius cavirostris*)
- Dwarf sperm whale (*Kogia simus*)
- False killer whale (*Pseudorca crassidens*)
- Fin whale (*Balaenoptera physalus*)
- Humpback whale (*Megaptera novaeangliae*)
- Killer whale (*Orcinus orca*)
- Melon-headed whale (*Peponcephala electra*)
- North Pacific right whale (*Eubalaena japonica*)
- Pygmy killer whale (*Feresa attenuata*)
- Pygmy sperm whale (*Kogia breviceps*)
- Sei whale (*Balaenoptera borealis*)
- Short-finned pilot whale (*Globicephala macrorhynchus*)
- Sperm whale (*Physeter macrocephalus*)

4.14.3 ESSENTIAL FISH HABITAT

Congress enacted amendments to the Magnuson-Stevens Fishery and Conservation and Management Act (MSFCMA)(Public Law 94-265) in 1996 that established procedures for identifying Essential Fish Habitat (EFH) and required interagency coordination to further the conservation of federally managed fisheries. Rules published by NMFS (50 CFR Sections 600.805 – 600.930) specify that any federal agency that authorizes, funds or undertakes, or proposes to authorize, fund or undertake an activity which could adversely affect EFH is subject to consultation provisions of the MSFCMA and identifies consultation requirements.

EFH consists of those habitats necessary for spawning, breeding, feeding, or growth to maturity of species managed by the Regional Fishery Management Councils, as described in a series of Fishery Management Plans, pursuant to the Act. EFH is designated in the Hawaii Archipelago of the Western Pacific Region in marine waters from the shoreline out to the Economic Exclusion Zone. There is no EFH designated in inland waters in the Hawaii Archipelago. While the study area involves only inland waters, the Corps considered potential impact to downstream EFH beginning at the shoreline transition from Waiakea Pond to Hilo Bay. EFH is designated downstream of the study area for the following federally managed fisheries:

- Bottomfish Fishery
- Pelagic Fishery
- Crustacean Fishery

4.14.4 CORAL REEFS

Executive Order (EO) 13089, Coral Reef Protection, was enacted to preserve and protect the biodiversity, health, heritage, and ecological, social, and economic values of U.S. coral reef ecosystems and the marine environment. An interagency task force, the U.S. Coral Reef Task Force, was created in order to fulfill the EO's protection efforts. The task force works with State, territorial, commonwealth, and local government agencies, nongovernmental organizations, the scientific community, and commercial interests to develop and implement measures to restore damaged coral reefs and to mitigate further coral reef degradation (EPA, 2019b).

The corals in Hilo Bay are limited in number and extent and consist of relatively small "recruit" colonies of coral, with no established coral reefs. The coral species in the Bay are comprised primarily of brown and blue *Montipora* sp. and some *Porites* sp (Gulko, 1998). The Hilo Bay breakwall, which was constructed on Blonde Reef, limits the growth of the coral population within Hilo Bay as the breakwall limits circulation of salt water entering the bay. The breakwater also concentrates freshwater entering the Bay from ground water and streams including Waiakea and Palai Streams. The freshwater inflows result in salinities that are below the threshold for most coral species.

4.15 SOCIOECONOMICS

Socioeconomics is defined as the basic attributes and resources associated with the human environment, particularly population, demographics, and economic development. Demographics entail population characteristics and include data pertaining to race, gender, income, housing, poverty status, and educational attainment. Economic development or activity typically includes employment, wages, business patterns, and area's industrial base, and its economic growth.

Hilo is the fifth largest city in the State of Hawaiʻi with a population of 43,263 based on the 2018 U.S. census estimate data (U.S. Census Bureau, 2018). Hilo is the County seat and the only metropolitan area of Hawaiʻi County. Hilo functions as the industrial, commercial, distribution, and population core of the island.

According to the 2010 census, the population of Hawaii County includes approximately 185,079 residents, which is an approximately 19.7 percent increase from the 2000 census (U.S. Census Bureau, 2018). The project area is located within census tract number 207.02. Census tract 207.02 had a population of 4,861 in the 2010 census, which is approximately 2.6 percent of the total population of Hawaii County. Persons aged 18 years and over account for 143,992 of the population of Hawaii County, or 77.8 percent, while this age group makes up about 83.5 percent of the census tract population. Hawaii County's 65 years and older population is approximately 29,427, or 15.9 percent of the County population, while this age group consists of 859 or 17.7 percent of the census tract population.

Population growth for Hawaiʻi County is estimated to increase over the next 50 year. Future population estimates for the County are provided in **Table *2***. It is expected that the current demographics of the area (e.g. race, age) proportions would be similar to the existing condition.

Table 2: Future population estimates and growth to 2045 for the State and County of Hawaiʻi

	State of Hawaiʻi		County of Hawaiʻi	
Year	Average growth rate (%)	Population Estimate	Average growth rate (%)	Population Estimate
2010	-	1,363,621	-	185,406
2018	-	1,420,191	-	-
2025	0.7	1,514,700	1.3	222,400
2035	0.5	1,592,700	1.1	248,500
2045	0.3	1,648,600	1.0	273,200

US Census Bureau, 2019

Hawaii Island is divided into nine districts and the study area is within the South Hilo District. According to the County of Hawaii General Plan (County of Hawaii, 2014), desirable economic actions for the South Hilo District are to encourage development of the university and airport facilities; implement programs to revitalize downtown Hilo; encourage manufacturing operations utilizing local raw materials; assist the local fishing industry; improve the skill level of the local work force; expand the existing athletic-exhibition-conference facilities; and support aquaculture and terrestrial agricultural investments.

The median household income estimates are provided in **Table *3***.

Table 3: Mean Income of the Study Area

Geographic Unit	Mean Income
Hawaiʻi	$95,569

Hawaiʻi County	$73,391
Hilo	$69,843
Census Tract 207.02	$76,699

U.S. Census Bureau, 2018

The income of approximately 19-percent of Hilo residents are considered as persons of poverty, compared to 15-percent for the County and 9.5-percent for the State. Racial distribution for Hilo, Hawaiʻi County, and the State are provide in **Table *4***.

Table 4: Racial Distribution for the City of Hilo and the State of Hawaiʻi

Race	% Census Tract 207.02	% of Hilo	% of Hawaiʻi County	% of State of Hawaiʻi
White	34.2	18.5	34.0	25.7
African American	0.8	0.9	0.8	2.2
American Indian/Alaska Native	0.6	0.2	0.6	0.4
Asian	22.5	32.6	21.4	37.8
Native Hawaiian/Pacific Islander	12.5	9.5	13.1	10.2
Two or more races	29.5	37.7	30.1	23.8
Hispanic or Latino	-	11.2	12.7	10.5
White/Not Hispanic or Latino	-	15.7	30.3	21.9

Source: U.S. Census Bureau Quick Facts (U.S. Census Bureau, 2018)

4.15.1 ENVIRONMENTAL JUSTICE

In order to comply with EO 1289, ethnicity and poverty status in the study area were examined and compared to regional, state, and national data to determine if any minority or low-income communities could potentially be disproportionately affected by the implementation of the proposed action. No indication of disproportionately low income or minority specific populations were identified during site surveys of the study area. The data provided in **Table *3*** and **Table *4*** above also supports the field investigation.

4.15.2 PROTECTION OF CHILDREN

EO 13045 requires that federal actions consider potentially health and safety risks to children resulting from that action. The locations of areas where children may congregate (e.g., child care centers, schools, parks, etc.) were identified within the study area. Due to the extent of the study area, these areas, and the impacts resulting from the proposed action, are identified in the Consequences Chapter (**Chapter 4**).

4.16 HAZARDOUS, TOXIC, AND RADIOACTIVE WASTE

To complete the Phase I Hazardous, Toxic, and Radioactive Waste (HTRW) survey, USACE reviewed existing environmental documentation and environmental regulatory databases. USACE contacted the Hawaiʻi State Departments of Health (DOH), Land and Natural Resource (DLNR), OEQC, and the Hawaiʻi County Planning Department to obtain information about property history, environmental conditions, and any HTRW incidents, violations, or permit actions which may have occurred within the areas encompassing the final array of alternatives.

Federal, state, and local agency environmental records and regulatory databases were searched to determine the existence of any license or permit actions, violations, enforcements, and/or litigation against property owners, and to obtain general information about potential past incidents of HTRW releases. Results of the database searches include:

- No U.S. EPA National Priority List (NPL) or Superfund sites are within a one mile radius of the project alternative areas
- No Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS) site is located within a 0.5-mile radius of the project alternative areas
- No Resource Conservation and Recovery Information System (RCRIS) treatment, storage, or disposal (TSD) facility is located with a 0.5-mile radius from the project alternative areas
- No Resource Conservation and Recovery Act (RCRA) Corrective Action Reports (CORRACTS) were identified within a one mile radius of the project alternative areas
- No RCRA generators are located within the project alternative areas or adjacent properties
- No underground storage tanks (USTs) are located within a 0.25-mile radius of the project alternative areas
- One leaking underground storage tank (LUST) was located within a one mile radius of the project alternative areas
- No active landfills are located within a 0.5-mile radius of the project alternative areas
- No spills or incidents connected with the properties of the project alternative areas are entered in the Emergency Response Notification System (ERNS) database.

The records search of the DOH Solid and Hazardous Waste Branch, USTs Section was conducted for information on the LUSTs within, and in the vicinity of the project alternative areas. As stated in the synopsis above, the LUST database revealed one UST (Kawailani Laundromat, 511 West Kawailani Sreet) with a confirmed release of diesel fuel on 13 November 1997. The release was less than 25 gallons and resulted in appropriate remedial action including removal of the LUST. This site is located approximately one mile northwest of the project alternative areas.

A visual survey was conducted for areas included in the final array of alternatives on 12 January 2005 to look for evidence of potential HTRW or impacts therefrom. Follow-up HTRW surveys were performed on 5 February and 7 May 2019. Project alternative sites were reconnoitered for evidence of possible HTRW contamination including partially buried containers, discolored soil, seeping liquids, film or sheen on water surfaces, abnormal or dead vegetation or animals, malodors, dead-end pipes, anomalous grading, fills, depressions, or other evidence of possible environmental contamination. Based on the visual survey of the area, no apparent signs of HTRW contamination exists within the proposed alternative project areas.

4.17 CULTURAL RESOURCES

Archaeology

Several archaeological surveys have been conducted as part of various development projects in the vicinity of the study area, and were reviewed to characterize potential archaeological resources within the study area. The majority of the study area has been developed with residential and community land uses (e.g., parks, community centers, churches) and a few small-scale commercial uses. Due to the land use history of intensive agricultural cultivation and residential development, most archaeological, historic or cultural features that remain are likely to be associated with the sugar plantation or other historic uses of the area. Any pre-contact resources likely would have been destroyed by the agricultural operations or during subsequent suburban development of the area. (Escott, 2004, Geometrician Associates, 2006, Pacific Legacy, 2005).

Historic Resources

A total of 331 properties and historic districts are listed on the National Register of Historic Places (NRHP) for the State of Hawaii; of these, 73 are located on Hawaii Island. The listed historic property closest to the study area is the Waiakea Mission Station – Hilo Station (NPS, 2014). The Waiakea Mission Station – Hilo Station is located on Haili Street, approximately 4.8 miles from the study area.

The Hawaii Register of Historic Places formally recognizes districts, sites, structures, buildings and objects and their significance in Hawaii's history, architecture, archaeology, engineering and culture. No structures within the vicinity of study area are listed on the Hawaii Register of Historic Places for the Island of Hawaii (SHPD, 2014). The historic property closest to the study area is the S. Hata Building, approximately 5.0 miles from the study area.

Traditional or Cultural Practices

Hawaii Revised Statutes Section 7-1 has codified some recognized traditional and cultural practices. These traditional and cultural practices include the right to gather firewood, house-timber, aho cord, thatch, or ki leaf, for private use. Other traditional or cultural practices not specifically enumerated in the Constitution of the State of Hawaii or its statutes have also been recognized. These practices may include the stewardship and healing/restoration of lands established by actual practice. A Cultural Impact Study (CIS) was conducted for the study area in 2005. The CIS concluded that, based on the results and findings from interviews and archival research there are no known culturally significant traditional properties and resources in the study area; and the study area does not appear to support any traditional cultural practices. Archival research indicated a rich past of Hawaiian settlements, agriculture, and temples; however, little evidence remains due to the extensive and intensive cultivation of sugar cane in the late 19th and early 20th centuries (Pacific Legacy, 2005).

4.18 NOISE

Noise is generally defined as unwanted sound. Noise can be any sound that is undesirable because it interferes with communication, is intense enough to damage hearing, or is otherwise annoying. Human responses to noise vary depending on the type and characteristics of the noise, distance between the noise source and receptor, receptor sensitivity, and time of day.

Determination of noise levels are based on 1) sound pressure level generated (decibels [dB] scale); 2) distance of listener from source of noise; 3) attenuating and propagating effects of the medium between the source and the listener; and 4) period of exposure.

An A-weighted sound level, measured in dBA, is one measurement of noise. The human ear can perceive sound over a range of frequencies, which varies for individuals. In using the A-weighted scale for measurement, only the frequencies heard by most listeners are considered. This gives a more accurate representation of the perception of noise. The noise measure in a residential area, similar to conditions within the study area, is estimated at approximately 70 dBA. Normal conversational speech at a distance of five to ten feet is approximately 70 dBA. The decibel scale is logarithmic, so, for example, sound at 90 dBA would be perceived to be twice as loud as sound at 80 dBA. Passenger vehicles, motorcycles, and trucks use the roads in the vicinity of the project area. Noise levels generated by vehicles vary based on a number of factors including vehicle type, speed, and level of maintenance. Intensity of noise is attenuated with distance. Some estimates of noise levels from vehicles are listed in **Table *5*** (Cavanaugh and Tocci, 1998).

Table 5: Typical Noise Sources

Source	Distance (ft)	Noise Level (dba)
Automobile, 40 mph	50	72
Automobile Horn	10	95
Light Automobile Traffic	100	50
Truck, 40 mph	50	84
Heavy Truck or Motorcycle	25	90

Source: Cavanaugh and Tocci, 1998

State of Hawaii HAR Title 11, Chapter 46 Community Noise Control, sets permissible noise levels in order to provide for the prevention, control, and abatement of noise pollution in the State. The regulation creates noise districts based on land use that dictate acceptable noise levels. The study area is located in a conservation/open space within the vicinity of residential use. Therefore, the study area is in a Class A zoning district, as defined by HAR 11-46. The maximum permissible sound level in a Class A district is 55 dBA from 7:00am-10:00pm and 45 dBA from 10:00pm-7:00am.

The EPA has identified a range of yearly day-night sound level (DNL) standards that are sufficient to protect public health and welfare from the effects of environmental noise (EPA, 1977). The EPA has established a goal to reduce exterior environmental noise to a DNL not exceeding 65 dBA and a future goal to further reduce exterior environmental noise to a DNL not exceeding 55 dBA. Additionally, the EPA states that these goals are not intended as regulations as it has no authority to regulate noise levels, but rather they are intended to be viewed as levels below which the general population will not be at risk from any of the identified effects of noise.

The U.S. Occupational Safety and Health Administration (OSHA) has established acceptable noise levels for workers. **Table *6*** shows permissible noise levels for varying exposure times.

Table 6: OSHA Permissible Noise Exposures

Duration per day-hours	Sound level dBA slow response
8	90
6	92
4	95
3	97
2	100
1.5	102
1	105
0.5	110
0.25 or less	115

Source: OSHA, 2012

The Noise Control Act of 1972 (42 United States Code [U.S.C.] 4901 to 4918) established a national policy to promote an environment for all Americans free from noise that jeopardizes their health and welfare. To accomplish this, the Act establishes a means for the coordination of Federal research and activities in noise control, authorizes the establishment of Federal noise emissions standards for products distributed in commerce, and provides information to the public respecting the noise emission and noise reduction characteristics of such products (42 U.S.C. 4901). The Act authorizes and directs that Federal agencies, to the fullest extent consistent with their authority under Federal laws administered by them, carry out the programs within their control in such a manner as to further the policy declared in 42 U.S.C. 4901.

Federal workplace standards for protection from hearing loss allow a time-weighted average level of 90 dBA over an 8-hour period, or 85 dBA averaged over a 16-hour period. Noise annoyance is defined by the EPA as any negative subjective reaction on the part of an individual or group (EPA, 1977). For community noise annoyance thresholds, a day-night average of 65 dBA has been established by the United States Department of Housing and Urban Development (HUD) as eligibility for Federally guaranteed home loans. (Federal Interagency Committee on Noise, 1992).

Noise impact analyses often identify facilities such as hospitals, churches, schools, and day care centers specifically as these facilities are relatively more sensitive to increased noise levels. These facilities are designated as sensitive receptors and are specifically used in noise impacts.

The study area is located in residential and open conservation land in the suburban town of Hilo on the Island of Hawaii. The noise environment in Hilo is characteristic of a suburban environment; the setting is dominated by vehicular and residential noise. The proposed project area is not significantly affected by airfield noise. The closest airfield to the proposed project area is Hilo International Airport, which is approximately seven miles northeast of the proposed project area.

4.19 VISUAL AESTHETICS

Visual resources are defined as the natural and manufactured features that comprise the aesthetic qualities of an area. These features form the overall impressions that an observer receives of an area or its landscape character. Landforms, water surfaces, vegetation, and manufactured features are considered characteristic of an area if they are inherent to the structure and function of a landscape.

The County of Hawaiʻi General Plan includes the goal to "protect scenic vistas and view planes from becoming obstructed" (County of Hawaiʻi, 2014). The plan states that important views within the South Hilo District include views of Mauna Koa, Mauna Loa, Hilo Bay, coastal areas, and waterfalls.

The study area is moderately urbanized, including residential and public lands. Relatively undeveloped and agricultural lands are found in the upper elevations of the study area with increasing development towards Hilo Bay. The visual aesthetics of these areas is typical of suburban and pastoral environments.

4.20 RECREATION

Recreation is comprised of terrestrial- and water-based activities associated with the local population or visitors to the island. Recreation may consist of aquatic activities such as swimming, windsurfing, surfing, fishing, jet skiing, kayaking, snorkeling, scuba diving, and water skiing. Terrestrial recreational activities may consist of hiking trails, biking trails, parks, golf courses, and ball fields.

There are eight neighborhood parks located within the study area, as well as 17 gymnasiums. The Ho'olulu Complex is the major regional recreational center and consists of 56 acres. There is an auditorium with a seating capacity of 2,800 that is used for pageants, private fundraising, musical entertainment, and sports events. The Panaewa Recreation Complex is located on a 173-acre parcel in South Hilo. The complex includes the Rainforest Zoo and the Equestrian Center, consisting of a race track, rodeo arena, and other equestrian facilities.

There are eight developed beaches in Hilo. These beaches include the Hilo Bayfront Beach, Mokuola (Coconut Island), Reed's Bay, Onekahakaha Beach Park, Leleiwi Beach Park, James Kealoha Beach Park, Carlsmith, and Richardson Ocean Park Beaches. In addition, Lihikai (Onekahakaha) has a small sand beach with shallow water and is especially good for children.

Hilo has two general use oceanfront parks: Liliuokalani and Bayfront-Mooheau Park. In addition, Honolii Beach Park (used primarily by surfers) and Kolekole Gulch Park at Wailea (used mainly for picnicking and camping with limited swimming in the stream) are also located in the South Hilo District.

Near the mouth of the Wailoa River is the State's Wailoa River State Recreation Area. The recreation area includes a pond maintained as a public fishing area. In addition, the park provides areas for picnicking, walking, and quiet relaxation. Further, the large pavilions at Wailoa River State Recreation Area are frequently used for community meetings and banquets. An 18-hole municipal golf course is located in the Waiakea Homesteads area. Other non-public recreational facilities occur in the study area such as baseball and softball fields.

5 FUTURE WITHOUT PROJECT CONDITION

The environmental consequences chapter describes the probable effects or impacts of implementing any of the action alternatives (the Future with Project condition or FWP). Effects can be either beneficial or adverse, and are considered over a 50-year period of analysis (2023-2073).

Environmental impacts will be assessed according to state environmental regulations (Hawaii Revised Statues Chapter 343 – Environmental Impact Statements and Hawaii Administrative Rules 11-200 – Environmental Impact Statement Rules), as well as federal guidelines (NEPA). Descriptions of the assessment criteria under both state and federal guidelines are presented below.

5.1 STATE ENVIRONMENTAL GUIDELINES

A "significant effect" is defined by HRS Chapter 343 as "the sum of effects on the quality of the environment, including actions that irrevocably commit a natural resource, curtail the range of beneficial uses of the environment, are contrary to the State's environmental policies or long-term environmental goals as established by law, or adversely affect the economic welfare, social welfare, or cultural practices of the community and State."

5.2 FEDERAL ENVIRONMENTAL GUIDELINES

The CEQ regulations (40 CFR 1508.7 and 1508.8) define the impacts that must be addressed and considered by Federal agencies in satisfying the requirements of the NEPA process, which includes direct, indirect and cumulative impacts.

Direct are caused by the action and occur at the same time and place. Indirect Impacts are caused by the action and are later in time or farther removed in distance, but are still reasonably foreseeable. Indirect impacts may include growth inducing impacts and other impacts related to induced changes in the pattern of land use, population density or growth rate, and related effects on air, water and other natural systems, including ecosystems.

Impacts include ecological (such as the effects on natural resources and on the components, structures, and functioning of affected ecosystems), aesthetic, historical, cultural, economic, social, or health, whether direct, indirect, or cumulative. Impacts may also include those resulting from actions which may have both beneficial and detrimental effects, even if on balance the agency believes that the effect will be beneficial (40 CFR 1508.8).

According to the CEQ regulations (40 CFR 1500-1508), the determination of a significant impact is a function of both context and intensity. This means that the significance of an action must be analyzed in several contexts such as society as a whole (human, national), the affected region, the affected interests, and the locality. Significance varies with the setting of the Proposed Action. For instance, in the case of a site-specific action, significance would usually depend upon the effects in the locale rather than in the world as a whole. Both short- and long-term effects are relevant.

Intensity refers to the severity of impact. Responsible officials must bear in mind that more than one agency may make decisions about partial aspects of a major action. The following should be considered in evaluating intensity:

1. Impacts that may be both beneficial and adverse. A significant impact may exist even if the Federal agency believes that on balance the effect will be beneficial.

2. The degree to which the Proposed Action affects public health or safety.
3. Unique characteristics of the geographic area such as proximity to historic or cultural resources, park lands, prime farmlands, wetlands, wild and scenic rivers, or ecologically critical areas.
4. The degree to which the effects on the quality of the human environment are likely to be highly controversial.
5. The degree to which the possible effects on the human environment are highly uncertain or involve unique or unknown risks.
6. The degree to which the action may establish a precedent for future actions with significant effects or represents a decision in principle about a future consideration.
7. Whether the action is related to other actions with individually insignificant but cumulatively significant impacts. Significance exists if it is reasonable to anticipate a cumulatively significant impact on the environment. Significance cannot be avoided by terming an action temporary or by breaking it down into small component parts.
8. The degree to which the action may adversely affect districts, sites, highways, structures, or objects listed in or eligible for listing in the National Register of Historic Places or may cause loss or destruction of significant scientific, cultural, or historical resources.
9. The degree to which the action may adversely affect an endangered or threatened species or its habitat that has been determined to be critical under the Endangered Species Act of 1973.
10. Whether the action threatens a violation of Federal, State, or local law or requirements imposed for the protection of the environment (40 CFR 1508.27).

To determine significance, the severity of the impact must be examined in terms of the type, quality and sensitivity of the resource involved; the location of the proposed project; the duration of the effect (short or long-term) and other consideration of context. Significance of the impact will vary with the setting of the Proposed Action and the surrounding area (including residential, industrial, commercial, and natural sites).

The No Action Alternative and three action alternatives, as described in the Plan Formulation section of the study's IFR/EA were considered in analyzing impacts from the implementation of any FRM measures:

1. No Action Alternative
2. Kupulau Ditch/Floodwall with Detention (Kupulau)
3. Hilo Municipal Golf Course with Detention (Golf Course)
4. Combination of the Alternatives 2, and 3 (Combination)

The future without project condition (FWOP), also known as the "No Action Alternative", is the most likely condition expected to occur in the future in the absence of the proposed action or action alternatives. As with the Future with Project Conditions, the impacts to resources are projected over a 50-year window, or the designed life of the proposed project. Therefore, the FWOP conditions project changes that would occur until the year 2072. For the study area, the No Action Alternative means that no FRM measures will be implemented in the future, and urbanization and development will continue at its present rate.

5.3 LAND USE

Under the FWOP conditions, land use is expected to continue to shift from pastoral land uses to urban development as the Hilo population continues to increase. The resulting expansion of residential, commercial, and industrial land uses will result in an increase of impervious cover, exasperating the intensity and frequency of flood events.

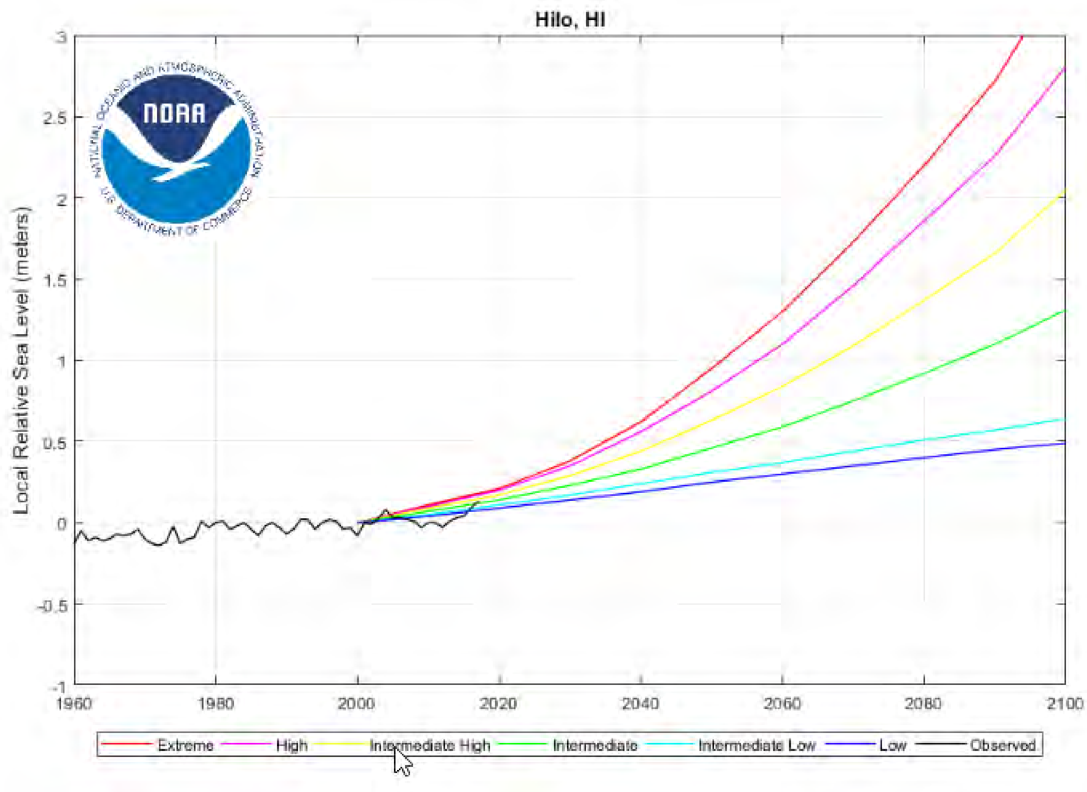
5.4 CLIMATE

Projected climate change caused by man-made increases in greenhouse gases will result in changes under the FWOP condition. Scientific research indicates that the Global Mean Sea Level has been increasing since the 1990s, which has seen a sea level rise (SLR) rate of approximately 0.14 inches per year or roughly twice the rate seen in the past 100 years. Rise in sea levels is linked to several climate-related factors, all induced by the ongoing global climate change including water thermal expansion, and melting of glaciers and ice sheets.

Relative sea level rise (RSLR) for Hilo were calculated using methods described by Sweet et al. (2017) and presented on the NOAA (National Oceanic and Atmospheric Administration) Sea Level Trend mapper (NOAAa, 2019). RSLR for Hilo is expected to increase 0.3 to 0.7 feet by 2030, 0.6 to 1.4 feet by 2050, and 1.6 to 4.6 feet in 2100 (Kopp et al., 2014; NOAAb, 2019)(**Figure *5***). Sea level rise not only results in the inundation of coastal areas and infrastructure, but can also exacerbate the encroachment of saline groundwater into freshwater aquifers. Climate change is predicted to influence weather patterns leading to an increase in periods of drought, higher temperatures and evaporation rates for soil and water bodies, and more intense storms and weather events. For the FWOP conditions, these factors will lead to an increased intensity of flood events within the study area.

Figure 5: Annual Mean Relative Sea Level Trends for Hilo, Hawaii

Station 1617760 (Source – NOAAb, 2019)



5.5 WATER RESOURCES

Under the FWOP conditions, water resources would be predominantly affected by climate change as increased drought, evaporation, and intensity of storm events would alter streams, ponds, and coastal bays and estuaries.

5.5.1 HYDROLOGY AND HYDRAULICS

Because the streams in the study area are intermittent, the FWOP conditions will trend towards less frequent flows in the streams and a higher probability of the streams flooding due to the increase in extreme storm events. The flooding rates will be exacerbated due to a projected increase in impervious cover as the urban landscape shifts from pastoral to an increase in residential, commercial, and industrial development. This increase in impervious cover of the watershed will increase storm water runoff into the streams and magnify intensity of the flooding.

5.5.2 FLOODPLAINS

Similar to the FWOP conditions for the streams, climate change will affect the 0.1 ACE floodplain as the higher intensity storm events will flood a larger footprint. Although the floodplains associated with the streams are restricted to relatively narrow corridors along the water courses, the increased flooding intensity will expand these floodplains and increase the sheet flow flooding in adjacent areas.

5.5.3 WETLANDS

No wetlands associated with Waiakea Stream, Palai Stream, and Four Mile Creek were identified; therefore, the FWOP for wetlands within the study area would not differ from the existing conditions.

5.5.4 SURFACE WATERS

In absence of the proposed project, the surface waters within the study area would not be affected by detention or diversion of the stream courses. However, as addressed in **Section 4.5.1** (Hydrology and Hydraulics) above, climate change will affect surface waters as increased storm intensities and extended droughts will alter the duration and flows of the streams.

5.5.5 GROUNDWATER

The freshwater aquifers within the study area would be infiltrated by saline groundwater as RSLR increases in the FWOP condition. The infiltration would result in a shallower freshwater lens in which to draw irrigation and drinking water. Deeper wells may no longer be viable as the saline ground water rises.

5.6 COASTAL ZONE MANAGEMENT RESOURCES

Under the FWOP, the FRM project would not be constructed and impacts to coastal zone management resources would continue to be affected by ongoing urban development.

5.7 AIR QUALITY

The study area is located in an attainment area for all NAAQS (EPA, 2019a). As laws have been implemented restricting the emissions of criteria pollutants and there is an increase in clean power initiatives, future air quality in the FWOP scenario is projected to improve or remain unchanged under the FWOP.

5.8 WATER QUALITY

Water quality changes under the FWOP are difficult to predict. HSDOH has not established TMDLs for the Waiakea Stream; however, the agency is required to set the limits according to the CWA. The establishment of the TMDLs is the first step in addressing the water quality of the streams. The water quality impairments associated with Waiakea Stream are the result of agricultural practices within the watershed. As the urbanization of the watershed extends into neighboring agricultural lands converting the land to residential and other urban land uses, the contribution of the criteria pollutants identified for the stream should decrease. However, an increase in the application of lawn and garden fertilizers and an increase in runoff from residential areas could result in a conversion of non-point sources resulting in no change, or possibly a decrease, in water quality. If the City of Hilo initiates best management practices to address the future TMDLs, the water quality of Waiakea Stream could improve under the FWOP conditions.

5.9 GEOLOGIC RESOURCES

Volcanism is the primary driver of change in the geologic resources of the study area. Due to the unpredictability of volcanic eruptions, it is impossible to predict whether the study area would be impacted by volcanic activity in the next 50 years. The FWOP condition is projected to remain unchanged with a slight probability that a lava flow resulting from the eruption of Mauna Loa could reach the coastline as it did in 1859, 1868, 1887, 1919, 1926, and three times in 1950.

5.10 SOILS

As urban development continues in the watershed, prime farmland and hydric soils will be lost. The act of annexing adjacent farmland in and of itself is a loss of prime farmland, even if farming practices continue on the annexed land. The FWOP condition for the spatial extent of prime farmland soils is expected to decrease over the next 50 years.

5.11 FISH AND WILDLIFE

Under the FWOP, impacts to fish and wildlife resources would not occur without the proposed alternatives. Effects of climate change on ecosystems are difficult to predict, due to both uncertainty in climate change scenarios (direction and magnitude of temperature and precipitation) and uncertainty in understanding how species will respond to those changes. These changes may increase the likelihood of species warranting conservation and protection.

As land use changes in the future, it is reasonable to expect that shifts in the distribution of fish and wildlife communities may occur to seek habitat which meets their life requisites. However, such range shifts are only feasible with adequate habitat, an ability to disperse and colonize, availability of food resources, and absence of physical barrier which might preclude movement. Displaced species may be subject to increased predation, be susceptible to disease, or be maladapted to their new habitat.

5.12 SOCIOECONOMICS

Under the FWOP conditions, existing conditions would remain and there would be no changes to the health risks for children or changes in the minority/low income populations.

5.13 HAZARDOUS, TOXIC, AND RADIOACTIVE WASTE

The HTRW conditions in the alternative study area will most likely stay the same in the FWOP condition. The alternative study area has been essentially built out and no new HTRW sources are expected to be introduced into the area.

5.14 NOISE

Under the FWOP conditions, existing conditions would remain and there would be no changes to the noise levels within the study area.

5.15 VISUAL AESTHETICS

Under the FWOP condition, no FRM features would be constructed; therefore no changes to the visual aesthetic would occur.

5.16 RECREATION

Under the FWOP conditions, the proposed action would not occur and access to recreational resources would remain unchanged.

6 ENVIRONMENTAL CONSEQUENCES

When considering impacts, it was assumed that, at a minimum, best management practices (BMPs) identified throughout this chapter would apply during project construction. Assumed BMPs are based on widely accepted industry, state, and federal standards for construction activities. Examples include, but are not limited to:

- Use of silt fencing to limit soil migration and water quality degradation
- Refueling and maintenance of vehicles and equipment in designated areas to prevent accidental spills and potential contamination of water sources and the surrounding soils; and,
- Limiting idling of vehicles and equipment to reduce emissions

The environmental consequences for the proposed alternatives are described below. The consequences of the "No Action" Alternative were presented in the Future without Project Conditions chapter (**Chapter 4**).

6.1 LAND USE

Although the proposed alternatives may temporally affect the use of the proposed project areas, there would be no changes in the land use of these areas. For instance, the detention area for the Golf Course, Kupulau, and Combination Alternatives would result in temporary inundation of the golf course and a baseball field located in the Kupulau project area. Although recreation activities would be impacted during flood events, these impacts would be temporary.

6.2 CLIMATE

Under each of the action alternatives, construction activities would generate greenhouse gas (GHG) emissions as a result of the combustion of fossil fuels while operating on- and off-road mobile sources. After construction is complete, all project related construction GHG emissions would cease and the area would return to baseline conditions. There are no apparent carbon sequestration impacts that would result from the implementation, thus the total direct and indirect impacts would be constrained to very small increases in GHG emissions to the atmosphere from the construction activities. These small increases would be far below the 25,000 metric ton per year threshold for discussion of GHG impacts (CEQ, 2014). In the years in which construction activities are implemented, emissions would incrementally contribute to global emissions, but would not be of such magnitude as to make any direct correlation with climate change.

6.3 WATER RESOURCES

The four action alternatives are all designed to alter the timing and magnitude of flows downstream of the project areas. The detention areas associated with the Golf Course, Kupulau, and Combination Alternatives would capture floodwaters from higher intensity flood events and mediate the flows of the water downstream. The stream impacts associated with alternatives would result in the extension of time when the intermittent streams would support flow as waters are released over a longer period of time from the detention basins. Because the stream bed of the creeks consist of lava bedrock, no adverse impacts due to erosion resulting from the higher flow velocity is anticipated. In addition, the increased inundation times for the streams would not affect the waterbodies as the form and function of the stream would remain unchanged.

6.3.1 FLOODPLAINS

The action alternatives would not adversely impact the floodplains within the project area. The alternatives are designed to reduce flood risk for the Hilo community; thereby decreasing the extent of the 1-percent floodplain. As much of the floodplain has been converted to urban uses, the environmental floodplain functions are already limited. Therefore, it is anticipated that adverse impacts to ecological floodplain functions would be minimal.

6.3.2 WETLANDS

There are no wetlands in the project areas for the final array of alternative; therefore, no impacts to wetland resources would occur from the implementation of the project.

6.3.3 SURFACE WATERS

For each of the alternatives, intermittent stream flow could be slightly altered if natural flow is interrupted during construction activities. However, construction activities would be planned to maintain a natural stream channel during the construction period. BMPs employed during construction (e.g. silt fencing, tarping/covering exposed and stockpiled soil, surface revegetation, etc.) would minimize impacts from storm water flow in the construction site and associated degradation of water quality. Each of the final array of alternatives would be completed in accordance with State and Federal regulations, including Section 404(b)(1) of the CWA.

Kupulau and Golf Course Alternatives: A four-foot diameter culvert would connect the Kupulau Detention Basin to Waiakea Stream. The construction of the culvert would impact less than a tenth of an acre of the Stream, a water of the U.S. The construction of the detention basin at the Hilo Golf Course would require the construction of a +/- 6.4-foot levee across Palai stream, ensuring normal flows would continue with the placement of two 6-foot diameter culverts. The construction of the levee would also result in the placement of fill material within less than a tenth of an acre of the Palai Streambed. Therefore, the impacts to Waters of the U.S. would be minimal and no compensatory mitigation would be required.

Under the Kupulau and Golf Course Alternatives, the storm water flows from the streams and the Kupulau Ditch would be captured by the floodwalls and levees and temporarily detained in the resulting detention basin. The detention basin would mediate stormwater flows into the Waiakea and Palai Streams, reducing flooding elevations downstream. The detention of the stormwaters would result in prolonged flows into the downstream portions of Waiakea and Palai Creeks as the basin drains after the rain event. However, the temporal increase of released flows would not be considered a significant impact on the stream resources.

Combination Alternative: The Combination Alternative would have the cumulative stream impact identified for each individual alternative listed above. The Combination Alternative would have a temporal impact on surface water resources; however, the cumulative impact of the project on the stream would not be considered significant.

6.3.4 GROUNDWATER

Because the estimated depth to groundwater is greater than 100 feet below the surface and the shallow depth of grading required to construct the alternatives, groundwater is not anticipated to be encountered. Under the FWP conditions for the final array of alternatives, there would be no anticipated impacts to groundwater.

6.4 WATER QUALITY

Construction activities associated with each of the action alternatives could temporarily affect water quality resulting from grading and excavation. BMPs employed during construction (e.g., silt fencing, tarping/covering exposed and stockpiled soils, surface revegetation, etc.) would minimize/eliminate storm water flow from the proposed construction site, and any associated degradation of water quality.

The Proposed Action would be completed in accordance with State and Federal regulations, including Section 404 (b)(1) of the CWA, which would further minimize any impacts to water quality in Waiakea Stream and Hilo Bay.

6.5 AIR QUALITY

Each of the alternatives would have relatively similar impacts to air quality. Ground disturbance could generate fugitive dust (e.g., PM) and use of construction equipment and personal vehicles to access the project area could lead to temporary increases in vehicular airborne pollutant concentrations.

These impacts would be temporary, and applicable BMPs, including silt fence and watering stockpiled soil, would be implemented. To reduce vehicle and equipment emissions, idling of vehicles and equipment would be minimized to the extent practicable and equipment would be maintained.

The CEQ requires a quantitative assessment of GHG emissions for activities that result in more than 25,000 tons of CO_2-equivalent per year. The final array of alternatives would contribute less than 25,000 tons of CO_2 into the atmosphere. With the possible exception of maintenance vehicles, each of the final array of alternatives is passive, with no further contribution of GHG.

6.6 GEOLOGIC RESOURCES

The proposed project would result in excavation of soils to a relatively shallow depth. No impacts on geologic resources are anticipated.

6.7 SOILS

The soils in the Golf Course alternative consist of Palaewa-Urban Land Complex soils. The Kupulau Alternative is located on Palaewa very cobbly hydrous loam. Neither of these soil types are prime farmland soils; therefore, the project alternatives would have no impact on prime farmland soils. No coordination with the NRCS is required.

6.8 FISH AND WILDLIFE RESOURCES

6.8.1 VEGETATION

Kupulau: The Kupulau Ditch Detention would include the construction of a series of three levees and one floodwall to create a detention basin to control floodwaters. The levees and floodwall would result in the conversion of approximately six acres of grassland and riparian vegetation into FRM features. Although the detention basin would be comprised of another six acres of maintained land associated with the baseball field, the frequency of flooding events and the short length of time the detention basin would be inundated is unlikely to result in adverse impacts to vegetation in the basin. The proposed alternative would not have any substantial adverse impacts to vegetation within the project area.

Golf Course: The golf course levee would convert approximately two acres of maintained golf course vegetation to FRM features. Approximately seven acres of the golf course would be temporarily inundated in the resulting detention basin. As with the alternative above, the flood frequency and detention time is unlikely to impact vegetation on the golf course. The proposed alternative would not have any substantial adverse impacts on vegetation within the project area.

Combination: The Combination Alternative would have the cumulative impact on vegetation of each of the previous alternatives. However, the cumulative impact on vegetation within the project area is not substantial.

6.8.2 AQUATIC RESOURCES

The final array of alternatives all occur within the intermittent portions of the Waiakea and Palai Streams. The FRM features of each of the alternatives would be designed to manage the higher flows associated with storm events, but also be designed to maintain lower flows associated with more frequent rainfall events. The levees and detention basins would not result in creating barriers for aquatic organisms immigrating/emigrating from downstream habitats to the upstream habitats. Minor short term adverse impacts to aquatic organisms may result during construction as significant rain events may displace soil from the construction site and increase turbidity in the streams. However, BMPs such as silt fence and temporary vegetation would minimize the water quality impacts to the aquatic biota. The effect of the FRM projects on aquatic resources may be of minor benefit to aquatic resources as the extended flows associated with the detention basins would prolong the time the streams flow allowing additional time for species to migrate to and from the higher reaches of the streams. No long-term adverse impacts to aquatic resources are expected.

6.8.3 TERRESTRIAL RESOURCES

Implementation of any of the final array of alternatives would have temporary, localized adverse impacts during construction, with some loss of less mobile species within the footprint of the levees. Mobile resident wildlife species would be temporarily displaced into adjacent habitats until construction activities were completed, with a minor loss of habitat associated with the approximately ten acres associated with the levee footprints. The maintained nature of these habitats associated with the levee footprints (baseball field, golf course, and maintained pasture) are not considered high quality habitats; therefore, there would be no substantial adverse impacts to terrestrial species resulting from the implementation of any of the alternatives.

6.8.4 THREATENED AND ENDANGERED SPECIES

A letter from USFWS dated 16 July 2008 in response to a request for an official threatened and endangered species list for the study area identified three species that may occur in the project area: the Hawaiian hoary bat, Hawaiian Hawk, and the Hawaiian Coot. No critical habitat for these, or any other endangered species, are located within the project areas.

There is a chance that Hawaiian hoary bats could utilize native and non-native woody plant species on the study area. However, most woody vegetation is located on the fringes of the project areas and would not be permanently impacted by the construction of the levees and floodwalls. The removal of woody vegetation would be limited to the extent practicable to minimize impacts to bat habitat. To eliminate impacts to bat roosting habitat, any woody vegetation that would need to be trimmed or removed would be would be done between August and April to avoid the birthing and pup rearing season for the bats. If the clearing of woody vegetation occurs between April and August, trees in the project area would be surveyed to determine the presence of hoary bats. If bats are observed, construction activities would cease until the USFWS has been consulted. The implementation of any of the final array of alternatives may affect, but is not likely to adversely affect the Hawaiian hoary bat.

Hawaiian hawks utilize grassland and forest habitats for foraging using trees to nest and perch while hunting. There is a chance that Hawaiian hawks could utilize native and non-native woody plant species on the study area. However, most woody vegetation is located on the fringes of the project areas and would not be permanently impacted by the construction of the levees and floodwalls. The removal of woody vegetation would be limited to the extent practicable to minimize impacts to the hawk habitat. The clearing of woody vegetation would occur between September and March to avoid the nesting season of the hawks. Should clearing of vegetation occur between March and September, nest surveys for the hawks will be conducted to ensure project activities do not affect breeding and nesting activities. During the nesting season, if an active nest is observed, construction activities would cease and the USFWS will be consulted. The implementation of any of the final array of alternatives may affect but is not likely to adversely affect the Hawaiian Hawk.

The Hawaiian Coot utilizes the wetland habitats surrounding Waiakea Pond in Hilo. Although the streams terminate into Waiakea Pond, the mediated flows would not substantially affect the wetland habitats of the pond. The implementation of any of the alternatives would allow base stream flows to continue downstream and would lessen the impacts of high velocity floodwaters entering the pond. Because the Hawaiian Coot habitat is located outside of the project areas and there would be no adverse indirect impacts to the coot’s habitat, the project alternatives may affect but is not likely to adversely affect the Hawaiian Coot.

6.9 SPECIAL STATUS SPECIES

6.9.1 MIGRATORY BIRDS

Bird surveys conducted in 2010 identified 16 avian species utilizing the project area (USACE, 2010a). With the exception of the Pacific Golden-plover, all bird species were not native to Hawaiʻi and not subject to the MBTA. The Pacific Golden-plover winters on the Hawaiian Islands and migrates to Alaska to breed. During the winter, foraging habitat for the plovers consists of areas where the vegetation cover is short and sparse. Due to the lack of breeding and foraging habitat within the project areas, no substantial impacts to the Pacific Golden-plover are anticipated. Similarly, the low quality habitat of the project area decreases the likelihood of other native bird species to utilize the habitat for nesting or foraging.

6.9.2 MARINE MAMMALS

Alternatives included in the final array include FRM measures approximately three miles from Hilo Bay. The stream length from the project areas to Hilo Bay more than three miles as the stream meanders increase the distance the stream travels. Because the FRM measures incorporated in the final array of alternatives would not substantially affect the quantity of environmental flows and would not increase sediment loading into the Bay, no substantial adverse impacts to marine mammals is anticipated.

6.9.3 ESSENTIAL FISH HABITAT

Similar to the marine mammal conditions described above, EFH resources would not be impacted by environmental flows and sedimentation into the Bay. The NMFS was invited to participate in a site visit to the study area on 27 February 2019, but did not participate citing the lack of potential impacts the study would have on EFH resources. As discussed in the Aquatic Resources Chapter (**6.8.2**), the extended inundation of the streams may have a slight benefit for diadromous organisms allowing extended periods of time for the fish to transition between habitats. The study area is located in freshwater tributaries inland of navigable waters and is absent designated EFH. The Recommended Plan would have no effect on designated EFH located downstream of the study area.

6.9.4 COASTAL ZONE MANAGEMENT

USACE applied for and obtained a Federal Consistency Determination from the State Office of Planning, Coastal Zone Management Office on September 14, 2020 (Attachment 3). The State CZM Office concurred that the proposed alternatives are compatible, consistent, and not conflict with any of the objectives of the CZM program and would not adversely impact coastal recreation opportunities, impede economic uses, increase coastal hazards, or conflict with development within the coastal zone. All conditions of the State's Federal Consistency Determination will be implemented in the design and construction phase to ensure consistency with the State CZM program.

6.10 CULTURAL RESOURCES

There are no known culturally significant traditional properties or resources in the study area. In addition, the area does not support any cultural practices. Therefore, the Recommended Plan would not impact any of these resources. Appendix C includes additional information regarding Cultural Resources coordination.

6.11 SOCIOECONOMICS

Kupulau Alternative: Based on the U.S. Census data and field observations, the implementation of the Kupulau Alternative would not have a disproportionate adverse impact on specific racial, ethnic, or socioeconomic group living in the vicinity of the project area and would not adversely impact environmental justice populations.

Children would be expected to concentrate at the New Hope Church and the adjacent baseball field. Measures would be incorporated to ensure the safety of children in the project area such as exclusion fencing, signage, and securing construction equipment. With these mitigative measures in place, the alternative would not have substantial adverse impacts on the local population of children.

Golf Course Alternative: Based on the U.S. Census data and field observations, the implementation of the Golf Course Alternative would not have a disproportionate adverse impact on specific racial, ethnic, or socioeconomic group living in the vicinity of the project area and would not adversely impact environmental justice populations.

The Golf Course Alternative would be implemented within an access controlled facility. In addition, children on the golf course would need to be accompanied by an adult; therefore there would be no adverse impacts to children as it relates to EO 13045 as long as the mitigative measures identified for the Kupulau Alternative in the text above are implemented.

Combination Alternative: The Combination Alternative would have the cumulative impact of the three alternatives described above. None of the project areas of the previous three alternatives have a disproportionate impact on racial, ethnic, or low income populations and the cumulative impacts are no different. With the appropriate mitigation measures in place, the Combination Alternative would not have an adverse impact on the safety and welfare of children.

6.12 HAZARDOUS, TOXIC, AND RADIOACTIVE WASTE

In the short-term, the Proposed Action may generate solid waste from the clearing of vegetation and unused construction materials in the proposed project area. During construction of the Proposed Action, the contractor would be responsible for such solid waste disposal. In the long-term, the Proposed Action would require infrequent solid waste disposal of cleared debris, in accordance with applicable regulations. Overall, implementation of the Proposed Action is expected to have a less than significant impact on solid waste generation in the affected environment for the foreseeable future.

During construction of the Proposed Action, there may be the potential of petroleum and petroleum-related products spillage associated with construction vehicles and equipment. To minimize this hazard, all applicable County of Hawaii Spill and Prevention Control BMPs would be implemented to ensure that accidental releases are minimized and contained. For example, vehicles and equipment would be regularly inspected for leaks and performance and maintained accordingly to prevent spills from occurring. Any potentially hazardous materials required for the project or any resultant hazardous waste will be managed and disposed of in compliance with all applicable state and federal regulations, including RCRA. In the long term, the potential for petroleum spillage exists from maintenance vehicles. Again, all applicable County of Hawaii Spill and Prevention Control BMPs would be implemented. Implementation of the Proposed Action is expected to have less than significant solid waste generation in the affected environment for the foreseeable future.

6.13 NOISE

For each of the alternatives in the final array, short-term noise impacts from construction activities may occur. A Noise Impact Assessment Report was conducted for the project in December 2008 to identify current conditions and to analyze potential impacts from construction work associated with the flood control project (Y. Ebisu & Associates, 2008). The baseline noise levels of the area are consistent with a suburban environment; ambient noise levels were recorded to be between 40 and 58 dBA. It was determined that adverse impacts from construction noise were not expected to be significant due to the temporary nature of the work as well as administrative controls.

The sensitive receptors closest in proximity to the proposed project area are residences, church, and golf course located in the immediate vicinity of the flood management features. Construction-related noise would be generated from equipment and vehicles. However, noise exposure from construction activities would not be continuous at any one location throughout the entire construction process and BMPs would be implemented to reduce or eliminate noise. Buffer zones between construction activities and sensitive receptors would be created, and construction work would be limited to the hours between 7:30am and 3:30pm on weekdays. In addition, sound barriers, mufflers, and other structures would be erected to reduce noise levels if they exceed Federal and State standards. Heavy truck and equipment staging areas would be located as far from noise sensitive properties as possible. As a result, short-term impacts from construction activities would be less than significant to the surrounding environment.

Upon completion, the Proposed Action would not be a source of any significant long-term noise generation. The only indirect noise generated from the Proposed Action in the long-term would be from maintenance vehicles infrequently clearing accumulated debris after significant flood events. However, the noise type and levels would be consistent with those already present in the Hilo suburban environment. Therefore, long-term noise impacts are expected to be less than significant.

6.14 VISUAL AESTHETICS

For each of the final array of alternatives, the visual aesthetic impacts would be temporary during the construction of the FRM features. However, the study area is moderately urbanized and the equipment would be isolated within the project area and staging areas. No equipment would be placed within park, beach, or scenic vista areas. Therefore, the temporary visual aesthetic impacts of each alternative would not be substantial.

Once construction of the FRM structures for any of the alternatives is completed, changes in the landscape would result from the installation of levees and floodwalls. The maximum levee height for any of the alternatives is 10 feet above grade and the Kupulau floodwall would be 5 feet above grade.

The proposed FRM features would blend in with the maintained grassland landscape and would not adversely contrast the aesthetic of the surrounding visual environment. The proposed alternatives would also be compatible with the County's General Plan as the FRM features would not obstruct the views of the volcanos, bays, or other significant visual resources. Therefore, none of the final array of alternatives would adversely affect the aesthetic environment.

6.15 RECREATION

Kupulau Alternative: During the construction of the Kupulau Alternative, construction activities and the operation of heavy machinery would temporarily close the baseball field located to the north of the New Hope Church. After construction, the baseball field would be returned to preconstruction conditions and the field would be located within the floodwater retention basin. Periodically, the ball field would be impacted as floodwaters filled the detention basin, limiting access to the fields. As water is retained and the ground saturated, there may be a delay in resuming the use of the ball field. However, due to the flashiness of Waiakea Stream, the ball field would not be inundated a significant amount of time, so these impacts would not be considered a substantial adverse impact.

Golf Course Alternative: The Golf Course Alternative entails the construction of a levees and detention basin on the Hilo Municipal Golf Course. During construction, golfing opportunities would be restricted during construction. Similar to the Kupulau Alternative above, golfing opportunities would be limited during periods of flooding when the detention basin was inundated; however, the basin is anticipated to drain relatively quickly. The constructed levee would be designed in cooperation with the County to ensure that the levee is integrated with the golf course features. Therefore, the Golf Course Alternative would not have substantial impacts on recreational resources.

Combination Alternative: The Combination Alternative would have the cumulative recreation resource impacts of the Kupulau and Golf Course Alternatives. The cumulative recreational impacts would not have a substantial impact on recreational resources in the project area.

7 CUMULATIVE IMPACTS

This section presents the cumulative impacts of the Recommended Plan. NEPA regulations require that cumulative impacts of the proposed action be assessed and disclosed in an Environmental Impact Statement (EIS) or EA. CEQ regulations define a cumulative impact as "the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably future actions regardless of what agency (federal or non-federal) or person undertakes such other actions." Cumulative impacts can result from individually minor, but collectively significant actions taking place over a period of time.

NEPA guidance (40 CFR 2508.25) identifies resources that would be considered in a cumulative impacts analysis that should be evaluated in an EIS or EA. For an action to have a cumulative action on a resource, the action must have a direct or indirect effect on that resource, unless that resource is in declining or in a significantly impaired condition. Even though a direct or indirect impact on a resource may not be significant, the cumulative impact of the project on that resource in combination with other past, present, and future projects outside of the federal action may be cumulatively significant. Therefore, an analysis must be conducted to assess the contribution of any significant direct or indirect impacts to the overall cumulative trends in resource health.

From a review of the likely environmental impacts analyzed in **Chapter 5** (Future without Project Conditions) and this chapter (Environmental Consequences), USACE determined that there would be minimal direct or indirect impacts to the human and natural environment and no resources of significant decline were identified within the project areas. Therefore, according to CEQ guidance, no cumulative impacts analysis is required.

8 ENVIRONMENTAL COMPLIANCE

Federal projects must comply with Federal and State environmental laws, regulations, policies, rules, and guidance. The IFR/EA is compliant with NEPA, HRS 343, and ER 200-1-1 (Environmental Quality: Policy and Procedures for Implementing NEPA, 33 CFR 230). Significant coordination with local, state, and federal resource agencies has occurred from the beginning of the feasibility study. In implementing the Recommended Plan, USACE would follow provisions of all applicable laws, regulations, and policies related to the proposed actions. The status of compliance with environmental laws is presented below (**Table *7***). The following sections present summaries of federal environmental laws, regulations, and coordination requirements to this study.

Table 7: Environmental Compliance Status of the Waiakea-Palai Stream FRM Study

Policies	Compliance Status	Notes
	Public Laws	
Abandoned Shipwrecks Act of 1988, as amended	Not Applicable	
Archeological and Historic Preservation Act of 1974, as amended	In Progress	**Section 7.1.3, Attachment *4***
Bald and Golden Eagle Protection Act of 1940, as amended	Not Applicable	
Clean Air Act of 1970, as amended	Compliant	**Section 7.1.2**
Clean Water Act of 1972	Compliant/In Progress	**Section 7.1.1 Attachment 2**

Coastal Barrier Resources Act of 1982, as amended	Not Applicable	
Coastal Zone Management Act of 1972, as amended	Compliant	**Section 5.9.4, Attachment *3***
Endangered Species Act of 1973, as amended	Compliant	**Section 7.1.4, Attachment *1***
Farmland Protection Policy Act of 1981	Compliant	**Section 5.7**
Fish and Wildlife Coordination Act of 1934, as amended	Compliant	**Attachment *5***
Magnuson-Stevens Fisheries Conservation and Management Act of 1976, as amended	Compliant	**Section 5.9.3**
Marine Mammal Protection Act of 1972, as amended	Compliant	**Section 5.9.2**
Marine Protection, Research, and Sanctuaries Act of 1972, as amended	Not Applicable	
Migratory Bird Treaty Act of 1918, as amended	Compliant	**Section 7.1.8**
National Environmental Policy Act of 1970, as amended	In Progress	
National Historic Preservation Act of 1966, as amended	In Progress	**Section 7.1.3**, **Attachment *4***
Native American Graves Protection and Repatriation Act of 1990	Not Applicable	**Section 7.1.3, Attachment *4***
Rivers and Harbors Act of 1899, as amended	Not Applicable	
Wild and Scenic Rivers Act, as amended	Not Applicable	
	Executive Orders	
Environmental Justice (E.O. 12898)	Compliant	**Section 7.1.9**
Flood Plain Management (E.O. 11988)	Compliant	**Section 7.1.7**
Protection of Wetlands (E.O. 11990)	Compliant	**Section 5.3.2**
Protection of Children from Environmental Health Risks (E.O. 13045)	Compliant	**Section 7.1.10**
Invasive Species (E.O. 13112)	Compliant	**Section 7.1.6**
Migratory Birds (E.O. 13186)	Compliant	**Section 7.1.8**

8.1 ENVIRONMENTAL COMPLIANCE DISCUSSION

The following sections present summaries of federal environmental laws, regulations, and coordination requirements to this study.

8.1.1 CLEAN WATER ACT

8.1.1.1 SECTION 404

USACE, under the direction of Congress, regulates the discharge of dredged and fill materials into waters of the U.S., including wetlands pursuant to Section 404 of the CWA. USACE does not issue itself permits for construction activities affecting waters of the U.S., but must meet the legal requirements of the Act. The Waiakea Stream is the only water of the U.S. subject to CWA jurisdiction within the project area. Based on the feasibility level of design, no discharges of dredged or fill material into the Waiakea Stream is proposed. However, further detail will arise in the design phase regarding construction means and methods that may propose a Section 404 discharge into the Waiakea Stream. If, in the design phase, a Section 404 discharge is proposed, then a Section 404(b)(1) analysis will be conducted for the discharge, when sufficient information regarding the discharge(s) is available and in conjunction with applying for a Water Quality Certification.

8.1.1.2 SECTION 402

Construction activities that disturb upland areas (land above Section 404 jurisdictional waters) are subject to the NPDES requirements of Section 402(p) of the CWA. Within Hawaii, DOH is the permitting authority and administers the federal NPDES program. Construction activities that disturb one or more acres are subject to complying with the NPDES requirements. Operators of construction activities that disturb five or more acres must prepare a Storm Water Pollution Prevention Plan (SWPPP), submit a Notice of Intent to DOH, conduct onsite posting and periodic self-inspection, and follow and maintain the requirements of the SWPPP.

During construction, the operator shall ensure that measures are taken to control erosion, reduce litter and sediment carried offsite (silt fences, hay bales, sediment retention ponds, litter pickup, etc.), promptly clean up accidental spills, utilize BMPs onsite, and stabilize against erosion before completion of the project.

8.1.1.3 SECTION 401

Section 401 of the Clean Water Act requires any applicant for a federal permit, for any discharges into waters of the U.S., obtain from the State a certification that the proposed discharges are consistent with the State water quality standards. USACE has determined, in coordination with the State of Hawaii Department of Health, Clean Water Branch (CWB), that the level of detail regarding the proposed discharges is inadequate to successfully apply for and obtain a Water Quality Certification (WQC) from the State of Hawaii CWB. USACE met with CWB on November 23, 2020 to discuss the feasibility study and propose the Corps' plan to apply for a WQC during the design phase. USACE followed up after the meeting with a letter dated December 8, 2020 to the CWB documenting the meeting and requesting confirmation of the Corps' plan to comply with the CWA during the feasibility and design phases. The CWB issued a letter of confirmation on December 14, 2020 acknowledging coordination with USACE, indicating a preliminary determination of no issue with USACE moving forward into design and concurring upon the Corps' plan to apply for a Section 401 WQC during the design phase when adequate information is available to do so, and prior to construction (Attachment 2). All conditions and avoidance and minimization measures of any WQC issued for this project will be implemented to ensure compliance with the State Water Quality Standards.

8.1.2 CLEAN AIR ACT

Federal agencies are required by this Act to review all air emissions resulting from federally funded projects or permits to insure conformity with the SIPs in non-attainment areas. The Hilo/Wiaakea-Palai Stream area is currently in attainment for all air emissions; therefore, the proposed project would be in compliance with the Clean Air Act.

8.1.3 NATIONAL HISTORIC PRESERVATION ACT OF 1966

Federal agencies are required under Section 106 of the National Historic Preservation Act (NHPA) of 1966, as amended, to "take into account the effects of their undertakings on historic properties" and consider alternatives "to avoid, minimize, or mitigate the undertaking's adverse effects on historic properties" [(36 CFR 800.1(a-c)] in consultation with the State Historic Preservation Officer (SHPO) and appropriate federally recognized Indian Tribes (Tribal Preservation Officers – THPO)[(36 CFR 800.2(c)]. There are other applicable cultural resource laws, rules, and regulations that will inform how investigations and evaluations will proceed throughout the study and implementation phases (e.g., Archeological and Historic Preservation Act of 1974, NEPA, Native American Graves Protection and Repatriation Act, and ER 1105-2-100).

In accordance with Section 106 of the NHPA, USACE consulted with the Hawaii SHPO (there are no recognized Native American tribes in Hawaii) regarding the potential to impact properties from the proposed undertaking (**Attachment *4***). There are no known culturally significant traditional properties or resources in the study area. In addition, the area does not support any cultural practices. Therefore, no further consultation is required.

8.1.4 ENDANGERED SPECIES ACT

In the early planning stages of this study, USACE initiated consultation with the USFWS by letter dated November 1, 2016, requesting concurrence on the USACE determination that the proposed action may affect, but is not likely to adversely affect the Hawaiian hoary bat, Hawaiian Hawk, and the Hawaiian Coot. By letter dated June 8, 2018, the USFWS concurred with the USACE determination and also informed USACE that the project area consists of intermittent streams with exposed bedrock that harbors no permanent aquatic biota and that the surrounding trees lack the height and breadth necessary to support the Hawaiian hawk. USACE sought further technical assistance pursuant to the Fisch and Wildlife Coordination Act from the USFWS and NMFS regarding potential impacts to threatened and endangered species within the project area. Dan Polhemus (USFWS) participated in a site visit to the study area on 27 February 2019; due to the absence of ESA or EFH resources in the proposed action areas under NMFS' jurisdiction, NMFS did not participate in the site visit. No endangered species or their habitats were observed within the project areas and Mr. Polhemus verbally supported the USACE determination that the proposed action may affect but is not likely to adversely affect listed species. The proposed action is in compliance with the ESA.

8.1.5 FARMLAND PROTECTION

8.1.6 FISH AND WILDLIFE COORDINATION ACT

The Fish and Wildlife Coordination Act (FWCA) requires federal agencies that are impounding, diverting, channelizing, controlling, or modifying the waters of any stream or other water body to consult with the USFWS and appropriate state fish and game agency to ensure that wildlife conservation receives equal consideration in the development of such projects. The Corps invited USFWS to a site visit on 27 February 2019 and to inform the USFWS' drafting of a FWCA report to assist the Corps in planning the design for this project. During the site visit, Mr. Polhemus stated that due to the urbanized nature of the project area and the lack of native natural resources, that a full Fish and Wildlife Coordination Act Report would not be required. The USFWS returned to the Corps a FWCA Planning Aid Report dated 18 February 2020 (Attachment 5), recommending implementation of the following standard best management practices (BMPs) designed to avoid and minimize adverse effects to riparian and marine ecosystems located downstream of the project area:

(1) (USACE) should make every effort to develop and implement a plan for conducting all anticipated work involving stream channels during the summer dry season. Work should be ceased and re-scheduled in the event of an out-of-season heavy rainfall;

(2) Avoid conducting construction or subsequent maintenance activities that will lead to mid- and long-term destabilization and exposure of bare sediment along the stream banks or in the stream bed;

(3) No debris, petroleum projects, or deleterious materials or wastes shall be allowed to fall, flow, leach, or otherwise enter any waters of the United States;

(4) All authorized activities shall be done in a manner to confine and isolate the construction activity and to control and minimize any turbidity that may result from in-water work. Silt curtains or other appropriate and effective silt containment devices approved by the USACE shall be used to minimize turbidity and shall be properly maintained throughout the entire period of any in-water work to prevent the discharge of any material to the downstream aquatic habitat. All sediment control devices installed as BMPs (i.e., fabric sandbags, silt curtains/screens, etc.) downstream or makai of the authorized work shall remain in place until the in-water work is completed and will be removed in their entirety and disposed of at an appropriate upland location once the water quality of the affected area has returned to its pre-construction condition;

(5) Return flow or runoff from upland dewatering site(s)/disposal site(s) shall be contained on land and shall not be allowed to discharge and/or re-enter any waters of the United States;

(6) No sidecasting or stockpiling of excavated materials in the aquatic environment is authorized. All excavated materials shall be placed above the ordinary high water mark of any designated waters of the United States, or disposed of in an upland location. The permittee shall demonstrate that there is no reasonable expectation that disposal locations adjacent to high tide lines on the ocean, or in floodplains adjacent to other rivers or streams, would result in the material being eroded into the nearby waterbody by high tides and/or flood events;

(7) Warning signs shall be properly deployed and maintained until the portion of the in-water work is completed and the affected area water quality has returned to its preconstruction condition and turbidity control devices have been removed from the waterway;

(8) Fueling, repair, and other activities with any potential to release pollutants will occur in a location where there is no potential for spills to have an effect on waters of the United States;

(9) When the USACE is notified that an authorized activity is detrimental to fish and wildlife resources, the USACE will issue a suspension order until all pertinent issues have been satisfactorily resolved. The construction contractor shall comply with any USACE-directed remedial measures deemed necessary to mitigate or eliminate the adverse effect.

The USFWS concluded that due to the absence of surface flow in the areas associated with the project footprints, the apparent absence of diadromous aquatic macrofauna in the headwater reaches above the project footprint, and the overwhelmingly non-native composition of the flora and fauna in the areas of suburban Hilo, USFWS does not consider that the Preferred Alternative with implementation of the above standard BMPs will have any significant or deleterious impacts to trust resources. Additionally, USFWS stated that the Planning Aid Report is sufficient to cover the Feasibility Study phase of the current project and as the project progresses to design and eventual construction, USACE should continue to coordinate with USFWS in order to avoid or minimize any potential environmental effects.

The Corps will insert the USFWS standard BMPs into any construction contract as a requirement for any construction contractor to implement and will coordinate any proposed modification to the preferred alternative with the USFWS. By email dated 8 February 2021 to the USFWS, the Corps accepted the FWCA Planning Aid Report in its entirety, including acceptance of the standard BMPs and trigger to reinitiate FWCA consultation..

8.1.7 EXECUTIVE ORDER 13112, INVASIVE SPECIES

EO 13112 recognizes the significant contribution native species make to the well-being of the nation's natural environment and directs federal agencies to take preventative and responsive action to the threat of the invasion of non-native species. The EO establishes that federal agencies "will not authorize, fund, or carry out actions that it believes are likely to cause or promote the introduction or spread of invasive species in the United States or elsewhere unless, pursuant to guidelines that it has prescribed, the agency has determined and made public its determination that the benefits of such actions clearly outweigh the potential harm caused by invasive species; and that all feasible and prudent measures to minimize risk of harm will be taken in conjunction with the actions."

The habitat impacted by the proposed action is dominated with non-native species. Construction activities will implement BMPs to ensure that the spread of the non-native species outside of the project area is avoided/minimized.

8.1.8 EXECUTIVE ORDER 13690, ESTABLISHING A FEDERAL FLOOD RISK MANAGEMENT STANDARD AND A PROCESS FOR FURTHER SOLICITING AND CONSIDERING STAKEHOLDER INPUT; AND AMENDMENT TO EXECUTIVE ORDER 11988, FLOODPLAIN MANAGEMENT

EO 13690 was enacted on January 30, 2015 to amend EO 11988 , enacted May 24, 1977, in furtherance of the NEPA of 1969, as amended (42 U.S.C. 4321 et seq.), the National Flood Insurance Act of 1968, as amended (42 U.S.C. 4001 et seq.), and the Flood Disaster Protection Act of 1973 (Public Law 93-234, 87 Star.975). The purpose of the EO 11988 was to avoid to the extent possible the long and short-term adverse impacts associated with the occupancy and modification of floodplains and to avoid direct or indirect support of floodplain development wherever there is a practicable alternative. The EO 13690 builds on EO 11988 by adding climate change criteria into the analysis.

These orders state that each agency shall provide and shall take action to reduce the risk of flood loss, to minimize the impacts of floods on human safety, health, and welfare, and to restore and preserve the natural and beneficial values served by floodplains in carrying out its responsibilities for (1) acquiring, managing, and disposing of federal lands and facilities; (2) providing federally undertaken, financed, or assisted construction and improvements; and (3) conducting federal activities and programs affecting land use, including but not limited to water and related land resources planning, regulating, and licensing activities. The FEMA Digital Flood Insurance Rate Map (DFIRM) of the study area was analyzed to establish the locations of the 100-year and 500-year flood zones. All alternatives were designed to reduce flood risk to the Hilo community. The proposed action would remain in compliance with EO 11988 and EO 13690.

8.1.9 MIGRATORY BIRD TREATY ACT, MIGRATORY BIRD CONSERVATION ACT, AND EXECUTIVE ORDER 13186, MIGRATORY BIRDS

The importance of migratory non-game birds to the nation is embodied in numerous laws, executive orders, and partnerships. The Migratory Bird Treaty Act demonstrates the federal commitment to conservation of non-game species. Amendments to the Act adopted in 1988 and 1989 direct the Secretary to undertake activities to research and conserve migratory non-game birds. EO 13186 directs federal agencies to promote the conservation of migratory bird populations, including restoring and enhancing habitat. Migratory Non-Game Birds of Management Concern is a list maintained by the USFWS. The list helps fulfill the primary goal of the USFWS to conserve avian diversity in North America. The USFWS Migratory Bird Plan is a draft strategic plan to strengthen and guide the agency's Migratory Bird Program. The proposed action would not adversely affect migratory birds and is in compliance with the applicable laws and policies.

8.1.10 EXECUTIVE ORDER 12898, ENVIRONMENTAL JUSTICE

EO 12898 "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations" dated February 11, 1994, requires all federal agencies to identify and address disproportionately high and adverse effects of its programs, policies, and activities on minority and low-income populations. Data was compiled to assess the potential impacts to minority and low-income populations within the study area. Environmental justice is the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies. Even though minorities account for a large portion of the local population and the low-income population is above the national averages, construction of the proposed alternatives would not have a disproportionately high or adverse effect on these populations.

8.1.11 EXECUTIVE ORDER 13045, PROTECTION OF CHILDREN

The EO 13045 "Protection of Children from Environmental Health Risks" dated April 21, 1997 requires federal agencies to identify and address the potential to generate disproportionately high environmental health and safety risks to children. This EO was prompted by the recognition that children, still undergoing physiological growth and development, are more sensitive to adverse environmental health and safety risks than adults.

Short-term impacts on the protection of children would be expected. Numerous types of construction equipment such as backhoes, bulldozers, dredgers, graders, and dump trucks, and other large construction equipment would be used throughout the duration of the construction of the proposed action. Because construction sites and equipment can be enticing to children, activity could create an increased safety risk. The risk to children would be greatest in construction areas near densely populated neighborhoods. During construction, safety measures would be followed to protect the health and safety of residents as well as construction workers. Barriers and "No Trespassing" signs would be placed around construction sites to deter children from playing in these areas, and construction vehicles and equipment would be secured when not in use. Since the construction area would be flagged or otherwise fenced, issues regarding Protection of Children are not anticipated.

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ATTACHMENTS

Attachment 1: U.S. FISH AND WILDLIFE SERVICE ESA INFORMAL CONSULTATION CORRESPONDENCE

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Pacific Islands Fish and Wildlife Office
300 Ala Moana Boulevard, Room 3-122
Honolulu, Hawaii 96850

In Reply Refer To:
01EPIF00-2008-SL-0264, 0265, 0266
01EPIF00-2017-I-0039

June 8, 2018

Mr. Michael Wyatt
Department of the Army, Honolulu District
U.S. Army Corps of Engineers
Fort Shafter, Hawaii 96858

Subject: Informal Consultation for Waiakea Flood Control Project, Hilo, island of Hawaii

Dear Mr. Wyatt:

The U.S. Fish and Wildlife Service (Service) received your letter dated November 1, 2016, requesting our concurrence with your determination that the Waiakea Flood Control Project for several streams in Hilo, Hawaii may affect, but is not likely to adversely affect the federally endangered Hawaiian hoary bat (*Lasiurus cinereus semotus*), Hawaiian coot (*Fulicia americana alai*), or Hawaiian hawk (*Buteo solitarius*). Our office recently discovered that this request was never addressed and reached out to you to ensure action was still warranted. During a phone call on May 23, 2018, Jodi Charrier (Service) confirmed with Mr. Michael Wyatt (U.S. Army Corps of Engineers [Corps]) that though the project has been on hold for over a year, it will be moving forward shortly and a Section 7 consultation is still needed. We apologize for our delay and appreciate your patience. This response is being provided pursuant to the Endangered Species Act (ESA) of 1973 [16 U.S.C. 1531-1544 *et seq*.], as amended.

Project description
The Corps is proposing to reduce flood risks associated with the Waiakea and Palai Streams located in Hilo, Hawaii. The project entails construction of detention basins and diversion structures and installation of new culverts. There is no concrete lining of streams proposed. Where the detention or diversion structures would cross a stream, stream flow will not be blocked and culverts will allow for stream flow and fish passage. The project site along Waiakea Stream is approximately 4.5 miles upstream from the ocean. The project sites along Palai Stream are approximately 3.25 and 4.5 miles upstream from the ocean. There is potential for sedimentation, turbidity from the construction to be dispersed downstream as it flows towards Hilo Bay. Best management practices to minimize sedimentation, turbidity or contaminants downstream will be implemented.

Biological surveys completed by the Corps in 2010 (*Flora and Fauna Surveys for the Waiakea Flood Control Project in Hilo, Hawaii, AECOS, Inc., March 17, 2010*), found no threatened or endangered species in the project areas.

The conservation measures enumerated below were included in your proposed project description to avoid and minimize impacts to the Hawaiian hoary bat which may occur within the action area of the proposed project. These avoidance and minimization measures are considered part of the project description. Any changes to, modifications of, or failure to implement these avoidance and minimization measures may result in the need to reinitiate this consultation.

Hawaiian hoary bat
No removal or trimming of any woody plant material greater than 15 feet tall will be conducted during the breeding season (June 1 to September 15).

Hawaiian coot
No Hawaiian coots were found during previous surveys and none are expected to be located within action area due to the lack of suitable habitat.

Hawaiian hawk
None found during previous surveys and none expected to be affected within action area due to the lack of suitable habitat.

Rapid Ohia Death
Rapid Ohia Death (ROD), a newly identified disease, has killed large numbers of mature ohia trees (*Metrosideros polymorpha*) in forests and residential areas of Hawaii Island. The disease is caused by a vascular wilt fungus (*Ceratocystis fimbriata*). Crowns of affected trees turn yellowish or brown within days to weeks and dead leaves typically remain on branches for some time. All ages of ohia trees can be affected and can have symptoms of browning of branches or leaves. As of early 2015 the disease was confined to Hilo and the Puna district on Hawaii Island, but has since been confirmed in Volcano, South Kona, and Hamakua districts. Additional information on ROD can be found at http://www2.ctahr.hawaii.edu/forestry/downloads/ROD-trifold-03.2016.pdf and http://www2.ctahr.hawaii.edu/forestry/disease/ohia_wilt.html.

The following avoidance and minimization measures will be followed this project:

- A survey of the proposed project site will be conducted within two weeks prior to any tree cutting to determine if there are any infected ohia trees. If infected ohia are suspected at the site, the following agencies will be contacted for further guidance.
    - USFWS – please contact the name at the bottom of this letter
    - Dr. J.B. Friday, University of Hawaii Cooperative Extension Service, 808-969-8254 or jbfriday@hawaii.edu
    - Dr. Flint Hughes, USDA Forest Service, 808-854-2617, fhughes@fs.fed.us
    - Dr. Lisa Keith, USDA Agriculture Research Service, 808-959-4357, Lisa.Keith@ars.usda.gov

- Both prior to cutting ohia and after the project is complete:
  - Tools used for cutting infected ohia trees will be cleaned with a 70 percent rubbing alcohol solution. A freshly prepared 10 percent solution of chlorine bleach and water can be used as long as tools are oiled afterwards, as chlorine bleach will corrode metal tools. Chainsaw blades will be brushed clean, sprayed with cleaning solution, and run briefly to lubricate the chain.
  - Vehicles used off-road in infected forest areas will be thoroughly cleaned. The tires and undercarriage of the vehicle will be cleaned with detergent if they have travelled from an area with ROD or travelled off-road.
  - Shoes and clothing used in infected forests will also be cleaned. Shoes will be decontaminated by dipping the soles in 10 percent bleach or 70 percent rubbing alcohol to kill the ROD Fungus. Other gear can be sprayed with the same cleaning solutions. Clothing can be washed in hot water and detergent.

- Wood of affected ohia trees will not be transported to other areas of Hawaii Island or interisland. All cut wood will be left on-site to avoid spreading the disease. The pathogen may remain viable for over a year in dead wood. The HDOA has passed a new quarantine rule that prohibits interisland movement, except by permit, of all ohia plant or plant parts.

Conclusion

The streams included in your project description are both intermittent bedrock channels that do not harbor any permanent aquatic biota. Therefore, there is not sufficient habitat in the project area to support the Hawaiian coot. The ohia trees that may be removed from the area are too small to be considered nesting habitat for the Hawaiian hawk and your project actions are not expected to adversely affect this species. Based on the inclusion of the above avoidance and minimization measures for the Hawaiian hoary bat and the unlikeliness of the Hawaiian coot or Hawaiian hawk to be nesting or found in the action area, we found the potential effects to these species to be discountable because they are unlikely to occur. Therefore, the Service concurs with your determination that this proposed project may affect, but is not likely to adversely affect these listed species. Unless the project description changes, or new information reveals that the proposed project may affect listed species in a manner or to an extent not considered, or a new species is listed or critical habitat designated that may be affected by the proposed action, no further action pursuant to section 7 of the ESA is necessary.

Thank you for your efforts to conserve listed species and native habitats. Please contact Endangered Species Biologist Jodi Charrier (jodi_charrier@fws.gov or (808)342-6607 if you have any questions or for further guidance.

Sincerely,

MICHELLE BOGARDUS Digitally signed by MICHELLE BOGARDUS Date: 2018.06.08 09:21:02 -10'00'

Michelle Bogardus
Island Team Leader
Maui Nui and Hawaii Island

Attachment 2: STATE DEPARTMENT OF HEALTH, CLEAN WATER BRANCH LETTER OF CONFIRMATION

DAVID Y. IGE
GOVERNOR OF HAWAII

STATE OF HAWAII
DEPARTMENT OF HEALTH
P. O. BOX 3378
HONOLULU, HI 96801-3378

ELIZABETH A. CHAR, M.D.
DIRECTOR OF HEALTH

In reply, please refer to:
EMD/CWB

12014PDCL.20

December 14, 2020

Ms. Jennifer Moore, PMP
Deputy District Engineer for
Programs and Project Management
Department of the Army
U.S. Army Corps of Engineers, Honolulu District
Fort Shafter, Hawaii 96858-5440

Dear Ms. Moore:

Subject: Waiakea and Palai Streams Feasibility Study
November 23, 2020 Coordination Meeting

Reference is made to your letter of December 8, 2020. The Department of Health (DOH), Clean Water Branch (CWB) confirms attending the subject coordination meeting with the U.S. Army Corps of Engineers (USACE), Civil and Public Works Branch.

Pursuant to Clean Water Act (CWA), Section 401 (33 USC § 1341), the USACE must obtain a Section 401 Water Quality Certification (WQC) from the DOH-CWB for the proposed discharge. The DOH-CWB acknowledges that the details of the feasibility level of conceptual design are inadequate to identify and describe the proposed discharges with sufficient detail to apply for and obtain a Section 401 WQC from the DOH-CWB. Although insufficient detail exists at the feasibility stage for USACE to apply and obtain a Section 401 WQC from DOH-CWB, DOH-CWB has no preliminary issues, based on information available at this time, with the USACE moving forward with further designs of this project. We acknowledge that USACE will seek a Section 401 WQC from DOH-CWB when sufficient detail is available. A Section 401 WQC must be obtained prior to construction

If you have any questions, please contact Mr. Darryl Lum of the Engineering Section, CWB, at (808) 586-4309.

Sincerely,

Alec Wong

ALEC WONG, P.E., CHIEF
Clean Water Branch

c: Mr. Jeffrey Herzog, USACE [via e-mail Jeffrey.a.herzog@usace.army.mil only]
Ms. Jessie Paahana, USACE [via e-mail Jessie.K.Paahana@usace.army.mil only]

Attachment 3: COASTAL ZONE MANAGEMENT DETERMINATION

OFFICE OF PLANNING
STATE OF HAWAII

DAVID Y. IGE
GOVERNOR

MARY ALICE EVANS
DIRECTOR
OFFICE OF PLANNING

235 South Beretania Street, 6th Floor, Honolulu, Hawaii 96813
Mailing Address: P.O. Box 2359, Honolulu, Hawaii 96804

Telephone: (808) 587-2846
Fax: (808) 587-2824
Web: http://planning.hawaii.gov/

DTS 202009091053NA

September 14, 2020

Mr. Stephen N. Cayetano, P.E.
Deputy District Engineer for
Programs and Project Management
U.S. Army Corps of Engineers, Honolulu District
Fort Shafter, Hawaii 96858-5440

Attention: Ms. Jessie Paahana, Civil and Public Works Branch

Subject: Hawaii Coastal Zone Management Program Federal Consistency Review of Waiakea-Palai Streams Flood Risk Management Feasibility Study, Hilo, County of Hawaii

The Hawaii Coastal Zone Management (CZM) Program has completed the federal consistency review for the U.S. Army Corps of Engineers Waiakea-Palai Streams Flood Risk Management Feasibility Study, Hilo, County of Hawaii. This federal consistency review covers the proposed activity as it is represented as the "Recommended Plan" in the Final Integrated Feasibility Report and Environmental Assessment (Final FR/EA), May 2020, that was included as supporting information for the consistency determination. We conditionally concur with the Corps' determination that the proposed activity is consistent to the maximum extent practicable with the enforceable policies of the Hawaii CZM Program. The following conditions shall apply to this consistency concurrence:

1. The proposed activity shall be completed as represented in the CZM federal consistency determination. Any changes to the proposal shall be submitted to the Hawaii CZM Program for review and approval. Changes to the proposal may require a full CZM federal consistency review, including publication of a public notice and provision for public review and comment. This condition is necessary to ensure that the proposed activity is carried out as reviewed for consistency with the enforceable policies of the Hawaii CZM Program. Hawaii Revised Statutes (HRS) Chapter 205A Coastal Zone Management, is the federally approved enforceable policy of the Hawaii CZM Program that applies to this condition.

2. The State Department of Land and Natural Resources, Commission on Water Resources Management (CWRM), indicated in a letter (August 24, 2020, enclosed) providing comments to the Hawaii CZM Program, that a "Stream Channel Alteration Permit is required before any alteration can be made to the bed and/or banks of a

stream channel." Therefore, the County of Hawaii Department of Public Works, as the non-federal sponsor for the proposed activity, shall obtain a Stream Channel Alteration Permit, or waiver, from the CWRM, before any alteration can be made to the bed and/or banks of any of the stream channels included in the proposed activity. This condition is necessary to ensure consistency with Hawaii CZM Program federally approved enforceable policies HRS Chapter 174C State Water Code, and Hawaii Administrative Rules (HAR) Chapter 13-169 Protection of Instream Uses of Water.

3. To mitigate potential adverse effects to water quality, the best management practices represented in the Final FR/EA (p. 27), shall be employed during construction (e.g., sediment erosion control barriers such as silt fencing, tarping/covering exposed and stockpiled soils, surface revegetation, etc.) to "minimize/eliminate storm water flow from the proposed construction site and any associated degradation of water quality for proximal surface waters." This condition is necessary to ensure consistency with Hawaii CZM Program federally approved enforceable policy HRS Chapter 205A Coastal Zone Management, Section 205A-2 Coastal Ecosystems.

4. The proposed activity shall be conducted in compliance with State of Hawaii water quality standards as specified in HAR Chapter 11-54 Water Quality Standards. This condition is necessary to ensure consistency with Hawaii CZM Program federally approved enforceable policies HRS Chapter 342D Water Pollution, and HAR Chapter 11-54.

5. The conservation measures that are represented in the Final FR/EA (p. 29) to protect the Hawaiian hoary bat (Lasiurus cinereus semotus), the Hawaiian coot (Fulica americana alai), and the Hawaiian hawk (Buteo solitarius), which are all State of Hawaii listed endangered species, shall be fully implemented. This condition is necessary to ensure consistency with Hawaii CZM Program federally approved enforceable policies HRS Chapter 205A Coastal Zone Management, Section 205A-2 Coastal Ecosystems, HRS, 183D Wildlife, HRS Chapter 195D Conservation of Aquatic Life, Wildlife, and Land Plants, and HAR Chapter 13-124 Indigenous Wildlife, Endangered and Threatened Wildlife, Injurious Wildlife, Introduced Wild Birds, and Introduced Wildlife.

6. To mitigate potential adverse effects to aquatic biota, as represented in the Final FR/EA (p. 31), best management practices such as silt fences and temporary vegetation shall be fully implemented. This condition is necessary to ensure consistency with Hawaii CZM Program federally approved enforceable policies HRS Chapter 205A Coastal Zone Management, Section 205A-2 Coastal Ecosystems, HRS, 183D Wildlife, HRS Chapter 195D Conservation of Aquatic Life, Wildlife, and Land

Plants, and HAR Chapter 13-124 Indigenous Wildlife, Endangered and Threatened Wildlife, Injurious Wildlife, Introduced Wild Birds, and Introduced Wildlife.

If the requirements for conditional concurrences specified in 15 CFR § 930.4(a), (1) through (3), are not met, then all parties shall treat this conditional concurrence letter as an objection pursuant to 15 CFR Part 930, subpart C.

This CZM conditional concurrence does not represent an endorsement of the proposed activity nor does it convey approval with any other regulations administered by any state or county agency. Thank you for your cooperation in complying with the Hawaii CZM Program. If you have any questions, please call John Nakagawa of our CZM Program at 587-2878.

Sincerely,

Mary Alice Evans

Mary Alice Evans
Director

Enclosure (CWRM letter 8/24/20)

cc: County of Hawaii Department of Public Works
County of Hawaii Planning Department (by email)
Commission on Water Resource Management - Dean Uyeno (by email)

Attachment 4: CULTURAL RESOURCES APPENDIX

ARCHAEOLOGICAL INVENTORY SURVEY
FOR THE
WAIĀKEA AND PALAI STREAMS FLOOD CONTROL PROJECT
WAIĀKEA AHUPUA'A, DISTRICT OF SOUTH HILO, HAWAI'I

ARCHAEOLOGICAL INVENTORY SURVEY
FOR THE
WAIĀKEA AND PALAI STREAMS FLOOD CONTROL PROJECT
WAIĀKEA AHUPUAʻA, DISTRICT OF SOUTH HILO, HAWAIʻI

Prepared by:
Rowland B. Reeve, M.A. (Pacific Legacy, Inc.)
and
Paul L. Cleghorn, Ph.D. (Pacific Legacy, Inc.)

Edited by:
Michael Desilets (USACE)

Prepared for:
GSI Pacific
600 Queen Street
Honolulu, HI 96813

27 April 2019

LIST OF ACRONYMS

APE	Area of Potential Effect
AWP	Archaeological Work Plan
CAP	Continuing Authorities Program
CFR	Code of Federal Regulations
CIS	Cultural Impact Study
EA	Environmental Assessment
GIS	Geographic Information System
NEPA	National Environmental Policy Act
NHO	Native Hawaiian Organizations
NHPA	National Historic Preservation Act
OHA	Office of Hawaiian Affairs
PI	Principal Investigator
SHPO	State Historic Preservation Officer
SHPD	State Historic Preservation Division
TCP	Traditional Cultural Property
USACE	U.S. Army Corps of Engineers

MANAGEMENT SUMMARY

Pacific Legacy, Inc., under contract to GSI Pacific, conducted an archaeological inventory survey of the proposed project areas for the Waiākea and Palai Streams Flood Control Project in the *ahupua'a* of Waiākea, district of South Hilo on the island of Hawai'i. The results of the study are intended to assist the U.S. Army Corps of Engineers in the preparation of an Environmental Assessment for the construction of flood control features and in fulfilling their Section 106 responsibilities under the National Historic Preservation Act of 1966, as amended.

Fieldwork for the archaeological investigation of the Waiākea and Palai Streams Flood Control Project was undertaken in July and August of 2015. A comprehensive pedestrian survey was conducted of each project area to ensure that any archaeological features present were located and identified. Systematic transects were walked by the two members of the archaeological field crew spaced between 5 and 10 meters apart, depending upon the density of the vegetation.

Rights of Entry could not be obtained for TMK (3) 2-4-065:036 in the Waiakea Ditch/Kupulau Ditch locale and all of the Ainalako locale (TMK (3) 2-4-030:001 and TMKs (3) 2-4-081:006, :007, and :011). These areas were observed and photographed from adjoining parcels, where possible. Based upon these observations, assessments were made as to the conditions of the properties and the likelihood of the presence or absence of archaeological features. These assessments could not, however, be field checked. As a result, it could not be conclusively determined that these properties did not contain archaeological features.

None of the project areas surveyed contain any surface archaeological features. Given the history of the area, it is likely that much of the area was dragged to remove surface stones prior to it being converted to sugar cane fields in the late 1800s. More recently, individual parcels have undergone additional ground disturbing activities as they have been turned to residential or other uses. Any surface pre-Contact archaeological sites which may have once existed in these project areas appear to have been obliterated by more recent land use.

Studies of the ethno-historic literature indicate that in the late pre-Contact and early historic periods this portion of Waiākea consisted of open grassland with scattered houses and cultivated fields. The evidences of this former land use were most likely destroyed when the land was converted to commercial sugar cane cultivation. Any potential historic properties dating from the plantation period appear to have been removed by more recent land modifications.

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LIST OF FIGURES

Frontispiece: Existing Kupulau Ditch from the New Hope Church property (view south).

1.0 INTRODUCTION

Pacific Legacy, Inc., under contract to GSI Pacific, has prepared the following Archaeological Inventory Survey report for the proposed Waiākea and Palai Streams Flood Control Project in the *ahupua*ʻ*a* of Waiākea, district of South Hilo on the island of Hawaiʻi (Figure 1). This study is intended to assist the U.S. Army Corps of Engineers (USACE) in the preparation of an Environmental Assessment (EA) for the construction of flood control features by identifying any potential historic properties located within the proposed project areas. This work will also support Section 106 consultation under the National Historic Preservation Act of 1966, as amended.

This report delineates the project areas covered by the archaeological survey, provides an overview of the natural, cultural, and historic context of the project areas, outlines the methods employed during the survey, and reports the results of the survey.

1.1 PROJECT BACKGROUND

The project consists of the construction of various flood control features along the courses of Waiākea and Palai Streams located in the district of South Hilo on the windward side of the island of Hawaiʻi. Within the town of Hilo, the Waiākea and Palai Streams are located adjacent to each other and share a hydraulic linkage that connects both streams.

The present flow of floodwaters through the Waiākea and Palai watersheds has resulted in frequent flooding within residential and urban areas. The County of Hawaiʻi, as the project's sponsor, has identified the following problems that need to be addressed:

1. The Waiākea and the Palai Streams are susceptible to flash flooding events. Local storm events can produce flood conditions in a matter of hours.

2. Significant rainfall events result in overland flow of water throughout the watershed, flowing towards the streams. The natural stream channels have limited capacity to transport flood waters. Water overtops the channels and floods downstream areas. This flooding has caused damage to residential properties, as well as to public infrastructure.

The goal of the Waiākea and Palai Streams Flood Control Project is to reduce the risk of flooding and resultant property damage within the drainage, as well as to improve safety.

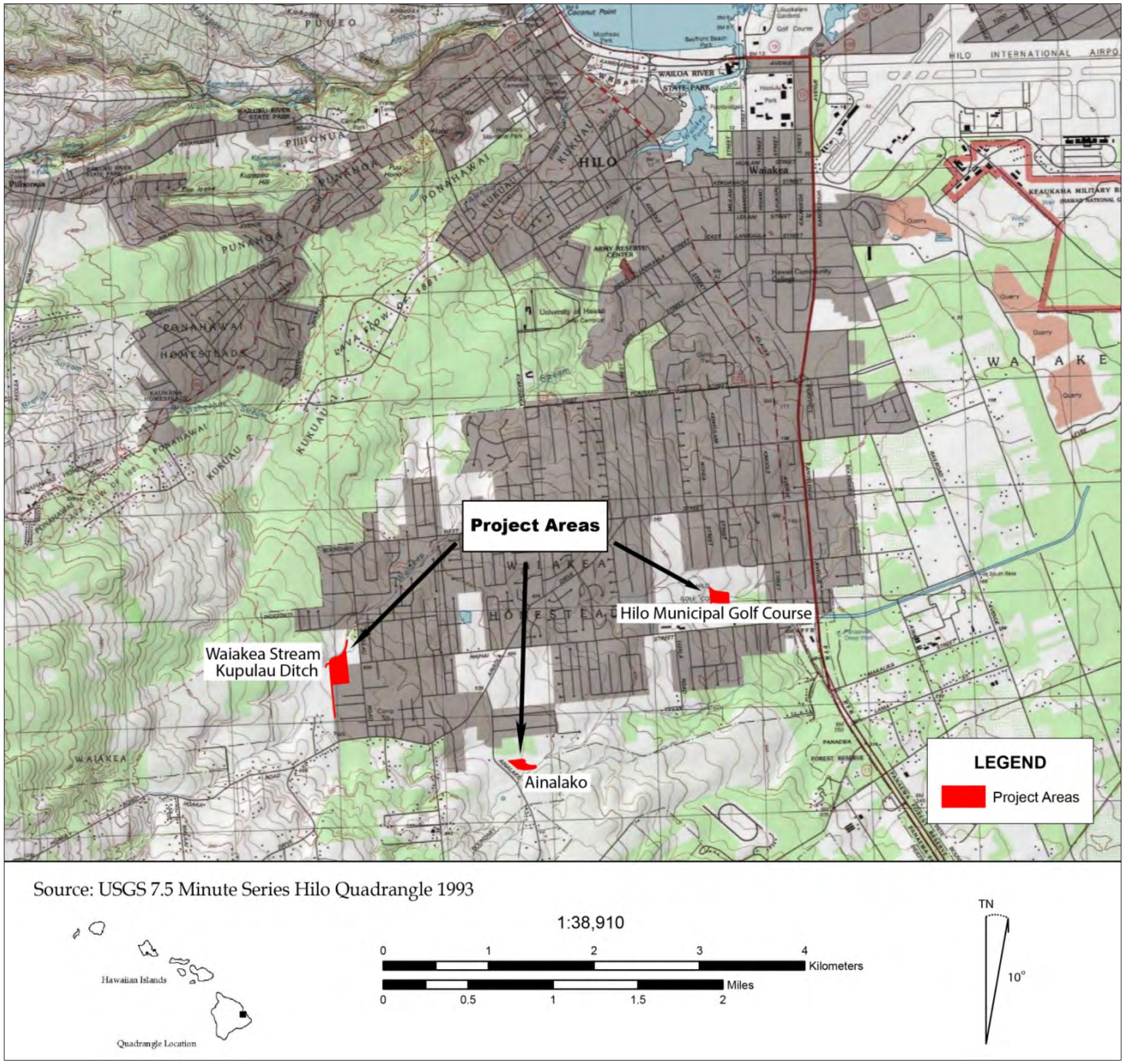

Figure 1. Locations of proposed flood control features (base map USGS Hilo quadrangle).

Previous cultural resource investigations for this project included a Cultural Impact Survey (CIS) study to determine the presence or absence of traditional cultural properties or practices associated with the project area. A CIS report was prepared by Pacific Legacy in 2005 for the Palai Stream segment of the flood control project (Fielder 2005). Although this report specifically addressed the Palai Stream segment of the project, the geographic scope of the archival research undertaken as part of this study, as well as the information obtained from informant interviews, makes its conclusion directly applicable to the current broadened Area of Potential Effect (APE).

1.2 Previous Project Study

The 2005 CIS report was prepared by Pacific Legacy for Wil Chee Planning on behalf of the USACE and covered only the proposed Palai Stream segment (Fielder 2005). The study, authored by Betty A. Fielder, involved a combination of archival research and oral history interviews. The primary aims of the CIS were to:

1. Identify potential Traditional Cultural Properties (TCPs) located within or adjacent to the project area.

2. Identify issues that may be of concern for people conducting traditional activities in the area.

At that time, the Palai Stream Flood Control Project entailed the construction of a flood channel alignment extending east from the Hilo Golf Course:

> The proposed channel alignment would begin at the Hilo Golf Course where the Palai Stream flows would be diverted into an unlined open channel. The unlined open channel configuration will be maintained for 1,400 lineal feet along the perimeter of the Hilo Golf Course until it reaches Haihai Street. Once there, the flow discharge would be conveyed through a 1,000 lineal foot underground box culvert until it reaches the Kanoelehua Avenue Bridge. After that the flows would be combined with other flows in the Waiākea -Uka Flood Control Channel (U.S. Army Engineer District, Honolulu: 2004:1).

The preparation of the 2005 CIS involved the compilation and analysis of ethno-historical data gathered during archival and record searches conducted in the following repositories:

- Hawaiʻi State Archives, Honolulu
- State Historic Preservation Division Library, Kapolei
- University of Hawaiʻi Library at Mānoa
- Bernice Pauahi Bishop Museum Library, Honolulu
- Lyman Museum, Hilo
- Hawaiʻi State Public Library, Honolulu

In addition to this ethno-historic research, a total of 15 oral history interviews were conducted with Hilo residents and other individuals identified by the community as being familiar with the cultural history of the project area. All of the informants interviewed were *kupuna* (elders) who were repeatedly recommended by various sources within the community. They were all active in the Hawaiian community and well respected for their leadership and knowledge of the project area and its history. These knowledgeable individuals provided personal accounts and other information as to the traditional uses of the proposed project area. The list of interviewees, points of contact, and other sources of traditional information were reviewed by the USACE environmental technical staff prior to field research. In addition to face-to-face interviews, several phone interviews were undertaken. The 15 informal interviews were conducted between 17 and 30 January 2005.

In general, the information gathered during these interviews, was consistent with the archival data. The informants confirmed that there were no known Traditional Cultural Properties (TCPs) located within the area of potential affect for the Palai Stream Flood Control Project, and that there were no known traditional cultural practices associated with (or currently being practiced within) the project area. All of the informants shared stories related to the gathering of native plants and other natural resources in the area when it still formed part of the Pana‘ewa Forest, prior to the development of the residential and agricultural lots. This gathering, however, was non site-specific and the activities took place within the forest in general. Among the items known to have been gathered were traditional medicinal plants; *lauhala* (the leaf of the *hala* or Pandanus tree [*Pandanus tectorius*], which were traditionally stripped of their thorns and woven into mats, baskets and other domestic items); *maile* (the native twining shrub *Alyxia oliviformis* whose shiny fragrant leaves were used for decoration and for *lei*); *lehua* (the brilliant red flowers of the *‘ōhi‘a lehua*, an indigenous forest tree [*Metrosideros polymorpha*], and fruits (Fielder 2005:11).

The informants also indicated that there were well worn paths through the Pana‘ewa Forest when it was still undeveloped. Many were used as routes of access for gathering. They generally felt that the paths located within the project area were either cleared or modified into roads during in the development of Hawaiian Home Lands properties (Fielder 2005:11). As with the literature sources, the interviewees believed that the area once supported traditional cultural practices and even settlements. They referred to the numerous fresh water springs and the presence of *ulu* (breadfruit, *Artocarpus altilis*), *kukui* (candlenut, *Aleurites moluccana*), *‘awa* (kava, *Piper methysticum*), *kī* (ti, *Cordyline fruticosa*) and other traditionally utilized flora in the Forest, which are usually associated with habitation (Fielder 2005:11).

The combination of archival research and oral interviews with knowledgeable individuals failed to identify any traditional cultural properties in the vicinity of the project area, nor did this research identify any traditional cultural practices that might be impacted by the proposed project.

1.3 WAIĀKEA AND PALAI FLOOD CONTROL MEASURES

The present Waiākea and Palai Streams Flood Control Project includes a number of different flood control measures including levees, floodwalls, and detention basins. These measures are to be implemented at three dispersed project locales, as shown in Figure 2 below. Each locale and its components are described in the following sections.

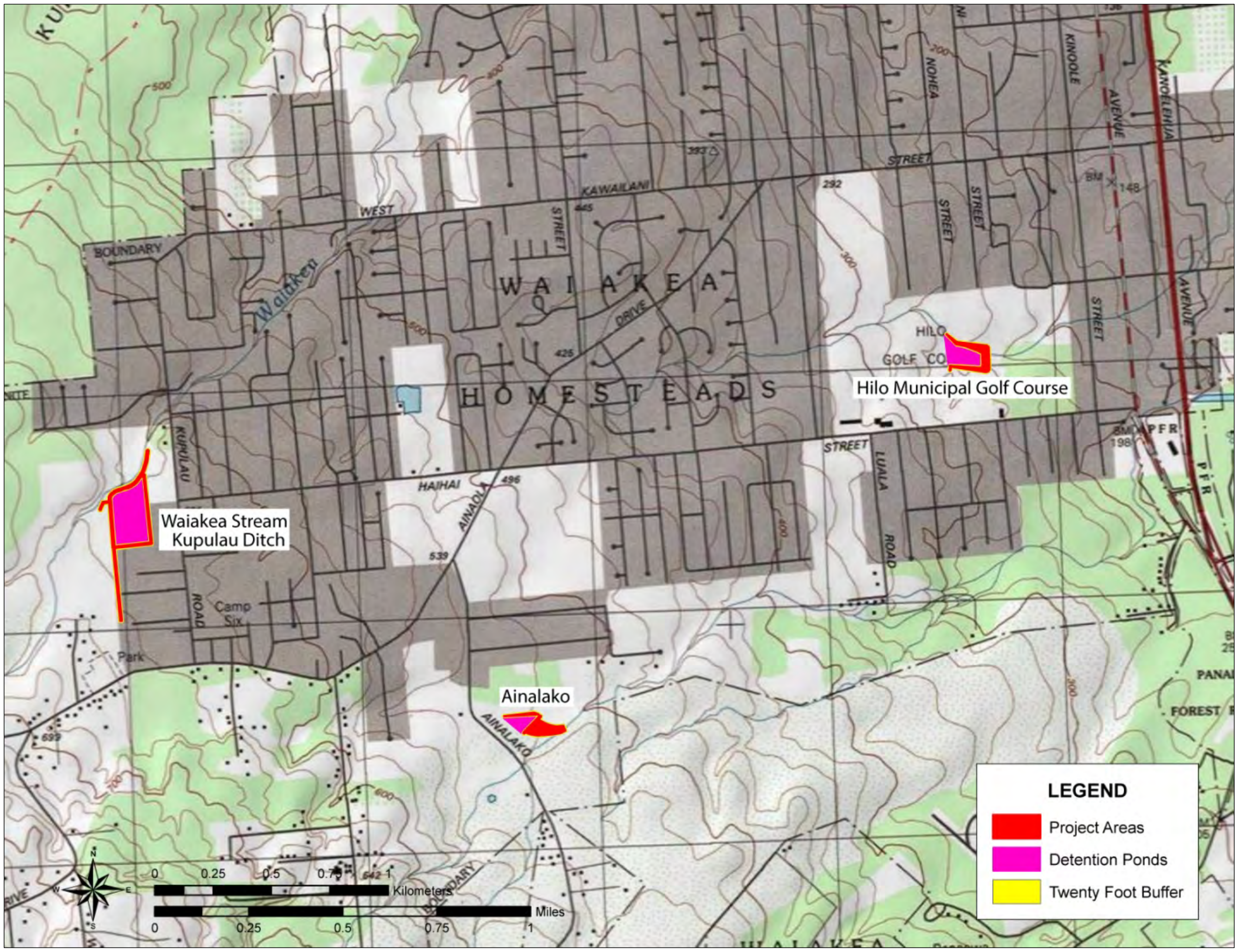

Figure 2. Relative locations of the alternate flood control measures being considered (base map USGS Hilo quadrangle).

1.3.1 Waiakea Stream/Kupulau Ditch

These flood control features will be located along the course of Waiākea Stream and Kupulau Ditch west of Kupulau Road (Figure 3). The components of this alternative will include a levee along the eastern bank of Waiākea Stream, a box culvert at the intersection of Waiākea Stream and Kupulau Ditch, a floodwall along the eastern bank of Kupulau Ditch, a containment levee framing a detention pond east of Waiākea Stream and Kupulau Ditch, as well as a construction access route and a staging area (Figure 4).

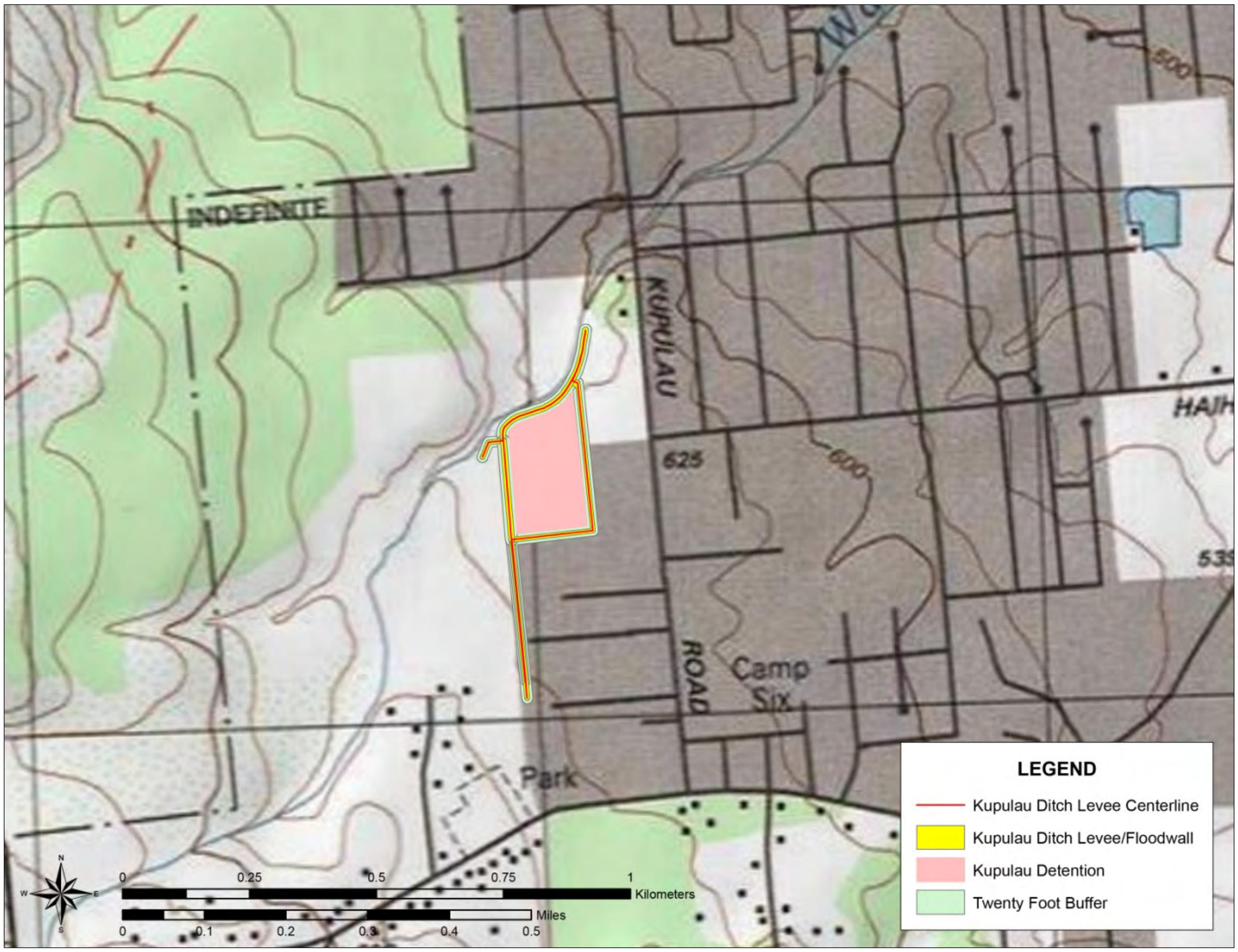

Figure 3. Location of the Waiakea Stream/Kupulau Ditch levee/floodwall and detention features (base USGS Hilo quadrangle).

Figure 4. Components of the Waiakea Stream/Kupulau Ditch locale (aerial base Google earth, 2015).

1.3.2 Hilo Municipal Golf Course

The Hilo Municipal Golf Course flood control features will consist of a detention basin near the center of the Hilo Municipal Golf Course (Figure 5), as well as levees to the north, east, and west framing a central detention basin with an outlet structure to the east designed to release flow to minimize flood damage to downstream property (Figure 6).

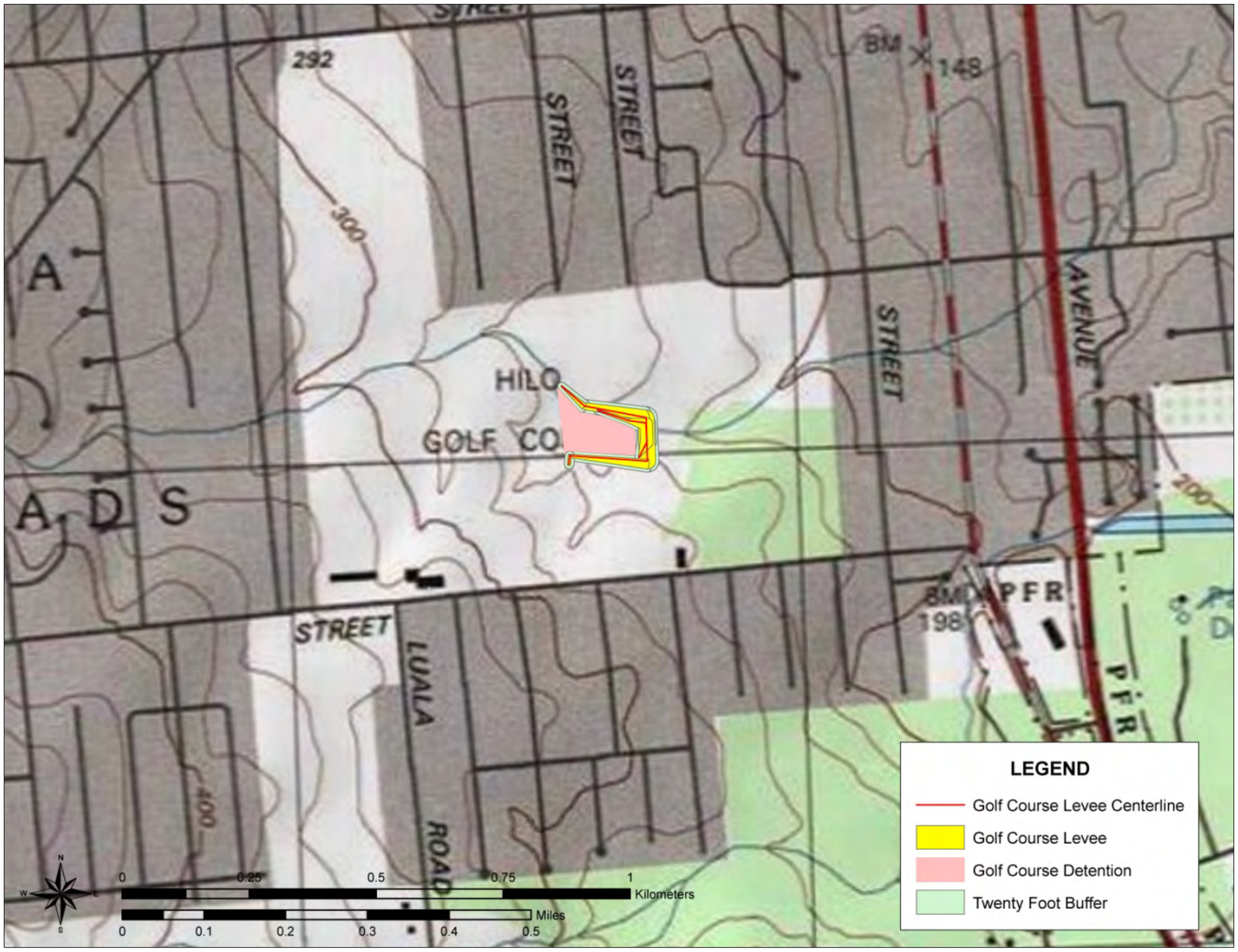

Figure 5. Location of the Hilo Municipal Golf Course detention features (base USGS Hilo quadrangle).

Figure 6. Components of the Hilo Municipal Golf Course locale (aerial base Google earth, 2015).

1.3.3 Ainalako

The Ainalako locale consists of levees and a detention pond along Palai Stream adjacent to and east of Ainalako Street (Figure 7). Its components include levees to the north and southeast framing a central detention basin with grassed swale to the southeast (Figure 6 and Figure 8).

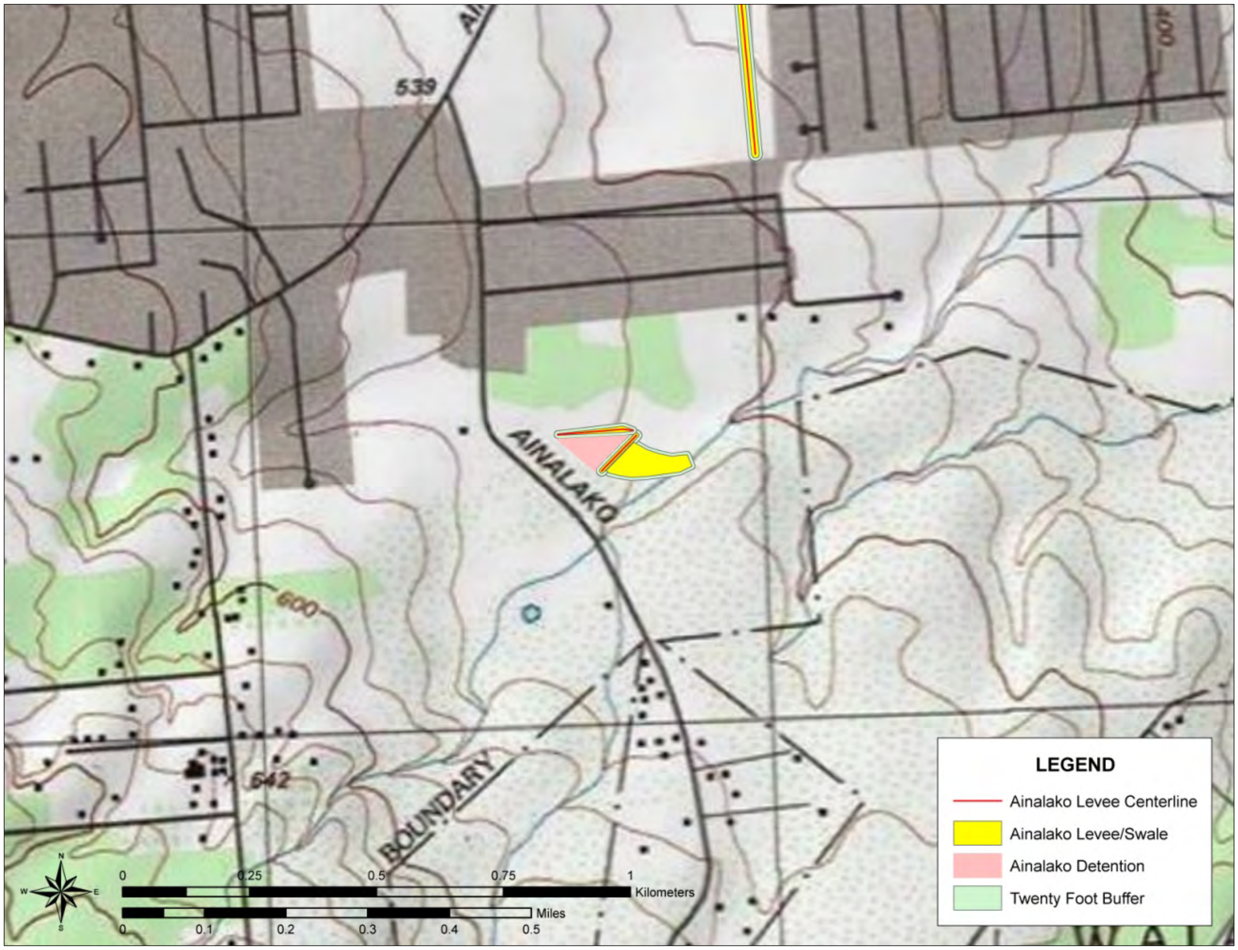

Figure 7. Location of the Ainalako detention features (base USGS Hilo quadrangle).

Figure 8. Components of the Ainalako locale (aerial base Google earth, 2015).

1.4 AREA OF POTENTIAL EFFECT (APE)

Given the locations of the proposed flood control features outlined above, it is possible to identify three distinct APE areas that would potentially be impacted by the implementation of the proposed flood control measures. These three areas, taken together, encompass a total APE of 14.9 acres.

1.4.1 Waiākea Stream and Kupulau Ditch

The APE for the Waiākea Stream and Kupulau Ditch flood control measures includes the eastern bank of Waiākea Stream from just upstream of its intersection with Kupulau Road to just beyond its intersection with Kupulau Ditch (Figure 9). It also includes the eastern bank of Kupulau Ditch from its intersection with Waiākea Stream south for approximately 200 meters. Additional portions of the project area include the baseball field located immediately north of the New Hope Church (a part of TMK (3) 2-4-036:001) and a portion of the property (TMK (3) 2-4-065:036) located between the ball field and the Waiākea Stream, which together encompass approximately 7.5 acres (Figure 10). This area will form the detention basin for the flood control measures. A route of access in from Kupulau Road (a portion of TMK (3) 2-4-036:999) and a construction staging area (part of the New Hope Church property, TMK (3) 2-4-036:001) also form part of the project area APE. The entire APE, with the exception of TMK (3) 2-4-036:999 rests on privately owned land and right-of-entry was required for these properties.

Figure 9. Waiākea Stream and Kupulau Ditch survey area (aerial base Google earth, 2015).

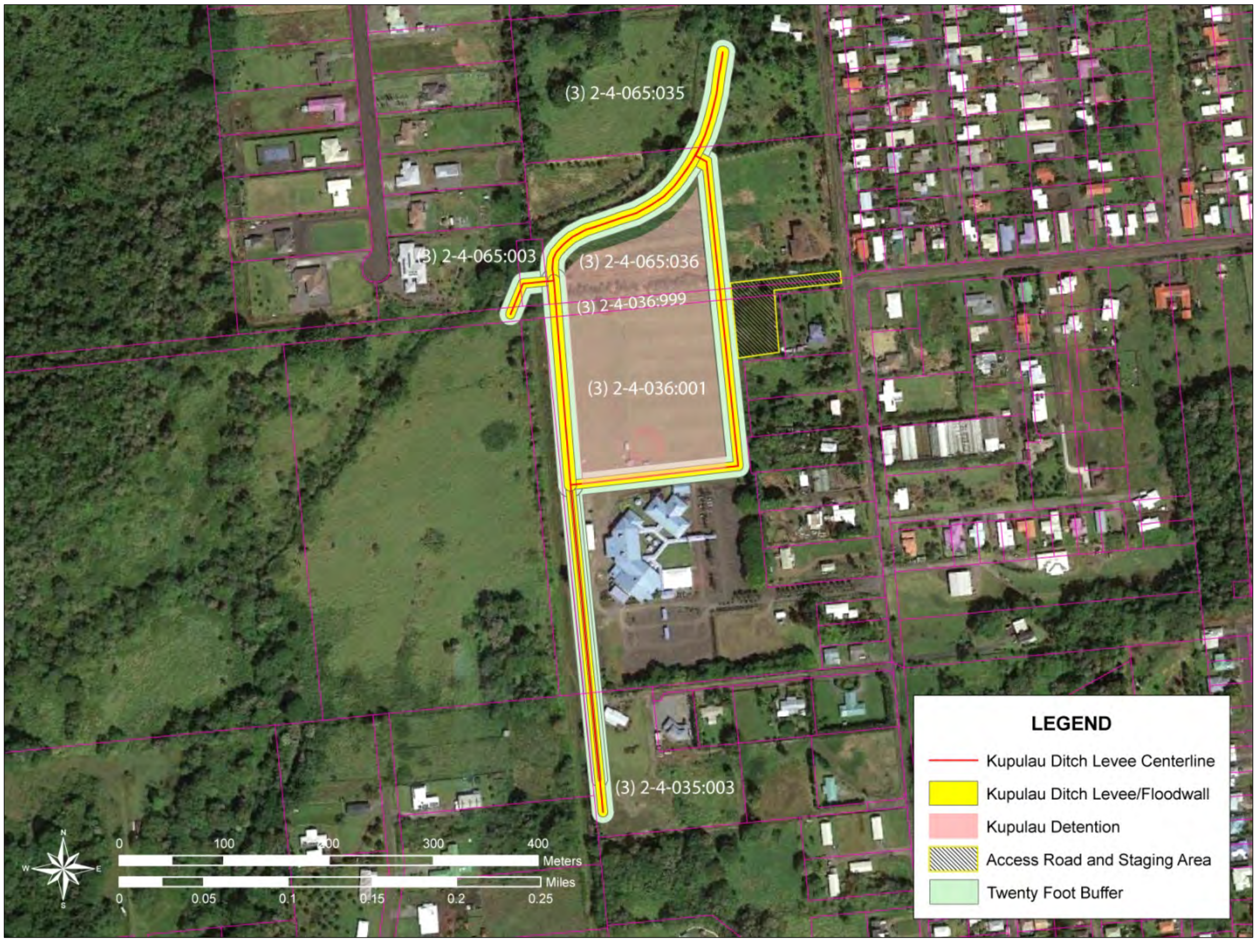

Figure 10. Tax map parcels included within the Waiākea Stream and Kupulau Ditch survey area (aerial base Google earth, 2015).

1.4.2 Hilo Municipal Golf Course Detention

The APE for the Hilo Municipal Golf Course flood control measures includes a roughly U-shaped levee located toward the center of the Hilo Golf Course, as well as the detention basin framed by it (Figure 11). The project area is totally encompassed within the Golf Course property (TMK (3) 2-4-002:001), which rests on State owned land. For this reason, right-of-entry onto private land was not required for this APE. The proposed Hilo Municipal Golf Course project area covers approximately 2.7 acres.

Figure 11. Hilo Municipal Golf Course Detention survey area (aerial base from Google earth, 2015).

1.4.3 Ainalako Detention

The APE for the Ainalako flood control measures includes a pair of adjoining levees, an adjacent constructed swale and a detention basin located within the triangular area framed by the two levees (Figure 12). The entire APE rests on privately owned land and right-of-entry was not obtained for these properties (Figure 13). The proposed Ainalako Detention project area covers approximately 4.7 acres.

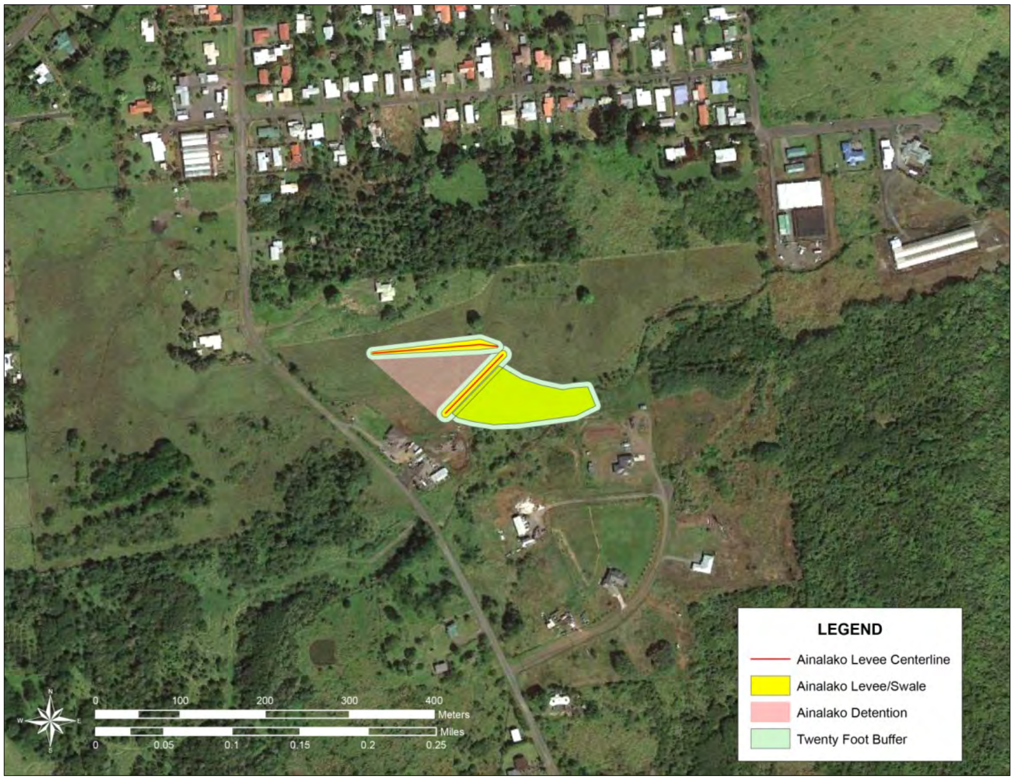

Figure 12. Ainalako Detention survey area (aerial base from Google earth, 2015).

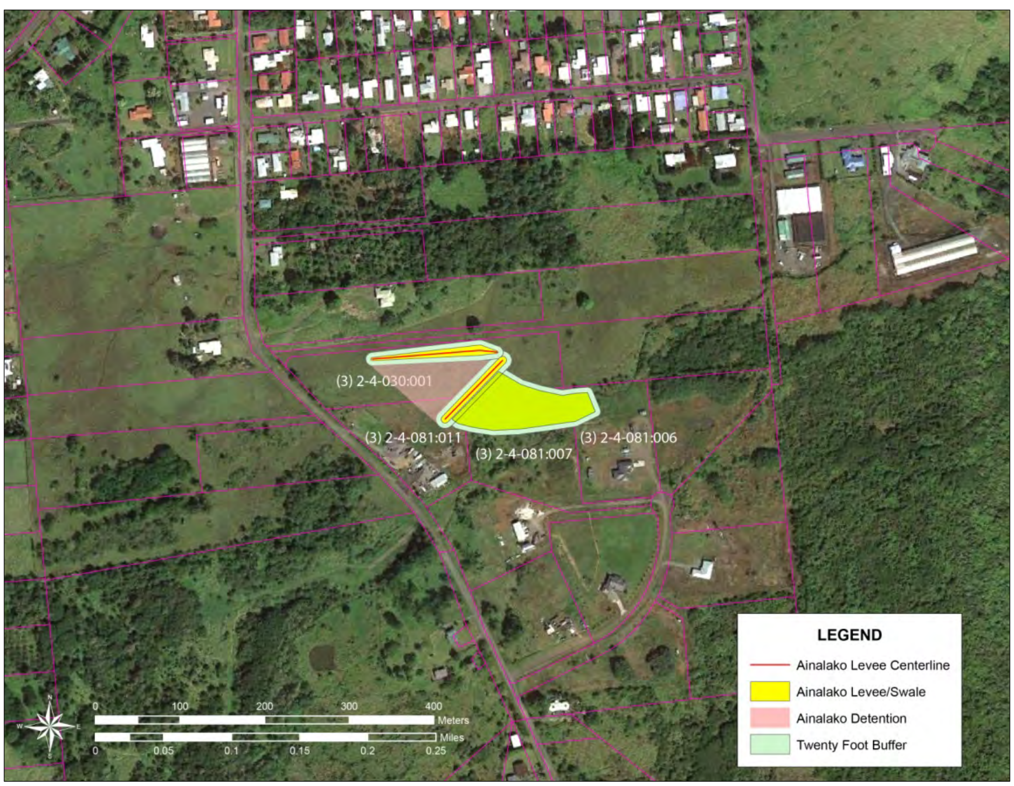

Figure 13. Tax map parcels included within the Ainalako Detention survey area (aerial base Google earth, 2015).

1.5 Rights of Entry

Since a number of the properties included within the three proposed project areas are privately owned, it was necessary to obtain Rights of Entry (ROE) to these parcels before any archaeological fieldwork could be conducted. Rights of Entry for survey and exploration were requested by the Army Corps of Engineers from the various land owners. Not all ROEs were granted. As a result, it was not possible to conduct a systematic ground survey of all parcels.

In the Waiākea Stream and Kupulau Ditch project area, ROE were acquired for all properties except TMK (3) 2-4-065:036 (Figure 10). This property was observed from the adjoining parcels.

The Hilo Municipal Golf Course project area is located on land owned by the State of Hawaiʻi and managed by the County of Hawaiʻi. Access to this survey area was not a problem.

No ROE were obtained for any of the four properties that compose the Ainalako project area (TMK (3) 2-4-030:001, TMK (3) 2-4-081:006, TMK (3) 2-4-081:007 and TMK (3) 2-4-081:011). For this reason, these properties could only be observed from the adjacent roadways.

1.6 Scope of Work

The focus of the current archaeological field survey is to determine whether any potential historic properties are present within the APE of the current project, document any that are discovered, and evaluate them for significance and integrity according to National Register of Historic Places criteria.

The three project locales described in Section 1.4 encompass a combined area of approximately 14.9 acres. Each of these locales, with the above described limitations, was subjected to a systematic pedestrian transect survey for the purpose of discovering and documenting any surface archaeological sites that might be present. In addition, erosional cuts were closely inspected for the presence of subsurface deposits.

2.0 ENVIRONMENTAL SETTING

2.1 PROJECT LOCATION

The current archaeological study covers the areas of potential effect for all of the proposed alternatives (see Section 1.3) of the Waiākea and Palai Streams Flood Control Project. The archaeological field survey covered the APE for the three identified project areas as described Section 1.4. These project areas are located along and adjacent to the course of the Waiākea and Palai Streams within the land division of Waiākea in the district of North Hilo, on the island of Hawaiʻi. All of the project areas are located inland of Hilo Bay along the southern fringe of Hilo Town (Figure 1), between approximately 180 and 640 feet in elevation (Figure 14).

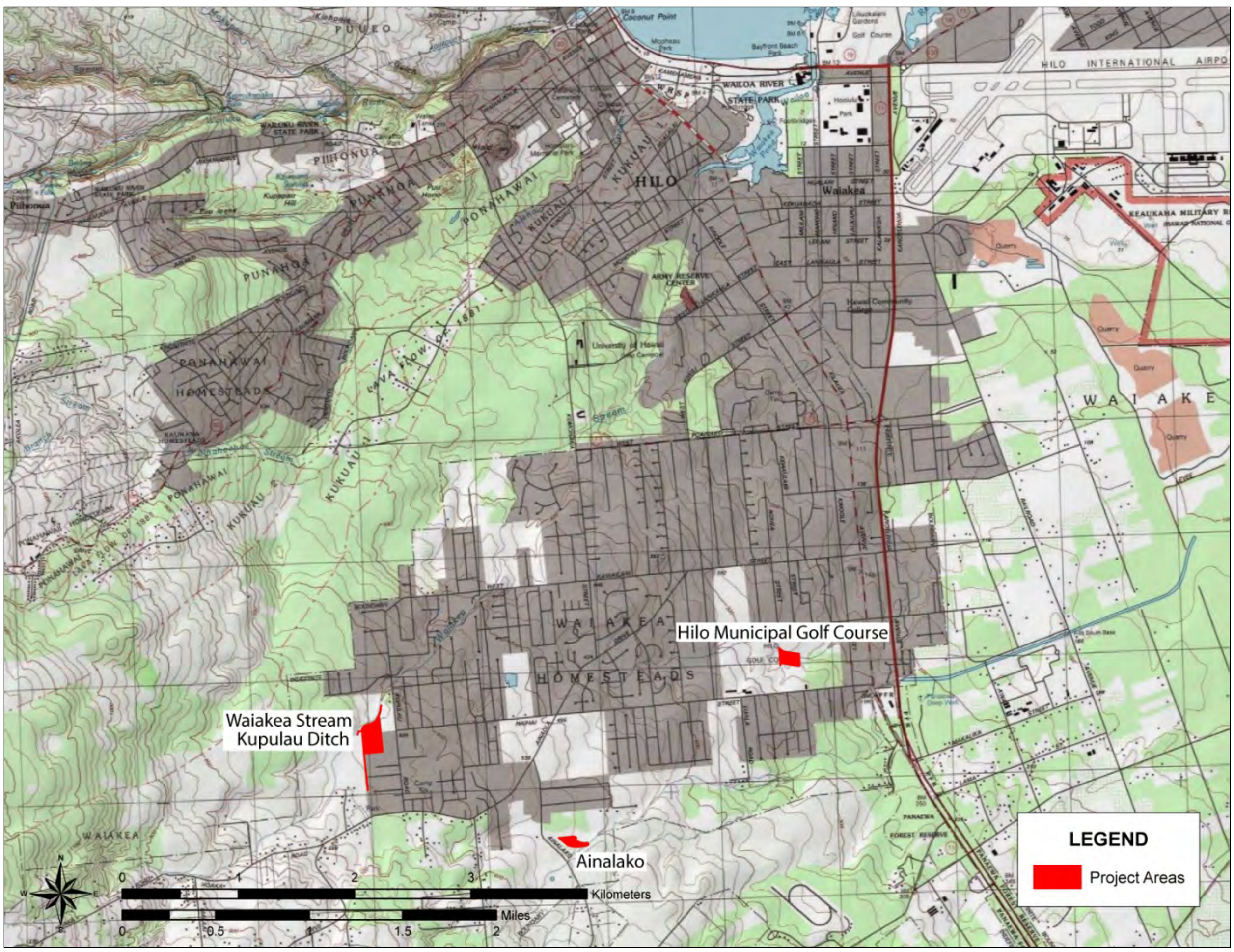

Figure 14. Location of identified project areas (base map USGS Hilo quadrangle).

2.2 THE NATURAL LANDSCAPE

The Waiākea-Palai watershed is located on the eastern flank of the Island of Hawaiʻi. Waiākea and Palai Streams are two of five streams that form the larger Wailoa River system, which flows down from the slopes of Mauna Loa and the adjoining saddle between Mauna Kea and Mauna Loa and feeds into Hilo Bay. The total watershed area for Waiākea and Palai Streams is 43.3 square miles.

Waiākea Stream has a drainage area of about 35.6 square miles. Its basin is linear in shape, approximately 25 miles in length and about 2 miles in width at its widest point. The Waiākea Stream basin originates along the slopes of Mauna Loa volcano (elevation 13,653 feet) and flows northeast through the residential community of upper Waiākea Uka Homesteads before entering the town of Hilo and ultimately emptying into Wailoa Pond, an estuary to Hilo Bay.

Palai Stream has a drainage area of about 7.7 square miles. Its basin is linear in shape, approximately 11 miles in length and about 2 miles in width at its widest point. Palai Stream originates down slope of the broad saddle formed between the Mauna Loa and Mauna Kea volcanoes (elevation 13,796 feet) and flows for about 7 miles through the Waiākea Forest Reserve with elevations ranging from 2100 feet to 1500 feet. Below the 1500 foot elevation, the basin is largely developed or planned for commercial, residential, and agricultural development. The stream flows an additional 4 miles through the town of Hilo before emptying into Wailoa Pond.

The focus of the present study is the area at which both streams enter the southern fringes of Hilo proper (Figure 1). This area of former forest is now occupied by mixed residential and open space.

2.2.1 Geology and Soils

The underlying geology of the Waiākea and Palai Streams Flood Control Project area consists of four distinct lava flows, all of which originated from the slopes of Mauna Loa, and all of which date to between 5,000 and 11,000 years of age (Wolfe and Morris 1996 map). Over time, these Kau Basalts developed into a variety of soil types (Figure 15). Four of these soils occur within the project areas.

- **HoC**: Hilo Silty Clay Loam. These are well drained silty clay loams that formed in volcanic ash. They are suitable for sugar cane cultivation, truck crops, orchards and pasture (Sato et al. 1973:17). These soils are present in the Ainalako survey area.

- **OlD**: Olaa Extremely Stony Silty Clay Loam. These are well drained silty clay loams that formed in volcanic ash and are often underlain by *ʻaʻā* lava. They are suitable for sugar cane cultivation and pasture (Sato et al. 1973:42). These soils are present in the Waiākea Stream and Kupulau Ditch survey area.

- **OHc**: Ohia Silty Clay Loam. These are well drained silty clay loams that formed in volcanic ash. They are deep enough for cultivation (Sato et al. 1973:41-42). These soils are present in the Waiākea Stream and Kupulau Ditch survey area.

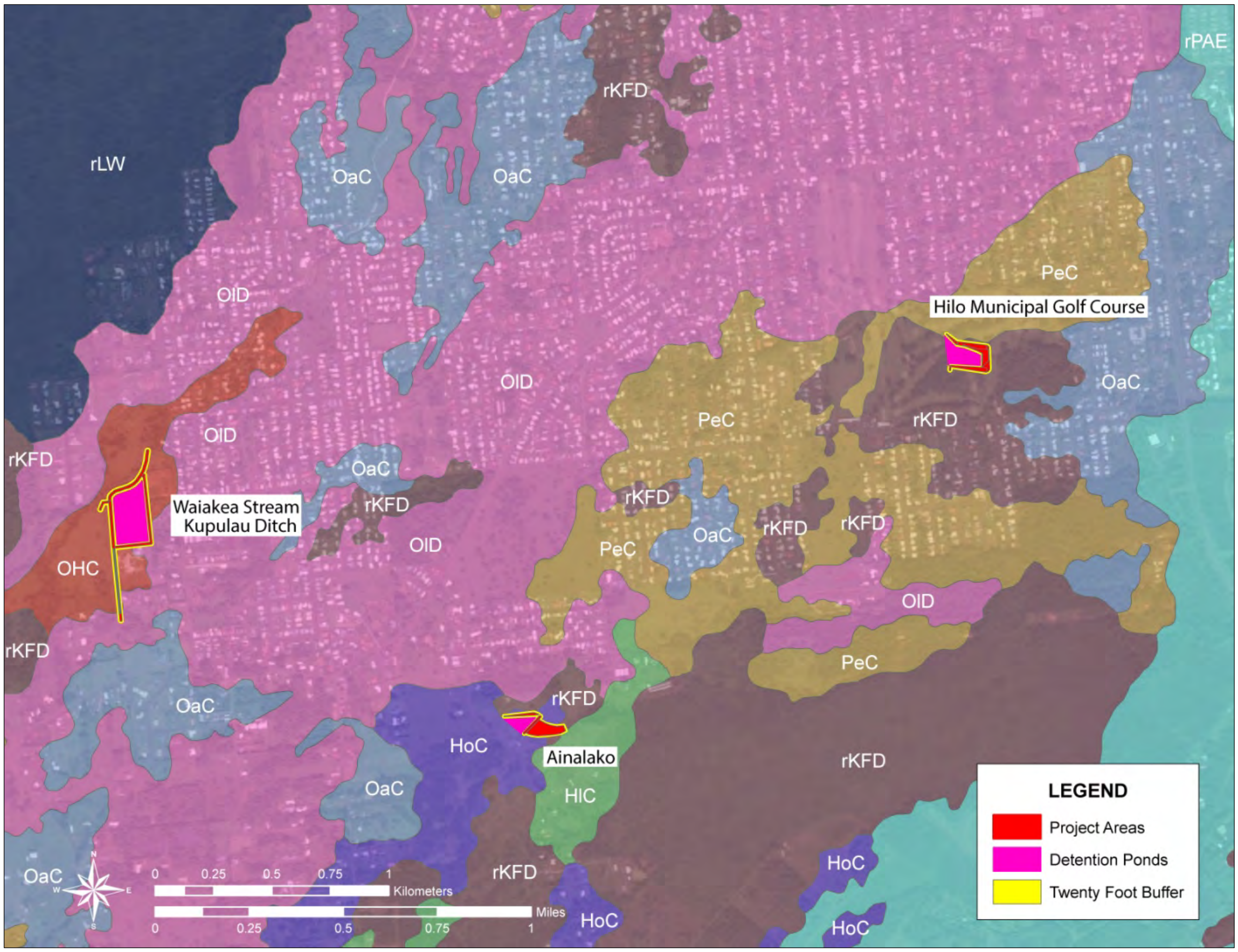

Figure 15. Soils present within the project areas (data from NRCS 1995).

- **rKFD**: Keaukaha Extremely Rocky Muck. These are well drained thin organic soils that have developed over *pāhoehoe* lava bedrock. They are suitable for pasture (Sato et al. 1973:27). These soils are present in the Hilo Municipal Golf Course survey area.

All of these soils found within the present project areas are suitable for pasture land, and all but the Keaukaha extremely rocky muck are suitable for sugar cane cultivation. The Hilo Silty Clay Loams are the most agriculturally productive.

2.2.2 Vegetation

Given the high rainfall in the area (approximately 400 centimeters/157 inches per year, Juvik and Juvik 1998:57), the original vegetation within the project areas would likely have consisted of indigenous *ʻōhiʻa lehua* (*Metrosideros polymorpha*) forest with an understory of *hāpuʻu* (tree fern, *Cibotium splendens*) and *ʻuluhe* (Pacific false staghorn, *Dicranopteris emarginata*) fern. Historic maps (see Section 3.2 and 3.3) indicate that during the 1800s this portion of Waiākea rested just below the boundary of the *ʻōhiʻa* forest zone, suggesting that the area was then under human use. It is likely that the land was cleared for cultivation at some time during the pre-Contact period.

Today, the vegetation within the various project areas is mixed. No native forest has survived, and almost all of the vegetation consists of introduced species.

Waiākea Stream and Kupulau Ditch

The vegetation that lines the eastern bank of the Waiākea Stream varies in density and composition along its length (Figure 10). Within TMK parcel (3) 2-4-065:035 (Figure 10the vegetation consists of high elephant grass (*Pennisetum purpureum*), and yellow ginger (*Hedychium flavescens*). Within TMK parcel (3) 2-4-065:036, the stream bank is shaded by mature *ʻohe (*bamboo, *Bambuseae spp.*), *maiʻa* (banana, *Musa paradisiaca*), and *niu* (coconut, *Cocos nucifer*), with very little ground cover. Where it intersects the Waiākea Stream, the eastern bank of the Kupulau Ditch (within TMK (3) 2-4-065:036) is covered by mature shade trees, while further south (within the New Hope Church parcel, TMK (3) 2-4-036:001) the bank is relatively open, being covered with grass of various heights (Figure 16). This grass is higher toward the southern end of the project area (Figure 17).

Figure 16. Vegetation within the northern portion of the Waiākea Stream and Kupulau Ditch project area (aerial from Bing Maps, image date 2015).

Figure 17. Vegetation within the southern portion of the Waiākea Stream and Kupulau Ditch project area (aerial from Bing Maps, image date 2015).

The area that would be covered by the eastern levee and of the detention pond is divided between two properties, the New Hope Church parcel (TMK (3) 2-4-036:001) and the more northern TMK (3) 2-4-065:036 parcel (Figure 10). The portion of the New Hope Church parcel resting within the limits of the detention basin consists of an open sports field with a baseball diamond. The area is all in close cropped grass. The TMK (3) 2-4-065:036 parcel shows signs of having been under garden crop cultivation, but is now mostly fallow with low grass and weeds. The boundaries of the property are planted in *mai'a* (banana, *Musa paradisiaca*) trees and *kī* (ti, *Cordyline fruticosa*) plants. The TMK (3) 2-4-036:999 access route (Figure 4) is presently covered in high elephant grass (*Pennisetum purpureum*), while the staging area, which shows signs of recent grubbing, is in grass and low weeds.

Hilo Municipal Golf Course

The Hilo Municipal Golf Course is a manicured environment of open grass and mature introduced trees (Figure 18). The Golf Course project area consists mostly of well tended greens with occasional shade trees, the majority of which are shower trees (*Cassia spp.*). One portion of the area is more densely vegetated in mature shower (*Cassia spp.*) and African tulip (*Spathodea campanulata*) trees. This area has been used as a mulch pile/dumping ground for cut logs and other green waste from the course.

Figure 18. Aerial view of the Hilo Municipal Golf Course detention pond area (source Bing aerial).

Ainalako
The four parcels that make up the Ainalako project area are in mixed use (Figure 13). The largest, TMK (3) 2-4-030:001 is covered in knee high grass and appears to have been utilized as pasture land. The remaining three parcels have been developed (or are under development) for residential use (Figure 19). They are vegetated in scattered shade trees, mowed grass, and areas of weeds.

Figure 19. Aerial view of the Ainalako project area (source Bing aerial).

2.3 Recent Impacts to The Project Areas

The three proposed Waiākea and Palai Streams Flood Control project areas are presently in a variety of land uses. These uses suggest the types and levels of impacts the lands have undergone in recent times. None of the survey areas have remained undisturbed, and all show evidence of ground clearance, either during the sugar cane era or more recently.

The Waiākea Stream and Kupulau Ditch project area parcels (Figure 10) are presently in mixed use, either agricultural, residential, religious, recreational or neglected. A small portion of land located along the boundary of TMK (3) 2-4-065:036 and Kupulau Ditch/Waiākea Stream that would be impacted by the present project appears to have been cultivated, but is presently lying fallow. Most of the land appears to have been graded and tilled. TMK (3) 2-4-065:035 is a residential property that appears to have been graded. The portion of the property adjoining onto the Waiākea Stream has been left to grow wild. TMK (3) 2-4-035:003 is also a residential property. The portion adjoining Kupulau Ditch shows evidence of having been graded and leveled. The New Hope Church parcel (TMK (3) 2-4-036:001) is in mixed use with church offices, meeting rooms and other facilities, as well as a paved parking lot and a ball field. Those areas adjoining Kupulau Ditch are open and well mowed grassland, as is the ball field, which would serve as the southern half of the detention basin. The ball field appears to have been filled and leveled. The proposed staging area shows evidence of having been roughly graded. It is presently neglected and in low weeds. The TMK (3) 2-4-036:999 access route into the project area from Kupulau Road has been left neglected for years and is overgrown with head high grass, but has evidently been graded at one time.

The Hilo Golf Course project area forms part of an operating municipal golf course. The proposed levee and detention basin areas include manicured greens and dense vegetation (Figure 11). The greens have very evidently been landscaped (which probably involved grading and brining in fill soil), while the vegetation areas also show evidence of previous ground disturbing activities, probably initial grubbing dating from the construction of the golf course.

The three residential properties (TMKs (3) 2-4-081:006, 007 and 011, Figure 13), portions of which are covered by the proposed levees and detention basin within the Ainalako project area, all show evidence of having been graded. The open property (TMK (3) 2-4-081:001) to the north of these consists of relatively level grassland. The ground modification of this property may date to the sugar era.

3.0 CULTURAL AND HISTORICAL BACKGROUND

The Waiākea and Palai Streams Flood Control Project survey areas are located within the *ahupuaʻa* of Waiākea in the *moku* (district) of South Hilo, inland of Hilo Bay. This broad bay, fringed by a sand beach, fed by a network of streams and ponds, and backed by gently sloping terrain, offers an ideal spot for human settlement. During the pre-Contact period, the shores of Hilo Bay were relatively densely populated. Houses were clustered just back from the beach, surrounded by groves of *niu* (coconut) and *ʻulu* (breadfruit). The swampy lands bordering the Wailoa River were planted in wetland *kalo* (taro) (Cordy 2000:353).

3.1 The Ahupuaʻa of Waiākea

The fertile agricultural soils that had developed at the mouth of the Wailoa River and the fish filled waters of Wailoa Pond made the land division of the Waiākea one of the most productive locations fronting the bay. Traditional accounts mention Waiākea as being the location of the residence of the chiefs of Hilo as early as the time of ʻUmi a Liloa (ʻUmi son of Liloa) in the sixteenth century (Kamakau 1961:15-17). Hawaiian historian Samuel Manaiakalani Kamakau refers to the Hilo chief Kulukuluʻa, whose daughter was married to ʻUmi, as holding a night celebration at Kanukuokamanu in Waiākea (Kamakau 1961:15). Chiefly activity appears to have been focused along the western side of the Wailoa River, within and around the *ʻili kūpono* of Piʻopiʻo (Kamakau 1961:75 and Cordy 2000:354-357). An *ʻili kūpono* is a land division paying tribute to the *aliʻi nui* (high chief) rather than directly to the *aliʻi* (chief) of the *ahupuaʻa* within which it rest. There were two *ʻili kūpono* within the *ahupuaʻa* of Waiākea, Piʻopiʻo and Honohononui. Both are located along the coast, and both possess several *loko iʻa* (fishponds). The *loko puʻuone* (inland fishponds) of Piʻopiʻo, located at the mouth of the Wailoa River, were reserved for the use of the *ʻili's* chiefly residents (Kelley et al. 1981:11-13).

Kamehameha I spent a great deal of time in Hilo, particularly during his campaigns to unify the Islands (Cordy 2000:355). Following his conquest of Hawaiʻi Island, Kamehameha acquired the *ahupuaʻa* of Waiākea for his own personal use. When Captain George Vancouver arrived at Hilo Bay in 1794, Kamehameha was living at Waiākea and preparing his fleet of war canoes for his coming conquest of the other Hawaiian Islands. Upon the death of Kamehameha, the lands of Waiākea passed to his son Liholiho (Kelly et al. 1981:11). Piʻopiʻo served as a chiefly residence down to the time of Princess Ruth Keʻelikolani in the 1870s. The focus of these chiefly activities, however, was the level lands just inland of the bay shore. Waiākea itself stretches far into the interior, encompassing not only coastal settlements and fishponds, but more inland agricultural areas and undisturbed native forest.

The *ahupuaʻa* of Waiākea is one of the largest *ahupuaʻa* within the Hawaiian Islands, covering approximately 95,000 acres (Escott 2013:5, Maly 1996:5). It extends from the southern shore of Hilo bay inland as far as the upper edge of the forest zone on the slopes of Mauna Loa. The boundaries of the *ahupuaʻa* appear on the tracing of a Government Survey map drafted in 1901, and based upon a survey conducted by William Webster in 1851 (Figure 20).

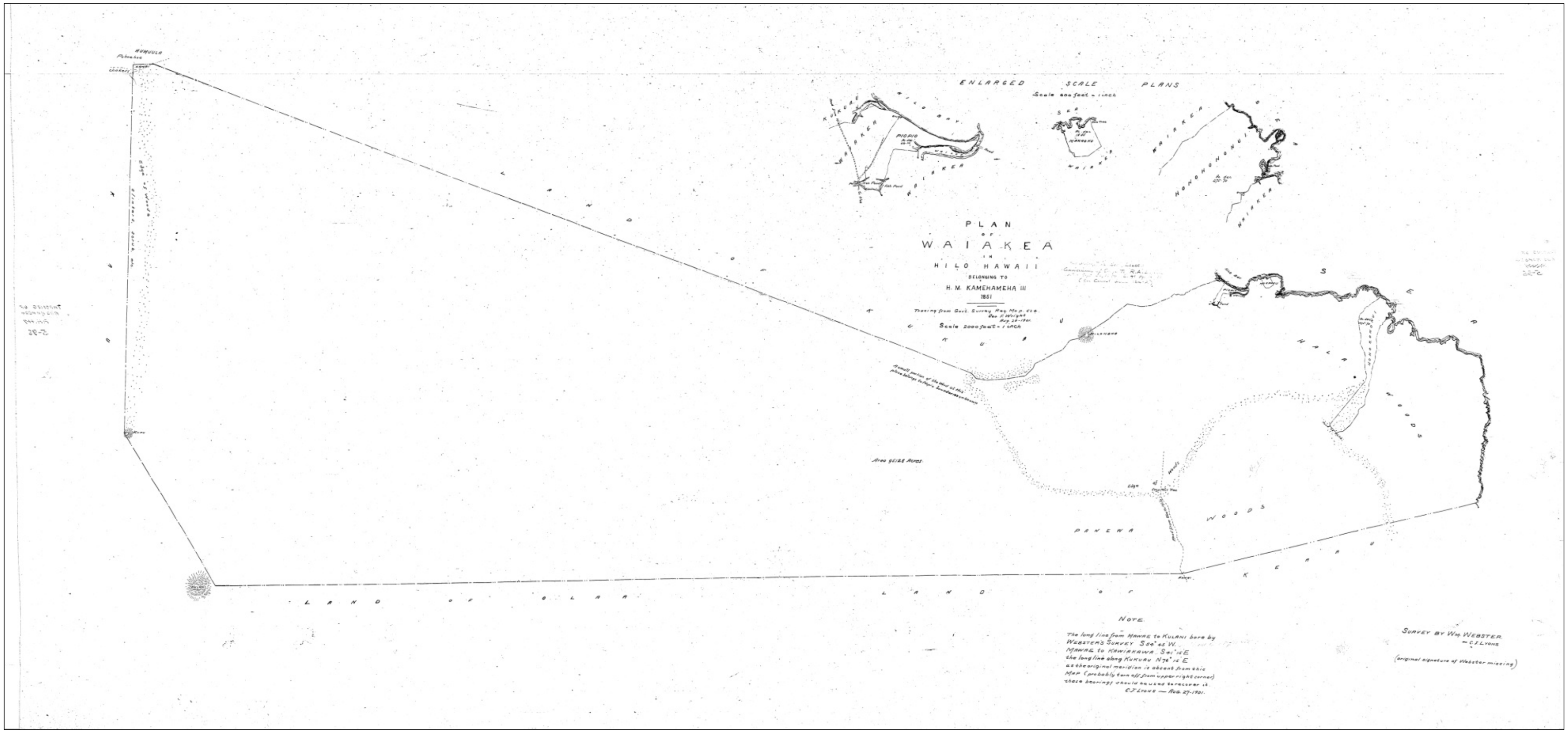

Figure 20. 1901 territorial government map showing the *ahupua'a* of Waiākea as it existed in 1851 (Wright 1901 Map).

This massive *ahupuaʻa* was traditionally divided into smaller land divisions known as *ʻili ʻāina*. These included the *ʻili* of Piʻopiʻo, Honohononui, Mohouli, Kawili, Kaleplepo, Keaukaha, Kalanakamaʻa, Puaʻaloa, Puʻainako, and Panaʻewa (Maly 1996:5). As previously noted, the *ʻili kūpono* of Piʻopiʻo and Honohononui owed tribute to the chiefs of East Hawaiʻi, and Piʻopiʻo contained the chiefly residence compound. The remaining *ʻili* were controlled by lesser chiefs.

Most of the lands of Waiākea were settled by the *makaʻāinana*, the common people, who made their living from the soil or the sea. Though it is difficult to determine the exact boundaries of these smaller land divisions, we know that Piʻopiʻo, Honohononui, Mohouli, Kawili, Kaleplepo, Keaukaha were for the most part coastal *ʻili*. The boundaries of Piʻopiʻo and Honohononui are shown on the 1901 map of the *ahupuaʻa* of Waiākea (Figure 20). Mohouli and Kaleplepo are the names of fishponds located adjacent to Piʻopiʻo that were destroyed by the Wailoa River Tributaries Flood Control Project (Soehren 2010). It appears that the Waiākea and Palai Streams Flood Control Project survey areas fall either within the *ʻili* of Panaʻewa, located along the inland eastern boundary of Waiākea *ahupuaʻa*, of the adjacent *ʻili* of Puʻainako.

3.2 THE ʻ*ILI* OF PANAʻEWA

During the pre-Contact period much of the *ʻili* of Panaʻewa was covered in dense forest, the remnants of which are now encompassed within the Waiākea Forest Reserve. The famous *ʻōhiʻa* forests of Panaʻewa are mentioned in several *mele* (chants) and *moʻolelo* (traditional narratives). Foremost among these is the tradition of Pele and Hiʻiaka, a chant cycle that recalls the journeys of the volcano goddess Pele and of her younger sister Hiʻiaka. The *moʻolelo* of Pele and Hiʻiaka appears in many variations (*Kuokoa Home Rula* 1908, Emerson 1915, Westervelt 1916). One of the chants included within the Pele and Hiʻiaka tradition describes the forested lands of Panaʻewa.

> *ʻO Pana-ʻewa nui, moku lehua*
> *ʻōhiʻa kupu hāʻoeʻoe i ka ua*
> (Emerson 1915:32)
>
> Great Panaʻewa, district with *lehua* flowers
> *ʻōhiʻa* trees growing scraggily in the rain
> (Pukui and Elbert 1971:54)

The name Panaʻewa belonged not only to a land division within the *ahupuaʻa* of Waiākea, but also to a *moʻo wahine* (lizard goddess) who dwelt within the dense *ʻōhiʻa* forests of Panaʻewa. The story of the encounter between Hiʻiaka and the *moʻo wahine* Panaʻewa is told in detail in the *moʻolelo* of Pele and Hiʻiaka. In this portion of the saga, Hiʻiaka and her companions are traveling from her home at Kīlauea to Waiākea in Hilo. There were two routes available to them. The *makai* (coastal) trail was the one most frequently traveled by those who journeyed from the district of Puna to Hilo, for although it was longer, it was also less dangerous. The more direct inland route led through the forested lands of the *moʻo wahine* Panaʻewa who was known to ambush wayfarers and devour them (Emerson 1915:32). Hiʻiaka chose the more direct route and engaged in a battle with Panaʻewa which led to the defeat of the *moʻo wahine*. In this way she made the trail through Panaʻewa safe for travelers.
The two trails available to Hiʻiaka may correspond to two paths which are shown on a map of

the *makai* portion of the *ahupuaʻa* of Waiākea apparently based upon a survey conducted by William Webster in 1851 (Figure 21). One of these trails, enters Waiākea along the *mauka* edge of the *ʻili kūpono* of Honohononui where the more *mauka ʻōhiʻa* forests of the "Panaewa Woods" meets the more *makai* "Hala Woods." The dominant tree in these coastal forests would have been the *hala* (pandanus, *Pandanus tectorius*), a Polynesian introduced tree whose leaves were traditionally woven into mats and baskets. This trail, labeled "Road to Puna," appears to have possibly been the longer but safer *makai* trail that was not taken by Hiʻiaka.

The more *mauka* trail, which ran right through the realm of the *moʻo wahine*, may have been the trail marked on the map as the "Road from Olaa to Hilo." The *ahupuaʻa* of ʻŌlaʻa in Puna borders the upper portions of Waiākea to the south. It is a large land division, extending inland almost to the summit of Kīlauea and the boundary with the district of Kaʻū. The trail from ʻŌlaʻa would have provided the most direct route from Kīlauea to Hilo. This trail would also have led to the inland settlement of Keaʻau and the trails that branched off into lower Puna. The trail from ʻŌlaʻa can be seen to run directly through the Panaʻewa woods. Boundary Commission documents suggest that this trail from ʻŌlaʻa to Hilo ended along the boundary of the *ʻili kūpono* of Piʻopiʻo (Soehren 2010). The map of the *makai* portion of Waiākea shows a section of trail marked "Road from Hilo to Olaa" running along the *mauka* edge of the *ʻili* of Piʻopiʻo (Figure 21).

The *ʻili* of Panaʻewa and the trail from ʻŌlaʻa to Hilo also feature prominently in historic events that led to the rise of Kamehameha I and the unification of the Hawaiian Islands. John Papa ʻĪʻī, writing in a series of articles published in the Hawaiian language newspaper *Ka Nupepa Kuokoa* from 1866 to 1870 (later collected into the book *Fragments of Hawaiian History*), described the death of Kamehameha's father Keoua in Hilo and the subsequent battle between the forces of Alapaʻi (*aliʻi nui* of Hawaiʻi Island) and his eventual successor Kalaniopuʻu over the young Kamehameha, which took place in Panaʻewa:

> Kamehameha was born at Kapakai, in Kokoiki, Kohala, Hawaii, and the chief Naeole carried the infant away as soon as he was delivered from his mother. Later, Alapai, ruler of Hawaii [from c. 1730 to 1754] and great uncle of Kamehameha, and his wife Keaka took charge of him [Kamehameha]. Some years later, Alapai and his chiefs went to Waiolama in Hilo, where Keoua Kupuapaikalani, father of Kamehameha, was taken sick and died. Before Keoua died he sent for Kalaniopuu, his older half brother and the chief of Kau, to come and see him. Keoua told Kalaniopuu that he would prosper through Kamehameha's great strength and asked him to take care of the youth, who would have no father to care for him. Keoua warned Kaniopuu, saying, "Take heed, for Alapai has no regard for you or me, whom he has reared." After this conversation, Keoua allowed his brother to go, and Kalaniopuu left that night for Puaaloa [in Panaʻewa].
>
> As Kalaniopuu neared Kalanakamaa [in Waiākea], he heard the death wails for Keoua and hastened on toward Kalepolepo [the *ʻili* between Mohouli and Kawili] where he had left his warriors. There they were attacked by Alapai's men, who had followed Kalaniopuu from Hilo. First the warriors from the lowland gained, then those from the upland, until night fell and the battle was postponed until the next day. Kalaniopuu continued his journey and at midnight reached Puaaloa, where he arranged for the coming battle. The next day all went as he had planned, his forward armies led the enemy into the forest of Paieie, where there was only a narrow trail, branchy on either

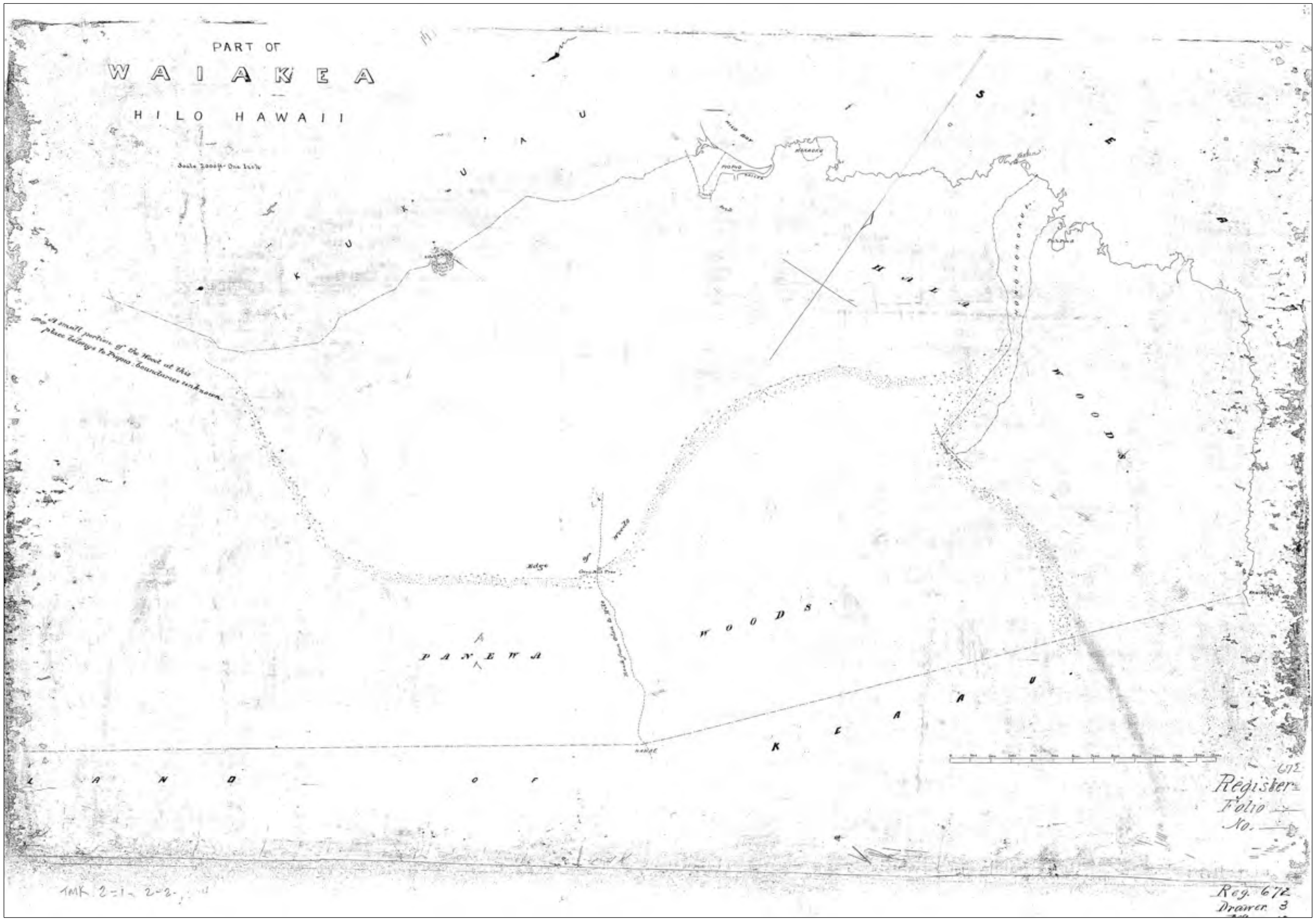

Figure 21. William Webster's 1851 map of the *makai* portion of Waiākea showing the trails leading into it from Puna (visible as a dotted line running just south of Pi'opi'o and Hilo Bay) and 'Ōla'a (visible as a dotted line crossing through the Pana'ewa Woods)(Webster 1851 Map).

> side and full of undergrowth. There his men in ambush arose up against the enemy warriors, and his rear armies closed in behind them. When Alapai‘s men realized that they were surrounded, they fell in ignominious death.
>
> When news reached Alapai that his warriors had been destroyed, he sent another company of warriors to meet Kalaniopuu at Mokaulele on the outer road, which was an ancient road, known from the time of remote antiquity. Again Alapai‘s men were destroyed and Kalaniopuu was the victor. He returned then to Kau, the land of his birth (‘Ī‘ī 1959:3-4).

The "forest of Paieie," which literally means "the ‘*ie*‘*ie* vine enclosure" (Pukui et al 1974:175), may be in some way related to the *heiau* (temple) of Kapaieie, which "was located near Honokawailani, Waiakea" (Thrum 1908:40, see Section 4.0).

Hawaiian historian Samuel Mānaiakalani Kamakau writes that the conflict between Alapa‘i and Kalani‘ōpu‘u arose from the Ka‘ū chief's attempt to abduct the young Kamehameha, for it was rumored that Alapa‘i had ordered his father Keōua killed (Kamakau 1961:75). In Kamakau's account the first battle was fought at Kalepolepo, with subsequent battles fought "at Pa‘ie‘ie adjoining Pua‘aloa" and "at Kualoa and Mokaulele all the way to Mahinaakaka [in Puna]" (Kamakau 1961:76).

Kamakau also records a much later battle that was fought by the forces of Kamehameha during his struggle to wrest control of the island of Hawai‘i. This battle too took place "just out of Pana‘ewa at a place called Pua‘aloa."

> As he was descending [from Kilauea], just out of Pana‘ewa at a place called Pua‘aloa, he met with a war party of Ka-hekili, which had been sent to the aid of Keawe-ma‘u-hili under Ka-haha-wai…The army was only saved by getting to the sea and going aboard Ke‘e-au-moku's fleet" (Kamakau 1961:125).

According to Land Commission testimony collected during the Māhele ‘Āina (see Section 3.6), Pua‘aloa (literally "long pig") was an ‘*ili* ‘*āina* of Waiākea, though it is not clear exactly where it was located (Foreign Testimony Book 5:27; Native Testimony Book 4: 453). Kamakau's account seems to suggest that Pua‘aloa was located immediately *makai* of Pana‘ewa (either the forest or the land division, or both).

3.3 TRADITIONAL TRAILS

The historical accounts described above, as well as the legendary traditions associated with the travels of Hi‘iaka, appear to suggest that a major trail leading from Hilo into Ka‘ū passed through the forest of Pana‘ewa. The course of this trail is shown on the 1901 Government Survey map (Figure 20) based upon William Webster's 1851 survey (Figure 21), as well as on an undated (but apparently later) map of Central Hawai‘i, Hilo and Hāmākua (Figure 22). This undated map appears to have been drafted based upon two earlier surveys, the 1851 survey conducted by Webster and an apparently later one by Lydgate. When the locations of the Waiākea and Palai Streams Flood Control Project survey areas are overlaid atop a copy of the 1851 Webster map (Figure 23), it can be seen that the traditional trail from Hilo to ‘Ōla‘a

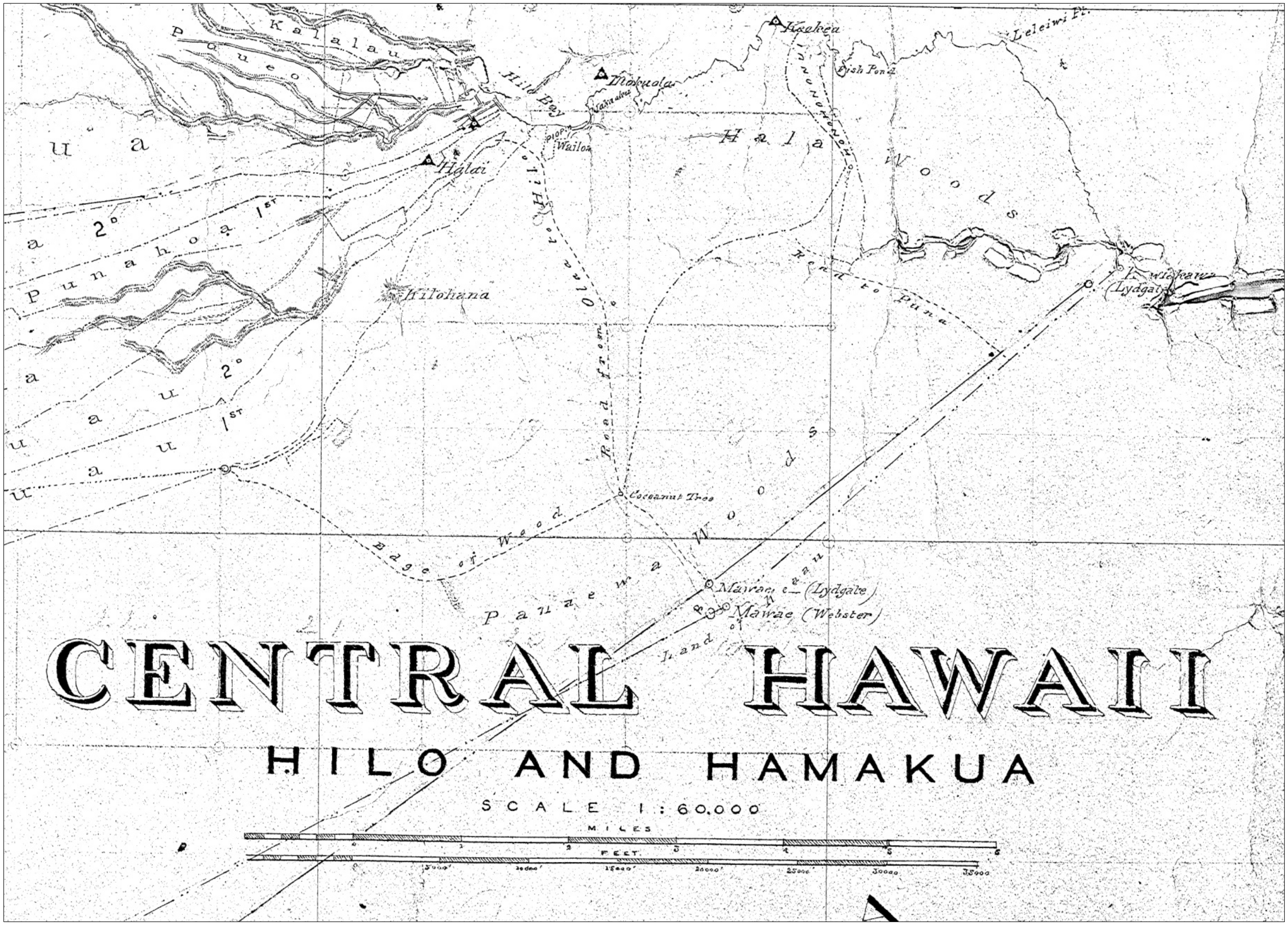

Figure 22. Undated map showing the trail leading into Hilo (Government Survey undated Map).

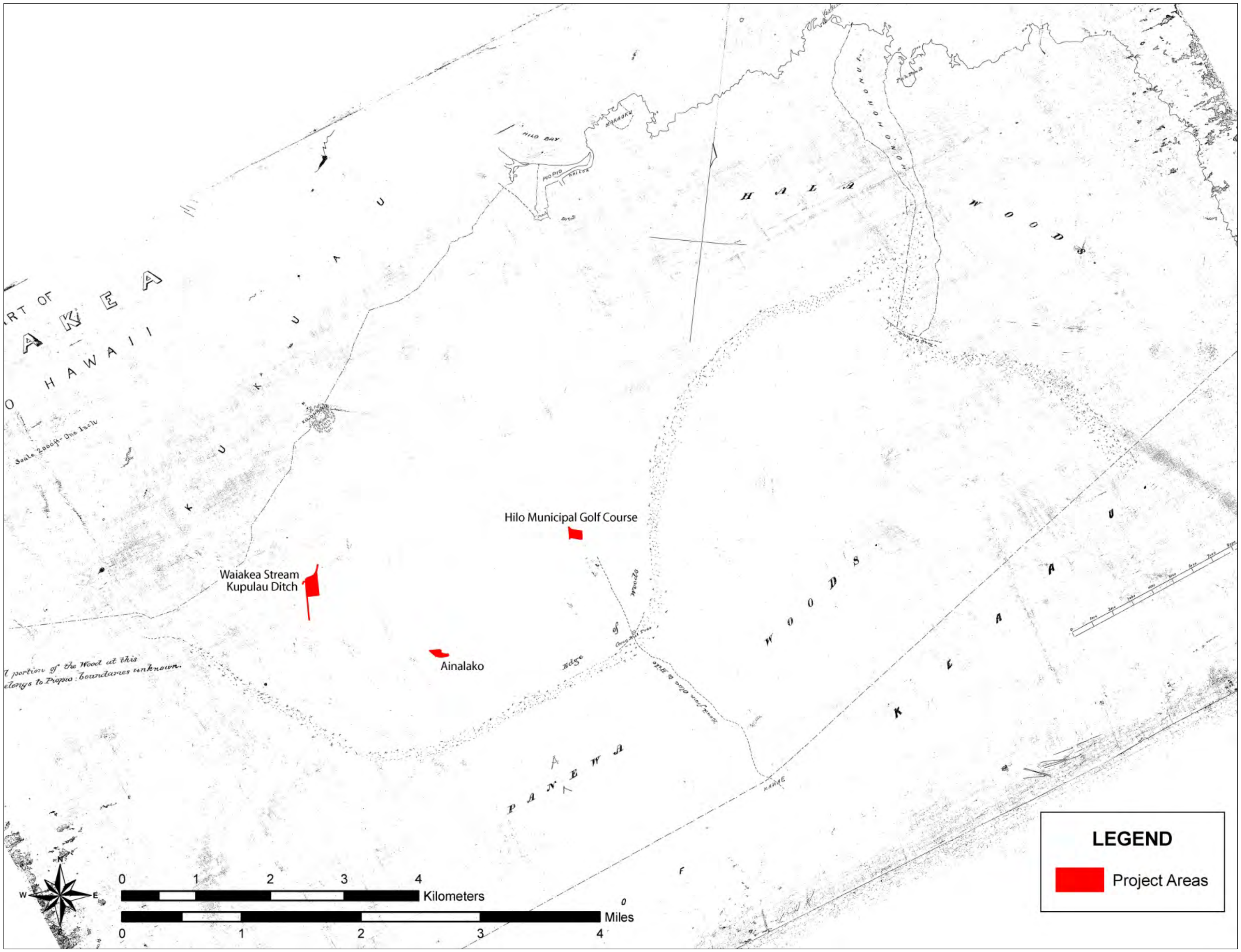

Figure 23. Locations of proposed survey areas overlaid atop a portion of Webster's 1851 map.

may have run just east of the Hilo Municipal Golf Course project area. If the survey area locations are overlain atop the undated map of Central Hawai'i, Hilo and Hāmākua, it is possible to see that the Webster survey differs slightly from the Lydgate survey in terms of the alignment of the 'Ōla'a to Hilo trail (Figure 24). The Lydgate survey shows the trail alignment running further to the east of the Golf Course. It appears to follow the alignment of the present Kīlauea Avenue (or Kino'ole Street that runs parallel to it), which was formerly the old Government Road to the Volcano (Figure 25). It is not clear if the traditional trail was realigned when it became the Government Road, or whether the difference is simply a matter of mapping error.

An account of a journey along the 'Ōla'a to Hilo trail appears in the journals of Reverend William Ellis, one of the most observant of the Westerners to visit the islands during the early historic period. An English missionary, Ellis accompanied a group of American Protestant missionaries making a two months circuit of the island of Hawai'i in 1823. Beginning in Kailua-Kona and traveling on foot and by canoe counter-clockwise around the coast, they walked through Puna and into Hilo, journeying from the inland settlement of Kea'au down to Waiākea. Ellis' journal notes that:

> Leaving the village of Kaau [Kea'au], we resumed our journey, and after walking between two and three hours, stopped in the midst of a thicket to rest, and prepare some breakfast . . . At half-past ten we resumed our walk, and passing about two miles through a wood of pretty large timber, came to open country in the vicinity of Waiakea (Ellis 1963:213).

Given the position of the "Edge of Wood" as shown on both Webster's 1851 map and the undated government survey map, it seems likely that at the time of Ellis' visit to Hilo the present survey areas were located within the "open country" mentioned by the missionary.

A similar description of the 'Ōla'a to Hilo trail was provided by the American Missionary C.S. Stewart who accompanied Lord Byron on his visit to Hilo in 1824. Stewart joined Lord Byron and his party on their journey inland to Kīlauea. He described the lands through which they passed on leaving the shores of Hilo Bay.

> For the first four miles the country was open and uneven, and beautifully sprinkled with clumps, groves, and single trees of the bread-fruit, pandanus, and candle tree. We then came to a wood, four miles in width, the outskirts of which exhibited a rich and delightful foliage. It was composed principally of the candle tree, whose whitish leaves and blossoms afforded a fine contrast to the dark green of the various parasitical plants which hung in luxuriant festoons and pendants from their very tops to the ground, forming thick and deeply shaded bowers round their trunks. The interior was far less interesting, presenting nothing but an impenetrable thicket, on both sides of the path (Stewart 1828:369).

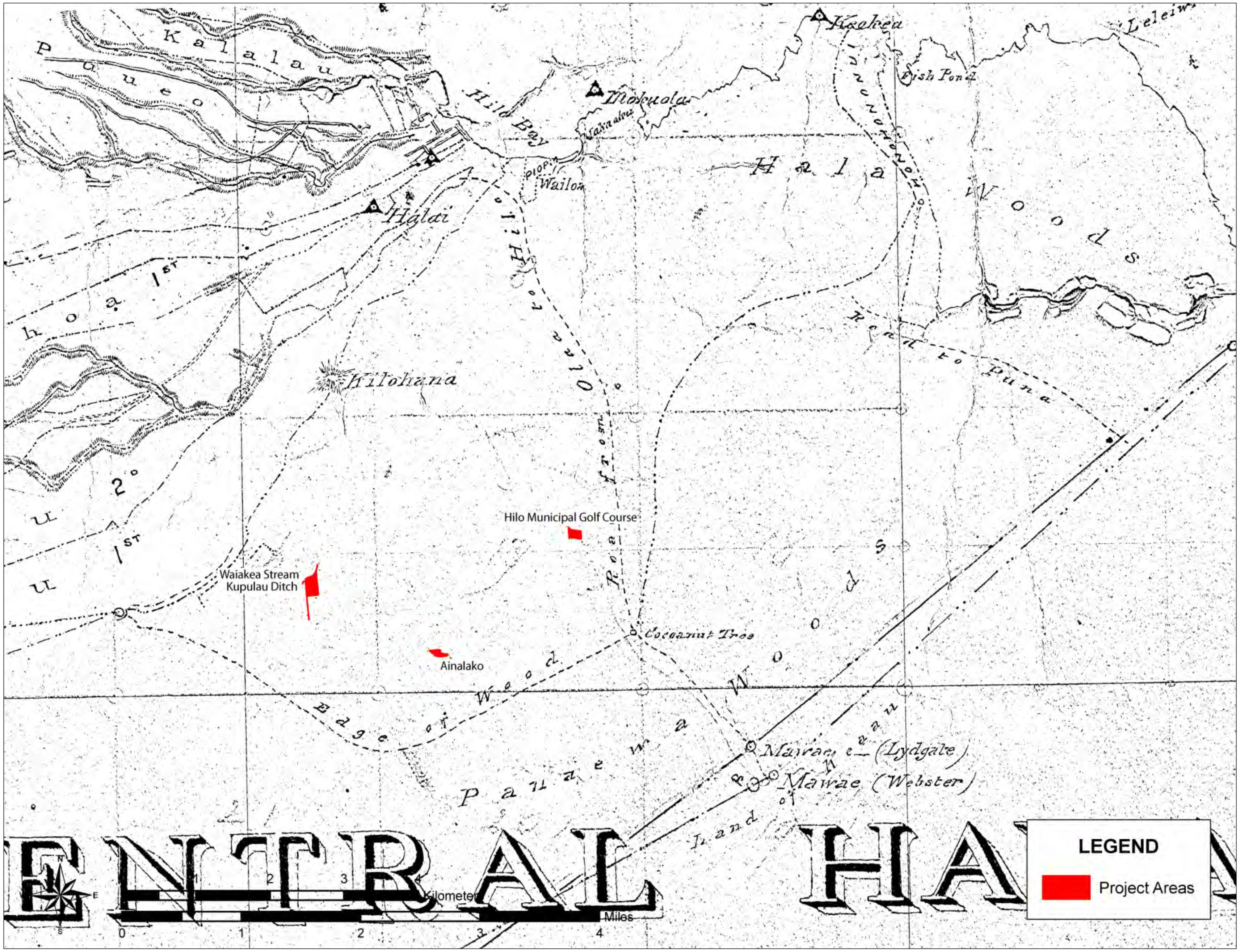

Figure 24. Proposed survey areas overlaid atop the undated Central Hawai'i map.

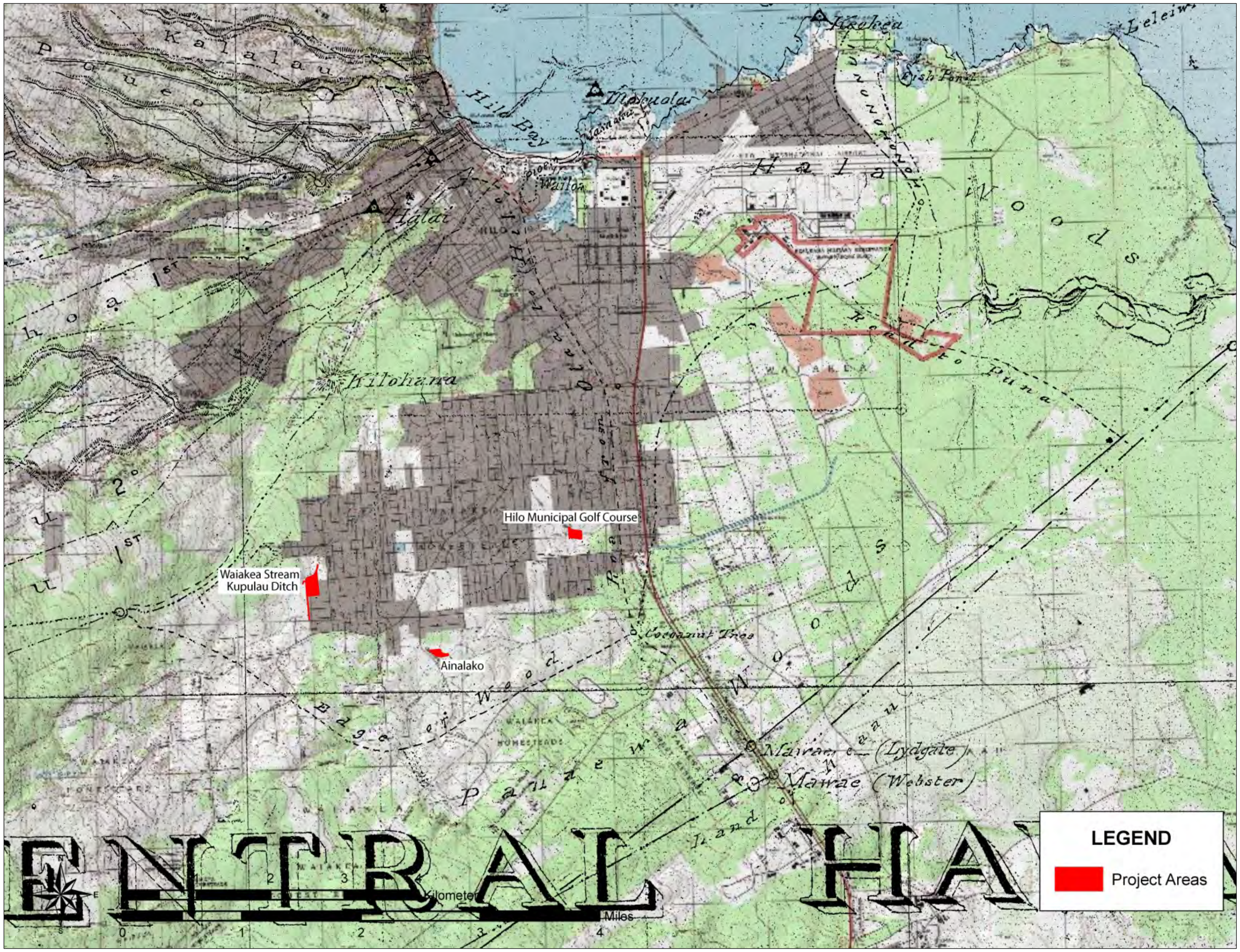

Figure 25. USGS map and survey areas overlaid atop the undated Central Hawai'i map (base map USGS Hilo quadrangle).

3.4 Traditional Land Use

Some idea of traditional land use within the Waiākea and Palai Streams Flood Control Project survey areas can be gained from a 1979 study undertaken by Holly McEldowney. This study recognized a series of environmental zones extending inland from Hilo Bay and identified the traditional land use practices and activities associated with each of them. McEldowney developed her classification of environmental zones and general patterns of land use based upon a detailed study of historical maps and documents. The traditional and early historic resource and land use zones identified by McEldowney included:

- I. Coastal Zone
- II. Upland Agricultural Zone
- III. Lower Forest Zone
- IV. Rainforest Zone
- V. Sub-Alpine Zone

When the locations of the present project areas are overlaid atop Webster's 1851 map of Waiākea (Figure 23), it becomes evident that all of the identified survey areas associated with the Waiākea and Palai Streams Flood Control Project are located *makai* of the Pana'ewa forest in the open area that would correspond to McEldowney's Upland Agricultural Zone (Zone II), which is located between roughly 50 to 1,500 feet in elevation. McEldowney describes this zone of traditional agricultural activity by saying:

> Although estimates as to the extent of this zone vary in early journal accounts, most confirm an expanse of unwooded grasslands or a 'plain' behind Hilo . . . [The zone is characterized by] scattered huts, emphasized by adjacent garden plots and small groves of economically beneficial tree species, dotted this expanse up to 1,500 ft elevation (i.e. the edge of the forest). The cumulative effects of shifting agricultural practices (i.e., slash-and-burn or swidden), prevalent among Polynesian and Pacific peoples, probably created and maintained this open grassland mixed with pioneering species and species that tolerate light and regenerate after a fire.
>
> This open but verdant expanse, broken by widely spaced "cottages" or huts, neatly tended gardens, and small clusters of trees… Estimates as to the extent of this unwooded expanse . . . [fall] between four or five miles (McEldowney 1979:18-20).

McEldowney notes that roughly the same range of crops was grown within the coastal settlement of Hilo (Zone I) as within the more inland agricultural areas (Zone II).

> The constituents of gardens and tree crops in the village basically continued in the upland except that dry-land taro was planted more extensively and bananas were more numerous. Wet or irrigated taro occurred along small streams, tributaries, and rivers . . . (McEldowney 1979:18-20).

This pattern of land use seems to characterize the present project area.

> This same pattern occurred between Waiakea Pond and the Pana'ewa Forest in the four or five miles of open country dominated by tall grasses. Here stands of *kukui* (*Aleurites*

> *molussana)*, pandanus, and mountain apple became more conspicuous, with large areas of dryland taro planted in rocky crevices… (McEldowney 1979:18-20).

While a wide variety of both root and tree crops were grown in the fields and gardens of Waiākea, the principle crop cultivated within McEldowney's upland agricultural zone was most likely dryland *kalo* (taro, *Colocasia esculenta*). This is documented by E. S. Craighill Handy, Elizabeth Handy and Mary Kawena Pukui in their book *Native Planters of Old Hawaii*.

> On the lava strewn plain of Waiakea and on the slopes between Waiakea and Wailuku River, dry taro was formerly planted wherever there was enough soil. There were forest plantations in Pana‘ewa and in all the lower fern-forest zone above Hilo town (Handy et al. 1972:539).

Wetland *kalo* was planted along the streams, while dryland *kalo* was cultivated in more open soil covered areas. ‘*Uala* (sweet potato, *Ipomoea batatas*) was observed by Ellis, grown atop rocky mounds in the "less fertile parts of the district" (Ellis 1963:239). It is also likely that *kō* (sugar cane, *Sacchrarum officinarum*) may have been grown along field boundaries. Among the tree crops known to have been traditionally grown in the *ahupua*‘*a* of Waiākea were *mai*‘*a* (bananas, *Musa sp*.), ‘*ulu* (breadfruit, *Artocarpus altilis*), *niu* (coconut, *Cocos nucifer*), *kukui* (candlenut, *Aleurites moluccana*) and *hala* (pandanus, *Pandanus tectorius*).

3.5 Early Historic Period

During his visit to the settlement of Hilo, the missionary William Ellis provided a description of Waiākea as it existed in the 1820s.

> The district of Waiakea, and the bay of the same name, the Whye-a-te-a Bay of Vancouver, form the southern boundary of the division of Hiro [Hilo], are situated on the north-east coast of Hawaii, and distant about twenty or twenty-five miles from the eastern point of the island….
>
> The face of the country in the vicinity of Waiakea is the most beautiful we have yet seen, which is probably occasioned by the humidity of the atmosphere, the frequent rains that fall here, and the long repose which the district has experienced from volcanic eruptions.
>
> The light and fertile soil is formed by decomposed lava, with a considerable portion of vegetable mould. The whole is covered with luxuriant vegetation, and the greater part of it formed into plantations, where plantains, bananas, sugar-cane, taro, potatoes, and melons, grow to the greatest perfection.
>
> Groves of cocoa-nut and breadfruit trees are seen in every direction loaded with fruit, or clothed with umbrageous foliage. The houses are mostly larger and better built than those of many districts through which we had passed. We thought the people generally industrious; for in several of the less fertile parts of the district we saw small pieces of lava thrown up in heaps, and potato vines growing very well in the midst of them, though we could scarcely perceive a particle of soil….

> The district of Waiakea, though it does not include more than half the bay, is yet extensive. Kukuwau in the middle of the bay is its western boundary, from which, passing along the eastern side, it extends ten or twelve miles towards Kaau [Keaʻau], the last district in the division of Puna (Ellis 1963:238-239).

Ellis goes on to discuss the advantages of establishing a mission station in Waiākea.

> Taking every circumstance into consideration, this appears a most eligible spot for a missionary station. The fertility of the soil, the abundance of fresh water, the convenience of the harbour, the dense population, and the favourable reception we have met with, all combine to give it a stronger claim to immediate attention than any other place we have yet seen, except Kairua [Kailua].
>
> There are 400 houses in the bay, and probably not less than 2000 inhabitants, who would be immediately embraced in the operations of a missionary station here, besides the populous places to the north and south, that might be occasionally visited by itinerant preachers from Waiakea (Ellis 1963:240).

The establishment of a mission station in Hilo marked the beginning of a transformation. Already an important harbor for the reprovisioning of Western whaling ships and other vessels, the traditional settlement strung along the fringes of Hilo Bay where life had been based upon fishing and farming gradually grew to become a major port and commercial center. This transformation was due in part to the abandonment of the traditional system of land tenure and the adoption of a Western system of land ownership.

3.6 MĀHELE ʻĀINA

In December of 1845, a Board of Commissioners to Quiet Land Titles (often referred to as the Land Board or Land Commission) was established by the Kingdom of Hawaiʻi to investigate land claims and make awards based upon these claims and their supporting testimony. This process of land division became known as the Māhele ʻĀina (also referred to as the Māhele or the Great Māhele). At the time of the Māhele ʻĀina, the lands of the Hawaiian kingdom became, "…divided into three parts – one to the Chiefs, one for the support of the Government, and a third for the King's personal use. These we know by the names of "Konohiki," "Government" and "Crown Lands"" (*Indices Of Awards* 1929:vii).

It was principally from within the chief's "…one-third of the Great Mahele that the common people, who were their tenants, received title to the small holdings which are known as "Kuleanas." These Kuleanas were areas which these tenants had improved and used for their own purposes" (*Indices Of Awards* 1929:vii). In order to be granted a *kuleana* holding, a member of the *makaʻāinana* (common people) had to present his claim before the Land Board and give testimony in support of it.

A total of only twenty-five *kuleana* claims were awarded within the *ahupuaʻa* of Waiākea. All but two of these were located near the coast (Escott 2013:8) and none were located within or near the present project areas. The remainder of the *ahupuaʻa* of Waiākea was designated as Crown Lands (Kelly et al. 1981:40). Though the changes wrought by the Māhele ʻĀina were not immediate, over time the former tenants of the land who had not claimed *kuleana* parcels would have been forced to abandon their ancestral lands and move to the more rural areas. The vacant crown lands could then be leased by the government for cattle pasture, and later sugar cane cultivation.

3.7 HISTORIC LAND USE CHANGES

Following the codification of land ownership brought about by the Māhele ʻĀina, the more inland areas of Waiākea were given over to cattle ranching and sugar cane cultivation. In 1861, S. Kipi leased the crown lands of Waiākea from Kamehameha IV for use as cattle pasture (Kelly et al. 1981:89). These pasturelands did not extend over the full extent of the *ahupua*ʻ*a*. The Panaʻewa forest still occupied the greatest portion of the land division, and only a relatively small percentage of the available lands were utilized for grazing.

3.7.1 Sugar

In 1879, Theo. H. Davies and Alexander Young established the Waiākea Mill Company, and set up a sugar mill at Wailoa Pond. The entire *ahupua*ʻ*a* of Waiākea, with the exception of its coastal fishponds, was leased by Davies and Young in 1888 for the growing of sugar cane (Kelly et al. 1981:89). By the early nineteen hundreds, nearly 7,000 acres of land in Waiākea had been put into sugar cultivation (Kelly el al. 1981:89,120). With the coming of the new century, sugar became the dominant economic force in Hilo and along the adjacent Hāmākua Coast. The Waiākea Mill Company continued in operation from 1879 to 1948.

The shift from traditional agriculture to the commercial cultivation of sugar cane resulted in significant alterations, not only to the cultural, but also to the physical landscape of central Waiākea. It was standard practice in the commercial cultivation of cane for the land set aside for planting to be first chain dragged to clear it of any loose surface stone. These loose stones would either be removed completely from the field or piled up in massive stone clearance mounds. This process of field clearance often resulted in the destruction of most, if not all, existing pre-Contact surface structures. Any surface evidence of human activity dating to the traditional period, such as house platforms, field walls or planting mounds, would usually be destroyed, with the exception of those features located on lands not conducive to mechanized agricultural pursuits, such as in gulches and valleys.

In 1911, the Waiākea Mill Company applied for title to several of the lands it leased in Waiākea. This application was rejected by the Board of Public Lands. The Territorial Government, which had acquired control of the former crown lands of Waiākea at the time of annexation, decided than instead of renewing its leases with the Waiākea Mill Company, it would implement a plan of subdividing the land into homestead lots that would be sold and sugar cane lots that would be leased to the public. By the terms of the government contract, the sugar cane grown on the leased lots was to be processed by the Waiākea Mill Company, which would take a share of the profits. As of 1919, a total of 2,003 acres of land within Waiākea had been set aside for house lots and 5,300 acres for leased cane fields (Maly 1996:27-28). These lands were designated as the Waiākea Homestead Lots.

A map of the Waiākea Homestead Lots drafted in 1930 for the Waiākea Mill Company shows the lands of central Waiākea subdivided into numerous house lots set along the old Volcano Road (now Kīlauea Avenue) and larger agricultural lots located further back from it (Figure 26). The present survey areas are all located within the lands subdivided for cane lots (Figure 27). The Waiākea Mill Company still possessed right of ways through these lots for the tracks of their narrow gauge plantation railway that hauled the cut cane from the fields to the mill. The routes of these railway lines also appear on the 1930 map, as do the few established road corridors (Figure 26).

Figure 26. Map of the Waiākea Homestead Lots prepared in 1930 (Arioli and Smith 1930).

Figure 27. Locations of present survey areas overlaid atop the 1930 Waiākea Homestead map.

In examining Figure 27, it is possible to see that branch and spur lines of the sugar railway ran along the northern edge of the Hilo Golf Municipal Course project area (Spur A of Branch Line 5), just west of the Ainalako project area (Branch Line 10), and through the Waiākea Stream and Kupulau Ditch project area (Branch Line 7). Some of these railway lines also appear on a Territory of Hawaii Survey Department map of the Hilo Municipal Golf Course (Figure 28). Following the demise of commercial sugar cultivation in Hilo and the closing of the Waiākea Mill, most of these narrow gauge tracks were dismantled and removed.

Several of the larger roads that presently cut through this portion of Waiākea (e.g., Haihai Street, Ainaola Drive, and Ainalako Drive) can be seen on the 1930 map (Figure 27). One such road can be seen to extend off the present eastern end of Haihai Street and run along the course of the TMK (3) 2-4-036:999 Right of Way. This suggests that the right of way was either planned or in use as of 1930.

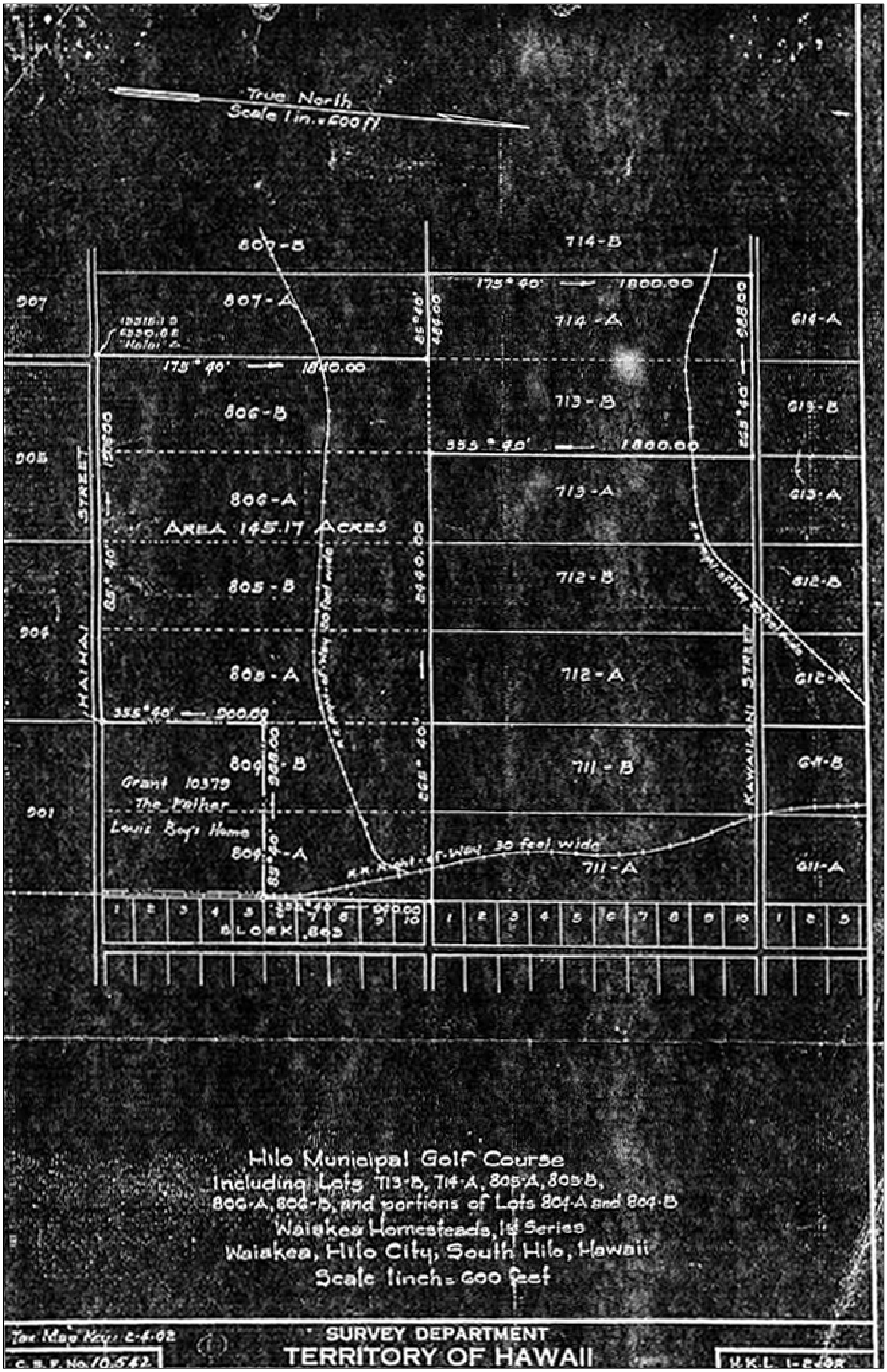

Figure 28. Early map of the Hilo Municipal Golf Course (from Fielder 2005: Figure2).

3.8 RECENT HISTORY

Local *kūpuna* (elders) interviewed during the 2005 Cultural Impact Study recalled that as far back as they could remember, the lands located "above"(west of) Kanoelehua Avenue were occupied by home lots and sugar cane fields, while the area "below" Kanoelehua was forested up until its clearance for Hawaiian Homes Lands (Fielder 2005:14-15). Following the abandonment of sugar production in 1948, the various Waiākea and Palai Streams Flood Control Project survey areas, all of which appear to have been utilized for sugar cane cultivation, were turned to other purposes such as residential and recreational use.

Hawaiʻi County tax records indicate that the Waiākea Mill Company's lease on what was to become the Hilo Municipal Golf Course parcel appears to have expired in 1941 (possibly 1947). The Municipal Golf Course was established in March of 1948 on 146 acres of former sugar cane land. Designed by Willard G. Wilkinson, the course officially opened in 1951 and has been in operation ever since.

4.0 PREVIOUS ARCHAEOLOGICAL INVESTIGATIONS

Although archaeological investigations were undertaken in the district of South Hilo as early as the 1900s (Thrum 1908, Stokes 1991), these surveys concentrated on documenting the area's major religious sites, the majority of which were located near the coast and had been destroyed by development during the previous century. One of the *heiau* (temple) sites identified as once having existed within the *ahupuaʻa* Waiākea is the *heiau* of Kapaieie. In his article on the "Heiau and Heiau Sites Throughout the Hawaiian Islands," published in the *Hawaiian Almanac and Annual for 1908*, Thomas Thrum notes that the *heiau* of Kapaieie was located near Honokawailani, Waiakea," and that it was "famed in the Hilo-Puna wars" (Thrum 1908:40).

It will be remembered that the forces of Kalaniopuʻu ambushed the soldiers of Alapaʻi within the "forest of Paieie" (ʻĪʻī 1959:3-4). The place name Paʻieʻie means "ʻ*ie*ʻ*ie* vine enclosure" (Pukui et al 1974:175) and this enclosure may correspond to the *heiau* of Kapaieie, which can be translated as "the ʻ*ie*ʻ*ie* vine enclosure". Thrum notes that the temple was, "In existence at the time of Byron's visit in the Blonde [1824]. Size and class uncertain" (Thrum 1908:40). He observes that, "Its ruins [were] still to be seen" at the time he was writing. The *heiau* of Kapaieie, Thrum indicates, was located near Honokawailani in the *ahupua*ʻ*a* of Waiākea. The place name Honokawailani may have given itself to Kawailani Street, which runs along the *makai* end of the Hilo Municipal Golf Course (Figure 14). Given these descriptions, it seems likely that the *heiau* of Kapaieie was located in or at the edge of the Panaʻewa forest along or adjacent to the Hilo to ʻŌlaʻa trail. During oral interviews conducted in 2005, local resident Donald Pakele indicated that he believed the site of the Kapaieie *heiau* to be located by the intersection of Kawailani and Komohana streets, west of the Hilo Municipal Golf Course property (Fielder 2005).

Although a number of more recent archaeological investigations have been undertaken within the *ahupua*ʻ*a* of Waiākea, the majority of these have taken place on lands further *makai* than the present study areas (these surveys are summarized in Escott 2013:12-26 and Figure 7). Most of the surface sites encountered during these surveys have been structures associated with historical sugar cane agriculture, such as stacked stone walls, stone clearance mounds, ramped platforms, terraces, enclosures, and railway berms (Hunt and McDermott 1993; Brothwick et al. 1993; Maly et al. 1994; Spear 1993; and Rechtman and Henry 1997).

Only one archaeological survey has been undertaken in areas close to the present survey parcels. This survey was undertaken as part of the previous Palai Stream Flood Control Project (Zulick 2005).

4.1 THE PALAI STREAM FLOOD CONTROL STUDY

In 2005, U.S. Army Corps of Engineers archaeologists conducted a four day archaeological inventory survey of those areas potentially impacted by the proposed Palai Stream Flood Control Project (Zulick 2005). This survey was undertaken to determine the presence or absence of cultural resources within the project area. For this purpose, the Palai Stream Flood Control project area was broken down into three distinct survey parcels (Figure 29).

These included the:

- **Church Parcel**: This parcel, owned by the Roman Catholic Church, is bordered to the north and west by the Hilo Municipal Golf Course, to the south by Haihai Street, and to the east residential lots. The existing Palai Stream drainage runs through the northern portion of this parcel.
- **Spillway**: This area consisted of the existing drainage ditch, which extends from the one-lane bridge on Kīlauea Avenue eastward, ending at a cleared area within the Detention Pond near the drag strip.
- **Detention Pond**: The largest of the survey areas, the approximately 150 acre Detention Pond area was located east of Railroad Avenue between the quarry and the drag strip.

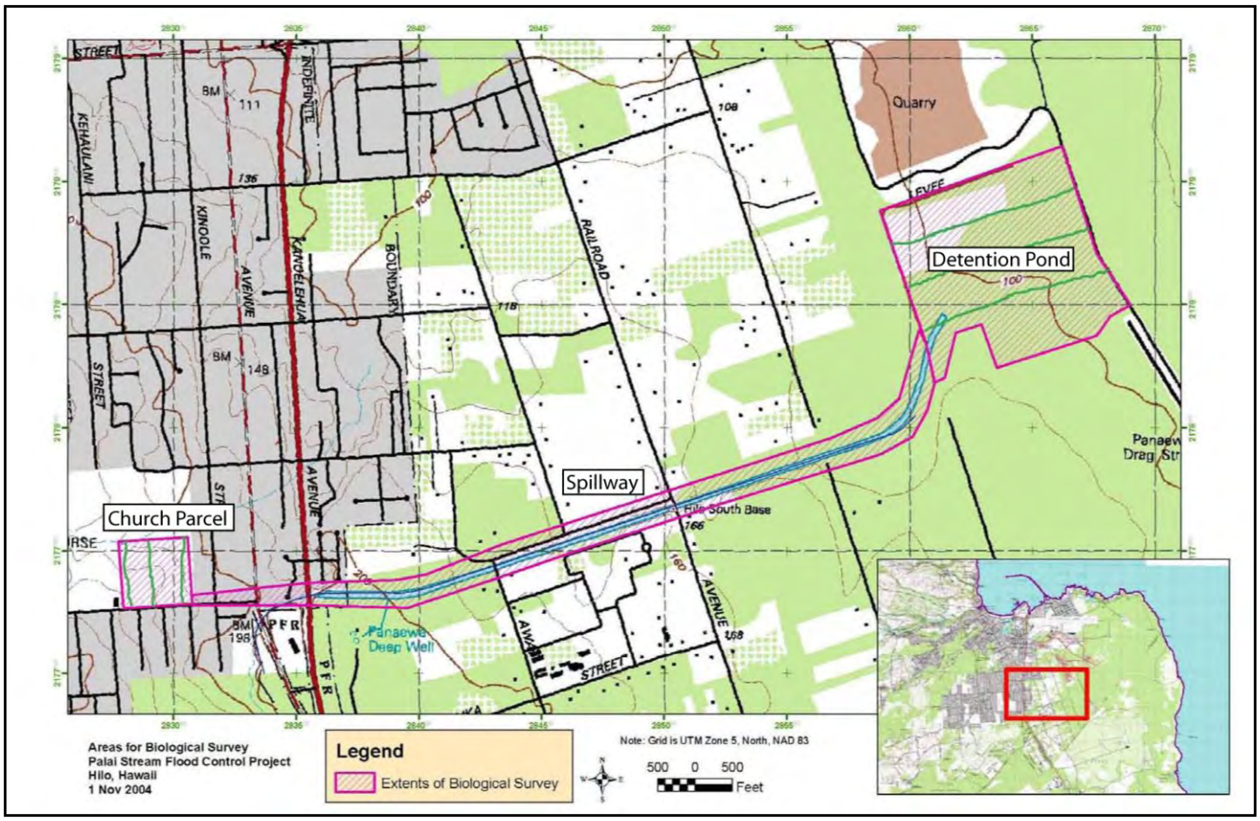

Figure 29. Palai Stream Flood Control Project survey areas (from Zulick 2005:Fig. 1).

A three member field crew conducted 10 meter wide pedestrian transects of the select survey areas.

Church Parcel

A total of three survey transects were walked, covering the western, northern and eastern boundaries of this parcel. Among the archaeological features encountered were what appeared to be the remains of a badly disturbed stone mound situated along the western boundary and an extensive site complex located behind the residential lots along the eastern boundary of the Church Parcel. This complex was comprised of at least six stone mound features ranging in length from 3 to 12 meters, and one 33 meter (110 feet) by 4.75 meter (15½ feet) concrete walled enclosure (Figure 30). Photographs present within the report reveal this to be a large cement pad, probably a structural foundation, with a raised outer lip. Other historic components present within the complex included a cistern, a shed, and fence posts. A number of ornamental plants were found to be growing around the site, which led the USACE archaeologists to suggest that the components of the complex might represent the remains of a historic nursery.

Hawaiʻi County tax records indicate that a plant nursery was built on the Golf Course parcel around 1969, but it appears to have consisted of two cement slab foundations (similar in design to the one identified by the 2005 survey) as well as a work shed and maintenance shop. The design of the building suggests it was not the same structure identified by the 2005 survey.

In 1936, the Roman Catholic Church acquired their present 19.38 acre parcel [TMK (3) 2-4-002:073] located just east of the Municipal Golf Course from the Territory of Hawaiʻi under Grant 10379 for use as a Boy's Home. The property is designated as the Father Louis Boy's Home in County tax records up until 1956. It also appears with that designation on the Territory era map of the Golf Course property (Figure 28). The boundaries of "Grant 10379 Father Louis Boy's Home" as they appear on the Golf Course map match those of the present Roman Catholic Church parcel. The planned Boy's Home was, however, never constructed, and the property has remained undeveloped (Marlene DeCosta pers. comm. 2014).

The structural remains encountered on the Church Parcel during the 2005 survey do not appear to be associated with the Father Louis Boy's Home, since the property was never developed for that purpose. It is possible that the large cement pad and other structural components identified may represent encroachment onto the property from the residential lots to the east.

Spillway

A transect was walked along the bottom and up the banks of the Spillway extended from the one-lane bridge on Kīlauea Avenue eastward, and ending at a cleared area within the Detention Pond by the drag strip (Figure 29). Chain link fences extend along the top of both berms, 20 feet back from the top of the embankment, for almost the entire length of the Spillway. The Spillway crosses under five bridges from Kīlauea Avenue to the Detention Pond.

- Kīlauea Bridge: The bridge itself may qualify as a historic property. Beyond the bridge, a basalt cobble and boulder retaining wall without mortar was noted. This wall was discontinuous and appeared on both sides of the drainage. The retaining walls extend just beyond the "driveway bridge".

- Driveway Bridge: This bridge crosses over the spillway and provides access to a private residence. A ¾ inch galvanized pipe (possible a waterline) was found to hang down below the bridge.

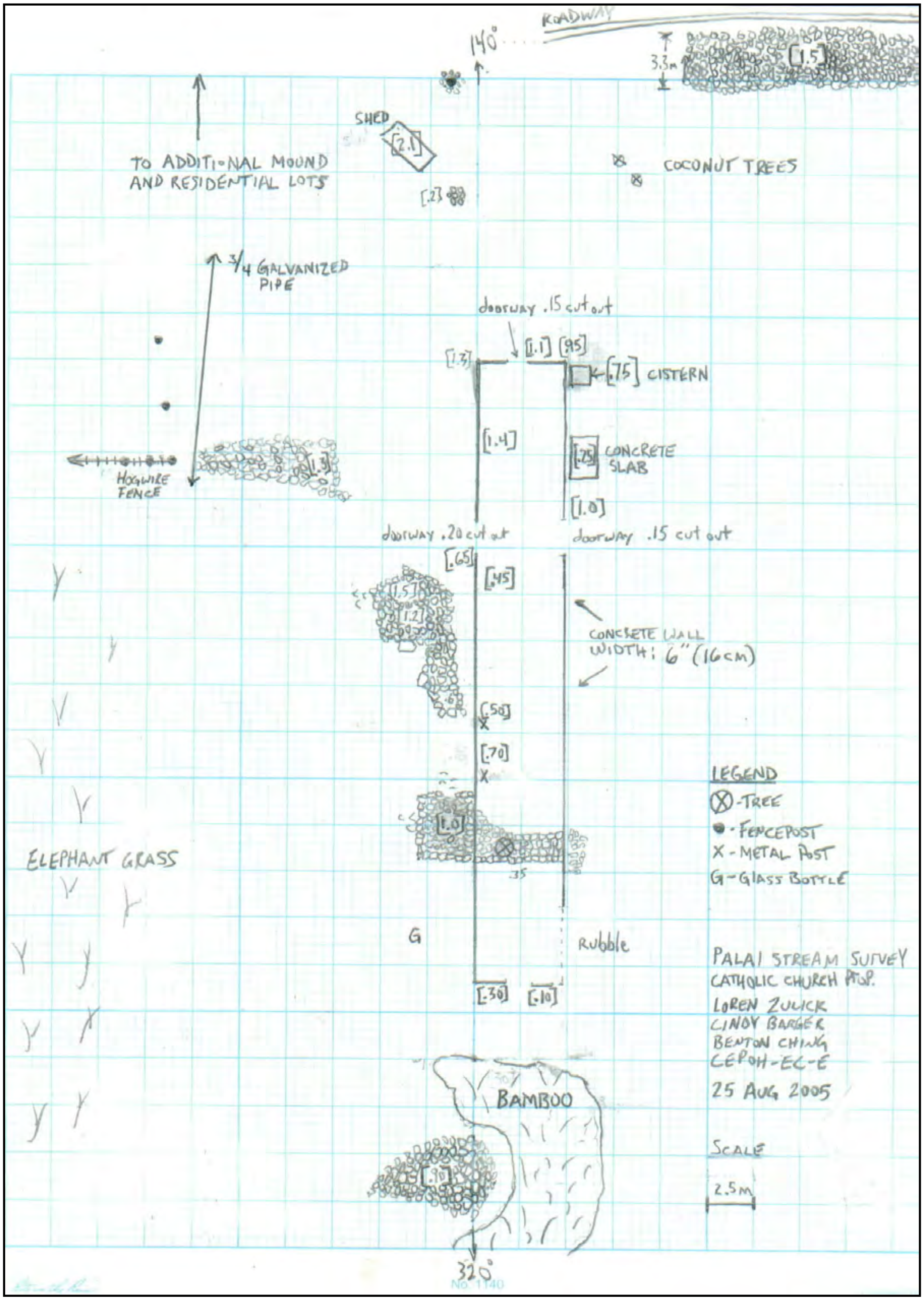

Figure 30. Plan view map of the Church Parcel site complex (from Zulick 2005:Fig. 6).

- Pana‘ewa Bridge: The Pana‘ewa Bridge, which is located on the divided highway of State Route 11, is known to have been constructed in 1976, and is therefore not eligible for listing as a historic property.

- Awa Bridge: The Awa Street Bridge was constructed in 1975.

- Railroad Bridge: The Railroad Avenue Bridge was also constructed in 1975.

Detention Pond

The Detention Pond is located at the eastern end of the Palai Stream Flood Control project area, near the quarry/landfill site and the drag strip (Figure 29). This parcel is approximately 150 acres in size. The density of vegetation made survey difficult, much of the area being covered with ‘*uluhe* (Pacific false staghorn, *Dicranopteris emarginata*) fern. Access was gained through several dirt roadways that led into the area, though these were strewn with modern rubbish. Three survey transects were completed. Aside from the modern rubbish, no cultural materials were observed in the area.

The only structures observed during the 2005 survey were the stone mounds and cement slab foundations located within the Church Parcel. The report identifies these as “traditional Hawaiian style and historic features,” though they appear most likely to be late historic or modern in age. The Spillway parcel appeared to be heavily disturbed during its construction. The only possible historic properties located within the Spillway were the one-lane bridge on Kīlauea Avenue, and the stacked stone retaining walls situated between Kīlauea Bridge and Pana‘ewa Bridge. The levee, the drag strip and the quarry, all located within the Detention Pond parcel, were not considered to represent historic properties. No other cultural resources were identified within the Detention Pond.

The 2005 report recommended that “a follow up archaeological study that includes testing of features and detailed mapping should be performed. This study will help with significance determinations of the features identified. The interior portion of the Church Parcel should be surveyed (it was not surveyed this time because there was no right-of-entry). It is likely that additional features will be uncovered within the interior. Areas where ground disturbing activities will occur within the Detention Pond should be identified. Once identified, additional survey of those areas could be performed. Archaeological monitoring of ground disturbing activities should be considered for those areas where vegetation is so dense that the ground cannot be observed” (Zulick 2005:3).

None of the present project areas were covered by the 2005 survey, whose efforts were focused east of the Hilo Municipal Golf Course levees and detention basin (Figure 31).

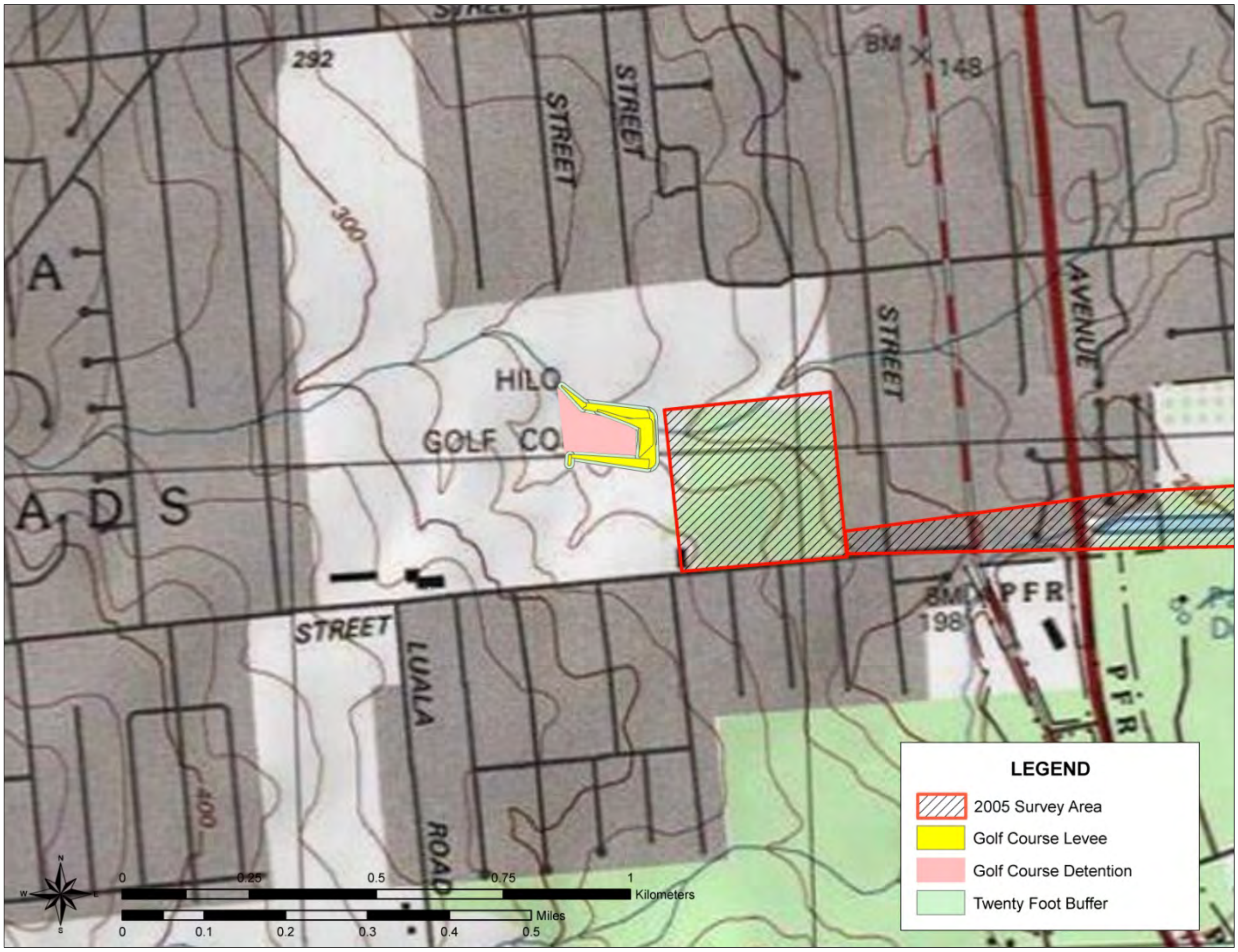

Figure 31. Comparative locations of the 2005 and present Hilo Municipal Golf Course survey areas (base map USGS Hilo quadrangle).

4.2 Anticipated Findings

Based upon the results of historic research and previous archaeological investigations, it was expected that little in the way of either traditional or early historic surface remains were likely to be encountered during the current survey. Historic maps indicate that the lands of central Waiākea, including the present project area, have been significantly modified by late historic agricultural activities. It seemed likely that whatever traditional Hawaiian structures may once have existed in the area were destroyed during the sugar cane era.

The possibility existed that historic features associated with the later use of the area might be encountered. Although it appeared unlikely that any evidence of the narrow gauge sugar cane railway lines whose tracks once ran through the survey areas has survived, an effort was made during the current survey to trace out these lines and examine the terrain for any landscape modifications such as raised embankments, cuts, or other earthworks, as well as any associated railroad or plantation era features.

Ethnohistoric evidence suggests that during the pre-Contact and early historic periods the present project area consisted of a modified landscape of open grasslands, tended garden plots and scattered residences (see Section 3.4). Despite the extensive disturbance that occurred throughout the area during the later historic period, the possibility existed that some remnant subsurface cultural deposits may have survived within the APE of the current project. The surface structures that would originally have been associated with these subsurface deposits were most likely destroyed during the period of sugar cane cultivation. Dragging and furrowing associated with the planting of cane would also have disturbed the upper levels of the soil. As a result, what subsurface deposits may survive would be remnant and difficult to locate without extensive excavation.

5.0 SURVEY METHODS

The archaeological fieldwork for the archaeological investigation of the Waiākea and Palai Streams Flood Control Project was undertaken in July and August of 2015. The survey was under the overall supervision of Principal Investigator Paul Cleghorn, Ph.D. Field operations were directed by Rowland Reeve, M.A., who was assisted by Ms. Aleksandra Helminiak, M.A.

5.1 SURVEY

A comprehensive pedestrian survey was conducted of each project area to ensure that any archaeological features present were located and identified. Systematic transects were walked by the two members of the archaeological field crew spaced between 5 and 10 meters apart, depending upon the density of the vegetation.

Those properties for which Rights of Entry had not been obtained were, when possible, observed and photographed from adjoining parcels. Based upon these observations, assessments were made as to the conditions of the properties and the likelihood of the presence or absence of archaeological features (see Section 6.0). These assessments could not, however, be field checked. As a result, it could not be conclusively determined that these properties did not contain archaeological features.

As no archaeological sites were observed or identified during the current archaeological survey (see Section 6.0), none of the detailed recording measures presented in the project Work Plan (Reeve and Cleghorn 2014:46-48) needed to be implemented. The currently proposed flood control project alternatives do not include the Roman Catholic Church parcel previously surveyed in 2005 (see Section 4.1). For this reason, the archaeological testing of four to six of the stone mounds, identified by the 2005 survey to determine if they contained human remains, as proposed in the Archaeological Work Plan (Reeve and Cleghorn 2014:47), was not carried out. Since no suitable archaeological sites were identified during the survey, no subsurface test excavations were undertaken.

5.2 CURATION

All field records (descriptions, notes and photographs) resulting from the inventory survey have been temporarily housed in the Pacific Legacy Kailua, O‘ahu office. These will be transferred to the USACE once the archaeological survey report has been fully approved.

6.0 FINDINGS

None of the project areas surveyed were found to contain any surface archaeological features. It became apparent upon examination that each of these project areas had, during either the period of sugar cane cultivation or more recently, been subject to ground disturbing activities (see Section 2.3). This ground disturbance has resulted in the obliteration of any pre-Contact or historic surface archaeological remains, if any once existed.

6.1 WAIĀKEA STREAM AND KUPULAU DITCH

The Waiākea Stream and Kupulau Ditch project area was the most complex in terms of the types of flood control measures to be constructed and the number of properties to be impacted (Figure 4 and Figure 10). A comprehensive surface survey was undertaken of all properties with the exception of TMK (3) 2-4-065:036, for which Rights of Entry had not been obtained. Due to the variation in vegetation and land use between these various properties, each of the parcels will be addressed separately below.

TMK (3) 2-4-065:035

Only a small portion of this property, where it borders the eastern bank of the Waiākea Stream will be impacted by flood control construction activities. Alternate 2 would involve the erection of an earthen levee, approximately 4 feet in height along the eastern bank of Waiākea Stream with a detention pond outlet at the southwest corner of the property (Figure 4). This portion of the TMK (3) 2-4-065:035 property shows signs of having been graded and leveled (probably at the time the house was constructed) with a very low earthen berm (less than 30 centimeters in height) running along the stream edge. This berm is presently heavily vegetated with elephant grass (*Pennisetum purpureum*), and yellow ginger (*Hedychium flavescens*). The area was walked and no evidence of any archaeological surface features or exposed subsurface deposits were observed.

TMK (3) 2-4-065:036

Rights of Entry were not obtained for this property. It was, however, possible to observe much of the property from the southern edge of the adjoining TMK (3) 2-4-065:035 parcel. The eastern bank of Waiākea Stream, which is proposed for the construction of an earthen levee, is relatively level with only a slight soil rise along the bank. It is presently vegetated by a planted row of mature *ʻohe (*bamboo, *Bambuseae spp.*), *maiʻa* (banana, *Musa paradisiaca*), and *niu* (coconut, *Cocos nucifer*) trees with very little ground cover (Figure 33).

The western half of this property has been identified as the possible site of a detention basin with an earthen containment levee forming its eastern edge (Figure 4). Aerial photographs indicate that this area was once tilled for cultivation (Figure 4). Observation from the adjoining parcels indicates that the land is now fallow and covered in low weeds with open patches of soil (Figure 34). It appears to have been both leveled and tilled. No surface archaeological features were observed, though the area was not directly surveyed.

Figure 32. Eastern bank of the Waiākea Stream within TMK (3) 2-4-065:035 (view northeast).

Figure 33. Eastern Bank of the Waiākea Stream within TMK (3) 2-4-065:036 (view south).

Figure 34. The western portion of TMK (3) 2-4-065:036 as seen from the Waiākea Stream (view east).

TMK (3) 2-4-065:003

A culvert with a cement box is planned for the intersection of Waiākea Stream and Kupulau Ditch within TMK (3) 2-4-065:003. This area is heavily overgrown with high grass and ferns (Figure 35). It was surveyed, but no archaeological features were observed.

Figure 35. Intersection of Waiākea Stream and Kupulau Ditch (view southwest).

TMK (3) 2-4-036:999

The linear and relatively narrow property that is TMK (3) 2-4-036:999 has been designated for an access road into the construction area from Kupulau Street (Figure 4). At present, this property is covered in head high elephant grass (*Pennisetum purpureum*) (Figure 36). A survey was made of the parcel and no archaeological features were encountered. It would appear that this property was graded for use as a road corridor, possibly as early as 1930 (see Section 3.7 and Figure 27).

Figure 36. TMK (3) 2-4-036:999 access corridor (view northwest).

TMK (3) 2-4-036:001

A portion of the New Hope Church property (TMK (3) 2-4-036:001) is intended to serve as a construction staging area (Figure 4). The entire area was surveyed and no archaeological features were observed. The area showed signs of having recently been grubbed. It is currently covered in low grass and weeds.

Figure 37. The proposed Waiākea Stream and Kupulau Ditch staging area (view south).

Another portion of the New Hope Church property, which is now an ball field, is planned to serve as a detention basin with an approximately 6.7 foot high earthen containment levee running along its eastern edge. The proposed detention basin covers portions of both TMK (3) 2-4-065:035 and TMK (3) 2-4-036:001 (Figure 4). The New Hope Church playing field is relatively level, open, and carpeted in mown grass (Figure 38). When compared to the adjacent staging area, the ball field appears to have been both filled with soil and leveled. No archaeological features were noted in either this area, or on the entire New Hope Church property.

An examination of the routes of the various narrow gauge sugar plantation railway lines as shown in the 1930 map of the Waiākea Homestead Lots (Figure 27) indicates that Branch Line 7 formerly crossed diagonally through the present New Hope Church ball field. The former presence of this branch railway line was taken into consideration during the archaeological field survey of the area and an effort was made to identify any traces of it. No physical evidence of the former Branch Line 7 was observed. It appears that the tracks were dismantled and removed at some time prior to the establishment of the ball field.

The portion of the New Hope Church property that forms the eastern bank of the Kupulau Ditch as also examined. A floodwall is planned to be erected along this bank of the ditch in the area south of the ball field (Figure 4). As with most of the remainder of the property, this area appears to have been graded and leveled (Figure 39 and Figure 40). No surface archaeological features or exposed subsurface archaeological deposits were noted.

TMK (3) 2-4-035:003

The proposed Kupulau Ditch floodwall is intended to extend south into the TMK (3) 2-4-035:003 property (Figure 4). This bank of the ditch was surveyed and found to have been graded. In places there is evidence of bulldozer push along the bank. No surface archaeological features or exposed subsurface archaeological deposits were observed within this parcel.

Figure 38. Ball field north of the New Hope Church that will be the site of the proposed detention basin (view southeast).

Figure 39. Eastern bank of the Kupulau Ditch within the New Hope Church property (view north).

Figure 40. Eastern bank of the Kupulau Ditch within the New Hope Church property (view south).

Figure 41. Eastern bank of the Kupulau Ditch within TMK (3) 2-4-035:003 (view south).

6.2 Hilo Municipal Golf Course

The Hilo Golf Course project area is located in the center of the Municipal Golf Course where two small watercourses, feeding in from the south and west, join into a single easterly flowing watercourse. The proposed modifications to this area will consist of a roughly U-shaped earthen levee framing a central detention basin (open to the west) with water flowing out a culvert set along the eastern edge of the levee (Figure 6).

A comprehensive surface survey was made of the entire area of potential effect. The full extent of the project area appears to have been landscaped as part of the construction of the Hilo Golf Course. Much of the APE is vegetated in manicured grass and scattered shade trees. Toward the center of the basin is an area of thicker vegetation that consists of mature shower (*Cassia spp.*) and African tulip (*Spathodea campanulata*) trees with an understory of mixed introduced shrubs (Figure 42). This area has also been used as a dumping ground for cut logs and other green waste from the Golf Course.

Figure 42. Hilo Municipal Golf Course project area (view northwest).

Interestingly, this vegetated area was found to contain much less soil than the surrounding greens and several areas of exposed *pāhoehoe* lava bedrock were encountered. A detailed examination of this area revealed no surface archaeological features or exposed subsurface deposits.

Early historic maps of Waiākea suggest that the traditional trail from ʻŌlaʻa to Hilo may have run close to the Hilo Municipal Golf Course. An effort was therefore made during the present survey to search for any remaining evidence of this pre-Contact walking trail. No evidence of the ʻŌlaʻa to Hilo trail was found.

6.3 AINALAKO

The Ainalako flood control measure consists of a pair of adjoining levees, an adjacent constructed swale and a detention basin located within the triangular area framed by the two levees (Figure 12). The APE for the Ainalako project area includes three adjacent residential properties and an area of relatively open grassland immediately north of them (Figure 13). All of these properties are privately owned land and right-of-entry was required to survey them. No official right-of-entry was acquired prior to the field survey.

During the field survey, although it was not possible to directly investigate any of the Ainalako properties, it was possible to observe and photograph them from Ainalako Road. Descriptions of the various parcels are provided below.

TMK (3) 2-4-030:001

The largest of the four potentially impacted properties (approximately 5 acres, Figure 13 and Figure 19), this parcel presently consists of an open field of high grass and weeds with a few scattered shade trees (Figure 43 and Figure 44). The property is relatively level and prone to flooding during heavy rain events. Although Pacific Legacy archaeologists were not able to enter the property, they were able to speak with Mr. Morgan Leopoldino who leases the parcel from its present owners and runs cattle on it. Mr. Leopoldino stated that he had never observed stone walls, mounds, or any other potential archaeological structures on the land. The parcel had formerly been planted in sugar cane and appeared to have been graded at some time in the past. Based upon observations from the adjoining road, and from Mr. Leopoldino's remarks, it would appear likely that TMK (3) 2-4-030:001 has been the subject of ground disturbing activities and that no surface archaeological remains survive on the property. This, however, could not be directly confirmed.

Figure 43. TMK (3) 2-4-030:001 as seen from its northwestern corner along Ainalako Road (view southeast).

Figure 44. TMK (3) 2-4-030:001 as seen from its southwestern corner along Ainalako Road (view east).

TMK (3) 2-4-081:006, 007 and 011
These three adjacent parcels, which mark the southern boundary of the proposed project area, are each presently in residential use (Figure 13). The proposed flood control structures would occupy their northern halves. The northern half of TMK (3) 2-4-081:006 (the easternmost parcel, which is visible from the cul-de-sac) is undeveloped and covered in mixed grass, shrubs and trees (Figure 19). A small watercourse crosses through this portion of the property before continuing into the adjacent TMK (3) 2-4-081:007. The northern half of TMK (3) 2-4-081:007, which is not visible from any roads, shows on aerial photographs as being somewhat similarly undeveloped, though portions of it have evidently been the subject of ground disturbing activities (Figure 19). The property has, however, recently been purchased and is under development for a private residence. The northern half of TMK (3) 2-4-081:011 is similarly undeveloped. Those portions visible from the adjacent Ainalako Road, however, show evidence of grading and leveling (Figure 45). Although it would appear likely that no surface archaeological features have survived on any of these three properties, it was not possible to confirm this through detailed physical inspection.

Figure 45. TMK (3) 2-4-081:011 as seen from Ainalako Road (view east)

7.0 SUMMARY AND DISCUSSIONS

The archaeological investigations conducted for the Waiākea and Palai Streams Flood Control Project did not reveal the presence of any surface archaeological features or exposed subsurface deposits. Each of the proposed project areas shows evidence of having been either grubbed or graded and leveled at some time in the past. Given the history of the area, it is likely that much of the area was dragged to remove surface stones prior to its being converted to sugar cane fields in the late 1800s (see Section 3.7.1). More recently, individual parcels have undergone additional ground disturbing activities as they have been turned to residential or other uses. The condition of each of these project areas and their components parcels have been described in detail in Sections 2.2, 2.3 and 6.0.

Any surface pre-Contact archaeological sites which may have once existed in these project areas appear to have been obliterated by more recent land use. Studies of the ethno-historic literature (see Section 3.4) indicate that in the late pre-Contact and early historic periods this portion of Waiākea consisted of open grassland with scattered houses and cultivated fields (McEldowney 1979). The evidences of this former land use were most likely destroyed when the land as converted to commercial sugar cane cultivation. Any archaeological features dating from the plantation period, such as the narrow gauge railway line running through the New Hope Church property (see Section 6.1), appear to have been removed by more recent land modifications.

The research questions developed and presented in the Archaeological Work Plan (Reeve and Cleghorn 2014:50-51), which had been developed based upon ethno-historical evidence and previous archaeological surveys, are addressed below. This is followed by discussion of Traditional Cultural Properties and visual impacts.

7.1 Do Any Remnants Survive Of The Traditional ʻŌlaʻa To Hilo Trail?

Early historic maps of Waiākea suggest that the traditional trail from ʻŌlaʻa to Hilo may have run close to the Hilo Municipal Golf Course. The 1851 map appears to show the trail alignment as passing just east of the Golf Course project area (Figure 23). An undated later map (Figure 24 and Figure 25) shows the road alignment as running further east along the route of the present Kīlauea Avenue (or Kinoʻole Street). No evidence of the traditional trail was observed during the present survey. It is probable that all traces of the original footpath trail were destroyed during the historic period. The trail was most likely overlain by the old Volcano Road, which eventually became Kīlauea Avenue.

7.2 Do The Survey Areas Contain Any Surviving Features From The Sugar Era?

The large scale commercial cultivation of sugar cane tends to destroy the surface physical evidence of any land use activities that have taken place before it. For this reason, it was not expected that the present survey would encounter any surface features dating to the pre-

Contact or early historic periods. However, the sugar era was itself a significant historic event and remnants dating from that era (stone walls, clearance mounds, irrigation ditches, labor camps, narrow gauge railway lines, etc.) have been found within the Waiākea area (see Section 4.0). During the current survey an effort was made to locate any plantation era remains that might still survive within the survey area. None were found.

The map of the Waiākea Homesteads dating from the 1930s (Figure 27) reveals that the area of central Waiākea was at that time crisscrossed by main, branch and spur lines of the Waiākea Mill Company's narrow gauge sugar railway. This rail line carried the cut cane from the fields to the mill at Wailoa Pond. An effort was made during the present survey to examine the identified railway alignment (Branch Line 7) that crossed through the Waiākea Stream and Kupulau Ditch project area to see if any traces of the former rail line remained. None were found. It seems likely that the original track was removed following the closing of the Waiākea Mill in the 1940s. Any foundation features, such as a railway berm, if it existed, appears to have been destroyed by the ground disturbing activity associated with the church ball field.

7.3 ARE THERE ANY NON-SUGAR RELATED HISTORIC STRUCTURES PRESENT WITHIN THE SURVEY AREAS, AND IF SO, WHAT IS THEIR TRUE AGE?

An attempt was also be made during the current survey to search for and document any structures dating from the historic period (over 50 years of age) that are not related to the cultivation of sugar cane. None of these were found.

The cement pad and associated features identified during the 2005 archaeological survey along the eastern edge of the Roman Catholic Church parcel (see Section 4.1) are located outside the present project areas and were therefore not examined during the current study. The same was true for the large stone mounds documented by the 2005 survey in the same area.

7.4 TRADITIONAL CULTURAL PROPERTIES

In preparing the previous Cultural Impact Study for the Waiākea and Palai Streams Flood Control Project a number of factors were taken into consideration. Among these are the potential impacts of the project on any archaeological remains located within the proposed project APEs, its impacts to potential Traditional Cultural Properties (TCPs) located in the broader area, and the project's effect upon any traditional gathering practices conducted in the area. The 2005 Cultural Impact Study for the Palai Stream Flood Control Project (Fielder 2005) addressed the question of TCPs, as well as traditional gathering practices (see Section 1.2). The combination of archival research and oral interviews with knowledgeable individuals undertaken as part of the 2005 study failed to identify any TCPs in the vicinity of the project area, nor did this research identify any traditional cultural practices that might be impacted by the proposed project (Fielder 2005:11). The archival research conducted as part of the present archaeological study supports this previous research. The only two potential Traditional Cultural Properties that could be identified from ethno-historic accounts were the *heiau* (temple) of Kapaieie (see Sections 3.2 and 4.0) and the traditional ʻŌlaʻa to Hilo trail (see Section 3.3). The location of Kapaieie *heiau* is unknown and the structure, the ruins of which could still be seen in 1907, may no longer be extant. Evidence, in the form of historic maps, suggests that the old trail from ‘Ōla‘a to Hilo may lie beneath the present Kīlauea Avenue. The present archaeological study has also determined that there are no surviving surface archaeological features within the investigated sections of the APEs for the three proposed project areas.

7.5 CONSIDERATION OF VISUAL IMPACTS

Consideration has also been given to any possible visual impacts that the proposed flood control project may have on the surrounding cultural landscape. An area of half of a mile around each project area was considered as the potential area of impact (Figure 46), and ethno-historic research was employed to identify significant cultural sites within this area. As mentioned above, only two potential Traditional Cultural properties were identified in the area, the exact locations of which are uncertain. The half mile buffer for the Hilo Municipal Golf Course project area just overlaps a portion of Kīlauea Avenue, which may correspond to the route of the traditional ‘Ōla‘a to Hilo trail. None of the half mile buffer zones overlap the intersection of Kawailani and Komohana streets, which was suggested by local resident Donald Pakele as being the location of the Kapaieie *heiau* (see Section 4.0).

The components of the proposed flood control alternatives are all relatively low elevation structures. The highest feature being considered is the 5.6 foot floodwall to be erected along the eastern bank of the Kupulau Ditch. Given the location of the three proposed flood control alternative project areas, their position at low points in the terrain, and the relative height of the vegetation surrounding them, it is unlikely that any of their component structures will be visible more than 1,000 feet distance. The visual impact of these structures will therefore be minimal, and will be less intrusive than most of the structures surrounding them.

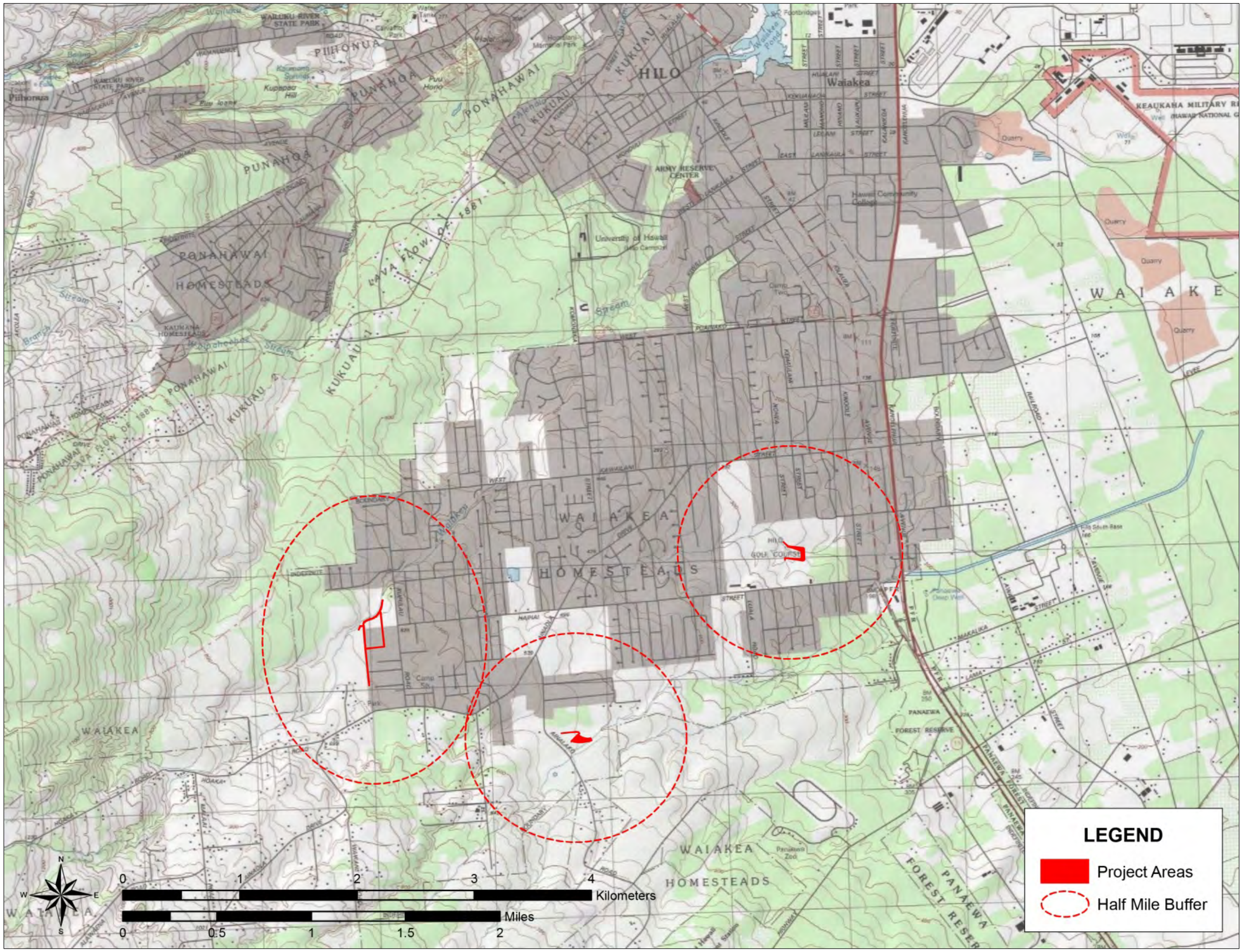

Figure 46. Half mile visual buffers surrounding the three proposed project areas (base USGS Hilo quadrangle).

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Pacific Legacy

Incorporated

CULTURAL RESOURCES CONSULTANTS

CULTURAL IMPACT STUDY (CIS) FOR THE PALAI STREAM FLOOD CONTROL PROJECT HILO, HAWAII

(Contract DACA83-00-D-0012/0081)

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U.S. Army Engineer District

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Fort Shafter, Hawaii 96859-5440

2005

ABSTRACT

A Cultural Impact Study was undertaken by Pacific Legacy for Wil Chee – Planning and Environmental under contract to the U.S Army Corps of Engineers for the Palai Stream Control Project in Hilo on the island of Hawai`i (Contract DACA83-00-D-0012/0081). This study consisted of archival research and oral history interviews with the aims of:

1. identifying potential Traditional Cultural Properties (TCPs) in the area; and
2. identifying issues that may be of concern for people conducting traditional activities in the area.

Archival research and oral interviews with knowledgeable persons failed to identify any traditional cultural properties in the vicinity of the project area nor did this research identify any traditional cultural practices that might be impacted by the project. Hence the project will not have any adverse affect on traditional cultural practices in the area.

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1.0 INTRODUCTION

This Cultural Impact Study (CIS) was undertaken by Pacific Legacy for Wil Chee Planning and Environmental under contract to the U.S. Army Corps of Engineers (Contract DACA83-00-D-0012/0081). The data gained from this project are to be used to prepare an Environmental Assessment (EA) for the Palai Stream Flood Control Project, a U.S. Army Corps of Engineers (USACE) project (Figure 1).

The project is described as follows:

> The proposed channel alignment would begin at the Hilo Golf Course where the Palai Stream flows would be diverted into an unlined open channel. The unlined open channel configuration will be maintained for 1,400 lineal feet along the perimeter of the Hilo Golf Course until it reaches Haihai Street. Once there, the flow discharge would be conveyed through a 1,000 lineal foot underground box culvert until it reaches the Kanoelehua Avenue Bridge. After that the flows would be combined with other flows in the Waiakea-Uka Flood Control Channel (SOW: 2004:1).

The CIS was conducted in compliance with Section 106 of the National Historic Preservation Act of 1966, as amended, and it's implementing regulations 36 CFR 800. The primary purpose of the CIS is to:

- identify potential Traditional Cultural Properties (TCPs), and
- identify issues that may be of concern for a cultural impact assessment (CIA) of the proposed project area.

Traditional Cultural Properties for this study are defined as:

> A property rooted in that community's history and is important for maintaining the cultural identity of that community. The property must be tangible and have an integral relationship to traditional practices or beliefs. The property must be in a condition such that the relevant relationship survives (Parker and King, 1998: 6-14).

This CIS includes summary data compiled from archival and record searches of the following repositories:

- Hawaii State Archives
- State Historic Preservation Division Library
- University of Hawaii Library
- Bishop Museum Library
- Lyman Museum
- State Public Library

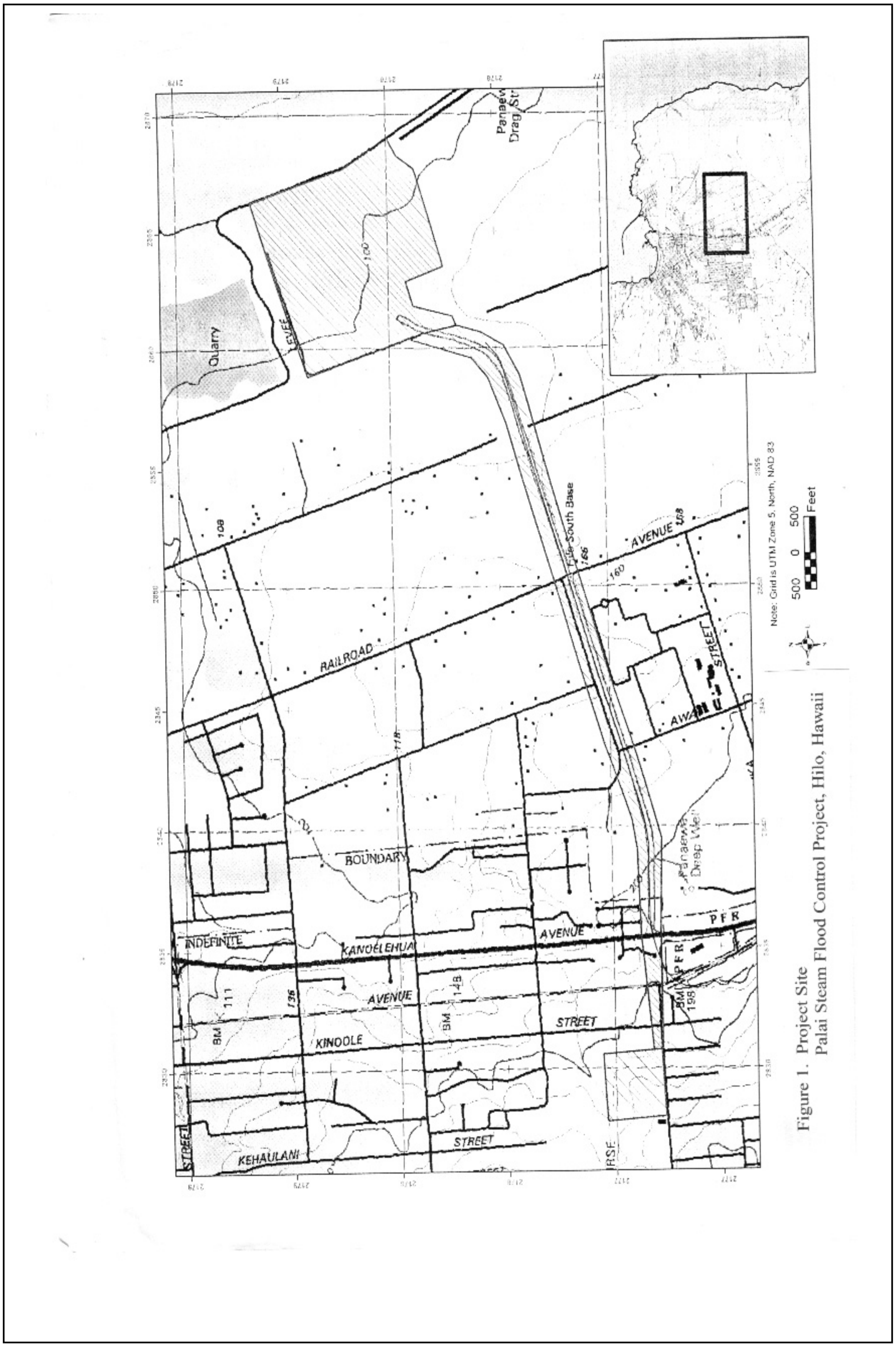

Figure 1. Location of Palai Stream Flood Control Project

Accounts of personal experiences and knowledge about TCPs in and traditional uses of the proposed project area were obtained from Native Hawaiians, as well as, other sources identified by the community as having information on the traditional uses of the proposed project area.

The list of interviewees, points of contact and other sources of traditional information was corroborated closely with the USACE environmental technical staff for review prior to field research.

2.0 ARCHIVAL RESEARCH SUMMARY

This section is a summary of archival data of Native Hawaiian traditional cultural practices, and traditional cultural places in the project area and in the general Hilo vicinity.

2.1 HISTORICAL BACKGROUND

The traditional land divisions fronting Hilo Bay are the *ahupua`a* of Pu`u`eo, Pi`ihonua, Punahoa, Ponahawai, Kukuau, and Waiakea. The project area is located in the *ahupua`a* of Waiakea.

The *ahupua`a* of Waiakea is one of the largest *ahupua`a* in all the islands (Maley 1996:5) and has a significantly rich history. The natural setting and the abundant resources (fresh water, marine and forest products, expansive arable land) made the Waiakea *ahupua`a* desirable property for the Hawaiian royalty. Waiakea became a powerful political center on the island. As summarized by Kelly et al. (1981) cultural activities documented to have taken place in Hilo were described by Samuel Kamakau (1961). Taken at face value, it establishes the early residence of the Hilo chiefs at Waiakea, and describes the gathering of the chiefs and people at night on the beaches—in this instance Ka nuku o kamanu on the western side of the Wailoa river- to amuse themselves with hula dancing, chanting, and the playing of games calling for forfeits of entertainment or sexual favors (1961: 15-17).

The *ahupua`a* of Waiakea was divided into smaller political units called *`ili* or *`ili kupono* -- Pana`ewa, Pu`ainako, Keaukaha, Kawili, Kaleplepo, Pi`opi`o, Mohouli, and Kalanakama`a (Maley 1996:5). *`Ili* Pi`opi`o was the home of legendary chiefly lineage going back to Umi, son of Liloa (supreme chief of the island) during the 16th century and spanning through time to Kamehameha. It was the quest of Umi to unify the island, which involved taking the Hilo chiefdom of Kulukulu`a, who lived at Waiakea (Kelly et al. 1981). It is said that the descendants of Umi created two ruling lines, the “Hilo” and “Kona” chiefs. Kalani`opu`u became victor of these two warring lines and took up residence at Pi`opi`o with his nephew Kamehameha for some time (Kelley et al. 1981).

The site of the Palai Stream Flood Control Project is in the *`ili* of Pana`ewa on the eastern boundary of *ahupua`a* Waiakea. Events of particular significance to the study include battles fought by both Kalani`opu`u and Kamehameha which can be assumed to have happened in *`ili* Pana`ewa.

Maley (1996:9) cites events in *ahupua`a* Waiakea from I`i (1959) which can be assumed to have happened in close proximity to the project site:

> Alapai, ruler of Hawaii (from c. 1730-1754) and great uncle of Kamehameha, and his wife Keaka took charge of him (Kamehameha). Some years later, Alapai and his chiefs went to Waiolama in Hilo, where Keoua Kupuapaikalani, father of Kamehameha, was taken sick and died. Before Keoua died he sent for Kalaniopuu, his older half brother and the chief of Kau, to come and see him. Keoua told Kalaniopuu that he would prosper through Kamehameha's great strength and asked him to take care of the youth, who would have no father to care for him. Keoua warned Kaniopuu, saying, "Take heed, for Alapai has no regard for you or me, whom he has reared." After this conversation, Keoua allowed his brother to go, and Kalaniopuu left that night for Puaaloa [situated in the *ahupua`a* of Waiakea, in the area called Pana`ewa].
>
> As Kalaniopuu neared Kalanakamaa [in Waiakea], he heard the death wails for Keoua and hastened on toward Kalepolepo [between Mohouli and Kawili] where he had left his warriors. There they were attacked by Alapai's men, who had followed Kalaniopuu from Hilo. First the warriors from the lowland gained, then those from the upland… Kalaniopuu continued his journey and at midnight reached Puaaloa, where he arranged for the coming battle. The next day all went as he had planned, his forward armies led the enemy into the forest of Paieie, where there was only a narrow trail, branchy on either side and full of undergrowth. There his men in ambush arose up against the enemy warriors, and his rear armies closed in behind them.. (I'i 1959:3-4)

Of the same event, Kamakau writes that the war between Alapa`i and Kalani`opu`u started over Kalani`opu`u's attempt to take custody of the young Kamehameha as his father had wished. The war started at Kalepolepo with subsequent battles fought at Pa`ie`ie and Pua`aloa (Kamakau 1961:75).

One of the battles Kamehameha fought and lost in his quest to rule the island was also in Pana`ewa. Kamakau describes the battle to have taken place on Kamehameha's travel between Kau and Hilo "…just out of Pana`ewa at a place called Pua`aloa, he met with a war party of Kahekili…" (Kamakau 1961:125).

2.2 HISTORIC RESOURCE AND LAND USE

Description and insights into early resource and land use practices and activities is provided by McEldowney's study of 1979. McEldowney reviewed and summarized historical documents to develop a classification of environmental zones categorized by general patterns of land use. The environmental land use zones are – I: Coastal, II: Upland Agriculture, III: Lower Forest, IV: Rainforest, and V: Sub-Alpine. The project area falls in Zone II of McEldowney's scheme of resource and land use classification:

> Zone II Upland Agricultural Zone
>
> Although estimates as to the extent of this zone vary in early journal accounts, most confirm an expanse of unwooded grasslands or a 'plain' behind Hilo . . . [The zone is characterized by] scattered huts, emphasized by adjacent garden plots and small groves of economically beneficial tree species, dotted this expanse up to 1,500 ft elevation (i.e. the edge of the forest). The cumulative effects of shifting agricultural practices (i.e., slash-and-burn or swidden), prevalent among Polynesian and Pacific peoples, probably created and maintained this open grassland mixed with pioneering species and species that tolerate light and regenerate after a fire .
>
> This open but verdant expanse, broken by widely spaced "cottages" or huts, neatly tended gardens, and small clusters of trees… Estimates as to the extent of this unwooded expanse . . . [fall] between four or five miles.
>
> The constituents of gardens and tree crops in the village basically continued in the upland except that dry-land taro was planted more extensively and bananas were more numerous. Wet or irrigated taro occurred along small streams, tributaries, and rivers . . .
>
> This same pattern occurred between Waiakea Pond and the Pana`ewa Forest in the four or five miles of open country dominated by tall grasses. Here stands of *kukui* (*Aleurites molussana)*, pandanus, and mountain apple became more conspicuous, with large areas of dryland taro planted in rocky crevices… (McEldowney 1979:18-20).

Handy and Handy (1972) add the following description of the upland agricultural zone of *ahupua`a* Waiakea in the vicinity of the project site:

> On the lava strewn plain of Waiakea and on the slopes between Waiakea and Wailuku River, dry taro was formerly planted wherever there was enough soil. There were forest plantations in Pana`ewa and in all the lower fern-forest zone above Hilo town…(Handy and Handy 1972:539)

Although Upland Agriculture or Zone II best characterizes the study area, all zones were exploited for their resources by the early Hawai`ians. The following is a brief description of resources exploited in the other zones (McEldowney 1979:14-30):

> Zone V-Sub-Alpine: hard woods and adz quarries
>
> Zone IV-Rainforest: culturally important bird species
>
> Zone III-Lower Forest: woods for homes, *olona* and *`ie `ie* fiber for cordage and basketry, *mamaki* for tapa, banana, plantains, taro, yams planted along streams and in small forest clearings, *koa* trees to make war canoes for which the

Hilo chiefs were famous in ancient times

Zone I-Coastal: conducive to irrigated taro cultivation and use of aquatic
Resources (rivers, fishponds and marine)

It should be noted that the descriptive characteristics of the zones are representative of and not exclusive to them. For example, Zone II was planted to the same crops as the lower Coastal settlement zone, except that dry land taro was more likely cultivated than the wet land varieties (Kelly et al: 1981:7):

2.3 TRADITIONAL CULTURAL PLACES

Written records consulted (Kelly et al. 1981:11-13, Hurst and Cleghorn 1991) indicate that the general area of Hilo abounds in potential TCPs. These TCPs include the royal ponds and natural cinder cones.

The fishponds were spring fed inland fishponds or *loko pu`one*. These ponds consist of:

- Ho`akimau or Pi`opi`o (*`ili* name) (Bishop Museum Site No. 50-Ha—H22-39)
- Mohouli
- Kalepolepo
- Waihole
- Waikea (largest ponds) (Bishop Museum Site No. 50-Ha-H22-45)

According to Kelly et al. (1981:11-13), the mullet in these latter four ponds was reserved for the king's use and remained so for three generations of the Kamehameha family. The mullet of Ho`akimau belonged to Ka`ahumanu (*kuhina nui*) and to her heirs.

Additionally, the Hāla`i Hills complex in Punahoa comprised of three cinder cones that range from 200 to 300 feet in elevation, is where a form of *holua* sledding took place.

> On the first of these, Halai itself, the universal sport of sliding downhill may have been enjoyed in ancient times, not in the classic sport of holua sledding, but as a mere pastime, using coconut fronds or ti leaves as "sleds". If we are to credit the information given to Chester Smith Lyman in 1846, the eastern side of the hill had been "the identical sliding place of King Kamehameha 1st when in this part of his dominions (Kelly et al. 1981:11-13).

However, archival research failed to identify potential TCPs within the immediate vicinity of the project area.

From Kanoelehua Ave *mauka* of the study area, the land was part of the nearly 7,000 acres in Waiakea *ahupua`a* under sugar cane cultivation**.** The Waiakea Mill Company operated between 1879 and 1947. The 1922 map (Figure 2) of the golf course area shows the distinctive sugar plantation railway lines as testimony of its past.

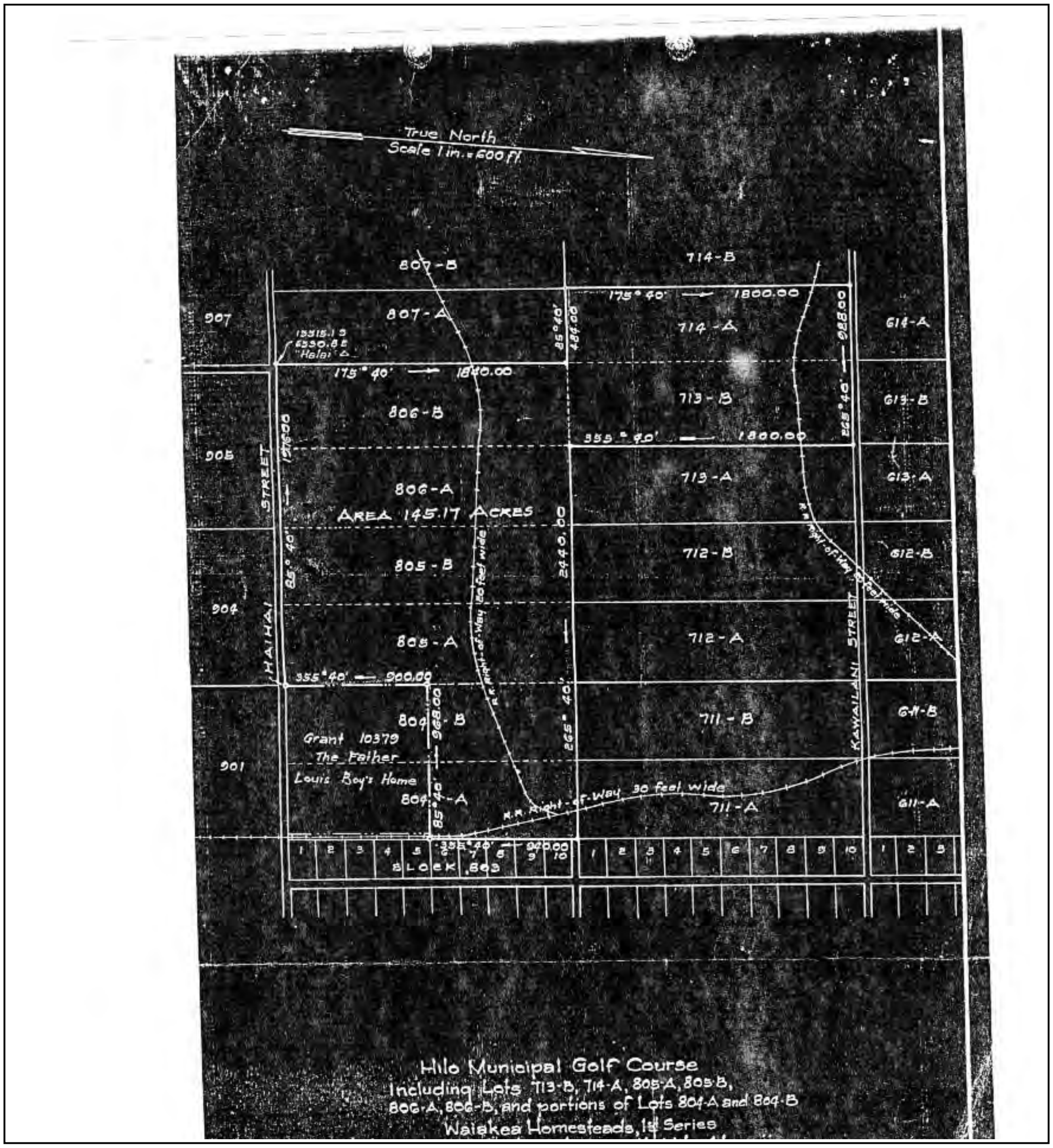

Figure 2. Railway System Right of Ways in the Hilo Municipal Golf Course Area.

The area *makai* of Kanoelehua Ave. of the study area runs through State Hawaiian Home Lands (HHL) designated property. The area of concern has been modified by: 1) the construction of the Waiakea-Uka Flood Control Channel and 2) the HHL residential, agricultural and commercial property development.

The EIS prepared for the development of the Waiakea-Uka Flood Control Channel indicated that no archaeological sites have been recorded inland from the coast. Although a complete survey was not conducted, no archaeological or historical sites and objects were expected to be affected by the development project (Wilson Okamoto and Associates 1996:6, 7, 9).

The 1973 HHL Master Plan: Preliminary Draft, outlines the department's objectives and implementation plans for development of HHL properties. Issues of historical or archaeological sites were not indicated in the Plan (Spencer et al. 1973).

A recent archaeological survey conducted on HHL in the vicinity of the project area was conducted in 1979 by William Bonk in the preparation of an EIS for the development of a commercial designated development. Bonk concluded that there were no archaeological sites on the property (1979).

Other recent archaeological studies in the general vicinity of Waiakea include: Hunt and McDermott (1993); Brothwick et al. (1993), Maly et al. (1994), Spear (1995) and Rechtman and Henry (1997). Except for Hunt and McDermott, all documented archaeological material recovered from the excavations were identified as late 19th/early 20th century artifacts related agricultural activity (sugar cane cultivation). In Hunt and McDermott's survey volcanic glass flakes recovered were reported as possible prehistoric origin.

Earlier archaeological studies consulted were conducted in the vicinity were of the general Hilo area documenting *heiau* sites. Thrum (1908), and Stokes (Stokes and Dye 1991) conducted *heiau* surveys on the island and provided a list of *heiau* in the Hilo region. Hudson (1932) conducted literature review of sites in the eastern portion of the island. Three (3) *heiau* sites identified by these researchers existed in *ahupua`a* Waiakea: *Heiau* Ohele (above the old Pitman store), *Heiau* Moku-ola (near Coconut Island), and *Heiau* Kapaieie (near Kawailani).

Of the three, *heiau* Kapaieie would have been the closest to the project site. It is reported to have been situated along the old Hilo-Ola`a trail. Nothing remains of the *heiau*.

Evidence of the existence of ancient trails in the vicinity of the project site is referenced in the accounts above of the battles of Kalani`opu`u and Kamehameha, and in the records of Ellis's tour of the island for the American Board of Commissioners for Foreign Missions in 1823 (Ellis 1963). Ellis writes about a journey from Kea`au to Hilo:

> Leaving the village of Kaau (Kea`au)…and after walking between two and three hours, stopped in the midst of a thicket to rest, and prepare some breakfast . . . At half-past ten we resumed our walk, and passing about two miles through a wood of pretty large timber, came to open country in the vicinity of Waiakea. (Ellis 1963:212-3).

Apple (1994) discusses two trails used by Ellis and his party during the 1823 journey which would have traversed *ahupua`a* Waiakea. The trail taken and described above by Ellis was the coastal route. Others from Ellis' party explored the inland Volcano to Hilo trail. This inland trail became the alignment of the present day Volcano to Hilo highway, State Route #11 (Apple 1994:30).

The map surveyed in 1912-1914 by R.B Marshall (a portion of the map is provided in Figure 3) shows a Puna Trail which traverses *ahupua`a* Waiakea. Interestingly, there is presently an unpaved "jeep" lane through HHL close to the drainage field of the Waiakea-Uka Flood Control Channel called Puna Trail.

In Apple's 1965 manuscript of Hawaiian trails, no reference is made of any remaining ancient trails in Hilo (Apple 1965:2-7).

3.0 INTERVIEWEES AND CONTACTS

Table 1 summarizes the list of people contacted for interviewee recommendations and/or information regarding the project area. Table 2 provides the list people interviewed and a summary of information gathered. The interviews were conducted to obtain and document accounts of personal experiences and knowledge of the project area. Particularly, information pertaining to TCPs and traditional cultural practices associated with the area.

The interviews were informal interviews conducted between 17-30 January 2005. A list of *kupuna* as possible interviewees was developed by contacting community leaders, academicians, and researchers.

In addition to face to face interviews, several phone interviews were conducted with community leaders, and people with knowledge of the project site.

Four informant interviews were conducted. A basic questionnaire (Appendix A) was used to solicit interviewees' biographical information, relationship and knowledge of the area. A map of the project area was used in explaining the project to the interviewees. Copies of their Personal Release of Interview Records forms are provided in Appendix B.

All of the informants interviewed were *kupuna* and were repeatedly recommended by various sources in the community. They are all active in the Hawaiian community and well respected for their leadership and knowledge of the project area and its history.

3.1 INTERVIEW SUMMARY

In general, the information they provided of the project area, was consistent with the archival data retrieved. The informants confirmed that there are no known TCPs and no known traditional cultural practices associated with or currently being practiced in the project area.

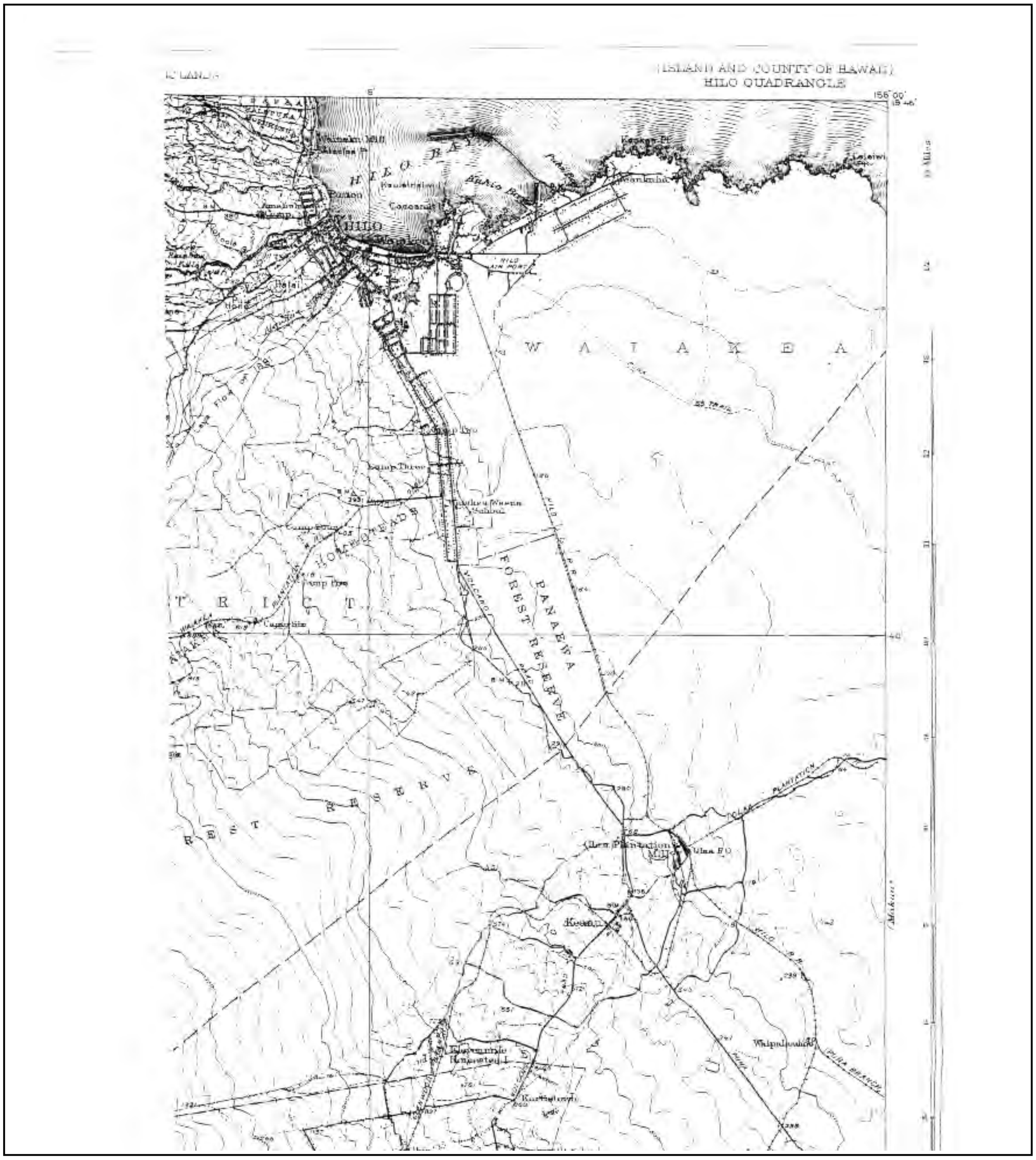

Figure 3. Puna Trail. Portion of Hilo Quadrangle Map.

They all shared stories of gathering in the area when it was still part of the Pana`ewa Forest and prior to the development of the residential and agricultural lots. But the gathering was not site specific and the activity took place in the Forest in general. Items they gathered were traditional medicinal plants, *lauhala*, *maile, lehua,* and fruits.

They all indicated that there were well worn paths through the area when it was still undeveloped. Many were used in there access to the area and the forest. They also feel that the paths in the project area were either cleared or modified into roads in the development of HHL properties.

As with the literature sources, the interviewees believe that the area once supported traditional cultural practices and even settlements. They referred to the numerous fresh water springs and the presence of flora in the Forest usually associated with habitation as evidence. The plants mentioned were: *ulu, kukui, `awa* and *ti.*

They all concur that any TCPs the project area above Kanoelehua Ave. would have been destroyed in the clearing of sugar cane fields. Mr. Lee Loy believes that there would have been ancient trails through that area at one time.

4.0 DISCUSSION

Based on the results and findings from interviews and archival research, it is concluded that there are no known culturally significant traditional properties and resources in the project area. Further, at this time the project site does not appear to support any traditional cultural practices.

Archival research data suggest that the area had a rich past supporting Hawaiian settlements, agriculture and temples. Unfortunately, little evidence remains. *Mauka* of Kanoelehua Ave the area was extensively and intensively cultivated with sugar cane in the late 19^{th} and early 20^{th} centuries. In the development of sugar cane fields and the processing of sugar, the cultural and physical landscapes were greatly modified.

Makai of Kanoelehua Ave, the closest feature existing in the project area linking to the past may be the Puna Trail "jeep" lane. It may quite possibly be the site of the original trail between Puna/Keaau and Hilo, but like many of the ancient trails it was converted into a road.

Other features that may have once existed in the project area *makai* of Kanoelehua Ave. were either cleared or modified in the recent development of residential and agricultural properties, and construction of the Waiakea-Uka Flood Control Channel.

It is reasonable to assume, based on the absence of any known TCPs and any traditional practices associated with the project area, that there would be no adverse impact to cultural activities from the project.

Table 1. List of Contacts.

CONTACTS	ROLE	DESIGNATION	PHONE #	COMMENTS
Ann Nathanial	Contacted for information	Former HHL Commissioner		Involved with the community during the Flood Control Channel construct. Confirms none existence of TCPs Informant recommendations
Lance Foster	Contacted for list of interviewees	Director of Native Rights, Land and Culture. Office of Hawn Affairs	(808) 594-5104	
Donald Pakele	Contacted for information and list of interviewees	Community leader. Former HHL Directory, Hilo	(808) 959-4178	Organized community youth heritage awareness program. Indicated that he has seen a habitation site of recent origin in HHL. Hunted in forest. (Caught piglets to raise at home. Flesh of wild pigs feeding on the forest fern has smell.) Confirms no-existence of TCPs. Believes that the site of the Kapaieie Heiau to be by the intersection of Kawailani and Komohana streets. No trails in project site, but usable Hilo/Puna trail exists in forest.
Pualani Kanahele Also of (Edith Kanakaole Foundation)	Contacted for information and list of interviewees	Asst Prof of Hawaiian Studies, Humanities Dept Chair, Hawaii Community College	(808) 973-0703 (808) 961-5642	Referred by Langlas. Tel con. No knowledge of TCPs ever in the area, except for trails.
Larry Kimura	Contacted for list of interviewees	Prof of Hawaiian Studies UH Hilo	(808) 974-7564	Informant recommendations. Concerned about contaminated run-off water from the golf course? Is diversion below or above golf course. Clean water is

				important in Hawaiian culture.

Continued:
Table 1: List of Contacts

CONTACTS	ROLE	DESIGNATION	PHONE #	COMMENTS
Charles Langlas	Contacted for list of interviewees	Prof of Social Sciences, UH Hilo		Informant recommendations
Ken Okimoto	Contacted for information and list of interviewees	Teacher at Waiakea Intermediate School, Media specialist		Active in Pana`ewa community. Assisting with compiling community history
Kepa Maly	Contacted for list of interviewees	Kumu Pono Associates	(808) 981-0196	Researcher, historian. Confirms no existence of TCPs. Informant recommendations
Namaka Rawlins	Contacted for list of interviewees	Director, `Aha Punana Leo	(808)935-4304	Informant recommendations
Ululani Sherlock	Contacted for list of interviewees	Office of Hawaiian Affairs, Hilo	(808) 920-6418	Referred by Langlas. Informant recommendations
Patrick Kahawaiolaa	Contacted for list of interviewees	Keaukaha Community Association Leader	(808) 961-5707	Confirms none existence of TCPs.

Table 2. List of Interviewees and Summarized Comments.

KUPUNA	PHONE #	COMMENTS
Elenor Ahuna	(808) 935-4915	Born Eleanor Simione in Keaukaha on Aug. 3, 1948. Lived all her life in Keaukaha. Has served as HHL Commissioner. Confirms that there are no Known TCPs in the project area. Recalls area above Kanoelehua Ave as home lots and sugar cane fields, and area below Kanoelehua as Pana`ewa and forested prior to clearing of HHL. Remembers gathering as a youth with family members in forest. Narrated how forest was dense and how one could get lost. Traveled on paths. Gathered medicinal plants, *maile*, *lehua*, *mamaki, lauhala*. Noticed *ulu*, *kukui*, and *ti* plants in forest. Mentions the abundance of springs in Pana`ewa. Confirms that traditional cultural practices, such as gathering, no longer occur in the project area since the forest has been cleared in the development of HHL residential and agricultural lots. The concerns the people had when the Waiakea-Uka Flood Control Channel was being built: The project was taking part of their property. How much water was to be diverted? Was there proper drainage? Her concern with this project include the issue of drainage (is the drainage field capable to handle the capacity of water anticipated?). Also, she is concerned about safety and would like to see the channel area securely fenced to keep children out, especially in times of heavy running water.
Maile Akimseu	(808) 959-1460	Born Maile Kukuhika in Kona on May 31, 1930. Spent her childhood between Kona and Keaukaha. Has lived in Keaukaha for over 13 years. Has worked for Hawaii County Opportunity Council (HCOC) and at the establishment of Alu Like. She does not know of any TCPs in the project area. Confirms traditional cultural practices in forest—gathering of medicinal plants, *lauhala, mamaki* and fruits. She can recall only about 5 times when the flood control channel has had flowing water. Above Kanoelehua was always under sugar cultivation as far as she remembers. Notes that Pana`ewa end of Kilauea Ave. was once a trail to Olaa. Remembers a pond below Kanoelehua by the 4-mile bridge (after the interview discovered that the pond was filled in with fill from the construction of

		the Waiakea-Uka Flood Control Channel. No knowledge of ancient trails existing in the project area today. Does not have any objection to the project.

Continued
Table 2: List of Interviewees and Summarized Comments

KUPUNA	PHONE #	COMMENTS
Nani Knutson		Born Nani Kukuhika on Maui on June 22, 1929. Moved to Keaukaha at the age of 4 and has lived in the Keaukaha-Pana`ewa area since then. Confirms that there are no TCPs and no traditional cultural activities practiced in the project area. Assumed that people practiced traditional gathering and hunting in the area, because the area used to be forested. Assumes that the same types of gathering and hunting activities in the Pana`ewa forest today, would be practiced if still forested. Anything above Kanoelehua would have been destroyed by the sugar cane cultivation and housing construction. Is supportive of the proposed flood control project.
Genesis Lee Loy	(808) 959-3262	Born in Hilo on Sept 21, 1919. He has lived in Keaukaha prior to moving to Pana`ewa. An active member of the Keaukaha since 1936 and in Pana`ewa since 1947. Has farmed in Pana`ewa since 1947. Was employed by the Hawaiian Telephone Company. Confirms that there are no known TCPs in project area. The project area was known as Pana`ewa. Above Kanoelehua Av. has been under sugar cane cultivation and developed. Prior to sugar cultivation, he understands that the area was part of the Pana`ewa Forest. There would have been trails connecting Hilo with Keaau/Olaa through there. Development of sugar cane lands destroyed everything. And, below Kanoelehua Av. the HHL development had cleared the area. The area was covered with "virgin" forest. At that time EIS was not required and saw it as a good opportunity to develop agriculture. Indicated that there was recent historical evidence prior to the development. For example, the military used the area. Domesticated related plants on property prior to clearing –breadfruit tree, `awa. Paths were also evident. Indicated that Keaukaha and Pana'ewa were a united community in the past. The extension of the airport has created a physical division between the two areas.

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APPENDIX A

QUESTIONNAIRE FOR PALAI STREAM FLOOD CONTROL PROJECT

The following questions were used as a guide in the informal interviews.

Name: Birth Name:
Birth Date: Birth Place:
If not born here, when did you move here?
Current Address:
Where did you grow up?
Parents:

What is your relationship to the area?
How familiar are you of the subject area?
What is this area called (What do you call this area)?
Above Kanoelehua Av.
Below Kanoelehua Av.

What are the physical characteristics of the area?
Type of vegetation
Type of animals
Any special features in this area
Land Use and River Use
What kinds of activities have you observed in the area?

Activities	What	Season	Who
Hunt			
Gather			
Fish			
Habitation			
Ceremonial			
Agriculture			

Intensity of land and/or resource use?

What have you heard of this area?

Have you observed land/resource modification in the area? Why?

Problems I the area (Flooding)?

What are your thoughts about the project proposal?

APPENDIX B

PERSONAL RELEASE OF INTERVIEW RECORDS

PACIFIC LEGACY, INC.

ORAL HISTORY STUDY
PERSONAL RELEASE OF INTERVIEW RECORDS

Project: Palai Stream Flood Control Project

Date of Interview: January 19, 2005

I, Eleanor Ahuna, have been previously interviewed by Betty Fielder of Pacific Legacy, Inc. for the above referenced project. I have reviewed the typed summary of the interview and agree that this documentation is complete and accurate, except for the clarifications and corrections noted below. I further agree that the interview information may be used in a report that may be made public, subject to my specific objections and restrictions set forth below.

CLARIFICATIONS AND CORRECTIONS:

SPECIFIC OBJECTIONS AND RESTRICTIONS:

PACIFIC LEGACY, INC.

ORAL HISTORY STUDY
PERSONAL RELEASE OF INTERVIEW RECORDS

Project: Palai Stream Flood Control Project

Date of Interview: Jan 25, '05

I, Nani Knutson, have been previously interviewed by Betty Fielder of Pacific Legacy, Inc. for the above referenced project. I have reviewed the typed summary of the interview and agree that this documentation is complete and accurate, except for the clarifications and corrections noted below. I further agree that the interview information may be used in a report that may be made public, subject to my specific objections and restrictions set forth below.

CLARIFICATIONS AND CORRECTIONS:

SPECIFIC OBJECTIONS AND RESTRICTIONS:

PACIFIC LEGACY, INC.

ORAL HISTORY STUDY
PERSONAL RELEASE OF INTERVIEW RECORDS

Project: Palai Stream Flood Control Project

Date of Interview: Jan. 25, 05

I, Maile Akimsu, have been previously interviewed by Betty Fielder of Pacific Legacy, Inc. for the above referenced project. I have reviewed the typed summary of the interview and agree that this documentation is complete and accurate, except for the clarifications and corrections noted below. I further agree that the interview information may be used in a report that may be made public, subject to my specific objections and restrictions set forth below.

CLARIFICATIONS AND CORRECTIONS:

SPECIFIC OBJECTIONS AND RESTRICTIONS:

PACIFIC LEGACY, INC.

ORAL HISTORY STUDY
PERSONAL RELEASE OF INTERVIEW RECORDS

Project: Palai Stream Flood Control Project

Date of Interview: January 30, 2005

I, ____________, have been previously interviewed by
of Pacific Legacy, Inc. for the above referenced project. I have reviewed the typed summary of the interview and agree that this documentation is complete and accurate, except for the clarifications and corrections noted below. I further agree that the interview information may be used in a report that may be made public, subject to my specific objections and restrictions set forth below.

CLARIFICATIONS AND CORRECTIONS:

SPECIFIC OBJECTIONS AND RESTRICTIONS:

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS, HONOLULU DISTRICT
FORT SHAFTER, HAWAII 96858-5440

0 9 OCT 2019

Civil and Public Works Branch
Programs and Project Management Division

Dr. Noe Noe Wong-Wilson
Pelekikena
Hawaiian Civic Club of Hilo
2106 Kaiwiki Road
Hilo, Hawaii 96720

Dear Dr. Wong-Wilson:

We are writing to consult with your organization pursuant to National Historic Preservation Act (NHPA) Section 106 and Hawaii Revised Statutes (HRS) 6E compliance requirements for our Waiakea-Palai Streams Flood Risk Management Project. The intent of this letter is to present the results of our cultural resource investigations for the project, our NHPA "determination of effect" finding, and to request your office's concurrence or, alternatively, communication of additional information you may have regarding potentially affected cultural resources.

The Waiakea-Palai Streams Flood Risk Management undertaking is focused on addressing flood risk problems in the Waiakea and Palai Stream watersheds on the Island of Hawaii. The purpose of the undertaking is to address the risks to life safety, residences, and public infrastructure from periodic flooding in certain locations within the vicinity of Waiakea and Palai Streams. A high risk of flooding exists within the watershed due to the magnitude and intensity of rain events, the limited capacity within stream channels, and the tendency of flood flows to disperse broadly as sheet flow within developed areas once stream banks overtop.

The Waiakea-Palai Streams Flood Risk Management Project is undertaken through authorization provided under Section 205 of the Rivers and Harbors Act of 1948, Public Law 80-858. Section 205 is an authority allowing the U.S. Army Corps of Engineers (USACE) to plan and construct small projects for flood damage reduction. The non-federal sponsor is the County of Hawaii, Department of Public Works. USACE is the agency responsible for compliance with Section 106 and the County of Hawaii is the agency responsible for compliance with HRS Chapter 6E for this project. The USACE is pursuing a single consultation with your office and all consulting parties to comply with both Section 106 and HRS Chapter 6E. Please continue communication as it relates to the consultation for this project with the USACE as the primary point of contact.

The preferred alternative for addressing flood risk in the Waiakea-Palai drainage includes engineered components (e.g., basins, earthen berms, and flow control features) that will be constructed at two locales:

1) Hilo Municipal Golf Course (7.55 acres total)

TMK (3) 2-4-002:001 por. (7.55 ac)

2) Kupulau Ditch (14.06 acres total)

TMK (3) 2-4-035:003 por. (0.22 ac)
TMK (3) 2-4-035:032 por. (0.16 ac)
TMK (3) 2-4-036:001 por. (7.60 ac)
TMK (3) 2-4-036:999 por. (0.63 ac)
TMK (3) 2-4-065:035 por. (0.44 ac)
TMK (3) 2-4-065:036 por. (4.83 ac)
TMK (3) 2-4-076:044 por. (0.18 ac)

These locales define the undertaking's 21.61-acre Area of Potential Effect (APE).[1] All ground-disturbing work will occur within the boundaries of these locales. A series of maps delineating the undertaking's APE and engineered components are provided in Enclosure 1.

Cultural resource data gathering investigations for this project were initiated in 2015 when an Archaeological Inventory Survey (AIS) was conducted for the Waiakea-Palai APE. The AIS report is included with this letter as Enclosure 2. During this work, one parcel (TMK 3-2-4-065:036) could not be directly accessed due to lack of right-of-entry. Supplemental archaeological survey was therefore conducted at this parcel by a Secretary of the Interior-qualified USACE archaeologist on September 17, 2019 to provide complete APE coverage. This systematic transect survey produced no evidence of historic properties within the remaining TMK parcel, in agreement with the 2015 results and conclusions. Between the original AIS and the supplemental survey, all parcels comprising the APE have now been surveyed.

Results of archaeological survey indicate that neither of the APE locales contain surficial historic properties. Given the history of the area, it is likely that much of the area was dragged to remove surface stones prior to it being converted to sugar cane fields in the late 1800s. More recently, individual parcels have undergone additional ground disturbing activities as they have been turned to residential or other uses. Any surface pre-Contact archaeological sites which may have once existed in these project areas appear to have been obliterated by more recent land use.

In addition to archaeological investigation, research has been conducted to address the potential for Traditional Cultural Properties in the project area. In 2005, a Cultural Impact Survey was completed by Betty A. Fielder on behalf of USACE (Fielder 2005). The study consisted of a combination of intensive archival research and 15 oral history interviews focused on the proposed Palai Stream segment. The research scope, however, necessarily

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[1] Note that the APE for the undertaking originally included a parcel at Ainalako. This area has since been removed from the final project design and is therefore no longer part of the APE.

covered the broader region and its results are therefore applicable to the whole Waiakea-Palai APE. The results of the study indicate that there were no known Traditional Cultural Properties located within the APE of the Waiakea-Palai Stream Flood Risk Management undertaking. The results are summarized in Section 1.2 of the enclosed AIS report.

Consideration has also been given to possible visual impacts that the proposed flood risk management project may have on the surrounding cultural landscape. The components of the preferred flood control alternative are all relatively low elevation structures. The highest feature considered is a 5.6-foot floodwall to be erected along the eastern bank of Kupulau Ditch. Given the location of the two proposed flood control locales, their position at low points in the terrain, and the relative height of the vegetation surrounding them, it is unlikely that any of their component structures will be visible from more than a 1,000-foot distance. The visual impact of these structures will therefore be minimal and, in fact, less intrusive than most of the current buildings and structures in the area.

Public involvement has been an integral and ongoing element of USACE's Section 106 compliance effort and has been conducted concurrent with NEPA/HRS 343 public involvement efforts. Stakeholder meetings have been held on three occasions (November 2018, February 2019, and March 2019). A general informational meeting for affected and regional homeowners was held on April 30, 2019 and a broader public meeting was held on May 21, 2019. All of these outreach and involvement actions included communication of cultural resource findings and provided ample opportunity for community questions and comment. According to the feedback received, there appear to be no issues concerning cultural resources or historic preservation, from the public's perspective, for the undertaking.

In summary, cultural resource investigation efforts conducted for this undertaking have produced no evidence of historic properties eligible for listing on the National Register of Historic Places or historic properties considered "significant" under Hawaii Administrative Rules §13-275-6 present within the APE. Our assessment has yielded a finding of "No Historic Properties Affected", as defined at 36 CFR 800.4(d)(1). We request your review of the USACE documentation of this finding in Enclosure 2 and respectfully request your concurrence with this determination within 30 days of your receipt of this letter.

Should you have any questions, comments, or wish to request either an extension for response or a meeting to discuss this consultation, please contact Ms. Jessie Paahana, Environmental Coordinator in my Civil and Public Works Branch, at (808) 835-4042 or e-mail jessie.k.paahana@usace.army.mil. A list of consulting parties to whom this letter has been sent is included for your information in Enclosure 3.

Sincerely,

CAYETANO.STEPHEN.N.1179660098
Digitally signed by CAYETANO.STEPHEN.N.1179660098
Date: 2019.10.08 17:31:26 -10'00'

Stephen N. Cayetano, P.E.
Deputy District Engineer for
Programs and Project Management

Enclosures

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS, HONOLULU DISTRICT
FORT SHAFTER, HAWAII 96858-5440

09 OCT 2019

Civil and Public Works Branch
Programs and Project Management Division

Dr. Kamana'opono Crabbe
Chief Executive Officer
Office of Hawaiian Affairs
State of Hawaii
560 North Nimitz Highway, Suite 200
Honolulu, Hawaii 96817

Dear Dr. Crabbe:

We are writing to consult with your office in accordance with National Historic Preservation Act (NHPA) Section 106 and Hawaii Revised Statutes (HRS) 6E compliance requirements for the Waiakea-Palai Streams Flood Risk Management Project. The intent of this letter is to present our "determination of effect" for the project, its basis in data, and to request your office's concurrence or, alternatively, communication of additional information you may have regarding potentially affected cultural resources.

The Waiakea-Palai Streams Flood Risk Management undertaking is focused on addressing flood risk problems in the Waiakea and Palai Stream watersheds on the Island of Hawaii. The purpose of the undertaking is to address the risks to life safety, residences, and public infrastructure from periodic flooding in certain locations within the vicinity of Waiakea and Palai Streams. A high risk of flooding exists within the watershed due to the magnitude and intensity of rain events, the limited capacity within stream channels, and the tendency of flood flows to disperse broadly as sheet flow within developed areas once stream banks overtop.

The Waiakea-Palai Streams Flood Risk Management Project is undertaken through authorization provided under Section 205 of the Rivers and Harbors Act of 1948, Public Law 80-858. Section 205 is an authority allowing the U.S. Army Corps of Engineers (USACE) to plan and construct small projects for flood damage reduction. The non-federal sponsor is the County of Hawaii, Department of Public Works. USACE is the agency responsible for compliance with Section 106 and the County of Hawaii is the agency responsible for compliance with HRS Chapter 6E for this project. The USACE is pursuing a single consultation with your office and all consulting parties to comply with both Section 106 and HRS Chapter 6E. Please continue communication as it relates to the consultation for this project with the USACE as the primary point of contact.

The preferred alternative for addressing flood risk in the Waiakea-Palai drainage includes engineered components (e.g., basins, earthen berms, and flow control features) that will be constructed at two locales:

1) Hilo Municipal Golf Course (7.55 acres total)

TMK (3) 2-4-002:001 por. (7.55 ac)

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Results of archaeological survey indicate that neither of the APE locales contain surficial historic properties. Given the history of the area, it is likely that much of the area was dragged to remove surface stones prior to it being converted to sugar cane fields in the late 1800s. More recently, individual parcels have undergone additional ground disturbing activities as they have been turned to residential and farming uses. Any surface pre-Contact archaeological sites which may have once existed in these project areas appear to have been obliterated by more recent land use.

In addition to archaeological investigation, research has been conducted to address the potential for Traditional Cultural Properties in the project area. In 2005, a Cultural Impact Survey was completed by Betty A. Fielder on behalf of USACE (Fielder 2005). The study consisted of a combination of intensive archival research and 15 oral history interviews focused on the proposed Palai Stream segment. The research scope, however, necessarily covered the broader region and its results are therefore applicable to the whole Waiakea-

[1] Note that the APE for the undertaking originally included a parcel at Ainalako. This area has since been removed from the final project design and is therefore no longer part of the APE.

Palai APE. The results of the study indicate that there were no known Traditional Cultural Properties located within the APE of the Waiakea-Palai Stream Flood Risk Management undertaking. The results are summarized in Section 1.2 of the enclosed AIS report.

Consideration has also been given to possible visual impacts that the proposed flood risk management project may have on the surrounding cultural landscape. The components of the preferred flood control alternative are all relatively low elevation structures. The highest feature considered is a 5.6-foot floodwall to be erected along the eastern bank of Kupulau Ditch. Given the location of the two proposed flood control locales, their position at low points in the terrain, and the relative height of the vegetation surrounding them, it is unlikely that any of their component structures will be visible from more than a 1,000-foot distance. The visual impact of these structures will therefore be minimal and, in fact, less intrusive than most of the current buildings and structures in the area.

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CAYETANO.STEPHEN.N.1179660098 Digitally signed by CAYETANO.STEPHEN.N.1179660098 Date: 2019.10.08 17:33:55 -10'00'

Stephen N. Cayetano, P.E.
Deputy District Engineer for
Programs and Project Management

Enclosures

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS, HONOLULU DISTRICT
FORT SHAFTER, HAWAII 96858-5440

0 9 OCT 2019

Civil and Public Works Branch
Programs and Project Management Division

Mr. Alan S. Downer, PhD
Administrator
State Historic Preservation Division
Department of Land and Natural Resources
State of Hawaii
601 Kamokila Boulevard, Suite 555
Kapolei, Hawaii 96707

Dear Dr. Downer:

We are writing to continue consultation with your office in accordance with National Historic Preservation Act (NHPA) Section 106 and Hawaii Revised Statutes (HRS) Chapter 6E compliance requirements for the Waiakea-Palai Streams Flood Risk Management Project. The intent of this letter is to present our "determination of effect" for the project, its basis in data, and to request your office's concurrence.

The Waiakea-Palai Streams Flood Risk Management undertaking is focused on addressing flood risk problems in the Waiakea and Palai Stream watersheds on the Island of Hawaii. The purpose of the undertaking is to address the risks to life safety, residences, and public infrastructure from periodic flooding in certain locations within the vicinity of Waiakea and Palai Streams. A high risk of flooding exists within the watershed due to the magnitude and intensity of rain events, the limited capacity within stream channels, and the tendency of flood flows to disperse broadly as sheet flow within developed areas once stream banks overtop.

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TMK (3) 2-4-076:044 por. (0.18 ac)

These two locales define the undertaking's 21.61-acre Area of Potential Effect (APE).[1] All ground-disturbing work will occur within the boundaries of these locales. A series of maps delineating the undertaking's APE and engineered components are provided in Enclosure 1.

Section 106 consultation for this project was initiated on May 20, 2014 with the submittal of a Work Plan describing the proposed Archaeological Inventory Survey (AIS) methodology for the Waiakea-Palai APE, as well as a completed Cultural Impact Study (2005) associated with the previously separate Palai Stream Flood Control Project. No comments were received on the Work Plan and the AIS was therefore conducted according to its terms in July and August 2015 (Enclosure 2). During this work, one parcel (TMK 3-2-4-065:036) could not be directly accessed due to lack of right-of-entry. Supplemental archaeological survey was therefore conducted at this parcel by a Secretary of the Interior-qualified USACE archaeologist on September 17, 2019 to provide complete APE coverage. This systematic transect survey produced no evidence of historic properties within the remaining TMK parcel, in agreement with the 2015 results and conclusions. Between the original AIS and the supplemental survey, all parcels comprising the APE have now been surveyed.

Results of archaeological survey indicate that neither of the two APE locales contain surficial historic properties. Given the history of the area, it is likely that much of the area was dragged to remove surface stones prior to it being converted to sugar cane fields in the late 1800s. More recently, individual parcels have undergone additional ground disturbing activities as they have been turned to residential and farming uses. Any surface pre-Contact archaeological sites which may have once existed in these project areas appear to have been obliterated by more recent land use.

In addition to archaeological investigation, research has been conducted to address the potential for Traditional Cultural Properties in the project area. In 2005, a Cultural Impact Survey was completed by Betty A. Fielder on behalf of USACE (Fielder 2005). The study consisted of a combination of intensive archival research and 15 oral history interviews

[1] Note that the APE for the undertaking originally included a parcel at Ainalako. This area was surveyed for historic properties, but has since been removed from the final project design and is therefore no longer part of the APE.

focused on the proposed Palai Stream segment. The research scope, however, necessarily covered the broader region and its results are therefore applicable to the whole Waiakea-Palai APE. The results of the study indicate that there were no known Traditional Cultural Properties located within the APE of the Waiakea-Palai Stream Flood Risk Management undertaking. The results are summarized in Section 1.2 of the enclosed AIS report.

Consideration has also been given to possible visual impacts that the proposed flood risk management project may have on the surrounding cultural landscape. The components of the preferred flood control alternative are all relatively low elevation structures. The highest feature considered is a 5.6-foot floodwall to be erected along the eastern bank of Kupulau Ditch. Given the location of the two proposed flood control locales, their position at low points in the terrain, and the relative height of the vegetation surrounding them, it is unlikely that any of their component structures will be visible from more than a 1,000-foot distance. The visual impact of these structures will therefore be minimal and, in fact, less intrusive than most of the current buildings and structures in the area.

Public involvement has been an integral and ongoing element of USACE's Section 106 compliance effort and has been conducted concurrent with National Environmental Policy Act/HRS Chapter 343 public involvement efforts. Stakeholder meetings have been held on three occasions (November 2018, February 2019, and March 2019). A general informational meeting for affected and regional homeowners was held on April 30, 2019 and a broader public meeting was held on May 21, 2019. All of these outreach and involvement actions included communication of cultural resource findings and provided opportunity for community questions and comment. According to the feedback received, there appear to be no issues concerning cultural resources or historic preservation, from the public's perspective, for the undertaking.

In summary, cultural resource investigation efforts conducted for this undertaking have produced no evidence of historic properties eligible for listing on the National Register of Historic Places or historic properties considered "significant" under Hawaii Administrative Rules §13-275-6 present within the APE. Our assessment has yielded a finding of "No Historic Properties Affected", as defined at 36 CFR 800.4(d)(1). We request your review of the USACE documentation of this finding in Enclosure 2 and respectfully request your concurrence with this determination within 30 days of your receipt of this letter.

Should you have any questions, comments, or wish to request either an extension for response or a meeting to discuss this consultation, please contact Ms. Jessie Paahana, Environmental Coordinator in my Civil and Public Works Branch, at (808) 835-4042 or e-mail jessie.k.paahana@usace.army.mil. A list of consulting parties to whom this letter has been sent is included for your information in Enclosure 3.

Sincerely,

CAYETANO.STEPHEN.N.1179660098 Digitally signed by CAYETANO.STEPHEN.N.1179660098 Date: 2019.10.08 17:35:28 -10'00'

Stephen N. Cayetano, P.E.
Deputy District Engineer for
Programs and Project Management

Enclosure

Attachment 5: FISH AND WILDLIFE COORDINATION ACT REPORT

DEPARTMENT OF THE ARMY
HONOLULU DISTRICT, U.S. ARMY CORPS OF ENGINEERS
FORT SHAFTER, HAWAII 96858-5440

NOV 01 2016

Civil and Public Works Branch
Programs and Project Management Division

Dr. Mary M. Abrams
Field Supervisor
Pacific Islands Fish and Wildlife Office
U.S. Fish and Wildlife Service
300 Ala Moana Boulevard, Room 3-122
Box 50088
Honolulu, Hawaii 96850

Dear Dr. Abrams:

The Honolulu District, U.S. Army Corps of Engineers (Corps) is planning to reduce flood risks associated with the Waiakea and Palai Streams located in Hilo, Hawaii. A joint National Environmental Policy Act (NEPA) and Hawaii Environmental Policy Act (HEPA) compliant Integrated Feasibility Study/Environmental Assessment is being prepared for the proposed action under the authority of Section 209 of the Rivers and Harbors Act of 1962, Public Law 87-874, as amended (76 U.S.C. 1197s). The Department of Public Works, County of Hawaii is the non-federal sponsor and the requesting agency for concurrent compliance with NEPA and HEPA. The project location and site maps are presented in Enclosures 1 and 2. The need for and summaries of the proposed features are provided in Enclosure 3.

We request that you provide us with a Planning Aid Letter in accordance with the Fish and Wildlife Coordination Act (FWCA) of 1934 (16 U.S.C. 661-667e), as amended, for the proposed project. If you determine that an investigation and report under Section 2b of the FWCA is required for the proposed project, we request a scope of work and cost estimate.

Previous biological surveys and consultations in the vicinity of the proposed project include the following:

a. A letter from the U.S. Fish and Wildlife Service (USFWS), dated July 16, 2008, subject: Species List for Projects to Repair Waiakea, Aleniao and Waioloa Stream Flood Damage Reduction Structures, Hilo, Hawaii, identified potential impacts to Hawaiian hoary bats, Hawaiian hawks, and Hawaiian coots for proposed work in the stream areas for another project. The enclosed Best Management Practices and referenced letter identify measures to avoid and minimize adverse effects (Enclosures 4 and 5).

b. The "Stream biological and water quality surveys for the Waiakea Flood Control Project In Hilo, Hawaii," *AECOS*, Inc., March 17, 2010, noted that the oopu fish, the *'o'opu akupa* and the *'o'opu nākea,* have been identified in Waiakea Stream but no native fish were seen in the project area during the survey (Enclosure 6). The proposed project alternatives identified in the survey have changed and are no longer current, but the survey included the Waiakea Stream area that is in the current proposed project, which is adjacent to previously cleared and/or developed land at the existing Kupulau Ditch, where it intersects Waiakea Stream.

c. The "Flora and fauna surveys for the Waiakea Flood Control Project in Hilo, Hawaii," *AECOS*, Inc., March 19, 2010, found no threatened or endangered species (Enclosure 7). The survey noted the Hawaiian hoary bat could be present in the project areas. The proposed project alternatives identified in the survey have changed and are no longer current, but the survey area included the area along Waiakea Stream that is in the current proposed project, which is adjacent to previously cleared and/or developed land at the existing Kupulau Ditch, where it intersects Waiakea Stream.

d. The "Biological Survey for the Palai Stream Flood control Project," *AECOS*, Inc., March 2, 2005, was prepared for the project, but the project sites along Palai Stream have shifted to the west (Enclosure 8). The current proposed measures along Palai Stream are in urban and agricultural areas that are similar to the areas covered in the survey. The survey found no threatened or endangered species.

e. The USFWS FWCA draft Planning Aid Report, "Phase 1 Marine Habitat Characterization, Hilo Commercial Harbor, Hawaii Island, Hawaii, Planned Modification 2015," February 2015, covered the Hilo Harbor area beginning about half a mile east of Wailoa River. Waiakea and Palai Streams flow through Waiakea Pond to Wailoa River, which is the outlet to the ocean at Hilo Bay.

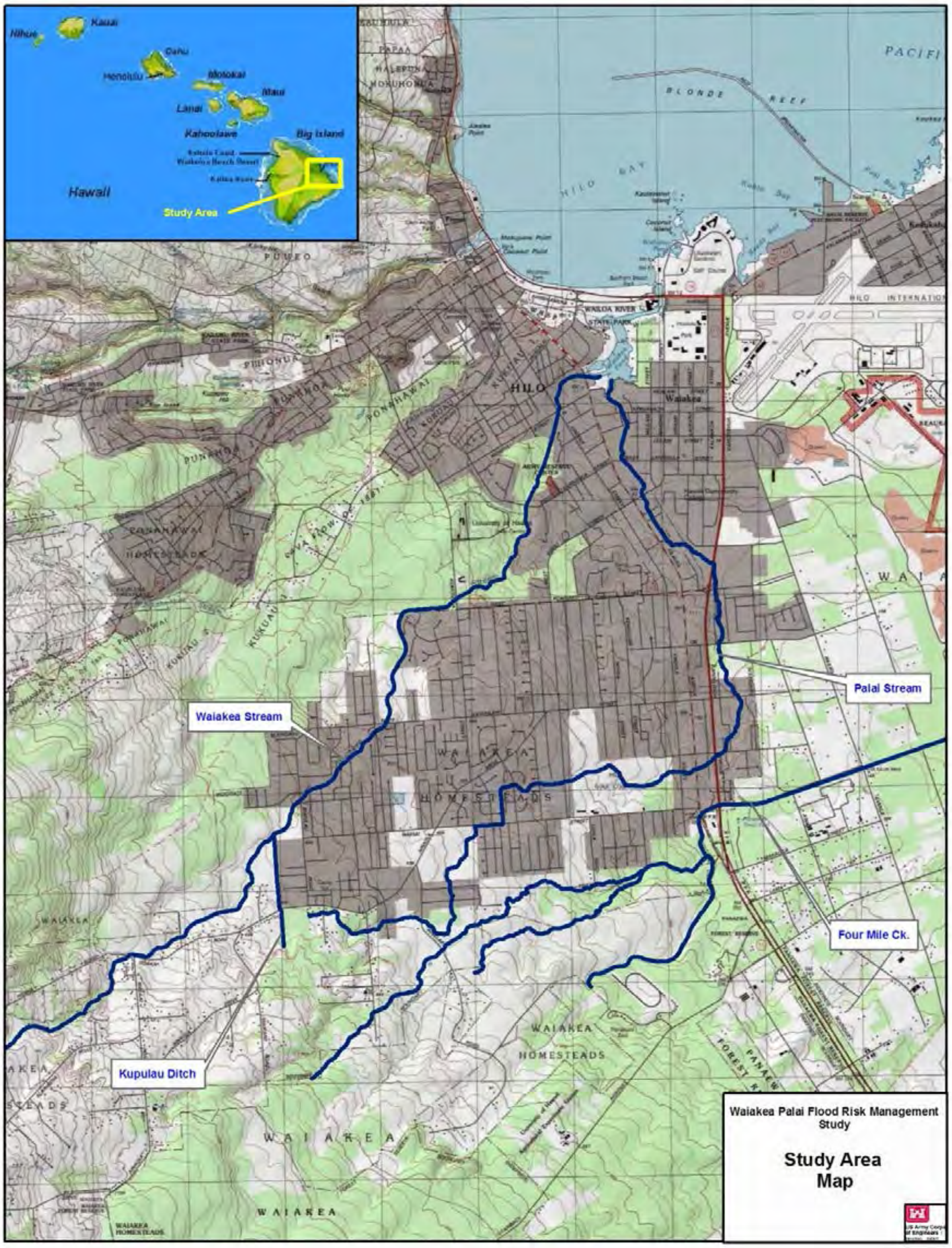
If you have any questions or require additional information, please contact Mr. Michael Wyatt, Project Manager of my Civil and Public Works Branch, at (808) 835-4031 or e-mail michael.d.wyatt@usace.army.mil. Your response concerning the proposed action within 30 days of receipt of this letter would be appreciated.

Sincerely,

Stephen N. Cayetano, P.E.
Deputy District Engineer for
Programs and Project Management

Enclosures

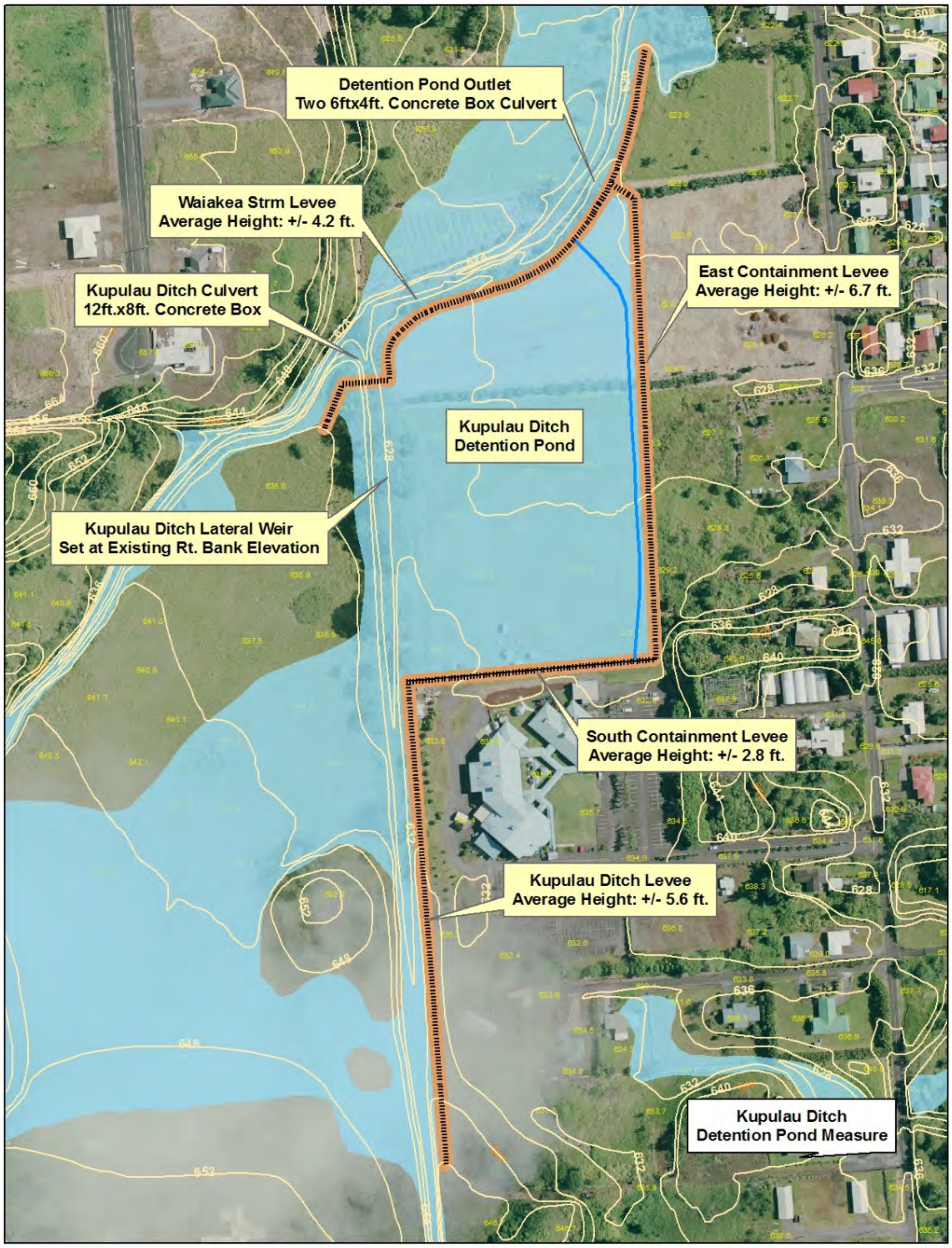
Project Location Map



Enclosure 1

Proposed Project Alternatives

Kupulau Detention Basin Levee/Floodwall



Site Map - Enclosure 2

Proposed Project Alternatives

Hilo Municipal Golf Course Detention Basin

Proposed Project Alternatives

Ainalako Diversion Measures

PROJECT DESCRIPTION

Waiakea-Palai Streams Flood Risk Management Project:

The proposed project is in the feasibility study stage, so detailed plans have not been develop yet, and an array of alternative measures are being considered and screened for implementation. The Project is necessary to address periodic flooding caused by waters overtopping existing drainage channels within the project area. Project alternative measures under consideration include the following:

Kupulau Ditch Detention Basin & levee/floodwall: This measure, located at approximately latitude 19º40’32” N and longitude 155º06’51” W, would include the construction of a detention basin near the intersection of Kupulau Ditch and Waiakea Stream. The detention basin would retain and slow flood waters before releasing water into Waiakea Stream via a new outlet culvert. A levee/floodwall would also be constructed along portions of the makai side of the Kupulau Ditch, Waiakea Stream and the proposed detention basin in order to channel and temporarily retain flood waters within the proposed detention basin (Enclosure 2).

Ainalako Diversion: This measure, located at approximately latitude 19º39’79” N and longitude 155º05’49” W, would include the construction of diversion structure and culvert pipes to divert excess flood flows from Palai Stream into Four Mile Creek. The diversion structure would be located just downstream of Ainalako Road on Palai Stream. It takes advantage of the natural topography along the right overbank of Palai Stream and the natural drainage pattern of the immediate area (Enclosure 2).

Hilo Municipal Golf Course Detention Basin: This measure, located at approximately latitude 19º40’61” N and longitude 155º04’36” W, would include the construction of a detention basin, as well as associated levees and outlet culvert within the Hilo Municipal Golf Course. This measure would reduce the velocity of downstream floodwaters in Palai Stream by temporarily retaining collected floodwaters (Enclosure 2).

There is no concrete lining of streams proposed. Where the detention or diversion structure would cross a stream, stream flow would not be blocked and culverts or pipes would allow stream flow for fish passage. Stream flow would also be maintained during construction.

The project site along Waiakea Stream is approximately four and a half miles upstream from the ocean. The project sites along Palai Stream are approximately three and a quarter miles and four and a half miles upstream from the ocean. With the distance of the project sites from the ocean, potential sedimentation, turbidity or contaminants from the construction may settle out or be dispersed as it flows downstream and through Waiakea Pond and Wailoa River before reaching the ocean at Hilo Bay. Best management practices would be implemented during construction to minimize flow of sedimentation, turbidity or contaminants downstream. (Enclosure 4) Four Mile Creek would be connected to Palai Stream at the proposed Ainalako Diversion site and flows east to the existing 172 acre drainage basin near the quarry and Drag Strip, so the diverted flood flow from Palai Stream would not flow directly to the ocean. Streams in this part of Hawaii island can lose so much flow to infiltration in the highly porous, relatively recent lava flow, that the streams can disappear into the landscape before reaching the ocean. (Biological Survey for the Palai Stream Flood Control Project,” AECOS Inc., March 2005)

U.S. Fish and Wildlife Service
Recommended Standard Best Management Practices

The Fish and Wildlife Service recommends that the following measures be incorporated into projects to minimize the degradation of water quality and adverse impacts to fish and wildlife resources.

1. Turbidity and siltation from project-related work shall be minimized and contained to within the vicinity of the site through the appropriate use of effective silt containment devices and the curtailment of work during adverse tidal and weather conditions.

2. Dredging/filling in the marine environment shall be scheduled to avoid coral spawning and recruitment periods and sea turtle nesting and hatching periods.

3. Dredging and filling in the marine/aquatic environment shall be designed to avoid or minimize the loss of special aquatic site habitat (coral reefs, wetlands etc.) and any ecological functions unavoidably lost as a result of the project shall be replaced.

4. All project-related materials and equipment (dredges, barges, backhoes etc) to be placed in the water shall be cleaned of pollutants prior to use.

5. No project-related materials (fill, revetment rock, pipe etc.) should be stockpiled in the water (intertidal zones, reef flats, stream channels, wetlands etc.);

6. All debris removed from the marine/aquatic environment shall be disposed of at an approved upland or ocean dumping site.

7. No contamination (trash or debris disposal, non-native species introductions attraction of non-native pests etc.) of adjacent marine/aquatic environments (reef flats, channels, open ocean, stream channels, wetlands, beaches, forests etc.) shall result from project-related activities. This shall be accomplished by implementing a litter-control plan and developing a Hazard Analysis and Critical Control Point Plan (HACCP – see http://www.haccp-nrm.org/Wizard/default.asp) to prevent attraction and introduction of non-native species.

8. Fueling of project-related vehicles and equipment should take place away from the water and a contingency plan to control petroleum products accidentally spilled during the project shall be developed. Absorbent pads and containment booms shall be stored on-site, if appropriate, to facilitate the clean-up of accidental petroleum releases.

9. Any under-layer fills used in the project shall be protected from erosion with stones (or core-loc units) as soon after placement as practicable.

10. Any soil exposed near water as part of the project shall be protected from erosion (with plastic sheeting, filter fabric etc.) after exposure and stabilized as soon as practicable (with native or non-invasive vegetation matting, hydroseeding etc.).

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Pacific Islands Fish and Wildlife Office
300 Ala Moana Boulevard, Room 3-122, Box 50088
Honolulu, Hawaii 96850

JUL 16 2008

In Reply Refer To:
2008-SL-0264
2008-SL-0265
2008-SL-0266

RECEIVED 7/17/08

Mr. Anthony J. Paresa, P. E.
Deputy District Engineer Programs and Project Management
Department of the Army
U. S. Army Engineer District, Honolulu
Fort Shafter, Hawaii 96858-5440

Subject: Species List for Projects to Repair Waiakea, Aleniao and Wailoa Stream Flood Damage Reduction Structures, Hilo, Hawaii

Dear Mr. Paresa:

Thank you for your three letters, received on June 17, 2008, requesting species lists for three proposed projects to repair flood damage reduction structures in Waiakea, Aleniao and Wailoa streams in Hilo, Hawaii. The proposed projects entails placement of shotcrete, boulders, and/or concrete at the base of existing levees and stream channels which were damaged by erosion in the February 2008 flood. Based on the project information you provided and pertinent information in our files, including data compiled by the Hawaii Biodiversity and Mapping Program, and the Hawaii GAP Program, the endangered Hawaiian hoary bat (*Lasiurus cinereus semotus*), Hawaiian coot (*Fulica americana alai*) and Hawaiian hawk (*Buteo solitarius*) occur in the project vicinity. We recommend you address potential project impacts to these listed species. We provide the following recommendations to assist you in identifying measures to avoid impacts to these listed species:

- Hawaiian hoary bats roost and give birth in both exotic and native woody vegetation. However, the extent to which Hawaiian hoary bats use the project area is currently unknown. To avoid impacts to this species, no woody plants suitable for bat roosting should be removed or trimmed during the bat birthing and pup rearing season (April to August). If you must clear the property during the Hawaiian hoary bat pupping season, we recommend that you conduct biological surveys to determine if bats are present. Please contact our office for information regarding survey methodology.

- Hawaiian hawks also nest in both exotic and native woody vegetation. To avoid impacts to Hawaiian hawks we recommend you avoid brush and tree clearing during the March through September breeding season if Hawaiian hawks nests are present.

- Hawaiian coots occur in the wetlands surrounding Waiakea Pond in Hilo. The Waiakea, Aleniao and Wailoa streams drain into Waikea Pond. Impacts to Hawaiian coots can be avoided by ensuring surface water flows into Waiakea Pond are not appreciably reduced as a result of the proposed projects.

We hope this information assists you in identifying measures to avoid impacting listed species. If you have questions regarding this letter, please contact Dr. Jeff Zimpfer, Fish and Wildlife Biologist, Consultation and Technical Assistance Program (phone: 808-792-9431; fax: 808-792-9581).

Sincerely,

Christa Russell

for Patrick Leonard
Field Supervisor

AECOS No. 1198A

Stream biological and water quality surveys for the Waiākea Flood Control Project in Hilo, Hawaiʻi

Prepared by:

AECOS Inc.
45-939 Kamehameha Hwy, Suite 104
Kāneʻohe, Hawaiʻi 96744-3221

March 17, 2010

Enclosure 6

Stream biological and water quality surveys for the Waiākea Flood Control Project in Hilo, Hawai‘i

March 17, 2010 | ***Draft*** | *AECOS* No. 1198A

Chad Linebaugh and Eric Guinther
AECOS, Inc.
45-939 Kamehameha Hwy, Suite 104
Kāne’ohe , Hawai’i 96744
Phone: (808) 234-7770 Fax: (808) 234-7775 Email: aecos@aecos.com

Introduction

In June 2009, *AECOS*, Inc. biologists conducted water quality and aquatic biota surveys along an approximately 3-mi (4.8-km) segment of Waiākea Stream and Kupulau Ditch in the Waiākea Homesteads above Hilo, Island of Hawai‘i (Fig. 1). In order to reduce flooding in the region, the Army Corps of Engineers (USACE) is proposing various improvements along segments of Waiākea Stream and Kupulau Ditch as part of the Waiākea Flood Control Project. A*ECOS*, Inc. was contracted by Will Chee Planning, Inc.[1] to ascertain aquatic resources and assess water quality within the project area. This report details findings of those surveys.

Plans for the project include some combination of the following:

1. Channel improvements to Kupulau Ditch, to include widening the channel width from 15 to 30 ft (4.6 to 9 m) and construction of a 10-ft (3-m) high levee extending approximately 2082 ft (635 m) along the right (east) bank of the ditch to contain a greater volume of flood water.
2. Channel improvements to Kupulau Ditch (as above), and construction of a 3531-ft (1076-m) long levee/floodwall along Waiākea Stream from Kupualu Road downstream to a point located at the upstream end of the Kawalani Street Bridge.

[1] This document will be incorporated into the Environmental Assessment (EA) for the Waiakea Flood Control Project and will become part of the public record.

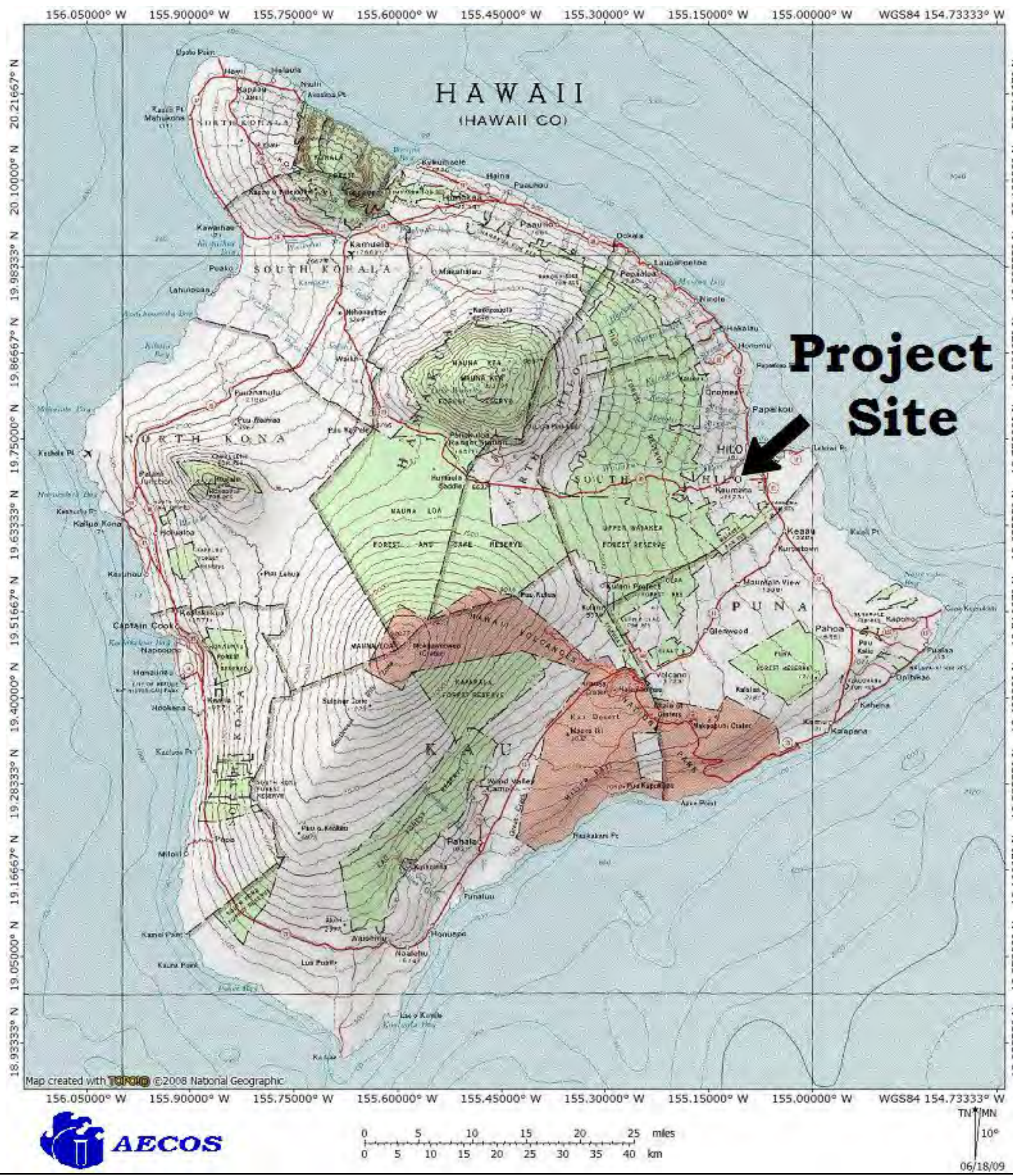


Figure 1. General location of the project in Hilo, Hawaiʻi.

3. Channel improvements to Kupulau Ditch (as above), and widening and channelization of a 3155-ft (962-m) segment of Waiākea Stream between Kupulau Road and Kawalani Street.
4. Channel improvements to Kupulau Ditch (as above), and construction of a diversion channel from just below Kupulau Ditch and extending downslope north, then northeast on State of Hawaiʻi

property bordering Waiākea Homesteads before re-connecting with Waiākea Stream near Puainako Extension.

5. Channel improvements to Kupulau Ditch (as above) and improvements to Waiākea Stream, including channel improvements and levee and floodwall construction, deepening of the channel, construction of a debris control structure, grade control measures, and the removal of a privately owned bridge.

6. Creation of a water storage area between Kupulau Ditch and Waiākea Stream, construction of levees and floodwalls on Kupulau Ditch and improvements to Waiākea Stream, including channel deepening and levee and floodwall construction, construction of a debris control structure, grade control measures, and the removal of a privately owned bridge

Waiākea Stream is one of several streams which feed into Waiākea Pond and the Wailoa River system (State ID No. 8-2-61), emptying into the southern part of Hilo Bay. Wailoa Stream is a perennial system and one of the few stream systems draining Mauna Loa (south) despite high annual rainfall averaging over 100 inches in the Hilo area and nearly 200 inches at Mountainview (Telliaferro, 1959). However, an absence of perennial streams is characteristic of volcanic high islands were the surface material is composed of geologically recent lava flows. In contrast, the older Mauna Kea slopes north of Hilo are deeply dissected. The Hāmākua Coast which extends north along the north flank of Mauna Kea supports many streams, including the extensive Wailuku River system located on the cleft between Mauna Kea and Mauna Loa and discharging into the southwest corner of Hilo Bay. Wailoa Stream is located on the south side of the contact boundary between Mauna Kea and Mauna Loa,

Waiākea Stream has several branches, some fed by springs at higher elevations above Hilo and some segments are perennial. Certainly between about the 1000-ft (305-m) elevation and the University of Hawaiʻi campus at around 150 ft (46 m) above sea level (ASL), Waiākea Stream is intermittently flowing. The topographic map (USGS, 1981, 7.5-minute series, Hilo Quadrangle) shows a perennial stream channel arising from the edge of 1881 lava flow at about the 260-ft (80-m) elevation, joining Waiākea Stream just upstream of West Lanikaula Street, then continuing downslope into Waiākea Pond. This confluent branch appears to exist as a normally dry, overgrown ditch that carries flow only intermittently. However, this branch of Waiākea Stream is thought to be a continuation of Waipahoehoe Stream (also intermittent in some reaches; see Guinther et al., 2009) buried by the 1881 lava flow, but still connected underground.

No substantial part of Waiākea Stream in the vicinity of the University of Hawaiʻi at Hilo campus is perennial flowing, although Waiākea Pond backs up into the channel under Kilauea Avenue. The substratum of the stream bed varies considerably from dense basalt outcrops, to loose, cinder-like material, to finer sediment. Where the bed is dense basalt, pools of water are retained, and these pools are fed by both the considerable rainfall received in the Hilo area and, in some cases, influent flow producing short segments of interconnected pools.

In the project area, from Kupulau Drive to just above the U.H. Hilo campus, Waiākea Stream is a modified channel, designed to move freshet flows quickly through Hilo to Waiākea Pond in the lowlands at Wailoa River State Park and into Hilo Harbor. Along most of this stream course, portions of the channel are lined with levees and reveted margins. The stream bed alternates between a boulder and basalt bedrock in a somewhat natural state, to sections of boulders cemented into the concrete-lined channel. Large concrete box culverts are associated with road crossings.

Survey Methods

AECOS, Inc. biologists surveyed a 3-mi (4.8-km) segment of Waiākea Stream and Kupulau Ditch on June 9, 2009, to identify any aquatic biota present and survey water quality within the project site. Some areas were revisited on December 8-9 by the flora/fauna biologists (*AECOS*, 2009). Field measurements of water quality characteristics and water quality samples were collected from three isolated pools within the generally dry stream bed. Station "Puainako" was located approximately 850 ft (260 m) downstream from the Puainako St/Komohana St. bridge crossings. Station "Kawailani" was located a few meters upstream from the Kawailani St. crossing. Station "Kupulau" was located from a well-shaded, isolated pool located approximately 325 ft (100 m) upstream of the stream's Kupulau Dr. bridge crossing. Aquatic biota and observations on stream flow were noted at a location off Hoaka Road, far upstream of the project area.

Temperature, dissolved oxygen (DO), pH, and conductivity were measured *in situ* at each of the three stations. The samples were collected in one 1-L, one 250-mL, and two 125-mL plastic bottles that were pre-rinsed with the water to be sampled prior to sampling. The samples were placed in a cooler and delivered to the *AECOS* laboratory on Oʻahu the same day. Table 1 lists the analytical methods and instruments used for each water quality parameter measured.

Table 1. Analytical methods and instruments used for June 9, 2009 water quality sampling of Waiākea Stream.

Analysis	Method	Reference	Instrument
Ammonia Nitrogen	SM4500-NH3 B/C	Grasshoff et al. (1986)	Technicon AutoAnalyzer II
Dissolved Oxygen	EPA 360.1	USEPA (1979)	YSI DO meter
Nitrate + Nitrite Nitrogen	EPA 353.2 Rev. 2.0	USEPA (1993)	Technicon AutoAnalyzer II
pH	SM 4500-H+	SM (1998)	Hannah pocket pH meter
Conductivity	EPA 120.1	USEPA (1993)	YSI DO meter
Temperature	thermister calibrated to NBS cert. thermometer (EPA 170.1)	USEPA (1979)	YSI DO meter
Total Nitrogen	persulfate digestion	Grasshoff et al. (1986)	Technicon AutoAnalyzer II
Total Phosphorus	EPA 365.3	USEPA (1993)	Technicon AutoAnalyzer II
Total Suspended Solids	SM 2540D	SM (1998)	Mettler H31 balance
Turbidity	EPA 180.1, rev. 2.0	USEPA (1993)	2100N Hach Turbidimeter

Survey Results

Water Quality

Table 2 lists water quality characteristics of Waiākea Stream on the June 9, 2009 survey date and historical data from surveys previously conducted by *AECOS*, Inc. in the area. Water throughout the project area was restricted to isolated pools without flow. Numerous pools, including those at stations "Kawailani" and "Puainako," contained dense mats of filamentous green algae. The only stream flow on June 9, 2009 was observed at a location off Hoako Rd. about 2.3 mi (3.7 km) southeast (upslope) of the proposed project site.

Broad ranges in temperature, dissolved oxygen (DO), and pH are evident when comparing water quality characteristics on June 9, 2009. Station "Kupulau," located in a well shaded segment of the stream, has a lower temperature, DO, and pH than stations "Kawailani" and "Puainako," that are located in pools receiving direct sunlight and containing an abundance of algae, resulting in elevated readings for these parameters.

Table 2. Water quality characteristics of Waiākea Stream on June 9, 2009 listed with historical data from AECOS, Inc. surveys.

Station	Time (hh:mm)	Temp. (°C)	Dissolved Oxygen (mg/l)	Dissolved Oxygen (% sat.)	pH --	Conductivity (µmhos/cm)
Jun. 2009						
Kupulau	1255	24.9	6.69	81	6.13	88
Kawailani	1325	31.1	12.89	174	8.20	53
Puainako	1350	31.8	12.98	177	8.28	60
Nov. 2001						
Sta. A	1150	27.4	6.14	78	--	--
Sta. B	1200	24.9	7.20	87	--	--
Sta. C	1220	23.9	5.88	70	--	--
Aug. 1996						
Hoaka Rd	--	23.6	9.30	110	--	14.6
UH-Hilo	--	27.7	8.95	114	--	26.9

Station	TSS (mg/l)	Turbidity (ntu)	Ammonia (µg/l)	Nitrate+ Nitrite (µg/l)	Total N (µg/l)	Total P (µg/l)
Jun. 2009						
Kupulau	5	2.72	5	<1	765	41
Kawailani	10	5.12	<1	<1	1100	94
Puainako	27	11.6	<1	<1	1920	110
Nov. 2001						
Sta. A	0.9	--	<1	2	230	42
Sta. B	1.5	--	28	2	363	41
Sta. C	1.8	--	106	19	680	44
Aug. 1996						
Hoaka Rd	1.06	1.4	26	28	321	16
UH-Hilo	1.22	2.0	1	5	292	18

Low ammonia concentrations at all stations may indicate that water flow is fairly frequent for an intermittent stream, since biotic waste is not accumulating in sampled pools that contain both fish and invertebrates. Total nitrogen concentrations in all stations may well be elevated due to decomposition of organic matter that has accumulated in the stream bed.

Historical Water Quality

Turbidity (not sampled for in November 2001) and TSS levels were relatively low, suggesting still water, isolated from runoff inputs, and biological primary productivity dominated by benthic algae. Although 2001 values compared with 1996 values show slightly lower dissolved oxygen (DO) and slightly higher conductivity, the values obtained are not indicative of significant water quality problems.

The primarily unshaded sites (Stations UH-Hilo, A, and B) had lower inorganic nutrients (nitrate + nitrite at least) and abundant benthic algae, suggesting these plants are utilizing available dissolved nutrients to support growth. High ammonia values, such as those found at Station C, can be indicative of stagnant water. Total N and total P values are fairly typical for Hawaiian streams in rural or undeveloped watersheds, although the total N values are all above the perennial streams criteria of 180 and 250 µg N/L (as dry and wet seasons geometric means, respectively) set forth in Hawai`i's Water Quality Standards (Hawaii Administrative Rules Chapter 11-54; HDOH, 2004). Total P values obtained in November 2001 are also slightly elevated, but do not exceed the stream criterion of 50 µg P/L (as a wet season geometric mean).

Aquatic Biota

The aquatic biota identified from the isolated pools present in Waiākea Stream during the June 9, 2009 survey are listed in Table 3. Swordtails (*Xiphophorus helleri*) and marine toad tadpoles (*Bufo marinus*) are abundant throughout the survey area. Dragonfly and damselfly naiads (Order Odonata) and crayfish (*Procambarus clarkii*) are common. Guppies (*Poecilia reticulata*) are occasionally encountered schooling with swordtails. Mosquitofish (*Gambusia affinis*), bullfrogs (*Rana catesbeiana*), and adult marine toads are uncommon. Numerous pools in the survey area appear dark green due to heavy algae growth. *Spirogyra* sp. is the only alga identified from collections made from several such pools.

Similar biota was observed in Waiākea Stream, 2.3 mi (3.7 km) upstream of the project area, at a location bordering private property off Hoaka Rd. Table 3 lists all aquatic biota observed by *AECOS*, Inc. biologists in Waiākea Stream during both recent (June, 2009) and previously conducted surveys.

Table 3. Checklist of aquatic biota observed by *AECOS*, Inc. biologists in Waiākea Stream, South Hilo District, Hawai‘i.

PHYLUM, CLASS, ORDER, FAMILY *Genus species*	Common name	Abundance	Status	Notes
	ALGAE			
CYANOPHYCOTA, CYANOPHYCEAE, NOSTOCALES				
OSCILLATORIACEAE				
Oscillatoria sp.?	blue green algae	A	Ind.	<2>
CHLOROPHYTA, CHLOROPHYCEAE, ZYGNEMATALES				
ZYGNEMATACEAE				
Spirogyra sp.	green algae	C	Ind.	<1,2>
	INVERTEBRATES			
ARTHROPODA, INSECTA, ODONATA				
AESHNIDAE				
Anax junius Drury	green darner	C	Nat.	<2>
LIBELLULIDAE				
Crocothemis servilia Drury	scarlet skimmer	U	Nat.	<2>
Orthemis ferruginea Fabricius	roseate skimmer	U	Nat.	<2>
Pantala flavescens Fabricius	globe skimmer	C	Nat.	<1,2>
COENAGRIIDAE				
Ischnura ramburii Selys-Longchamps	damselfly	U	Nat.	<2>
ARTHROPODA, MALACOSTRACA, DECOPODA				
CAMBARIDAE				
Procambarus clarkii Girard	American crayfish	C	Nat.	<1,2>
	FISHES			
CHORDATA, ACTINOPTERYGII				
POECELIIDAE				
Gambusia affinis Baird&Girard	mosquitofish	U	Nat.	<1,2>
Poecilia reticulata Peters	guppy	O	Nat.	<1,2>
Xiphophorus helleri Heckel	swordtail	A	Nat.	<1,2>
ELEOTRIDAE				
Eleotris sandwicensis Vaillant&Savage	*‘o‘opu akupa*	U	End.	<2>

Table 3, continued.

PHYLUM, CLASS, ORDER, FAMILY *Genus species*	Common name	Abundance	Status	Notes
GOBIIDAE				
Awaous guamensis (Valenciennes)	*ʻoʻopu nākea*	A	Ind.	<2>
	AMPHIBIANS			
BUFONIDAE				
Bufo marinus L.	giant cane toad	A	Nat.	<1,2>
RANIDAE				
Rana catesbeiana Shaw	American bullfrog	U	Nat.	<1,2>

KEY TO SYMBOLS USED:

Abundance categories:
- R – Rare – only one or two individuals observed.
- U – Uncommon – several to a dozen individuals observed.
- O – Occasional – seen irregularly in small numbers
- C – Common -observed everywhere, although generally not in large numbers.
- A – Abundant – observed in large numbers and widely distributed.

Status categories:
- End – Endemic – species found only in Hawaiʻi
- Ind. – Indigenous – species found in Hawaii and elsewhere
- Nat. – Naturalized – species were introduced to Hawaiʻi intentionally, or accidentally.

Identification codes:
- <1> – identified or collected on June 9, 2009
- <2> – identified by *AECOS* in previous surveys (1994/1997/2002)

Conclusions

Waiākea Stream is correctly classification as perennial (Timbol and Maciolek, 1978; Hawaii Cooperative Park Service, 1990), although the middle reach is only intermittently flowing (*AECOS*, 1994, 1997, 2002). Thus, the correct description would be an “interrupted perennial” stream. The isolated pools and systems of pools support a moderately diverse assemblage of fauna and flora. The reason may be that, unlike intermittent streams, the wetter windward environment confers a longevity on these pools that allows the inhabitants to survive all but the most prolonged drought periods.

Water quality within the proposed project area is highly variable and dependent on freshet flow events. The water quality characteristics of isolated pools following such events typically declines as the pool dissipates via evaporation and percolation. Accumulation and decomposition of organic debris, algal growth, biotic waste, and pool size will all have effects on the water quality characteristics of such water bodies. In early June 2009 all stations sampled contained total nitrogen concentrations well elevated with respect to Hawaiʻi's Water Quality Standards (Hawaii Administrative Rules Chapter 11-54; HDOH, 2004) during the dry season (Table 4).

Table 4. State of Hawaiʻi water quality criteria for streams (geometric mean values) for wet (Nov. 1-Apr. 30) and dry (May 1-Oct. 31) seasons from HAR §11-54-05.2(b).

Parameter	**Total Nitrogen** (µg N/l)	**Nitrate + Nitrite** (µg N/l)	**Total Phosphorus** (µg P/l)	**Turbidity** (NTU)	**Total Suspended Solids** (mg/l)
Not to exceed given value					
(dry season)	180.0	30.0	30.0	2.0	10.0
(wet season)	250.0	70.0	50.0	5.0	20.0
Not to exceed more than 10% of the time					
(dry season)	380.0	90.0	60.0	5.5	30.0
(wet season)	520.0	180.0	100.0	15.0	50.0
Not to exceed more than 2% of the time					
(dry season)	600.0	170.0	80.0	10.0	55.0
(wet season)	800.0	300.0	150.0	25.0	80.0

- pH – shall not deviate more than 0.5 units from ambient and not be lower than 5.5 nor higher than 8.0.
- Dissolved oxygen – not less than 80% saturation.
- Temperature – shall not vary more than 1 °C from ambient.
- Conductivity – not more than 300 micromhos/cm.

The aquatic macrofauna community appears to be typical for an interrupted stream in a rural or urban setting. Freshets provide passage up and down the stream for aquatic animals, including native fishes which are reported to inhabit the lower reaches of the stream system (DAR, 2009). The permanent pools provide habitat for native and introduced fishes, crustaceans, and insects when the stream is not flowing. No native species were observed in Waiākea Stream within the confines of the project area during the June 9, 2009 survey.

None of the aquatic species observed during these surveys is listed as threatened or endangered by the U.S. Fish and Wildlife Service under the Endangered Species Act of 1973, as amended, or by the State of Hawaii under its endangered species program (DLNR 1998; USFWS, 2009).

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Flora and fauna surveys for the Waiākea Flood Control Project in Hilo, Hawaiʻi

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March 19, 2010

Enclosure 7

Flora and fauna surveys for the Waiākea Flood Control Project in Hilo, Hawai'i

March 19, 2010 | ***Draft*** | *AECOS* No. 1198B

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Introduction

In December 2009, *AECOS*, Inc. and Rana Biological Consultants, Inc. biologists conducted flora and fauna surveys within and upslope of the Waiākea Homesteads subdivision in Hilo on the Island of Hawai'i (Fig. 1). In order to address flooding concerns in the developed areas of the subdivision, the U.S. Army Corps of Engineers (USACE) is proposing various alternative improvements along segments of Waiākea Stream and Kupulau ditch as part of a Waiākea Flood Control Project. A*ECOS*, Inc. was contracted by Will Chee Planning, Inc.[2] to ascertain aquatic resources and assess water quality within the project area (AECOS, 2010) and describe the flora and fauna potentially impacted by alternative flood control approaches. This report details findings of the flora and fauna surveys.

The project area encompasses the developed Waiākea Homesteads subdivision and undeveloped land upslope of the subdivision. Proposed plans for the project include some combination of the following alternative actions:

1. Within the developed (suburban) portion of Waiākea Homesteads, potential flood control measures include a levee to be built along the subdivision side of Kupulau Ditch, channel improvements to Kupulau ditch (parallels Kupalau Road upslope of the developed lots and south of Waiākea Stream), construction of levees on either side of Waiākea Stream upstream of Kawailani Street, and/or

[1] Rana Biological Consultants, Inc., Kailua-Kona, Hawai'i.
[2] This document will be incorporated into the Environmental Assessment (EA) for the Waiakea Flood Control Project and become part of the public record.

channelization of Waiākea Stream between Kupulau Road and Kawailani Street,

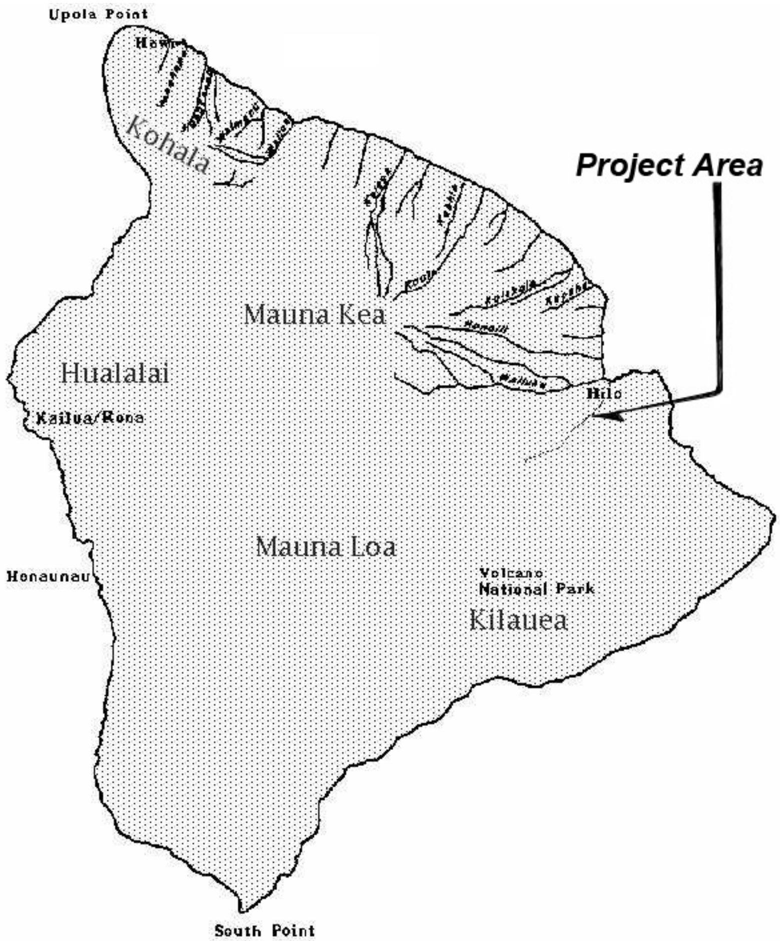

Figure 1. Project location on the Island of Hawai'i.

2. Within agricultural lots of the Waiākea Homesteads subdivision, alternatives include utilization of undeveloped lots for flood detention by constructing levees upslope of and along Kupulau Ditch, and/or on the south side of Waiākea Stream below the confluence of Kupulau Ditch and Waiākea Stream.
3. One alternative involves constructing a diversion channel upslope of the developed subdivision. This 10,400-ft (3170-m) long channel would start at a point just downstream of the confluence of Kupulau Ditch and Waiākea Stream and extend north, then

northeast to re-connect with Waiākea Stream near Puainako Extension (road).

The alternatives described above could involve project impacts within the developed subdivision or on agricultural lands, or (in the case of the long diversion channel), undeveloped lands upslope of the suburban environment. The flora/fauna surveys described in this report investigated all of these various areas, but a majority of the effort was spent along the proposed route of the diversion channel for the reason that this area was undeveloped land.

Methods

Botanical, avian, and mammalian surveys were conducted in the project area on December 8 through 10, 2009. The purpose of the surveys was to describe the natural environment potentially impacted by various flood control alternatives and to determine if there were any botanical, avian, or mammalian species currently listed as endangered, threatened, or proposed for listing under either the federal or state endangered species programs on, or within the immediate vicinity of the project. Federal and State of Hawaiʻi listed species status follows species identified in the following referenced documents: Division of Land and Natural Resources (DLNR; 1998), Federal Register (2005), and U. S. Fish & Wildlife Service (USFWS; 2005, 2009).

Hawaiian and scientific names are italicized in the text. Place names follow *Place Names of Hawaii* (Pukui et al., 1974). A glossary of technical terms and acronyms used in the document, which may be unfamiliar to the reader, is included at the end of the narrative text.

Flora Survey Methods

Botanical resources were surveyed by wandering through areas that would potentially be impacted by proposed flood control alternatives and noting plant species present as well as their relative abundance using a qualitative scale of relative abundance. This methodology relies on encountering most or all of the plant species growing in an area and may miss very rare species or species whose presence is seasonal. However, the method is superior for producing a list of species present in an area when compared with fixed, linear transects. Since an important reason for the surveys is to establish whether or not individuals of listed species are present, a wandering "transect" best suits this purpose.

Floral surveys were undertaken on December 8 and 9, 2009. Plant names follow *Hawai'i's Ferns and Fern Allies* (Palmer, 2003) for ferns, *Manual of the Flowering Plants of Hawai'i* (Wagner et al., 1990, 1999) for native and naturalized flowering plants, and *A Tropical Garden Flora* (Staples and Herbst, 2005) for crop and ornamental plants. Common and Hawaiian names are from various sources, but mostly these same texts.

Faunal Survey Methods

Avian surveys were conducted on December 8, 9, and 10. Fifteen count stations were sited roughly equidistant from each other along the length of the proposed Kupulau levee and the diversion channel feature. An additional three count stations were located in each of three proposed detention basin areas. Eight-minute point counts were made at each of the 15 count stations. Each station was counted once. Field observations were made with the aid of Leica 10 X 42 binoculars and by listening for vocalizations. Counts were concentrated during early morning hours, the peak of daily bird activity. Additionally, the zoologist walked the site in a similar fashion as the botanist, to ensure that no additional species or habitats not encountered during the time dependant avian counts were present in the project area.

The zoologist also inspected portions of the proposed channelization areas of Waikea Stream to determine if additional count stations would shed any useful information on potential impacts to avian species that may occur due to widening/channelization of the stream. It was determined that no additional count stations were necessary in this area to address potential impact to avian and mammalian species resulting from alternatives involving the stream channel.

All observations of mammalian species were of an incidental nature. With the exception of the endangered Hawaiian hoary bat (*Lasiurus cinereus semotus*) or *'ōpe'ape'a* as it is known locally, all terrestrial mammals currently found on the Island of Hawai'i are alien species, and most are ubiquitous. The survey of mammals was limited to visual and auditory detection, coupled with visual observation of scat, tracks, and other animal sign. A running tally was kept of all vertebrate species observed and heard while the biologists were within the project area.

Avian phylogenetic order and nomenclature follow *The American Ornithologists' Union Check-list of North American Birds 7th Edition* (American Ornithologists' Union 1998), and the 42nd through the 50th supplements to *Check-list of North American Birds* (American Ornithologists' Union 2000; Banks et al., 2002, 2003, 2004, 2005, 2006, 2007, 2008; Chesser et al., 2009). Mammal scientific names follow *Mammals in Hawaii* (Tomich, 1986).

Biological Survey Results

The results of a survey of aquatic biota associated with streams in the project area are given in a separate report (see *AECOS*, 2009). This report discusses the nature of the terrestrial environments in the project area and the biota associated with those environments.

Figure 2. Kupulau Ditch is a manmade channel characterized by ruderal vegetation. Note evidence on left bank of herbicide use to clear weedy overgrowth.

Botanical Survey Results

The results of the botanical survey include a description of the vegetation and a listing of plant species given in Table 1. Three distinct types of environments are present in the project area. 1) suburban developed housing (and church) lots, 2) agricultural lots, and 3) undeveloped land. Each supports one or more types of vegetation as described following.

Table 1. Checklist of plants found in the Waiākea Stream Flood Control Project area, South Hilo District, windward Hawaiʻi.

Species	Common name	Status	Abundance Subd	Undv	Notes
FERNS & FERN ALLIES					
BLECHNACEAE					
Blechnum appendiculatum Willd.	---	Nat.	R3	AA	
CYATHEACEAE					
Sphaeropteris cooperi (Hook. ex F. Muell.) R. M. Tryon	Australian tree fern	Nat	R	--	
DENNSTAEDTIACEAE					
Pteridium aquilinum (L.) Kuhn	*kilau, warabi*	**Ind**	U3	--	<1>
DICKSONIACEAE					
Cibotium chamissoi Kaulf.	*hapuʻu*	**End**	--	R	<2>
GLEICHENIACEAE					
Dicranopteris linearis (Burm. f.) Underw.	*uluhe*	**Ind**	U	AA	<2>
LINDSAEACEAE					
Sphenomeris chinensis (L.) Maxon	*palaʻā*	**Ind**	R	O	
NEPHROLEPIDACEAE					
Nephrolepis multiflora (Roxburgh) Jarrett ex Morton	common sword fern	Nat	--	C	
POLYPODIACEAE					
Lepisoris thunbergianus (Kaulf.) Ching	*pakahakaha*	**Ind**	--	R	
Phlebodium aureum (L.) J. Sm.	*lauaʻe haole*	Nat	R	U	
Phymatosorus grossus (Langsd & Fisch.) Brownlie	*lauaʻe*	Nat	--	U	
PTERIDACEAE					
Pityrogramma calomelanos (L.) Link	silverback fern	Nat.	R	R	
Pteris cretica Gaudich.	*waimakanui*	**Ind**	--	U	
SCHIZAEACEAE					
Lygodium japonicum (Thunb.) Sw.	Japanese climbing fern	Nat	R	R	
THELYPTERIDACEAE					
Christella parasitica (L.) H. Lév	wood fern	Nat	--	U	
Cyclosorus interruptus (Willd.) H. Ito	neke	**Ind**	--	R	<2>
GYMNOSPERMS					
CONIFERS					
ARAUCARIACEAE					
Araucaria columnaris (G. Forst.) D. Hook.	Cook pine	Nat	U	--	<3>

Table 2 (continued)

Species	Common name	Status	Abundance Subd	Undv	Notes
FLOWERING PLANTS					
DICOTYLEDONES					
ACANTHACEAE					
Asystasia gangetica (L.) T. Anderson	Chinese violet	Nat	R	--	
Thunbergia fragrans Roxb.	clock vine	Nat	R	R	
ANACARDIACEAE					
Mangifera indica L.	mango	Nat	R	--	
Rhus sandwicensis A. Gray	*neleau*	**End**	U	--	
Schinus terebinthifolius Raddi	Christmasberry	Nat	U	U	
APIACEAE					
Centella asiatica (L.) Urb.	Asiatic pennywort	Nat	U	--	
ARALIACEAE					
Scheflera actinophylla (Endl.) Harms	octopus tree	Nat	R	U	
ASTERACEAE (COMPOSITAE)					
Ageratum conyzoides L.	*maile hohono*	Nat	A	O	
Ageratum cf. *houstonianum* Mill.	*maile hohono*	Nat	R	R	
Conyza bonariensis (L.) Cronq.	hairy horseweed	Nat	U	--	
Crassocephalum crepidioides (Benth) S. Moore	---	Nat	U	--	
Emilia fosbergii Nicolson	Flora’s paintbrush	Nat	R	--	
Erichtites valerianifolia (Wolf) DC	fireweed	Nat	R	--	
Pluchea carolinensis (Jacq.) G Don	sourbush	Nat	R	R	
Sphagneticola trilobata (L.) Pruski	wedelia	Nat	A	O	
Youngia japonica (L.) DC	Oriental hawksbeard	Nat	R	--	
BALSAMINACEAE					
Impatiens walleriana J.D. Hook.	busy Lizzy	Nat	R	R	
BEGONIACEAE					
Begonia hirtella Link	---	Nat	O	U	
BIGNONIACEAE					
Spathodea campanulata P. Beauv.	African tulip tree	Nat	C	A	
BUDDLEIACEAE					
Buddleia asiatica Lour.	dog tail	Nat	U	--	
CARYOPHILLACEAE					
Drymaria cordata (L.) Willd. Ex Roem. & Schult.	*pipili*	Nat	U2	--	
CLUSIACEAE					
Clusia rosea Jacq.	autograph tree	Nat	O	--	
CONVOLVULACEAE					
Ipomoea triloba L.	little bell	Nat	U	--	

Table 2 (continued)

Species	Common name	Status	Abundance Subd	Undv	Notes
EUPHORBIACEAE					
Aleurites moluccana (L.) Willd.	*kukui*	**Pol**	U	O	
Chamaesyce hirta (L.) Millsp.	garden spurge	Nat	R	--	
Chamaesyce hypericifolia (L.) Millsp.	graceful spurge	Nat	R	--	
Euphorbia heterophylla L.	*kaliko*	Nat	U	--	
Phyllanthus tenellus Roxb.	---	Nat.	U	--	<4>
FABACEAE					
Alysicarpus vaginalis (L.) DC	alyce clover	Nat	R	--	
Chamaecrista nictitans (L.) Moench	partridge pea, *lauki*	Nat	R	--	
Crotalaria cf. *assamica* Benth.	---	Nat	--	R	<4>
Crotalaria lanceolata E. May	---	Nat	U	--	
Crotalaria pallida Aiton	smooth rattlepod	Nat	R	--	
Desmodium incanum DC	Spanish clover	Nat	O	--	
Desmodium tortuosum (Sw.) DC	Florida beggarweed	Nat	U	--	
Desmodium trifolium (L.) DC	---	Nat	U	--	
Falcataria moluccana (Miq.) Barneby & Grimes	Moluccan albizia	Nat	U	O	
Mimosa pudica L.	sensitive plant	Nat	U	--	
LAMIACEAE					
Hyptis pectinata (L.) Poit.	comb hyptis	Nat	U2	--	
LAURACEAE					
Persea americana Mill.	avocado	Nat	U	--	<3>
LYTHRACEAE					
Cuphea hyssopifolia Kunth	false heather	Nat	U1	--	<1>
MELASTOMATIDAE					
Clidemia hirta (L.) D..	Koster's curse	Nat	C	U	
Dissotis rotundifolia (Sm.) Triana	---	Nat	O	U	
? *Melastoma candidum* D. Don	---	Nat	C	C	<2>
MORACEAE					
Artocarpus altilis (Z) Fosberg	*'ulu*, breadfruit	**Pol**	R	--	
Ficus microcarpa L.	Chinese banyan	Nat	O	U	
MYRTACEAE					
Metrosideros polymorpha Gaud.	*'ōhi'a*	**End**	R	C	<2>
Psidium cattleianum Sabine	strawberry guava	Nat	U	AA	
Psidium guajava L.	common guava	Nat	O	O	
ONAGRACEAE					
Ludwigia octovalvis (Jacq.) Raven	primrose willow	Nat	R	--	<1>
OXALIDACEAE					
Oxalis corniculata L.	*'ihi'ai*	**Ind**	U	--	

Table 2 (continued)

Species	Common name	Status	Abundance Subd	Undv	Notes
PASSIFLORACEAE					
Passiflora edulis Sims	*liliko'i*	Nat	U	--	
POLYGALACEAE					
Polygala paniculata L.	bubblegum plant	Nat.	O	--	
ROSACEAE					
Rubis rosifolius Sm.	thimbleberry	Nat	O3	C	
RUBIACEAE					
Hedyotis corymbosa (L.) Lam.	---	Nat	U	--	
Paederia foetida L.	*maile pilau*	Nat	U	R	
Spermacoce cf. *assurgens* Ruiz & Pav.	buttonweed	Nat	U	--	
RUTACEAE					
Citrus sp.		Orn	R	--	<4>
SAPINDACEAE					
Filicium decipiens (Wight & Arnott) Thwaites ex J..D. Hook.	fern tree	Nat	R	--	
SCROPHULARIACEAE					
Castilleja arvensis Cham. & Schlechtend.	Indian paintbrush	Nat	R	--	
Lindernia crustacea (L.) F. v. Muell.	false pimpernel	Nat	R2	--	
STERCULIACEAE					
Melochia umbellata (Houtt.) Stapf.	melochia	Nat	C	O	
ULMACEAE					
Trema orientalis (L.) Blume	gunpowder tree	Nat	O	C	
VERBENACEAE					
Lantana camara L.	lantana	Nat	R	R	
Stachytarpheta australis Moldenke	*owi*	Nat	O	--	
Stachytarpheta jamaicensis (L.) Vahl.	Jamaican vervain	Nat			
MONOCOTYLEDONES					
AGAVACEAE					
Cordyline fruticosa (L.) A. Chev.	*ki*, ti	**Pol**	U	U	<2>
ARECEAE					
Alocasia macrorhizos (L.) G. Don	*'ape*	**Pol**	R	--	
Epipremnum pinnatum (L.) Engl	variegated pothos	Nat	U	U	
ARECACEAE					
Archontophoenix alexandrae (F.v. Muell) H.A. Wendl. & Drude	king palm	Nat	R	--	
Cocos nucifera L.	coconut	**Pol**	O2	--	

Table 2 (continued).

Species	Common name	Status	Abundance		
			Subd	Undv	Notes
ARECACEAE (cont.)					
Dypsis lutescens (H. Wendl.) Beentje & Dransfield	golden-fruited palm	Orn	R	--	
COMMELINACEAE					
Commelina diffusa Burm. f.	dayflower	Nat	O3	--	
CYPERACEAE					
Carex sp.	---	---	--	R	<4>
Cyperus gracilis R. Br.	McCoy grass	Nat	R	--	
Cyperus halpan L.	---	Nat	U	U	
Cyperus polystachyos Rottb.	---	**Ind**	O	--	
Cyperus rotundus L.	nut sedge	Nat	O	--	
Kyllinga brevifolia Rottb.	*kili‘o‘opu*	Nat	C	--	
Rhynchospora sp.	beak rush	**---**	--	R	<2>
DRACAENACEAE					
Dracaena marginata (Lam.)	money tree	Orn	R	--	
MUSACEAE					
Musa hybrid	banana	**Pol**	U1	U	<3>
ORCHIDACEAE					
Arundina graminifolia (D. Don) Hochr.	bamboo orchid	Nat	U2	C	
Phaius tankervilleae (L'Héritier) Blume	Chinese ground orchid	Nat	--	R	
PANDANACEAE					
Pandanus tectorius S. Parkinson ex Z	*hala*	**Ind**	U	--	
POACEAE (GRAMINEAE)					
Andropogon virginicus L.	broomsedge	Nat	O	O	
Axonopus compressus	carpetgrass	Nat	C	--	<3>
Bambusa vulgaris J. Wendl.	common bamboo	Orn	R	--	
Coix lachryma-jobi L.	Job's tears	Nat	O	U	
Digitaria sp.	---	Nat	R	--	
Digitaria ciliaris (Retz.) Koeler	Henry's crabgrass	Nat	U2	--	
Eleusine indica (L.) Gaertner	goosegrass	Nat.	R	--	
Eragrostis brownie (Kunth) Nees ex Steud.	sheepgrass	Nat	R	--	
Eragrostis pectinaceae (Michx.) Nees	Carolina lovegrass	Nat	U	--	
Melinus minutiflora P. Beauv.	molasses grass	Nat	C	O	
Melinus repens (Willd.) Zizka	Natal redtop	Nat	R	--	
Oplismenus compositus (L.) P. Beauv.	basket grass	Nat	O3	C	
Panicum repens L.	*wainaku* grass	Nat	O3	U	
Paspalum conjugatum Bergius	Hilo grass	Nat	O	--	
Paspalum urvillei Steud.	Vasey grass	Nat	U	R	

Table 2 (continued).

Species	Common name	Status	Abundance		
			Subd	Undv	Notes
POACEAE (cont.)					
Pennisetum purpureum Schumach.	elephant grass	Nat	C2	R1	
Sacciolepis indica (L.) Chase	Glenwood grass	Nat	A	--	
Saccharum officinarum L.	sugar cane	Nat	R	--	
Schizostachyum glaucifolium (Rupr.) Munro	*'ohe*, bamboo	**Pol**	U	--	<3>
Setaria palmifolia (J. König) Stapf	palmgrass	Nat	U	O3	
Themeda villosa (Poir.) A. Camus	Lyon's grass	Nat	R	--	
Urochloa maxima (Jacq,.) Webster	Guinea grass	Nat	U	--	
Urochloa mutica (Forssk.) Nguyen	para grass	Nat	A	--	
STRELITZIACEAE					
Ravenala madagascariensis Sonnerat	traveller's palm	Orn	R	--	
ZINGIBERACEAE					
Hedychium flavescens N. Carey ex Roscoe	yellow ginger	Nat	O3	A	
Zingiber zerumbet (L.) Sm.	*'awapuhi*	**Pol**	R	O3	

Table 2 Legend

Status = distributional status

- E**nd**. = endemic; native to Hawaii and found naturally nowhere else.
- **Ind**. = indigenous; native to Hawaii, but not unique to the Hawaiian Islands.
- Nat. = naturalized, exotic, plant introduced to the Hawaiian Islands since the arrival of Cook Expedition in 1778, and well-established outside of cultivation.
- Orn. = exotic, ornamental; plant not naturalized at this location (not well-established outside of cultivation).
- **Pol**. = Polynesian introduction before 1778.

Abundance = occurrence ratings for plants by area: Subd = Waiākea Str., Kupulau Ditch, and homestead lots (residential and agricultural); Undv = undeveloped land (diversion channel).

- R – Rare - only one or two plants seen.
- U - Uncommon - several to five plants observed.
- O - Occasional - found between five and ten times; not abundant anywhere (unless Oc or Oa).
- C - Common - considered an important part of the vegetation and observed numerous times.
- A - Abundant - found in large numbers; may be locally dominant.
- AA - Abundant - abundant and dominant; defining vegetation type for the layer.

Subnumbers (such as O2) indicate more localized abundances.

Notes:

- <1> – Generally associated with Waiākea Stream or Kupulau Ditch.
- <2> - Generally associated with the native forest area.
- <3> - A naturalized species in this situation likely planted as an ornamental.
- <4> - Specimen(s) lacking fruit or flowers.

Housing and church lots comprise the majority of the project area. The vegetation in these areas is mostly ornamental plantings, with some areas of ruderal plant growth and scattered, naturalized trees. Much of Waiākea Stream and Kupulau Ditch (Fig. 2, above) within the survey area flows through this environment, and the riparian vegetation (Fig. 3) is mostly naturalized trees, shrubs, and herbs. Plantings (ornamentals) in these areas were mostly ignored in the botanical survey as the project would not impact on this vegetation.

Figure 3. Waiākea Stream above Kupulau Road showing low flow, but evidence (stripped and bent grass) of much stronger flow sometime prior to December 8, 2009. Vegetation here is mostly para or California grass.

Undeveloped lots typically support some form of agriculture (ungulate grazing) or are fallow and support mostly grasses and scattered trees. These lots, where situated close to Waiākea Stream and Kupulau Ditch, have potential to serve as detention areas for flood waters and the vegetation was catalogued. Bird surveys were conducted on these lands as well. The proposed diversion channel is envisioned as starting on undeveloped lots off of Koaniani Street.

Undeveloped land in the project area extends upslope from the developed lots northwest of the homestead lands, mostly on State of Hawaiʻi property. The vegetation in this area is natural and consists mostly of forest, but is clearly divisible into two distinct types: one largely native and one largely non-native in composition. The non-native vegetation lies closest to the homestead lands and is secondary forest and scrub dominated in most areas by dense growths of strawberry guava (*Psidium cattleianum*), or a mix of trees—predominately gunpowder (*Trema orientalis*), African tulip (*Spathodea campanulata*), common guava (*Psidium guajava*), albizia (*Falcateria moluccana*), melochia (*Melochia* *umbellata*), and *kukui* (*Aleurites moluccana*). Yellow ginger (*Hedychium flavescens*) dominates some areas of the understory, although many of the plants appear to be suffering from an unidentified malady. Non-native ferns and melastomes are common components of the understory of this mixed forest. Close to Puainako Extenstion, the fern, *Blechnum appendiculatum*, is extremely abundant under strawberry guava.

The native vegetation extends upslope from the secondary forest and is dominated by scattered *ʻōhiaʻa* (*Meterosideros polymorpha*) trees and dense patches of *uluhe* (*Dicranopteris linearis*) fern (Fig. 4). In this area, the open forest is being invaded by non-native melastome (*Melastoma* sp.) shrubs. The understory is poorly developed in areas where trees provide dense shading. A few small areas of incipient, isolated wetlands were observed. The boundary between the native and non-native forests, while not necessarily sharp everywhere, appears to possibly represent an upper elevation limit in this area of agricultural activities sometime in the not too distant past. After these upper "fields" were abandoned, the land reverted back to forest, but forest dominated by the more aggressive non-native trees now typical of the Hilo area.

Figure 4. The dominant species in the native open forest: *ʻōʻhiʻa*, *uluhe*, and Melastoma.

The total number of species of plants identified during the survey is 127 (Table 1). This count includes 15 ferns and one gymnosperm; the remaining are flowering plants (angiosperms). Considering the full count, three (3) species are endemic, 9 are indigenous, and 8 are early aboriginal introduction to the Hawaiian Islands (so-called "canoe plants"). The percent of truly native plants species is thus 9.4%. Including all pre-1778 species, this ratio increases to 15.7%.

Avian Survey Results

A total of 309 individual birds of 16 different species and representing 12 families, were recorded during station counts (Table 2). One avian species present, Pacific-Golden Plover (*Pluvialis fulva*), is an indigenous, migratory shorebird. The remaining 15 species recorded are considered to be alien to the Hawaiian Islands. No avian species currently listed, or proposed for listing under either the federal or state endangered species statutes was detected during the course of this survey.

Table 2 - Avian Species Detected during Station Counts
Waiakea Stream Flood Control Project.

Common Name	***Scientific Name***	***ST***	***RA***
	GALLIFORMES		
	PHASIANIDAE - Pheasants & Partridges		
	Phasianinae - Pheasants & Allies		
Red Junglefowl	*Gallus gallus*	D	0.53
	CICONIIFORMES		
	ARDEIDAE - Herons, Bitterns & Allies		
Cattle Egret	*Bubulcus ibis*	A	0.07
	CHARADRIIFORMES		
	CHARADRIIDAE - Lapwings & Plovers		
	Charadriinae - Plovers		
Pacific Golden-Plover	*Pluvialis fulva*	IM	2.00
	COLUMBIFORMES		
	COLUMBIDAE - Pigeons & Doves		
Rock Pigeon	*Columba livia*	A	0.20
Spotted Dove	*Streptopelia chinensis*	A	1.80
Zebra Dove	*Geopelia striata*	A	1.73

Table 2 (continued).

	PASSERIFORMES		
	SYLVIIDAE - Old World Warblers & Gnatcatchers		
	Sylviinae - Old World Warblers		
Japanese Bush-Warbler	*Cettia diphone*	A	0.07
	TIMALIIDAE - Babblers		
Hwamei	*Garrulax canorus*	A	2.40
Red-billed Leiothrix	*Leiothrix lutea*	A	1.07
	ZOSTEROPIDAE - White-eyes		
Japanese White-eye	*Zosterops japonicus*	A	6.53
	STURNIDAE - Starlings		
Common Myna	*Acridotheres tristis*	A	4.20
	CARDINALIDAE - Cardinals Saltators & Allies		
Northern Cardinal	*Cardinalis cardinalis*	A	1.87
	FRINGILLIDAE - Fringilline and Carduleline Finches & Allies		
	Carduelinae - Carduline Finches		
House Finch	*Carpodacus mexicanus*	A	3.40
	PASSERIDAE - Old World Sparrows		
House Sparrow	*Passer domesticus*	A	0.80
	ESTRILDIDAE - Estrildid Finches		
	Estrildinae - Estrildine Finches		
Nutmeg Mannikin	*Lonchura punctulata*	A	2.47
Java Sparrow	*Padda oryzivora*	A	0.20

Legend to table 2

ST Status

D Domesticated – Not considered to be established in the wild on the island of Hawaiʻi

A Alien – Introduced to the Hawaiian Islands by humans

IM Indigenous Migratory – Native migratory species, non-breeding in Hawaiʻi

RA Relative Abundance –Number of birds detected divided by the number of count stations (15)

Avian diversity and densities were in keeping with the habitat present within the project corridor. Three species; Japanese White-eye (*Zosterops japonicus*), Common Myna (*Acridotheres tristis*), and House Finch (*Carpodacus mexicanus*) accounted for slightly less than 69 percent of the total number of birds recorded during station counts. The most frequently recorded species was Japanese White-eye, which accounted for slightly less than 32 percent of the total number of birds recorded during station counts. An average of 21 birds was recorded per station count.

Mammalian Survey Results

Four mammalian species were detected during the course of the time spent in the project area. Over 30 dogs (*Canis f. familiaris*) were seen in the developed areas of the project, mostly adjacent to Waiakea Stream. Three Indian mongooses (*Herpestes a. auropunctatus*) were seen along the southern third of the project corridor, and one dead pig (*Sus s. scrofa*) was encountered near the northern terminus of the proposed diversion channal. Additionally, dogs were heard barking from areas outside of the survey corridor, virtually at every count station. Tracks, sign and scat of dogs, and pig were encountered along the entire length of the channel corridor. No mammalian species currently listed, or proposed for listing under either the federal or state endangered species statutes was detected during the course of this survey.

Discussion

Botanical Resources

Most of the area encompassed by the project is developed or disturbed (relatively recently graded or used for grazing or some other form of agriculture). Therefore the plants present are typically ornamentals or ruderal weeds, and various naturalized tree species common to the Hilo area, such as gunpowder tree, melochia, albizia, and African tulip tree. No species listed as threatened or endangered by the state or federal government were observed or are expected to occur in the developed homestead lands surveyed for the flood control project.

The diversion channel, as presently laid out, runs close to the boundary between the native and non-native forests. The elevation varies from approximately 360 ft (110 m) above sea level (ASL) at the Puainako end (Sta. 0+00) to 600 ft (180 m) ASL where the route enters undeveloped lots between Koaniani and Kahalani streets. The route mostly cuts through a dense non-native forest, except for the segments between about Sta. 22+00 and Sta. 36+00 and between Sta. 53+00 and Sta. 65+00, judging from interpretations of aerial photographs following the ground-truthing survey. The proportion of the channel in native forest would be roughly 25% of the 10,400-ft (3170-m) length. Approximately 8% of the proposed channel traverses undeveloped (agricultural) lots, located at either end of the route. No species listed as threatened or endangered by the state or federal government were observed or are expected to occur in the undeveloped lands surveyed for the proposed flood control channel alternative.

Avian Resources

All but one of the 16 avian species detected during the course of this survey are considered to be alien to the Hawaiian Islands. The lone native species detected, Pacific-Golden Plover is an indigenous migratory species, which nests in the high Arctic during the late spring and summer months, returning to their wintering grounds in Hawaii, Japan, Okinawa, Polynesia, Micronesia, Melanesia, New Zealand, Australia Indonesia, Philippines, southern China, southeast Asia, Bangladesh, Nepal, India, Sri Lanka, Pakistan, Iran, Bahrain, and northeast and southern Africa (Johnson and Conners 1996). Wintering Pacific-Golden Plover usually leave Hawaiʻi for their trip back to the Arctic in late April or the very early part of May, and return to their wintering grounds in late July. Some individuals overwinter, and thus are present all year.

One species detected—Red Junglefowl (*Gallus gallus*)—is currently not considered to be established in the wild on the Island of Hawaiʻi, thus the eight birds that we recorded during station counts were probably domesticated chickens or fighting cocks present on lots adjacent to portions of the project corridor along the southern end of the project.

Avian diversity and densities were much higher along the southern portion of the project corridor in the more open and developed areas. Bird diversity and densities were very low within the almost totally closed guava forest found along the bulk of the project corridor.

The Hawaiian Hawk, or *ʻio*, is the only extant *falconiforme* in Hawaiʻi. It is currently endemic to the Island of Hawaiʻi. Sub-fossil remains indicate that it was also formerly found on Molokaʻi and Kauaʻi (Olson & James, 1997). Several incidental, unconfirmed sightings of this species exist from Kauaʻi (Dole, 1879; Beaglehole, 1967) and Maui (Banko, 1980c). This species was first mentioned in the western literature by Cook and King in 1784 and was scientifically described by Peale in 1848 from a specimen collected in "Kealakekua" (Medway, 1981; Peale, 1848).

Although not detected during this survey it is possible that the endemic, endangered Hawaiian Hawk (*Buteo solitarius*) uses resources within the general project area on a seasonal basis. Hawaiian Hawks are currently found in nearly all habitats on the Island that still have some large trees. They are regularly seen foraging in the general project area. Hawk densities are highest in mature, native species dominated forests, with grassy understories. This habitat, with high amounts of forest edge, supports large populations of game birds and the four species of introduced rodents known from the Island, all of which are prey items for the hawk. Additionally, this type of habitat also provides numerous perches and nesting sites suitable for this raptor species (Klavitter, 2000). Current population estimates based on John Klavitter's research extrapolates that there are currently 1,450 Hawaiian Hawks that, in his estimation, equals or exceeds what was present in pre-contact times (Klavitter, 2000). The Hawaiian Hawk breeding season starts in late March; chicks hatch in May and begin to fledge in July (Griffin et al., 1998). Although hawks use resources in most forest environments, they usually nest in *ʻōhiʻa* trees. Of 112 nests found during the 1998 and 1999 nesting seasons, 82% of the nests were located in ʻ*ōhi'a* trees (Klavitter, 2000).

Most of the proposed diversion channel corridor is currently vegetated in dense, secondary forest (see above) which is not an environment favored by Hawaiian Hawks. Areas along the southern third of the project adjacent to existing housing developments are more conducive to hawks than that found in the denser secondary forest found along the northern two thirds of the corridor. There are no appropriate nesting trees present along the bulk of the channel corridor for this species. The USFWS published a proposed rule to delist the Hawaiian Hawk in the *Federal Register* on August 6, 2008. The proposal is still open (*Federal Register*, 2008).

Endangered, endemic Hawaiian Petrel (*Pterodroma sandwichensis*), or *uaʻu*, were once common on the Island of Hawaiʻi (Wilson and Evans, 1890–1899). This pelagic seabird reportedly nested in large numbers on the slopes of Mauna Loa and in the saddle area between Mauna Loa and Mauna Kea (Henshaw, 1902), as well as at the mid- to high-elevations on Hualālai. It has, within recent historic times, been reduced to relict breeding colonies located at high elevations on Mauna Loa and possibly Hualālai (Banko, 1980a; Banko et al., 2001; Cooper and David, 1995; Cooper et al., 1995; Day et al., 2003; Harrison, 1990; Hue et al., 2001; Simons and Hodges, 1998).

Threatened, Newell's Shearwater (*Puffinus auricularis newelli*), or *ʻaʻo*, another pelagic seabird species, were formerly common on the Island of Hawaiʻi (Wilson and Evans, 1890–1899). This species breeds on Kauaʻi, Hawaiʻi and Molokaʻi in extremely small numbers. Newell's Shearwater populations have dropped precipitously since the 1880s (Banko, 1980b; Day et al., 2003b). This species nests high in the mountains in burrows excavated under thick vegetation, especially *uluhe* fern.

The primary cause of mortality in both Hawaiian Petrels and Newell's Shearwaters is thought to be predation by alien mammalian species at the nesting colonies (U.S. Fish & Wildlife Service, 1983; Simons and Hodges, 1998; Ainley et al., 2001). Collision with man-made structures is considered to be the second most significant cause of mortality of these seabird species in Hawaiʻi. Nocturnally flying seabirds, especially fledglings on their way to sea in the summer and fall, can become disoriented by exterior lighting. When disoriented, seabirds often collide with manmade structures, and if they are not killed outright, the dazed or injured birds are easy targets of opportunity for feral mammals (Hadley, 1961; Telfer, 1979; Sincock, 1981; Reed et al., 1985; Telfer et al., 1987; Cooper and Day, 1998; Podolsky et al., 1998; Ainley et al., 2001).

It is possible that small numbers of the endangered Hawaiian Petrel or *ua'u*, and the threatened Newell's Shearwater or *'a'o*, over-fly the project area between the months of May and November (Banko, 1980a, 1980b; Day et al., 2003a; Harrison, 1990). Suitable nesting habitat does not occur within or close to the proposed project area for either of these pelagic seabird species.

Mammalian Resources

The findings of the mammalian survey are consistent with the environments present in the proposed project area. Although, no Hawaiian hoary bats were detected during the course of this survey, it is probable that bats do use resources within the project area. Hawaiian hoary bats are regularly seen in here on a seasonal basis (David, 2009). Recent research (Bonaccorso et al., 2004, 2007) on the Island of Hawai'i has shown that this species is present, on a seasonal basis, in almost all areas on the Island where dense vegetation and tree cover are present. The research also indicates that the bat is a human commensal species, often associated with tree farms and other agricultural efforts. The bat is attracted to outdoor lights, which attract volant insects upon which this mammal feeds.

Although none of the four established alien rodents known from the Island of Hawai'i were detected during the course of the survey, it is probable that roof rat (*Rattus r. rattus*), Norway rat (*Rattus norvegicus*), Polynesian rat (*Rattus exulans hawaiiensis*), and European house mouse (*Mus musculus domesticus*), use resources within the project area.

Potential Impacts to Protected Species

<u>Hawaiian Petrel and Newell's Shearwater</u> ~ The only potential impact that the flood control project could pose to Hawaiian Petrels and Newell's Shearwaters is an increased threat that birds could be downed after becoming disoriented by outdoor lighting that may be installed as part of the construction. However, if no such lighting is planned, then there would be no risk to these species by the project.

<u>Hawaiian Hawk</u> ~ It is not expected that either the construction or operation of the proposed flood control measures will result in deleterious impacts to this species, as there is very little suitable foraging or nesting habitat currently within the project area. [What if trees are removed for the channel?]

<u>Hawaiian Hoary Bat</u> ~ The principal potential impact that the construction of the flood control features poses to bats is during clearing and grubbing phases

of construction. The removal of the dense woody vegetation taller than 15 ft (5 m) high within the project area may temporarily displace individual bats. As bats use multiple roosts within their home territories, the potential disturbance resulting from the removal of vegetation is likely to be minimal. Hawaiian hoary bats are thought to be less able to vacate a roost tree rapidly during the pupping season when adult females carry their pups with them. Potential adverse effects from such disturbance can be avoided or minimized by not clearing woody vegetation taller than 15 ft in height between about April 15 and August 15, the period in which bats most likely would be carrying young.

Conclusions

The modification of the current habitats found within the proposed project area is not expected to result in significant impacts to any botanical, avian or mammalian species currently listed as threatened, endangered or proposed for listing under either the federal or state endangered species programs. Furthermore, the development of the project is not expected to have a significant deleterious impact on native floral or faunal resources found within the South Hilo District, since even the most potentially destructive alternative (the diversion channel) would mostly impact non-native, secondary forest and agricultural fields. Some native open forest of *ʻōhiʻa* and *uluhe*, a common plant association in the Hilo area, would be removed.

To reduce the potential impact clearing of portions of the lot may have on Hawaiian hoary bats, it is recommended, if the dense woody vegetation taller than 15-ft high currently found along the diversion channel corridor not be removed during the April 15 through August 15 bat pupping season.

Replanting of appropriate native trees along the disturbed corridor of the diversion channel should offset (mitigate) losses resulting from construction. *Uluhe* should naturally reclaim open areas along this corridor and do so fairly quickly.

Glossary

Alien - Introduced to Hawaiʻi by humans
Commensal – Animals that share humans' food and lodgings, such as rats and mice
Diurnal – Daytime
Domesticated – Feral species, not considered established in the wild on the Island of Hawaiʻi.
Endangered – Listed and protected under the ESA as an endangered species
Endemic – Native and unique to the Hawaiian Islands

Falconiforme – Diurnal birds of prey – 271 species worldwide.
Indigenous - Native to the Hawaiian Islands, but also found elsewhere naturally
Naturalized – A plant or animal that has become established in an area that it is not indigenous to
Nocturnal – Nighttime, after dark
Ruderal – Disturbed, rocky, rubbishy areas, such as old agricultural fields and rock piles
Sign – Biological term referring tracks, scat, rubbing, odor, marks, nests, and other signs created by animals by which their presence may be detected
Threatened - Listed and protected under the ESA as a threatened species
Volant – Flying, capable of flight - as in flying insect

ASL – Above mean sea level
DLNR – Hawai‘i State Department of Land & Natural Resources.
ESA - Federal Endangered Species Act of 1973, as amended.
USFWS – U.S. Fish & Wildlife Service

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(FINAL)

BIOLOGICAL SURVEY
FOR THE
PALAI STREAM FLOOD CONTROL PROJECT

March 2, 2005

Prepared for:

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Contract No. DACA83-00-D-0012, Task Order No. 0081

Enclosure 8

Biological survey for the Palai Stream Flood Control Project[1]

March 2, 2005 *AECOS* No. 1075

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Introduction

This report presents the results of a biological field survey undertaken in the Waiakea area of Hilo, Hawaii (Figure 1) for the purpose of establishing the presence or absence of sensitive biological elements in the landscape relative to the proposed Palai Stream Flood Control Project. Palai Stream drains a portion of the Waiakea Homesteads area to the east of Waiakea Stream and is, in a sense, a tributary to Waiakea Stream (State Perennial Stream ID No. 8-2-61.01). Waiakea Stream is one of several streams that flow into Waiakea Pond and the Wailoa River, which discharges into the south part of Hilo Bay. This stream system is one of only a few that drains the Mauna Loa side of the boundary between ancient lava flows originating from Mauna Kea and those originating from Mauna Loa. Streams are sparse on the Mauna Loa lavas despite an annual rainfall averaging over 100 inches in the Hilo area and nearly 200 inches at Mountain View further upslope (Telliaferro, 1959). The absence of perennial streams is characteristic of volcanic substrata where the surface material is composed of recently (in a geological sense) laid down lavas. In contrast, the much older Mauna Kea slopes north of Hilo are deeply dissected by streams (AECOS, 1997, 2002)

The slopes to the east and south of the Waiakea Stream watershed, drain in an east-south-easterly direction towards the broad lava plain east of Hilo. These several other streams in the Waiakea area are shown (unnamed) on earlier topographic maps (USGS, 1932, 1981) as arising from branches around the 800-foot elevation, and disappearing a short distance east of Kanoelehua Avenue (State Highway 11, Hawaii Belt Highway south out of Hilo; formerly Kilauea Avenue and Volcano Road). The smaller (in terms of length) of the multiple branches is Palai Stream which arises around the 420-foot elevation near Ainaola Drive in Waiakea Homesteads,

[1] This report was prepared for use by Wil Chee Planning in an Environmental Assessment document for the Palai Stream Flood Control Project. The EA will become part of the public record.

flowing mostly eastward through the Hilo Municipal Golf Course, crossing under Kanoelehua Avenue, and turning north then "disappearing." However, the topography in this area suggests a continued northerly course, paralleling the highway, before turning northwesterly and joining a small branch of Waiakea Stream between Kawili Street and East Lanikula Street and then flowing towards or into Waiakea Pond. Considering contours alone, and not mapped stream courses, this seems to be the general pattern of flow for all of these intermittent streams. However, most streams in this part of the island loose so much flow to infiltration in the highly porous, relatively recent lava flows, that they cease eroding distinct channels and disappear into the landscape before reaching the ocean shore.

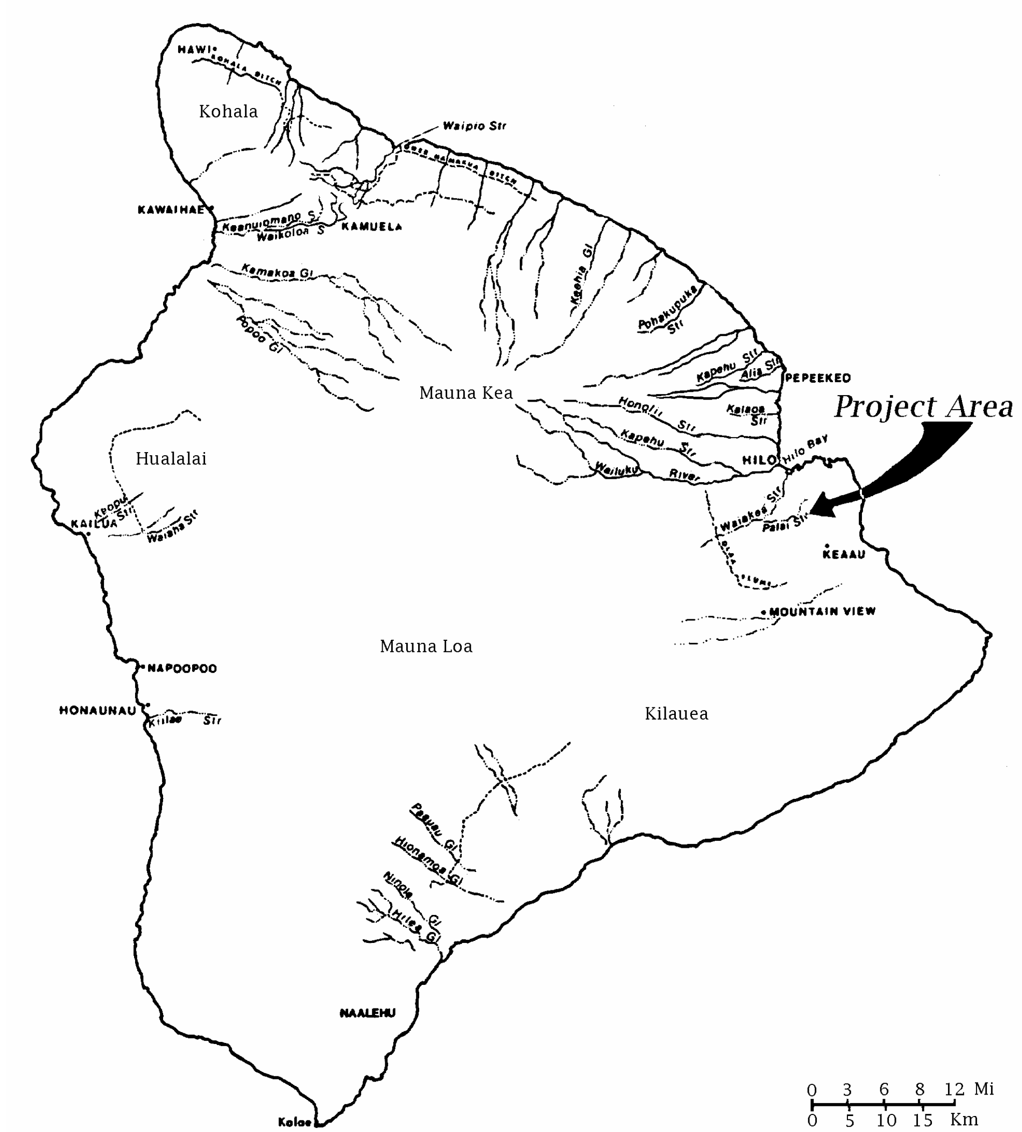

Figure 1. Project location south of Hilo on a stream map of the Island of Hawaii.

A flood waters diversion project (shown partially completed on the 1981 USGS topographic map) known as the Waiakea-Uka Flood Control Channel collects water from the more southerly complex of streams (Four Mile Creek and tributaries), diverting flood flows eastward to low sloping, porous lava flows to the east of Hilo. This diversion project was eventually completed up to and beneath Kanoelehua Avenue, intercepting the flows in Four Mile Creek upslope of its former confluence with Palai Stream. The purpose of the present flood control project is to join Palai Stream to the Waiakea-Uka Flood Control Channel, thereby diverting its flow away from significant developed areas around Kanoelehua Avenue.

Figure 2. The Waiakea-Uka Flood Control Channel looking upslope from the Awa Street bridge. This portion of the channel was completed before 1981.

The size of the diversion channel constructed previously is quite substantial, consisting of a trapezoidal channel bounded by high levees (Figure 2, above). Portions of this channel are now 25 years old, and it is not surprising that the vegetation is mature and includes large trees. Although all of these streams that flow into the channel are intermittent and contain water only infrequently because of the highly porous nature of the drainage basin, flows of considerable magnitude certainly can and do occur (Figure 3). Of course, as the Waiakea area has continued to develop, the proportion of impermeable surfaces within the watershed has steadily increased.

Figure 3. This pandanus tree is growing in the diversion channel at the lower end close to where the channel starts to broaden out. Despite a channel width approaching 60 feet, vegetation matter was deposited by a previous flood in branches more than six feet off the channel bottom.

Methods

The biological survey for the Palai Stream Flood Control Project was undertaken by site visits over a two day period (January 8 and 9, 2005) to the area of interest (survey site; see Figure 4) and conducting wandering transects through the designated subareas in order to observe and record the flora and fauna. Field notes were made by the *AECOS* biologist (Eric Guinther) and all flowering plants and ferns identified as they were encountered, or specimens collected for later identification, or digital photographs taken. Observations on wildlife (especially birds) were made

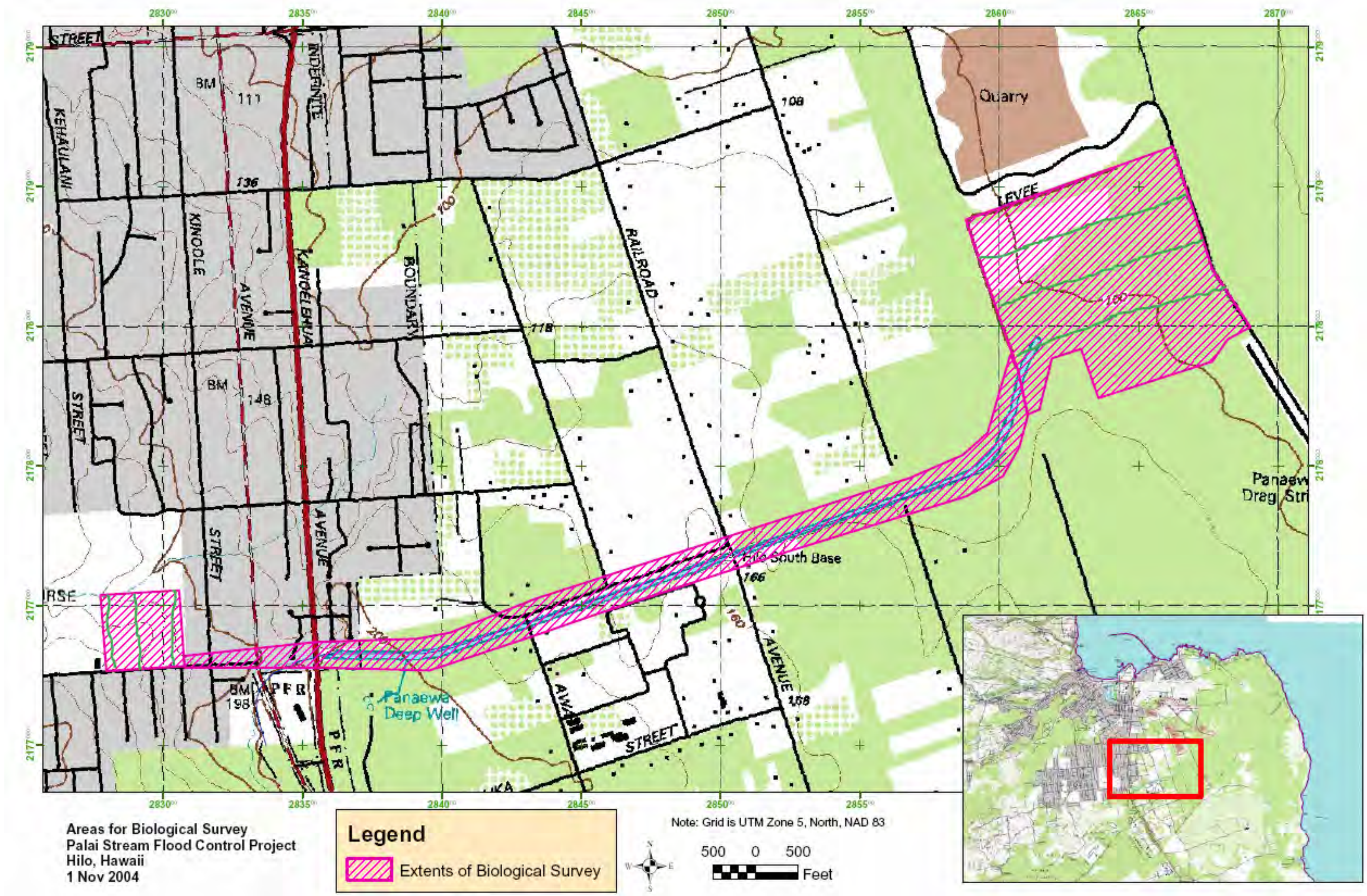

Figure 4. Army Corps of Engineers project site map showing project area for biological survey.

incidental to the plant survey by all members of the survey team. Based upon the rate of additions of new plant species, it was felt that the observational "transects" were thorough, although different approaches were used for different subareas. Thus, for the uppermost parcel of land (known as the "Catholic Church Site") the area was covered by a long wandering transect that twice crossed and once circled the parcel. For the Four Mile Creek and Waiakea-Uka Flood Channel area, access was made at each road/highway crossing, and forays made up and down "stream". Observations from bridges and from along the levee roads confirmed the consistency of the vegetation between access points in most cases, although access to Four Mile Creek above the diversion channel was sporadic due to private land-holdings. None-the-less, this latter area and the proposed construction area along Haihai Street between the Catholic Church Site and the upper end of the Flood Channel is mostly developed house lots with vegetation dominated by ornamental species planted in yards.

A more technical approach was used for the large "Drainage Basin" parcel at the eastern or lower end of the Waiakea-Uka Flood Control Channel as shown in Figure 5. First, several GPS readings[2] were made at key points surrounding the area—essentially to serve as a check on the accuracy of an overlay map produced for this report. These points are labeled "A" through "E" (see Table 1). It was initially proposed to conduct three transects crossing the basin from roughly east to west (green lines in Figure 4). This proved impractical for a variety of reasons including weather and timing during the 2-day survey. Consequently, only one west to east transit was completed (Transect 3). However, the other two transects were divided into forays that surveyed specific areas to satisfy the three transects and parcel coverage required by the contract. Thus, Transect 1 covered the southern, heavily forested part of the area and the lower end of the drainage channel, but consisted of a loop foray made from and back to the road in the southeast corner (Transect 1a) and a second loop from the end of Elama Road into the basin and back out (transect 1b), with a portion extending up the lower end of the drainage channel to Auwae Road and back. Likewise, Transect 2 was divided into a quarry/levee foray (Transect 2a) and an "outlet"/northeast corner foray (Transect 2b).

In all cases, the actual traverse as shown in Figure 5 is an approximated route based upon GPS readings taken at the start and finish and two or more GPS readings made along the way. In the dense forested areas that typified especially the central to southern part of the basin, poor satellite reception was experienced in many places; only GPS readings based upon four or more satellites were recorded. It proved very difficult to maintain a compass heading much less a straight line in the rugged terrain, so the actual area covered (length of transect) would have been substantially more than the line shown on the map.

[2] Garmin handheld "GPS III Plus".

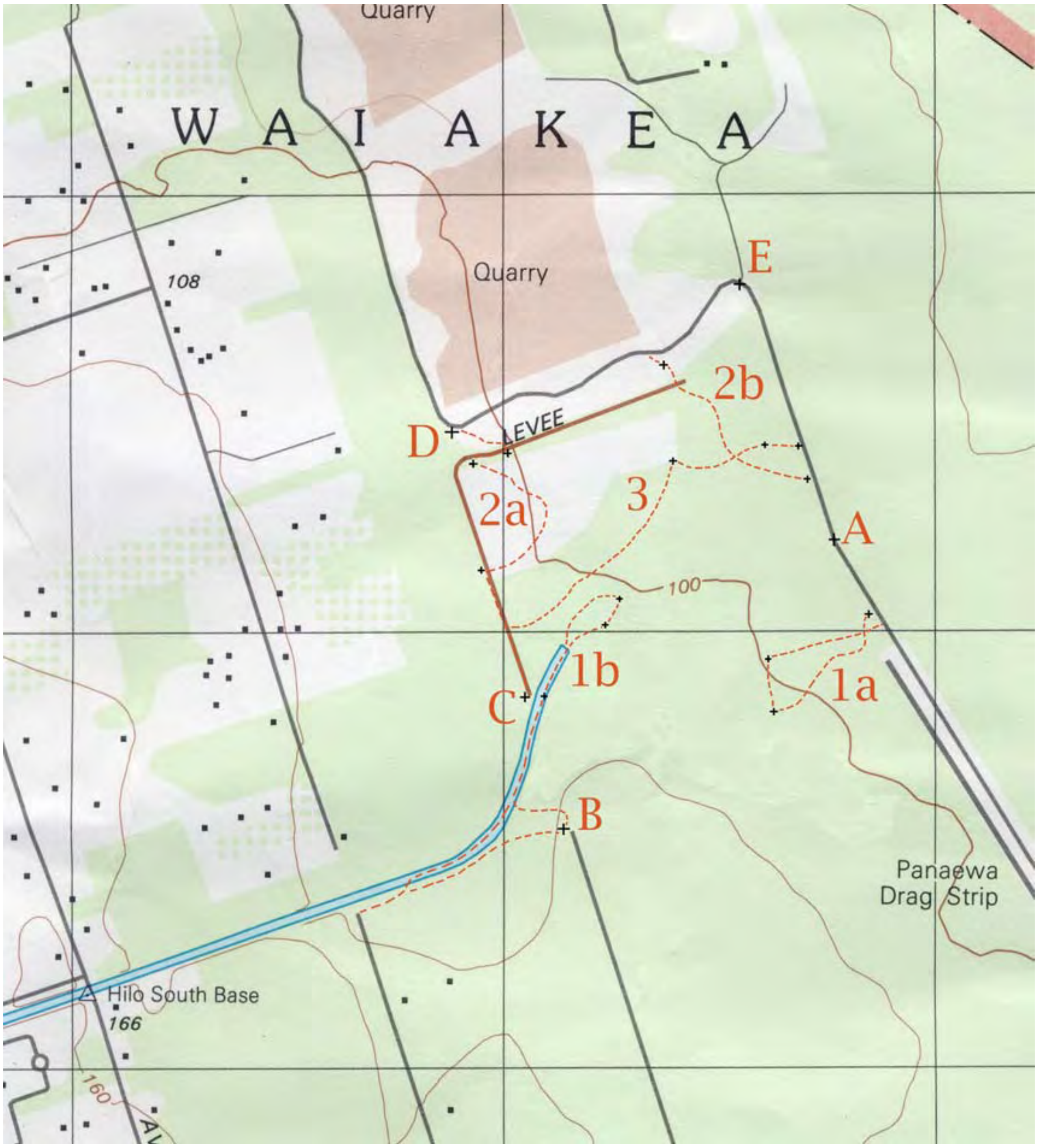

Figure 5. Portion of USGS topographic map sheet (Hilo quadrangle, 7.5-minute series, 1995) with our GPS points ("+") and approximate traverses (dashed lines) of the biological transects conducted in the lower channel and receiving basin areas of the project. Points "A" through "E" are GPS plots used to confirm the accuracy of the overlay map. Transects are numbered "1a", "1b", etc. through "3". North is up and grid lines represent the 1000 m grid for UTM Zone 5, North, NAD 83.

Table 1. Transect time and location (UTM coordinates) information for the "Drainage Basin" survey area.

TRANSECT POINTS	START		FINISH	
TRANSECT 1a	01/08/05	0286852	01/08/05	On road 30 m
"	11:45	2178037	13:15	SE of start point
TRANSECT 1b	01/08/05	0286139	01/08/05	Return to start
"	14:00	2177541	15:50	point
TRANSECT 1b[1]	14:30	0286094	15:15	Return to start
"		2177847		point[1]
TRANSECT 2a	01/09/05	0285880	01/09/05	0285943
"	08:40	2178460	09:35	2178143
TRANSECT 2b	01/09/05	0286376	01/09/05	0286712
"	11:30	2178617	12:16	2178347
TRANSECT 3	01/09/05	--[2]	01/09/05	0286683
"	09:45	--	11:10	2178424
MAP POINTS:				
Point A	01/09 /05	12:35	0286768	2178209
Point B	01/08/05	14:07	0286139	2177541
Point C	01/09/05	09:41	0286046	2177849
Point D	01/09/05	08:40	0285880	2178460
Point E	01/09/05	12:37	0286550	2178800

[1] - Basin or "forest" segment only; [2] - GPS instrument malfunction.

A plant checklist (Table 2) was compiled from our observations with entries arranged alphabetically under family names. Included are the scientific name, the common name, and status of the species. The nomenclature of the higher plants follows that of Wagner, Herbst, & Sohmer (1990) and Wagner & Herbst (1999) for the native and naturalized plants and Palmer (2003) for the ferns.

Water Quality Methods — Although containers and field instruments were taken into the field for water quality testing, the only occurrences of open water were small pools, especially those associated with pig wallows within the basin survey area. No standing or flowing water was observed anywhere in the channel or the small segments of Four Mile Creek and Palai Stream surveyed. Therefore, no water quality samples were collected, despite the circumstance that the survey was conducted during a period of scattered light rains.

Environment Description

The project area, located in the south Hilo District (Waiakea area) of the Island of Hawaii is aligned from Palai Stream at the Hilo Municipal Golf Course (220 ft elevation), along Haihai Street to Four-Mile Creek, then down the Waiakea-Uka Drainage Channel to the receiving or Drainage Basin of the flood control channel (around the 100-ft elevation). The survey area is divisible into relatively distinct parts: (1) a 19-acre, vacant lot adjacent to the municipal golf course and known as the "Catholic Church Site," (2) a narrow strip of land along Haihai Street connecting the Catholic Church Site with Four Mile Creek at the bottom of Haihai Street, (3) Four-mile Creek between the one-lane bridge on Kilauea Avenue and Kanoelehua Avenue where the stream empties into (4) the Waiakea-Uka Drainage Channel, the approximately 12,000-foot long drainage channel, and (5) an area of 172 acres forming the lower receiving basin for the flood channel.

Partly on the basis of the characteristic vegetation, as well as the approach and effort made to identify and describe the natural resources, the survey area was divided into three survey subareas by combining the Catholic Church Site with Haihai Street and Four-Mile Creek parts, comprising all of the project area above Kanoelehua Avenue ("Upper Survey SubArea") and being mostly urban in character. This was done partly because the vegetation in all of these areas was highly influenced by the developed nature of the landscape, and partly because time and weather required that only minimal effort could be expended within neighborhood areas where nearly all of the plants were species planted and maintained in residential yards.

UPPER SURVEY SUBAREA — The Catholic Church Site is a wooded, rectangular lot overgrown with trees (a mostly open forest of *Melochia umbellata*, *Trema orientalis*, and *Psidium cattleianum*) and shrubs (especially common are *Melastoma candidum* and *Ardesia elliptica*), with scattered open areas of dense grasses (mostly *Pennisetum purpureum*). *Dissotis rotundifolia,* wedelia (*Sphagneticola trilobata*), *Mimosa pudica*, and *Ageratum* cf. *houstonianum* form extensive ground cover over much of the property, but overall, the vegetation is very diverse, with numerous naturalized and ornamental species being locally abundant on different parts of the lot.

Palai Stream clips the northwest corner of the parcel where the stream bed crosses the municipal golf course fairways. The stream bed is evident on and close to the Catholic Church property as a narrow, excised channel 1-1.5 m deep and 2 m across, draining a low area overgrown with para grass (*Brachiaria mutica*). Most of the lot is an undulating surface with scattered outcrops of rock, but covered by a relatively deep, rich soil. Plants present include a number of ornamentals, especially along the eastern side bordering a neighborhood, suggesting this parcel had one or more occupied residential structures on the land in the past. A similar predominance of plants more typical of landscaping characterize the west and north margins facing greens of the golf course.

Table 2. Checklist of plants found on the Palai Stream Flood Conrol Project sites in South Hilo District, windward Hawai`i.

Species	Common name	Status	ABUNDANCE Upper	Chan.	Basin
FERNS & FERN ALLIES					
ASPLENIACEAE					
Asplenium nidis L.	*ekaha,* birds nest fern	**Ind.**	--	--	R
BLECHNACEAE					
Blechnum appendiculatum Willd.	---	Nat.	U	--	AA
DENNSTAEDTIACEAE					
Pteridium aquilinum (L.) Kuhn	*kilau, warabi*	**Ind.**	AA	U	--
DICKSONIACEAE					
Cibotium chamissoi Kaulf.	*hapu`u*	**End.**	--	--	U
GLEICHENIACEAE					
Dicranopteris linearis (Burm. f.) Underw.	*uluhe*	**Ind.**	--	--	Ca
NEPHROLEPIDACEAE					
Nephrolepis multiflora (Roxburgh) Jarrett ex Morton	common sword fern	Nat.	A	AA	A
OPHIOGLOSSACEAE					
Ophioderma pendulum (L.) C. Presl.	*puapuamoa*	**Ind.**	--	--	R
POLYPODIACEAE					
Lepisoris thunbergianus (Kaulf.) Ching	*pakahakaha*	**Ind.**	R	--	O
Phlebodium aureum (L.) J. Sm.	*laua`e haole*	Nat.	O	R	U
Phymatosorus grossus (Langsd & Fisch.) Brownlie	*laua`e*	Nat.	O	O	O
PSILOTACEAE					
Psilotum complanatum Sw.	*moa nahele*	**Ind.**	--	--	U
PTERIDACEAE					
Pityrogramma calomelanos (L.) Link	silverback fern	Nat.	--	--	R
(1) *Pteris cretica* Gaudich.	*Waimakanui*	**Ind.**	--	--	U
(1) *Pteris hillebrandii* Copel.	---	**End.**	--	--	R
THELYPTERIDACEAE					
Christella cf. *dentata* (Forrsk.)	wood fern	Nat.	C	A	AA
FLOWERING PLANTS					
DICOTYLEDONES					
ACANTHACEAE					
Odontonema cuspidatum (Nees) Lorence et al.	---	Orn.	U	--	--
Thunbergia fragrans Roxb.	white thunbergia	Nat.	U	--	--

Table 2 (continued)

Species	Common name	Status	ABUNDANCE Upper	Chan.	Basin
ANACARDIACEAE					
Mangifera indica L.	mango	Nat.	R	--	--
Schinus terebinthifolius Raddi	Christmasberry	Nat.	U	R	--
APOCYNACEAE					
Allamanda cathartica L.	yellow allamanda	Orn.	R	--	--
ARALIACEAE					
(3) *Scheflera actinophylla* (Endl.) Harms	octopus tree	Nat.	U	--	U
ASTERACEAE (COMPOSITAE)					
(2) *Ageratum conyzoides* L.	*maile hohono*	Nat.	U	--	--
(1) *Ageratum* cf. *houstonianum* Mill.	*maile hohono*	Nat.	AA	U	A
(2) *Bidens pilosa* L.	beggar's tick	Nat.	U	--	--
(2) *Calyptocarpus vialis* Less.	---	Nat.	U	--	--
(2) *Crassocephalum crepidioides* (Benth) S. Moore	---	Nat.	R	--	--
(2) *Emilia sonchifolia* (L.) DC	Flora's paintbrush	Nat.	U	U	--
(3) *Pluchea carolinensis* Jacq.) G Don	sourbush	Nat.	--	Oc	O
Sphagneticola trilobata (L.) Pruski	wedelia	Nat.	AA	AA	Oa
BALSAMINACEAE					
Impatiens walleriana J.D. Hook.	busy Lizzy	Nat.	U	U	--
BEGONIACEAE					
Begonia hirtella Link	---	Nat.	--	R	R
BIGNONIACEAE					
Spathodea campanualta P. Beauv.	African tulip tree	Nat.	O	--	--
CARYOPHILLACEAE					
(2) *Drymaria cordata* (L.) Willd. Ex Roem. & Schult.	*pipili*	Nat.	R	--	--
CECROPIACEAE					
Cecropia obtusifolia Bertol.	guarumo	Nat.	U	U	O
CLUSIACEAE					
Clusia rosea Jacq.	autograph tree	Nat.	--	Uo	R
CONVOLVULACEAE					
Ipomoea indica (Burm.) Merr..	*koalai `awa*	**Ind.**	O	U	
Ipomoea triloba L.	little bell	Nat.	U	--	--
Meremia tuberosa (L.) Rendle	wood rose	Nat.	R	--	--
CRASSULACEAE					
Kalanchoë pinnata (Lam.) Pers.	air plant	Nat.	U	--	--
CUCURBITACEAE					
Momordica charantia L.	balsam pear	Nat.	--	R	--

Table 2 (continued)

	Species	Common name	Status	ABUNDANCE Upper	Chan.	Basin
	EUPHORBIACEAE					
	Acalypha hispida Burm. f.	chenille plant	Orn.	R	--	--
	Aleurites moluccana (L.) Willd.	kukui	Pol.	U	--	--
(2)	*Chamaesyce hypericifolia* (L.) Millsp.	graceful spurge	Nat.	R	--	R
	Macaranga mappa (L.) Müll. Arg.	bingabing	Nat.	--	R	R
	Phyllanthus debilis Klein ex Willd.	niruri	Nat.	Oc	--	--
	Ricinus communis L.	castor bean	Nat.	R	--	--
	FABACEAE					
(3)	*Acacia confusa* Merr.	Formosan koa	Nat.	--	--	R
(3)	*Calliandra haematocephala* Hassk.	red powderpuff	Orn.	--	--	R
	Chamaecrista nictitans (L.) Moench	partridge pea, *lauki*	Nat.		O	--
(3)	*Crotalaria pallida* Aiton	smooth rattlepod	Nat.	--	U	Oc
	Desmodium incanum DC	Spanish clover	Nat.	O	U	--
	Desmodium tortuosum (Sw.) DC	Florida beggarweed	Nat.	---	O	--
	Desmodium trifolium (L.) DC	---	Nat.	O	U	--
(3)	*Erythrina variegata* L. cv. "Tropic coral"	---	Orn.	--	R	R
	Falcataria moluccana (Miq.) Barneby & Grimes	Moluccan albizia	Nat.		O	U
	Leucaena leucocephala (Lam.) deWit	*koa-haole*	Nat.	U	R	--
	Mimosa pudica L.	sensitive plant	Nat.	C	C	O
(1)	*Neonotonia wightii* (Wight & Arnott) Lackey	---	Nat.	U	--	--
(1)	Indet.	---	Orn.	R	--	--
	Indet.	flowering pea	Orn.	R	--	--
	LAMIACEAE					
	Hyptis pectinata (L.) Poit.	comb hyptis	Nat.	O	O	R
	LAURACEAE					
(1)	*Cassytha filiformis* L.	*kauna`oa pehu*	**Ind.**	--	--	C
	Persea americana Mill.	avocado	Nat.	U	R	--
	LYTHRACEAE					
	Cuphea hyssopifolia Kunth	false heather	Nat.	R	--	--
	Cuphea sp.	---	Orn.	U	--	--
	MELASTOMATIDAE					
	Clidemia hirta (L.) D..	Koster's curse	Nat.	--	O	Ca
	Dissotis rotundifolia (Sm.) Triana	---	Nat.	C	A	--
	Melastoma candidum D. Don	---	Nat.	C		AA
	Miconia calvescens DC	miconia	Nat.	R	--	R
	Tetrazygia bicolor (Mill.) Cogn.	---	Nat.	--	--	R
	MORACEAE					
	Ficus microcarpa L.	Chinese banyan	Nat.	--	--	R

Table 2 (continued)

	Species	Common name	Status	ABUNDANCE Upper	Chan.	Basin
	MYRSINACEAE					
	Ardesia elliptica Thunb.	shoebutton ardesia	nat	A	--	--
	MYRTACEAE					
	Melaleuca quinquenervia (Cav.) Blake	paperbark	Nat.	--	--	R
	Metrosideros polymorpha Gaud.	*`ohia*	**End.**	--	O	C
	Syzigium cumini (L.) Skeels	Java plum	Nat.	O	--	--
	Syzigium malaccense Merr. & Perry	mountain apple	Nat.	U	--	--
	Psidium cattleianum Sabine	*waiawi*	Nat.	C	Oc	AA
	Psidium guajava L.	common guava	Nat.	U	R	--
	OXALIDACEAE					
	Averrhoa carambola L.	star fruit	Orn.	R	--	--
	PASSIFLORACEAE					
	Passiflora mollissima (Kunth) L.H. Bailey	banana *poka*	Nat.	--	--	R
	PLANTAGINACEAE					
(2)	*Plantago lanceolata* L.	narrow-leaved plantain	Nat.	R	--	--
	PLUMBAGINACEAE					
(1)	*Plumbago cf. aurculata*	plumbago	Orn..	Uo	--	--
	POLYGALACEAE					
	Polygala paniculata L.	bubblegum plant	Nat.	U	U	--
	POLYGONACEAE					
(3)	*Polygonum capitatum* F. Ham.	---	Nat.	--	--	Uo
	ROSACEAE					
	Eriobotrya japonica (Thunb.) Lindl..	loquat	Orn.	R	--	--
	Rubis rosifolius Sm.	thimbleberry	Nat.	O	--	--
	RUBIACEAE					
	Paederia foetida L.	*maile pilau*	Nat.	O	U	--
	Psychotria hawaiiensis (A.Gray) Fosb.	*kopiko `ula*	**End.**	--	--	O
	Spermacoce assurgens Ruiz & Pav.	buttonweed	Nat.	O	O	R
	SAPINDACEAE					
	Filicium decipiens (Wight & Arnott) Thwaites ex J..D. Hook.	fern tree	Nat.	U	--	--
	STERCULIACEAE					
(3)	*Melochia umbellata* (Houtt.) Stapf.		Nat.	C	A	O
	TILIACEAE					
	Heliocarpus popayanensis Kunth	moho	Nat.	R	--	--
	TURNERACEAE					
	Turnera ulmifolia L.	politician's flower	Orn.	R	--	--
	ULMACEAE					
	Trema orientalis (L.) Blume	gunpowder tree	Nat.	C	C	C

Table 2 (continued)

	Species	Common name	Status	ABUNDANCE Upper	Chan.	Basin
	URTICACEAE					
	Pilea microphylla (L.) Liebm.	artillery plant	Nat.	--	Ua	--
	VERBENACEAE					
	Clerodendrum philippinum Schauer	*pikake honohono*	Nat.	O	--	--
	Lantana camara L.	lantana	Nat.	--	O	U
	Stachytarpheta cayennensis (Rich.) Vahl	*owi*	Nat.	--	U	--
(3)	*Stachytarpheta jamaicensis* (L.) Vahl.	Jamaican vervain	Nat.	--	R	R
	MONOCOTYLEDONES					
	AGAVACEAE					
	Cordyline fruticosa (L.) A. Chev.	*ki*, ti	**Pol.**	O	U	O
	ARECEAE					
	Alocasia macrorrhizos (L.) G. Don	*`ape*	**Pol.**	--	R	--
	Dieffenbachia cv.	dumb cane	Orn.	R	--	--
	Epipremnum aureum (Linden ex André) Bunting	variegated pothos	Nat.	Oc		--
(3)	*Monstera deliciosa* Liebm.	---	Orn.	R	--	R
	Philodendron scandens ssp. *oxycardium* (Schott) Bunting	heart-leaved philodendron	Orn.	--	R	--
	Philodendron sp.	indet. vine	Orn.	--	Uo	--
	Syngonium podophyllum Schott	nepthys	Esc.	R	--	--
	Xanthosoma roseum Schott	---	Nat.	R	--	--
	ARECACEAE					
	Archontophoenix alexandrae (F.v. Muell) H.A. Wendl. & Drude	king palm	Nat.	U	--	--
	Cocos nucifera L.	coconut	**Pol.**	U	--	--
	Rhapis excelsa (Thunb.) A. Henry ex Rehder	lady palm	Orn.	R	--	--
	COMMELINACEAE					
	Commelina diffusa Burm. f.	dayflower	Nat.	C	U	
	Commelina sp.	Upper. lvs. w/purple blush	Orn.	--	R	--
	CYPERACEAE					
	Cyperus halpan L.	---	Nat.	--	R	--
	Cyperus polystachyos Rottb.	---	**Ind.**	R	--	--
(2)	*Cyperus rotundus* L.	nut sedge	Nat.	U	--	--
	Machaerina mariscoides (Gaud.) J. Kern	*`ahanui*	**Ind**	--	--	U
	DRACAENACEAE					
	Dracaena fragrans (L.) Ker-Gawl.	corn-plant	Orn.	R	R	--
	Dracaena marginata (Lam.)	money tree	Orn.	--	R	--
	Dracaena reflexa Lam.	'Song of India'	Orn.	R	--	--
	Sansevieria trifasciata Prain	bowstring hemp	Orn.	--	R	--

Table 2 (continued)

Species	Common name	Status	ABUNDANCE		
			Upper	Chan.	Basin
HELICONIACEAE					
Heliconia collinsiana Griggs	collinsiana	Orn	R	--	--
Heliconia rostrata Ruiz & Pav.	hanging lobster-claw	Orn.	R	--	--
MUSACEAE					
Musa x *paradisica* L.	Banana, *mai`a*	Pol.	U	--	--
ORCHIDACEAE					
Arundina graminifolia (D. Don) Hochr.	bamboo orchid	Nat.	A	A	O
Spathoglottis plicata Blume	Malayan ground orchid	Nat.	--	C	O
PANDANACEAE					
Freycinetia arborea Gaud.	*`ie`ie*	**Ind.**	--	--	U
Pandanus tectorius S. Parkinson ex Z	*hala*	**Ind.**	--	--	C
POACEAE (GRAMINEAE)					
Andropogon virginicus L.	broomsedge	Nat	--	Ca	C
Brachiaria mutica (Forssk.) Stapf	para grass	Nat.	Ua	Oa	
Coix lachryma-jobi L.	Job's tears	Nat.	U	--	--
Digitaria ciliaris (Retz.) Koeler	Henry's crabgrass	Nat.			
(2) *Eleusine indica* (L.) Gaertner	goosegrass	Nat.	U	--	--
Melinus minutiflora P. Beauv.	molasses grass	Nat.	O	AA	C
(2) *Melinus repens* (Willd.) Zizka	Natal redtop	Nat.	U	--	--
Oplismenus compositus (L.) P. Beauv.	basket grass	Nat.	O	--	Oc
Panicum maximum Jacq.	Guinea grass	Nat.	U	--	--
Paspalum conjugatum Bergius	Hilo grass	nat.	U	--	R
(2) *Paspalum fimbriatum* Kunth	Panama paspalum	Nat.	O	Oc	--
Pennisetum purpureum Schumach.	elephant grass	Nat.	A	--	--
Phyllostachys viridis (Young) McClure	giant bamboo	Orn.	U	--	--
Sacciolepis indica (L.) Chase	Glenwood grass	Nat.	R	--	--
Schizostachyum glaucifolium (Rupr.) Munro	*'ohe*, bamboo	**Pol.**	O	--	--
Setaria gracilis Kunth	yellow foxtail	Nat.	R	--	--
Setaria palmifolia (J. König) Stapf	palmgrass	Nat.	O	--	--
(2) *Sporobolus* sp.		Nat.	U	--	--
Themeda villosa (Poir.) A. Camus	Lyon's grass	Nat.	U	O	--
Sansevieria zeylanica (L.) Willd.	bowstring hemp	Orn.	--	R	--
ZINGIBERACEAE					
Alpinia purpurata (Vieill.) K. Schum.	red ginger	Nat.	U	R	--
Etlingera elatior (Jack) R. M. Sm.	wax torch ginger	Orn.	R	--	--
Hedychium flavescens N. Carey ex Roscoe	yellow ginger	Nat.	O	--	--
Zingiber zerumbet (L.) Sm.	*`awapuhi*	**Pol.**	--	--	R

<u>Table 2 Legend</u>:
Status = distributional status
End. = endemic; native to Hawaii and found naturally nowhere else.
Ind. = indigenous; native to Hawaii, but not unique to the Hawaiian Islands.
Nat. = naturalized, exotic, plant introduced to the Hawaiian Islands since the arrival of Cook Expedition in 1778, and well-established outside of cultivation.
Orn. = exotic, ornamental; plant not naturalized at this location (not well-established outside of cultivation).
Pol. = Polynesian introduction before 1778.
Abundance = occurrence ratings for plants by area: Upper, Chan., and Basin (described in text)
R – Rare - only one or two plants seen.
U - Uncommon - several to five plants observed.
O - Occasional - found between five and ten times; not abundant anywhere (unless Oc or Oa).
C - Common - considered an important part of the vegetation and observed numerous times.
A - Abundant - found in large numbers; may be locally dominant.
AA - Abundant - abundant and dominant; defining vegetation type for the layer.
Subletters (such as O**c**) indicate more localized abundances.
NOTES:
(1) – Identification tentative owing to absence of flowers or fruit.
(2) – A species generally found only in disturbed, marginal areas such as along roadways; a ruderal plant.
(3) – Observed in the drainage basin, but only in the (highly disturbed) levee, quarry, or channel terminus areas.

Included in the flora listing (Table 2, "Upper") for the Catholic Church Parcel, are plants observed in and around Four-Mile Creek. This stream occupies a considerably more developed channel than Palai Stream at the same elevation, but was also without flowing or exposed standing water during our survey. The stream channel is overgrown with ferns (especially warabi or *Pteridium aquilinum*), vines, and typical wetland plants such as Job's tears (*Coix lachrymal-jobi*). The slopes surrounding the stream above the bank are partly forested with kukui (*Aleurites moluccana*) and bamboo; and partly the maintained yards of adjacent residences, the banks lined with banana (*Musa* x *paradisica*).

The total number of species (flowering plants and ferns) identified from the "upper" survey area was 104, nearly twice the number from the "channel" or "basin" subareas. This high number of species reflects the large number of naturalized and persisting ornamentals associated with the urban/suburban landscape. Thus, persisting ornamentals (20) constitute 19.2% of the species, and naturalized species (72; many escaped ornamentals) constitute 69.2% of the total. Endemic (none), indigenous (4), and Polynesian introductions (5) are correspondingly small proportions of the flora.

<u>WAIAKEA-UKA FLOOD CHANNEL</u> — The flood control channel (Table 2, "Chan.") is a man-made channel feature partly excavated from the low-sloping landscape between the Hawaii Belt Road and a drainage basin area. Levees border the channel and prevent flood waters from spreading away from the channel. The channel is mostly soil substratum on the surface (basalt flows presumably underlie the bed) and dominated by several grasses, mostly Molasses grass (*Melinus minutiflora*), broomsedge (*Andropogon virginicus*), and paragrass. The latter is especially abundant in the lower (further downslope) section of the channel. Various shrubs and trees are present, mostly on the levees, but now encroaching on the bed in some places. These include (trees): melochia, gunpowder tree, `ohia lehua

(*Metrosideros polymorpha*), waiawi, and Moluccan albizia (*Falcataria molucanna*); and (shrubs): Indian fleabane (*Pluchea carolinensis*). A number of autograph trees (*Clusia rosea*) occupy the levee down from the Awa Street bridge.

At the low end, the channel expands and terminates in the densely wooded southwest corner of the Drainage Basin parcel. There is no evidence of where the flow goes once it leaves the somewhat open area at the bottom. Indeed, with the exception of some debris high up in a pandanus tree (Figure 3), there is no sign that water ever flows in the channel, suggesting that large floods (called freshets) are space relatively far apart, but keeping in mind that the substratum here is a relatively thin soil over basalt and the vegetation grows quickly in the Hilo area. Evidence of a flood is very likely to be erased by regrowth of the herbaceous vegetation in less than a year.

The total number of species (flowering plants and ferns) identified from the "channel" survey area was 61, about the same as the number from the "basin" subarea, with a 38% overlap in species (23 species recorded from both subareas). Persisting ornamentals (7) constitute 11.5% of the species, and naturalized species (48) constitute 78.7% of the flora. Endemic (1), indigenous (2), and Polynesian introductions (2) are correspondingly small proportions of the flora (5% native excluding Polynesian introductions).

<u>FLOOD PROJECT DRAINAGE BASIN</u> — The drainage basin (Table 2., "Basin") is a roughly square parcel encompassing 172 acres with the drainage channel entering the area near the southwest corner. An outlet is located at the down slope, northeast corner. The "basin" is bounded on the north and east by a road serving a quarry site (north side) and the Panaewa Drag Strip located at the southeast corner. A massive levee bounds the west and north margins, and a quarry (presumably the source of the levee material) occupies between one-quarter and one third of the area in the northwest corner. Otherwise, the majority of this land is not especially basin-like, consisting of an undulating lava flow surface rising to the south with elevation differences on the order of 5 to 10 feet (2 to 3 m), but in places exceeding 30 ft (10 m). The area is easily divided into a highly disturbed part exemplified by the quarry, levee, and bottom end of the flood channel, where non-native vegetation predominates and an undisturbed part consisting of *`ohia* forest with scattered, open pockets of *uluhe* fern together covering the central to southern portion.

The vegetation in the disturbed quarry area is open grass and shrub land with mostly *Melastoma candidum* and broomsedge. The vegetation on the levee areas mostly resembles the vegetation described for the flood channel levees: gunpowder tree, melochia, molasses grass (*Melinus minutiflora*), bamboo orchid (*Arundina graminifolia*), sword fern (*Nephrolepis multiflora*), etc.

The vegetation on the undisturbed land is clearly the most interesting, representing a remnant native lowland wet forest described in Gagne and Cuddihy (1990) as a *`Ohia/Uluhe* (*Metrosideros/Dicranopteris*) Fern Forest. In this area, the association is growing on young lava flows, with a well developed moss/fern layer covering much of the forest floor and a mixture of native and alien plants present. It was expected that this area might harbor an *`Ohia/Lama* (*Metriosideros/Diospyros*) Wet Forest, although lama (*Diospyros sandwicensis*) was not observed, and the list of species present is more suggestive of the *`Ohia/Uluhe* Fern Forest, with bamboo orchid (*Arundina grammifolia*), *Lycopodium cernuum*, *Machaerina* sp. observed. However the drainage basin "native" forest is very heavily invaded by several aggressive non-native trees and shrubs, especially waiawi (*Psidium cattleianum*) and melastomes (mostly *Melastoma candidum*) Other native species observed during our survey were a number of ferns (see Table 2), kopiko`ula (*Psychotria hawaiiensis*), hala (*Pandanus tectorius*), and *`ie`ie* (*Freycinetia arborea*). *Kauna`oa pehu* (*Cassytha filiformis*), a parasitic vine considered indigenous, covers much of the growth along the east side close to the road. Species listed by Gagne and Cuddihy (1990) as also potentially characterizing the lowland wet forest association, namely *Broussaissa arguta*, *Dianella sandwicensis*, *Hedyotis centranthoides*, and *Sadleria* spp., were not noted in our survey as occurring in the drainage basin, although any could quite possibly be present in low numbers and not encountered along the transects.

Unfortunately, the vast majority of seedlings and young trees in this forest are those of the invasive non-natives. Not one seedling or young *`ohia lehua* was observed on any of the transects. This wet forest, whether natives or non-natives predominate as the overstory in any given area, continues to provide suitable habitat for a native understory plants: various ferns, mosses, lichens, and liverworts. *Uluhe* fern is presently abundant in mostly small patches throughout the site. *`Ohia* and patches of *hala* remain prominent, although replacement of the older `ohia trees appears not to be occurring.

The total number of species (flowering plants and ferns) identified from the "basin" survey area was 59, about the same as the number from the "channel" subarea, with a 38% overlap in species (23 species recorded from both subareas). Persisting ornamentals (3) constitute 5.1% of the species, and naturalized species (40) constitute 67.8% of the flora. Endemic (4), indigenous (10), and Polynesian introductions (2) are correspondingly small proportions of the flora (23.7% native excluding the Polynesian introductions). The diversity of ferns (23.7% of the species) is noteworthy; 57.1% of these are native fern species. Ten naturalized or ornamental species were identified as associated only with certain disturbed areas of the "basin" (see Table 2 legend), and can be subtracted from the total to give a percent native flora for the *`Ohia/Uluhe* Fern Forest association in the survey area of 28.6%.

FAUNA — Table 3 lists the birds seen or heard in the project area. Only the Pacific Golden Plover is native (indigenous); the others listed are naturalized alien species. The i`o or endemic Hawaiian hawk (*Buteo solitaries*) was not observed but expected to be found in at least the lower forested areas. Feral pig (*Sus scrofa*) were not observed, but there was evidence of their presence at the catholic Church Site and in the drainage basin wet forest. Other vertebrates presumed present but not observed are likely to be rats and mongooses. The coqui frog was heard in the area around Four-mile Creek and at the lower end of the drainage channel.

Table 3. Avifauna observed or heard on the survey.

Common Myna	*Acridotheres tristis*	common
Spotted Dove	*Streptopelia chinensis*	common
Zebra Dove	*Geopilia striata*	uncommon
Japanese White Eye	*Jasterops japonicus*	abundant
House finch	*Carpodicus mexicanus*	common
House Sparrow	*Passer domesticus*	common
Northern Cardinal	*Cardinalis cardinalis*	occasional
Pacific Golden Plover	*Pluvialis fulva*	seen on levees

Conclusions

No species listed either by the State of Hawaii (DLNR, 1998) or the U.S. Government (Federal Register, 1999, 2001, 2002, 2004) were encountered during the biological survey. No species of interest or concern were seen in the Upper or Waiakea-Uka Flood Channel survey subareas. Indeed, the disturbed areas of the previous flood control project (flood channel and levees of the flood channel and basin, and quarry) are heavily dominated by non-native vegetation, although some areas of the levee support *`ohia lehua*. On the other hand, despite considerable invasion by non-natives into the minimally disturbed native forest of the southern two-thirds of the drainage basin, this lower area does support a high percentage (29%) of native species. Expansion of the basin through mechanical disruption (i.e., increase in the aerial extent of the interior quarry, for example) will certainly prove detrimental to this forest and the native elements. While alien species are actively invading the native forest, it is evident that where the forest is disturbed (as in the quarry and levee areas), recovery of the vegetation is almost entirely by alien species.

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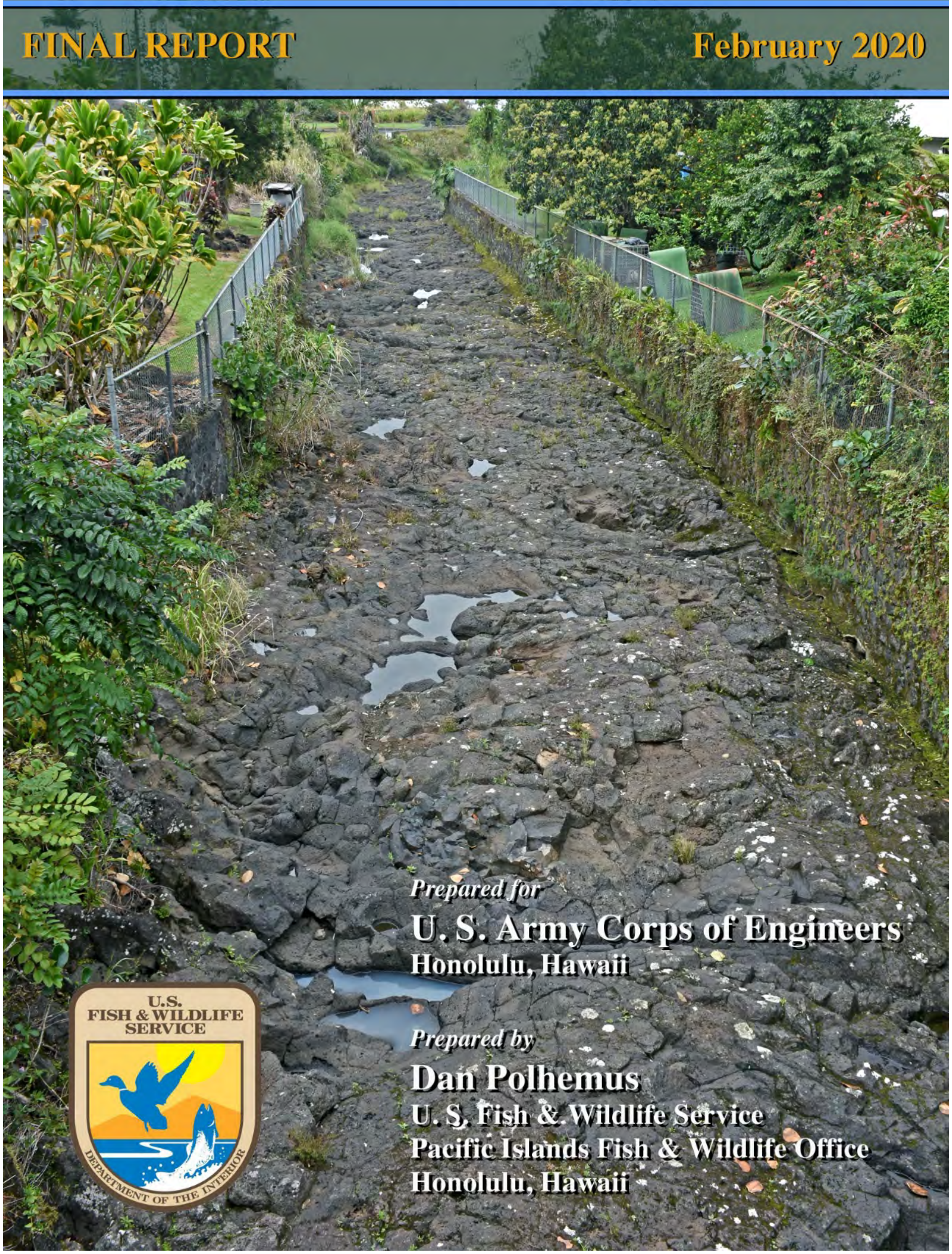
Appendix C:
Biological Study

Phase 1 Aquatic Resources Habitat Characterization

Waiakea and Palai Streams, Hawaii Is., Hawaii Flood Control

Planning Aid Report - Fish & Wildlife Coordination Act

FINAL REPORT **February 2020**



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Phase 1 Aquatic Resources Habitat Characterization: Waiakea and Palai Streams, Hawaii Island, Hawaii, Flood Risk Management

U. S. Fish and Wildlife Service, Pacific Islands Fish and Wildlife Office

Fish and Wildlife Coordination Act Planning Aid Report

14 February 2020

All photographs by Dan A. Polhemus.

Cover: Waiakea Stream at Kupulau Road bridge, looking downstream near the site of a proposed detention basin at New Hope Church.

FINAL

FISH AND WILDLIFE COORDINATION ACT
PLANNING AID REPORT

WAIAKEA-PALAI FLOOD RISK MANAGEMENT STUDY
HILO, HAWAII ISLAND, HAWAII

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14 Febuary 2020

TABLE OF CONTENTS

INTRODUCTION

Authority, Purpose and Scope

The current document constitutes the U.S. Fish and Wildlife Service's (Service) final planning aid report on plans developed by the U.S. Army Corps of Engineers – Honolulu District (USACE) for flood risk management along Waiakea Stream and Palai Stream, both located upslope of Hilo on the island of Hawaii, State of Hawaii (Figure 1). This report has been prepared under the authority of the Fish and Wildlife Coordination Act of 1934 (FWCA) [16 U.S.C. 661 *et seq.*; 48 Stat. 401], as amended, and other authorities mandating Department of the Interior (DOI) coordination to minimize impacts from federal projects. This report is also consistent with the National Environmental Policy Act of 1969 (NEPA) [42 U.S.C. 4321 *et seq.*; 83 Stat. 852], as amended and the Endangered Species Act of 1973 [16 U.S.C. 1531 *et. seq*.; 87 Stat. 884], as amended (ESA). The purpose of this report is to document existing fish and wildlife resources at the proposed project sites and to ensure that fish and wildlife conservation receives equal consideration with other proposed project objectives as required under the FWCA. The report includes an assessment of conspicuous diurnal fish and wildlife resources at the proposed project sites, an evaluation of potential impacts associated with the proposed alternative actions, and recommendations for fish and wildlife mitigation measures.

The proposed Waiakea-Palai Flood Risk Management Study is authorized under Section 205 of the Flood Control Act of 1948, Public Law 80-858 as amended (33 U.S.C. 701s) and Section 209 of the Flood Control Act of the Flood Control Act of 1962, Public Law 87-874, as amended (76 U.S.C. 1197s). Section 209 is a general study authority that authorizes surveys in harbors and rivers in Hawaii "with a view to determining the advisability of improvements in the interest of navigation, flood control, hydroelectric power development, water supply and other beneficial water uses, and related land resources." This civil works project is being undertaken by the USACE as the Federal sponsor, in partnership with the County of Hawaii as the non-Federal sponsor.

The overall purpose of the project is to reduce the risk of riverine flooding in the Waiakea Stream watershed. Flooding has occurred within the watershed on multiple occasions, resulting in recorded property damages, as well as health and safety risks.

The USACE is conducting an integrated Feasibility Study/Environmental Assessment to assess the technical, environmental and economic feasibility of the implementation of flood control improvements along the Waiakea and Palai stream channels. The initial study included evaluation of multiple structural measures, including detention basins, conveyance modifications, and berms or levees. On April 8, 2019 the USACE indicated to the Service that a Preferred Alternative had been selected, consisting of three elements. The first, Kupulau Ditch along Waiakea Stream, involved creation of a floodwall, levees and a detention basin near the New Hope Church. The second, Hilo Municipal Golf Course Detention along Palai Stream, involved a second detention basin at the Hilo Municipal Golf Course. The third, Ainalako Diversion, involved an overflow channel diverting flood flows from upper Palai Stream into the channel of Four Mile Creek. In January 2020, the USACE indicated to the Service that this latter element had been removed from the Preferred Alternative, but passing mention is made of it in the present report in the event it is reconsidered in the future, and because the sites involved were visited during a site visit in February 2019. Evaluation of the revised Preferred Alternative and its two remaining elements thus forms the basis for the current report.

Service biologists discussed the proposed project with staff of the National Marine Fisheries Service (NMFS) and the Hawaii Department of Land and Natural Resources, Division of Aquatic Resources (DAR). Copies of this report are being provided to the NMFS, DAR, the U.S. Environmental Protection Agency (EPA), the Hawaii Office of State Planning, Coastal Zone Management Program (CZMP), and the Hawaii Department of Health Clean Water Branch (CWB).

Prior Fish and Wildlife Service Studies and Reports

The service has prepared no prior FWCA reports related to this project. A site visit to the Waiakea-Palai FRM study area was conducted by Dr. Dan A. Polhemus from the Service, Troy Sakihara from the Hawaii Division of Aquatic Resources, and USACE staff on February 27, 2019 to assess existing conditions at the proposed project construction sites. The information gathered during that visit forms the basis for the current Planning Aid Report and associated recommendations.

DESCRIPTION OF THE PROJECT AREA

Waiakea Stream Catchment

The Waiakea watershed is located on the windward side of Hawaii Island, Hawaii, and drains a portion of the eastern slope of the active Mauna Loa volcano (Fig. 1). In the DAR Atlas of Hawaiian watersheds this stream is listed as a tributary of the larger Wailoa River catchment. The watershed is elongate and compact, covering about 37 square miles (96 km^2), being bounded to the north by the lower flanks of Mauna Kea, and to the south by the shield of Kilauea. The stream catchment is linear, as is typical for Hawaiian drainage basins, with no major forks or tributaries. The stream is considered intermittent under the classification of Polhemus et al. (1992), with flow occurring only during spates. This character is largely due to the nature of the channel, which is predominantly basalt bedrock, and as such has little or no hyporheic zone. The impervious nature of the stream channel also creates a very flashy discharge pattern, with sudden extreme flood peaks possible after heavy rains upslope.

Waiakea Stream originates near 4000 ft. (1220 m.) elevation on the eastern flank of Mauna Loa, and flows northeastward for approximately 15 miles (24 km.) before reaching its terminus at Waiakea Pond, on the shore of Hilo Bay. The upper half of the Waiakea catchment lies in sloping, forested terrain on the slopes Mauna Loa. Based on data from the Waiakea Scd precipitation gauge, located at 940 ft. (286 m.) elevation in the lower part of the catchment and with 55 years of record, the midreach zone of Waiakea Stream receives 192 inches, or 16 ft (4892 millimeters) of rain annually, with a relatively even monthly distribution throughout the year. Rainfall gradually attenuates down the length of the catchment, reducing to 142 inches

(3609 millimeters) annually at the coast (Giambelluca et al. 2013). The stream's headwaters consist of poorly defined channels shaded by forests of both native and introduced tree species. At approximately 585 ft. (178 m.) elevation the stream begins to traverse the suburban neighborhoods of Hilo, where its channel has been modified or straightened to varying degrees (see cover photo). The stream's terminal estuary is in Waiakea Pond, a large, natural estuarine limnocrene that connects via an outlet channel to Hilo Bay.

A stream gauging site was previously operated on Waiakea Stream at 1921 ft. (585 m.) elevation, a short distance below Middle Flume Spring. This gauge, however, is no longer active, and although it appears on older USGS topographic maps, it is not listed in the online data portal for the USGS National Water Information System. The USGS online system does, however, list two other gauges with more recent periods of record. The first of these lies at Hoaka Road (USGS code 16700600), at an elevation of 860 ft. (262 m.). During its two-year period of record from October 2003 to September 2005, this gauge recorded 5 discharge peaks in excess of 750 cubic feet per second (cfs), and one extreme peak of 1,330 cfs on 25 January 2004. Many of the intervening days had zero-discharge readings, indicating that flows in this system are highly variable and flashy.

The second gauge lies within the confines of Hilo (USGS code 16701300) at 80 ft. (24 m.) elevation. During its 15-year period of record from October 2003 to October 2018, this gauge recorded 3 peaks above 3,000 cfs, and one extreme peak of 5,760 cfs on 2 November 2000 (interestingly, the peak discharge at the Hoaka Road gauge on 25 January 2004 does not correlate with the peak discharge at this lower gauge, which on that date was only 750 cfs). As with the gauge further upstream, a large number of zero-discharge days were recorded between flood pulses, once again illustrating the flashy nature of the predominantly bedrock channel, although the higher discharge peaks also show the gaining nature of the system during flood events. In the case of both gauges, the data are not sufficient to calculate an annual mean or median flow with any statistical confidence.

During the course of the current investigation no continuous perennial flow was observed in the midreach of the stream where it passes under Kupulau Road. Based on previous survey work by the author in the Hilo area, this same condition prevails from this point all the way downstream to Waiakea Pond. The upper section of the Waiakea catchment is shown on USGS topographic maps as having a number of springs, including the Middle Flume Spring lying at 2100 ft. (640 m.) elevation, and the Waiakea-Uka Springs lying at 1500 ft. (457 m.) elevation, indicating that some reaches with perennial surface flow may exist in the upper midreach. Neither of these springs was investigated during the course of the present survey. Several wells are shown in and adjacent to the channel in the reach immediately below the Waiakea-Uka Springs, with an aqueduct leading to a water tank upslope of the Waiakea Homesteads, and as such, it is presumed that any surface flow which originally occurred in this area may now be diverted for municipal uses. Some limited areas of permanent water are likely to be present below this point in the form of pools and seeps, as indicated by the capture of the native damselfly *Megalagrion blackburni* by the author in 1994 along the stream channel immediately upstream of the University of Hawaii Hilo campus at 250 ft. (76 m.) elevation.

Palai Stream Catchment

The Palai watershed is much smaller than that of the Waiakea, heading near 800 ft. elevation in pastures on the outskirts of suburban Hilo. The stream channel is about 4.5 miles in length, passing through the Waiakea Homesteads subdivision and the Hilo Municipal Golf Course before eventually vanishing into swales and storm water conduits near the intersection of Mamalahoa Highway and Puainako Street. Palai Stream does not appear to exhibit perennial surface flow at any point along its length, and no previous USGS gauges, water wells, or diversions exist. During the site visit associated with the current report, no perennial flow was observed in the stream channel where it was inspected at Hilo golf course (200 ft.), or higher up at the crossing of Ainalako Road (530 ft.).

FISH AND WILDLIFE RESOURCE CONCERNS AND PLANNING OBJECTIVES

The Service's primary concerns with the proposed project were to determine any potential impacts to endangered species and any other fish and wildlife trust resources and their habitats from planned construction activities in the stream channels and adjacent riparian habitats. Specific Service planning objectives were to maintain and enhance any existing significant habitat values at the proposed project site by (1) obtaining basic biological data for the proposed project site, (2) evaluating and analyzing the impacts of proposed-project alternatives on fish and wildlife resources and their habitats, (3) identifying the proposed-project alternatives least damaging to fish and wildlife resources, and (4) recommending mitigation for unavoidable project-related habitat losses consistent with the FWCA and the Service's Mitigation Policy.

Under the authority of the ESA, the Department of the Interior and the Department of Commerce share responsibility for the conservation, protection, and recovery of federally listed endangered and threatened species. Authority to conduct consultations has been delegated by the Secretary of the Interior to the Director of the Service and by the Secretary of Commerce to the Assistant Administrator for Fisheries of the National Oceanic Atmospheric Administration (NOAA). Section 7(a)(2) of the ESA requires federal agencies, in consultation with and with the assistance of the Service or NMFS, to ensure that any action authorized, funded, or carried out by such agency is not likely to jeopardize the continued existence of any listed species or result in the destruction or adverse modification of designated critical habitats. The Biological Opinion is the document that states the opinion of the Service or NMFS as to whether the federal action is likely to jeopardize the continued existence of listed species or result in the destruction or adverse modification of critical habitat.

The Service's Mitigation Policy (Service, 1981) outlines internal guidance for evaluating project impacts affecting fish and wildlife resources. The Mitigation Policy complements the Service's participation under NEPA and the FWCA. The Service's Mitigation Policy was formulated with the intent of protecting and conserving the most important fish and wildlife resources while facilitating balanced development of the nation's natural resources. The policy focuses primarily on habitat values and identifies four resource categories and mitigation guidelines. The resource categories are the following:

a) Resource Category 1: Habitat to be impacted is of high value for the evaluation species and is unique and irreplaceable on a national basis or in the ecoregion section.

b) Resource Category 2: Habitat to be impacted is of high value for the evaluation species and is relatively scarce or becoming scarce on a national basis or in the ecoregion section.

c) Resource Category 3: Habitat to be impacted is of high to medium value for the evaluation species and is relatively abundant on a national basis.

d) Resource Category 4: Habitat to be impacted is of medium to low value for the evaluation species.

Given the naturally interrupted nature of the stream channels examined during this survey, the absence of riffle and pool habitat in the reaches where proposed flood control measures are proposed, and the existing channelization of the lower mid-reach and terminal reaches of these systems, the habitat to be impacted in this area is considered to represent Category 4

EVALUATION METHODOLOGY

Stream Channel Assessments

On February 27, 2019, Service biologist Dan Polhemus made a one-day visit to all of the sites currently proposed for flood control structures in the Waiakea and Palai stream basins. This visit, conducted in the company of USACE staff, allowed photographs and visual observations to be made of the various stream channels and adjacent riparian areas that might be subject to modification. Six individual sites were evaluated concerning the presence of freshwater fishes, crustaceans, mollusks, and insects (Fig. 1). Photographs of these sampling stations are provided in Figures 2-13, and summary data on station locations, elevations, presence or absence of surface flow, and faunal observations are provided in Table 1.

DESCRIPTION OF FISH AND WILDLIFE RESOURCES

Stream Channel Assessments

The results of the February 27, 2019, site visit by Dr. Polhemus are summarized in Table 1 below. The stream reaches examined were mostly dry, except for a few shallow, scattered pools in a basalt bedrock channel at Site 3 on the Hilo Municipal Golf Course, and in the bedrock channel of Waiakea Stream at the Kupulau Road bridge, which likely represented remnant runoff from recent rainfall. No freshwater fishes, crustaceans, or mollusks were seen at any of the sites surveyed. Individuals of the common native dragonfly *Pantala flavescens* were seen flying beats along the mostly dry stream channel in the Hilo golf course at Site 3, but it is likely that this

TABLE 1

Summary of results from a site visit to the proposed project area conducted from 07:30-11:30 hrs. on February 29, 2019 by Service biologist D. A. Polhemus. Site numbers correspond to those referenced in Figures 1-13. Sites with asterisks (*) were visited and assessed, but are no longer being considered as elements of the Preferred Alternative.

Site #	**Location**	**Elev.** (ft)	**Latitude** (Lat) & **Longitude** (Long)	**Flow**	**Pools**	**Fish**	**Aq. Ins.**	Hydrological Comments	Biological Comments
1	Kupulau Ditch at New Hope Church	635	Lat: 19.670257 Long: -155.108492	N	N	N	N	Ditch completely dry, no base flow. Proposed detention basin site.	Ditch overgrown with non-native vegetation.
2	Waiakea Stream at Kupulau Road Bridge	580	Lat: 19.675458 Long: -155.106021	N	Y	N	N	Basalt bedrock channel with scattered pools, no flow.	Non-native vegetation bordering channel.
3	Hilo Golf Course, Hole 10; detention basin site.	205	Lat: 19.677681 Long: -155.070181	N	Y	N	Y	Dry basalt bedrock channel with a few scattered pools, no base flow.	Native Odonata: *Pantala flavescens.*
4*	4 Mile Creek, Lower Bridge	195	Lat: 19.674908 Long: -155.064742	N	N	N	N	Dry, modified channel with no base flow; no water present.	Channel with dense, non-native vegetation.
5*	4 Mile Creek, Upper Bridge	200	Lat: 19.673864 Long: -155.066511	N	N	N	N	Dry channel, no base flow, no water present.	Channel overgrown with non-native vegetation.
6*	Swale between Palai Stream and 4 Mile Creek	530	Lat: 19.662573 Long: -155.092935	N	N	N	N	No base flow, no water present. Proposed Ainalako Diversion site.	Open pasture and swale with introduced grasses.

species is breeding in nearby golf course water features rather than in the stream channel itself. No diadromous native species were present, therefore it appeared that the proposed project elements did not pose a threat to biological connectivity in the Waiakea or Palai catchments.

The vegetation surrounding the proposed project construction sites in suburban Hilo was observed to consist largely of non-native, weedy species such as Guinea grass (*Panicum maximum*), and other herbaceous ground cover, with an over-story of albizzia (*Falcataria moluccana*), guava (*Psidium sp.*), Christmas berry (*Schinus terebinthifolius*), and various *Eucalyptus* species, as well as a variety of other ornamental cultivars at the Hilo golf course. No native plants were observed at any of the sites visited.

Vertebrates observed in the project area consisted of common, non-native birds found in the urbanized Hilo area. No rare or endangered plant, bird or insect species were observed, although it is likely that the project areas are traversed by the Hawaiian hoary bat (*Lasiurus cinereus*) during nighttime hours. The conclusion following the completion of the site visit was that native wildlife habitat functions and values in the Waiakea and Palai drainages appear to be extremely limited for native aquatic or terrestrial species at the present time.

DESCRIPTION OF ALTERNATIVES EVALUATED

Alternative 1 (Preferred): Detention Basin Construction

The proposed project involves modifications of portions of Waiakea and Palai streams for the purposes of controlling water flow and debris loading into the streams, in order to reduce flood risks. As alluded to previously, the proposed project alternatives originally provided to the Service in 2019 included, but were not limited to, construction of detention basins, conveyance modifications, and berms or levees to divert flow. Specifically, the alternatives included the construction of a floodwall, levees and a detention basin in the Waiakea Stream catchment near the New Hope Church (referred to as the Kupulau Ditch element); construction of a detention basin in the Palai Stream catchment near the lower end of the Hilo Municipal Golf Course (referred to as the Golf Course Detention element); and construction of an overflow channel in the upper Palai Stream basin that would divert flood flows into the headwaters of the adjacent Four Mile Creek (referred to as the Ainalako Diversion).

In December 2019 the USACE informed the Service through e-mail that the proposed project alternatives had been further refined. The proposed action alternative now consisted of the Kupulau Ditch and Golf Course Detention elements as described above, whereas the Ainalako Diversion had been withdrawn from further consideration.

Based on conceptual drawings provided by the USACE, the detention structures at the New Hope Church will consist of the following elements: 1) a Kupulau Ditch Floodwall with an average height of 5.6 ft. (1.7 m.), lying immediately west of the New Hope Church; 2) a South Containment Levee with an average height of 2.8 ft. (0.85 m.), runnning east-to-west immediately to the north of the New Hope Church; 3) a Kupulau Ditch Detention Pond occupying open grass playing fields to the north of the New Hope Church; 4) a Kupulau Ditch Lateral Wier set at existing right bank elevation along the west side of the detention pond; 5) an East Containment Levee with an average height of 6.7 ft. (2.0 m.), running along the east side of the detention pond; 6) a Waiakea Stream Levee with an average height of 4.2 ft. (1.28 m.), running along the south bank of Waiakea Stream and bordering the north side of the detention pond; and 7) a Kupulau Ditch Culvery consisting of a 12 x 8 ft. (3.6 x 2.4 m.) concrete box running under the far western end of the Waiakea Stream Levee, and conveying stored flood waters into the existing Waiakea Stream channel. An access road and staging area are also proposed on a vacant lot immediately to the east of the East Containment Levee.

Additional conceptual drawings provided by the USACE indicate that the detention structure at the Hilo Municipal Golf Course will consist of the following elements: 1) a North Side Levee with an average height of 6.4 ft. (1.9 m.), lying north of the Palai Stream channel, then bending south to connect to, b) a South Side Levee with an average height of 5.4 ft. (1.6 m.), lying south of the stream; and c) a Golf Course Culvert of 6 ft. (1.8 m.) diameter, designed to allow detained waters to gradually escape from the basin formed within the coterminous levee system.

All of the features listed above, at both New Hope Church and the Hilo golf course, are intended capture and temporarily detain floodwaters, gradually releasing them into the existing Waiakea and Palai stream channels over a period of days following a major flood event. As such, they do not involve the realignment or channelization of these streams, and would not create permanent barriers to the passage of diadromous native stream biota. In fact, such gradual release of water might actually prolong the period of surface flow in these catchments following a flood event.

Alternative 2: No Action

The only other alternative being considered is No Action, which would result in no changes to the Waiakea and Palai stream channels and their immediate surroundings.

PROJECT IMPACTS

It is understood that the density and encroachment of housing along the Waiakea and Palai drainages presents a substantial constraint to development of project alternatives, while at the same time constituting the underlying need for the proposed flood control project. The Service notes that the Preferred Alternative does not involve any straightening, concrete lining, or channelization of existing natural watercourses, or disconnection of streams and natural drainages from their floodplains. The detention basins will also preserve other functions, such as flood plain water storage and detention, and ground water recharge. Overall, native wildlife habitat functions and values in these lower sections of the Waiakea and Palai drainages appear to be extremely limited for native aquatic or terrestrial species. As such, it is the Service’s conclusion that the construction of the two detention basins as proposed would have minimal impact to aquatic or terrestrial habitat values.

FISH AND WILDLIFE SERVICE RECOMMENDATIONS

The Service recommends that the following best management practices be applied to all activities pertaining to construction and maintenance activities for this project, in order to to prevent construction impacts to riparian or marine ecosystems lying downstream.

Best Management Practices

(1) The permittee should make every effort to develop and implement a plan for conducting all anticipated work involving stream channels during the summer dry season. Work should be ceased and re-scheduled in the event of an out-of-season heavy rainfall;

(2) Avoid conducting construction or subsequent maintenance activities that will lead to mid- and long-term destabilization and exposure of bare sediment along the stream banks or in the stream bed;

(3) No debris, petroleum projects, or deleterious materials or wastes shall be allowed to fall, flow, leach, or otherwise enter any waters of the United States;

(4) All authorized activities shall be done in a manner to confine and isolate the construction activity and to control and minimize any turbidity that may result from in-water work. Silt curtains or other appropriate and effective silt containment devices approved by the USACE shall be used to minimize turbidity and shall be properly maintained throughout the entire period of any in-water work to prevent the discharge of any material to the downstream aquatic habitat. All sediment control devices installed as BMPs (i.e., fabric sandbags, silt curtains/screens, etc.) downstream or makai of the authorized work shall remain in place until the in-water work is completed and will be removed in their entirety and disposed of at an appropriate upland location once the water quality of the affected area has returned to its pre-construction condition;

(5) Return flow or runoff from upland dewatering site(s)/disposal site(s) shall be contained on land and shall not be allowed to discharge and/or re-enter any waters of the United States;

(6) No sidecasting or stockpiling of excavated materials in the aquatic environment is authorized. All excavated materials shall be placed above the ordinary high water mark of any designated waters of the United States, or disposed of in an upland location. The permittee shall demonstrate that there is no reasonable expectation that disposal locations adjacent to high tide lines on the ocean, or in floodplains adjacent to other rivers or streams, would result in the material being eroded into the nearby waterbody by high tides and/or flood events;

(7) Warning signs shall be properly deployed and maintained until the portion of the in-water work is completed and the affected area water quality has returned to its preconstruction condition and turbidity control devices have been removed from the waterway;

(8) Fueling, repair, and other activities with any potential to release pollutants will occur in a location where there is no potential for spills to have an effect on waters of the United States;

(9) When the USACE is notified that an authorized activity is detrimental to fish and wildlife resources, the USACE will issue a suspension order until all pertinent issues have been

satisfactorily resolved. The permittee shall comply with any USACE-directed remedial measures deemed necessary to mitigate or eliminate the adverse effect.

SUMMARY AND FISH AND WILDLIFE SERVICE POSITION

Due to the absence of surface flow in the areas associated with the project footprints, the apparent absence of diadromous aquatic macrofauna in the headwater reaches above the project footprint, and the overwhelmingly non-native composition of the flora and fauna in the areas of suburban Hilo in which the proposed project construction sites lie, the Service does not consider that the Preferred Alternative consisting of construction of two detention basins, one each at the New Hope Church and Hilo Municipal Golf Course, will have any significant or deleterious impacts to trust resources. Therefore, the Service concurs with the Preferred Alternative, if best management practices are implemented during construction.

The current FWCA Planning Aid Report is sufficient to cover the Feasibility Study phase of the current project. As the project progresses to design and eventual construction, USACE should continue to coordinate with the Service in order to avoid or minimize any potential environmental effects. The Service also notes that any changes to the proposed project plan at the current stage, such as reconsideration of the Ainalako Diversion, will also require additional coordination with the Pacific Islands Fish and Wildlife Office in Honolulu, Hawaii.

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Polhemus, D. A., J. Maciolek and J. Ford. 1992. An ecosystem classification of inland waters for the tropical Pacific islands. Micronesica 25 (2): 155–173.

FIGURES

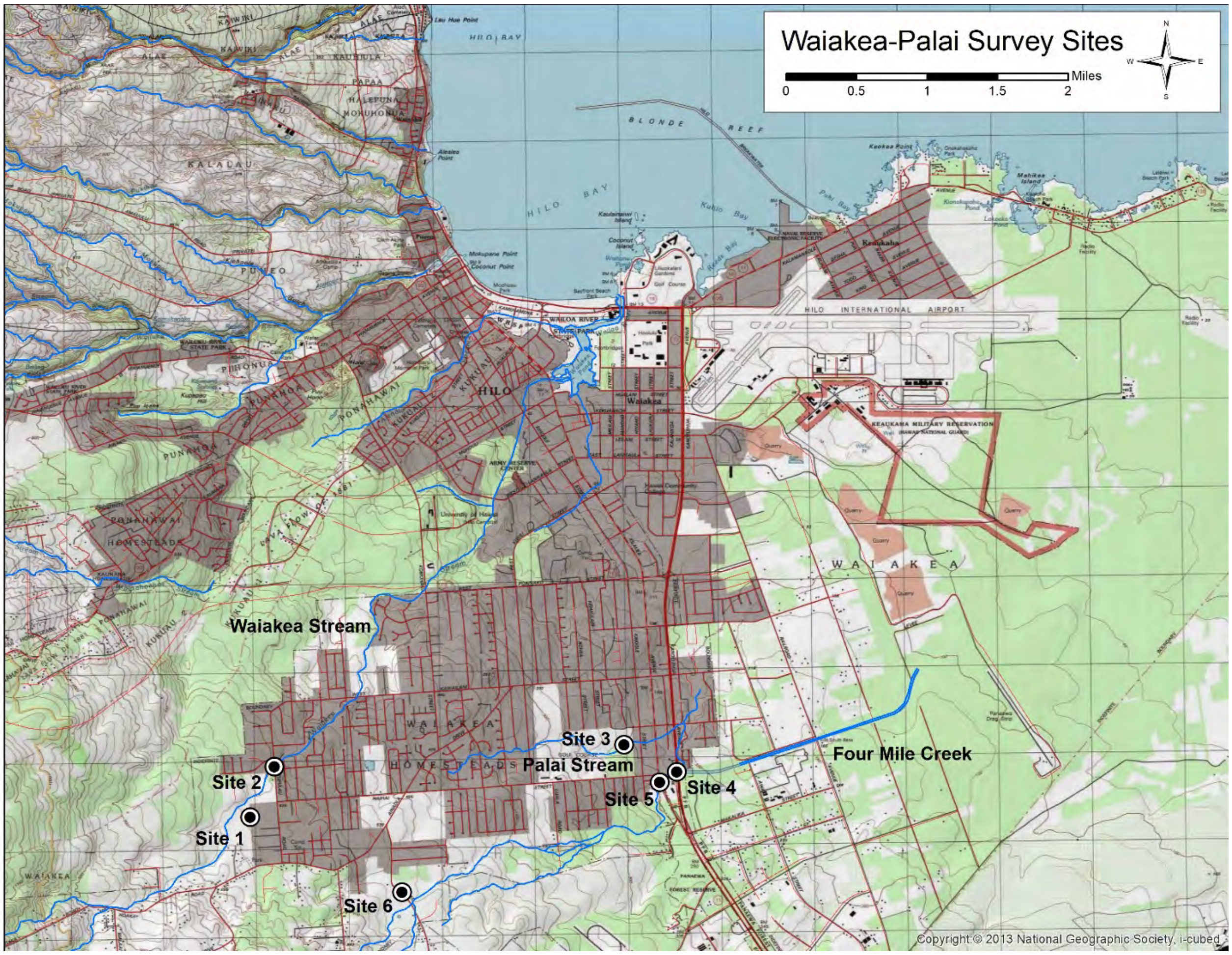

Fig. **1**. Map of the greater Hilo area, showing sampling sites surveyed. For specific details of site locations and elevations, see Table 1. For photographs of individual sites, see following Figures 2-13.

Fig. 2. Site 1 – Kupulau Ditch, behind New Hope Church, looking downstream.

Fig. 3. Site 1 – Kupulau Ditch, behind New Hope Church, looking upstream.

Fig. 4. Site 1 –New Hope Church athletic field, proposed site for detention basin.

Fig. 5. Site 2 – Waiakea Stream at Kupulau Road bridge, looking upstream.

Fig. 6. Site 2 – Waiakea Stream at Kupulau Road bridge, looking downstream.

Fig. 7. Site 6 – Pasture along Ainalako Road, formerly proposed diversion site.

Fig. 8. Site 3 – Hilo Golf Course, 10th Hole, looking downstream

Fig. 9. Site 3 – Hilo Golf Course, 10th Hole, looking upstream.

Fig. 10. Site 3 – Hilo Golf Course, channel in rough above 10th Hole, looking upstream.

Fig. 11. Site 4 - 4 Mile Creek, looking downstream from Hwy. 11 bridge.

Fig. 12. Site 4 - 4 Mile Creek, looking upstream from Hwy. 11 bridge.

Fig. 13. Site 5 - 4 Mile Creek, looking downstream from Kilauea Avenue bridge.

US Army Corps of Engineers®
Honolulu District

Real Estate Plan

Waiakea-Palai Flood Risk Management
Final Integrated Feasibility Report and Environmental Assessment
Section 205 of the Flood Control Act of 1948, as amended

June 2021

Prepared for:
U.S. Army Corps of Engineers, Honolulu District

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ATTACHMENTS

1. EXECUTIVE SUMMARY

The Waiakea-Palai Streams Flood Risk Management Integrated Feasibility Report and Environmental Assessment (Study) is authorized under Section 205 of the Flood Control Act of 1948, as amended. The purpose of the Study is to analyze alternatives to reduce flood risk within the Waiakea-Palai Watersheds including the Waiakea and Palai Streams as well as a portion of Four Mile Creek near Hilo, Hawaii. The Waiakea and Palai Stream channels have limited capacity to transport flood waters, which has led to water overtopping the channel and flooding downstream areas.

The Non-Federal Sponsor (NFS) for the Study is the County of Hawaii Department of Public Works (DPW). A Feasibility Cost Sharing Agreement was signed in October 2018, and the NFS is responsible for fifty percent (50%) of shared study costs.

A recommended plan was selected based on cost, ecological output, economic benefits, completeness, effectiveness, efficiency, and acceptability. The recommended plan for the Waiakea-Palai Streams Flood Risk Management proposed project includes the Kupulau Ditch levees (three), floodwall, and detention basin as well as the Hilo Golf Couse detention basin. Two roadways are planned for continued maintenance and operations. Additionally, two temporary staging areas are planned for project construction.

Pursuant to the National Environmental Policy Act (NEPA) and the Hawaii Environmental Policy Act (HEPA), the final Environmental Assessment (EA) resulted in a Finding of No Significant Impact (FONSI). Additionally, in accordance with USACE Hazardous, Toxic, and Radioactive Waste (HTRW) policy, no HTRW contamination was identified within or proximal to the proposed project site.

The Real Estate Plan (REP) is generally prepared as an appendix to the Study to support the acquisition requirements of the recommended plan. The REP presents the real estate requirements, proposes the acquisition strategy, develops a cost estimate for real estate acquisition, and incorporates an internal technical review.

The minimum estates required for the construction of Kupulau Ditch levees, floodwall, and detention basin are flood protection levee easements (3.00 acres), flowage easements for occasional flooding (10.43 acres), a roadway easement (0.63 acres), and a temporary work area easement (0.32 acres). The minimum estates required for the Hilo Golf Course construction of a detention basin are a flowage easement for occasional flooding (2.13 acres), flowage easement for permanent flooding (4.50 acres), roadway easement (0.60 acres), and temporary work area easement (0.32 acres). Temporary work area easements are estimated to be required for two (2) years during project construction. The County of Hawaii does not have any ownership interests in the project area, but it maintains control over existing roadways.

The estimated real estate cost associated with the recommended plan is approximately $976,900, including all recommended lands, easements, rights-of-way, relocations, and disposals (LERRDs), and administrative costs to be carried out by the Government and NFS. The NFS is considered moderately capable at present to acquire and provide the LERRDs necessary for the proposed project.

2. AUTHORITY AND PURPOSE

The Waiakea-Palai Streams Flood Risk Management Integrated Feasibility Report and Environmental Assessment (Study) is authorized under Section 205 of the Flood Control Act of 1948, as amended. The U.S. Army Corps of Engineers (USACE) Continuing Authorities Program (CAP) is a group of nine legislative authorities under which the Corps of Engineers can plan, design, and implement certain types of water resources projects without additional project-specific congressional authorization. The purpose of the CAP is to plan and implement projects of limited size, cost, scope, and complexity. The maximum federal expenditure per project is $10 million, including feasibility study, design, and construction costs.

The purpose of the Study is to analyze alternatives to reduce flood risk within the Waiakea-Palai Watersheds including the Waiakea and Palai Streams as well as a portion of Four Mile Creek near Hilo, Hawaii. The Study evaluates and compares the benefits, costs, and impacts of alternatives. The Waiakea Stream and Palai Stream each had individual studies initiated under the CAP 205 authority. However, when it was determined that the two streams were interdependent in the study area, the two individual draft studies were combined into a single study authorized as a general investigation study.

Previously, USACE completed a Waiakea Stream Flood Control Reconnaissance Study in December 2001. The Reconnaissance Study analysis indicated that continued federal participation in the Waiakea Stream study was warranted to determine viability and proper design of alternatives presented.

Pursuant to the National Environmental Policy Act (NEPA) and the Hawaii Environmental Policy Act (HEPA), a draft Environmental Assessment (EA) for Waiakea-Palai Stream was completed in September 2011. Public review of the draft EA and FONSI was completed in July 2019. The Final EA determined that the proposed action of construction of two detention basins, three levees, floodwall, and a channel barrier at Waiakea-Palai Stream would not result in significant adverse impacts on the environment. A Finding of No Significant Impact (FONSI) is included with the final Study and EA.

The Non-Federal Sponsor (NFS) for the Study is the County of Hawaii Department of Public Works (DPW). Previously, USACE and the NFS executed a Feasibility Cost Share Agreement for the Waiakea Stream Flood Control Project in February 2004. However, based on the combined scope of the Waiakea and Palai Streams, an updated Feasibility Cost Sharing Agreement for the current CAP 205 Integrated Feasibility Study was signed in October 2018. The NFS is responsible for fifty percent (50%) of shared study costs in accordance with the Feasibility Cost Sharing Agreement.

Generally, the Real Estate Plan (REP) is prepared by the USACE Honolulu District (District) as an appendix to the Feasibility Report. The REP presents the real estate requirements, proposes the acquisition strategy, develops a cost estimate for real estate acquisition, and incorporates an internal technical review. USACE Mapping determines private tract ownerships and acreages to prepare exhibits to the REP. USACE Appraisal prepares (or contracts for) and approves a cost estimate or gross appraisal, as needed for acquisitions. USACE Environmental provides applicable compliance memoranda and/or documentation in accordance with NEPA. HEPA, National Historic Preservation Act (NHPA), and USACE Hazardous, Toxic, and Radioactive Waste (HTRW) policy.

Project real estate requirements include a review of NFS-owned parcels as well as recommended lands, easements, rights-of-way, relocations, and disposals (LERRDs) to be carried out by the NFS. LERRDs recommendations are requirements that the Government has determined the NFS must meet for the construction, operation, and maintenance of the Project. If LERRDs are required, USACE District Real Estate coordinates with the NFS and provides the NFS with a partner packet outlining the sponsor's responsibilities and notice informing the NFS of the risks of early acquisition.

The information contained herein is tentative for planning purposes only. Final real estate acquisition acreages, limitations, and cost estimates are subject to change even after approval of a final Feasibility Report.

3. PROJECT DESCRIPTION AND LOCATION

The Study area encompasses the Palai Stream watershed and the Waiakea Stream watershed near the town of Hilo, Hawaii, located on the northeastern coast of the island of Hawaii (See Figure 1: Study Area Map). Waiakea Stream, Palai Stream, and Four Mile Creek are three of the five tributaries within the principal Wailoa River system, which drains a total of about 100 square miles and empties into Hilo Bay.

Waiakea Stream has a drainage area of about 35.6 square miles and is classified as an intermittent stream and is dry most of the year. Its basin is linear in shape, approximately 25 miles in length and about 2 miles in width at its widest point. The Waiakea Stream basin originates along the slopes of Mauna Loa volcano and flows northeast through the residential community of upper Waiakea-Uka Homesteads before entering the city of Hilo and ultimately emptying into Wailoa Pond and Hilo Bay. Portions of Waiakea Stream within the proposed study area have previously been altered to reduce flood risk in the Hilo area.

Palai Stream has a drainage area of about 7.7 square miles and is classified as intermittent and is dry most of the year. Its basin is linear in shape, approximately 11 miles in length and about two miles in width at its widest point. Palai Stream originates down slope of the broad saddle formed between the Mauna Loa and Mauna Kea volcanoes and flows for about seven miles through the Waiakea Forest Reserve with elevations ranging from 2,100 feet to 1,500 feet. The basin is largely developed below the 1,500-foot elevation. It flows an additional four miles through the City of Hilo before emptying into Wailoa Pond and Hilo Bay.

Four Mile Creek is an intermittent stream that drains into undeveloped lowlands near the Hilo Drag Strip south of Hilo International Airport. The creek flows away from Hilo through an unlined flood control channel that was constructed by the County of Hawaii. This 10,000-foot-long channel begins at the Kanoelehua Street Bridge and empties into an old quarry on the east side of Hilo. Upstream of this point, the stream flows mainly through open land with some scattered pockets of mixed residential structures and farmland.

The Waiakea and the Palai Streams are susceptible to flash flooding events where peak discharges typically occur within two hours of heavy rainfall. Local storm events can produce flood conditions in a matter of hours. Significant rainfall events result in overland flow of water throughout the watershed, flowing towards the streams. The existing stream channels have limited capacity to transport flood waters, which has led to water overtopping the channel and flooding downstream areas.

Waiakea Stream above Kupulau Ditch is characterized by poorly defined channels. It has a channel capacity of fewer than 1,020 cfs, which is comparable to a 50% AEP storm event. Excess water leaves the Waiakea Stream by overtopping the right bank at the 50% AEP event and flows overland eastward toward Kupulau Ditch. Between Kupulau Ditch and the Kupulau Rd Bridge, Waiakea Stream has an average channel capacity of about 1,630 cfs, which is comparable to a 20% AEP storm event. Flows greater than the 20% AEP event flood the right and left overbanks.

In addition, the City of Hilo has experienced significant growth over recent decades. In addition to some of Hilo's busiest intersections, thoroughfares and shopping areas, the project area floodplain also contains about 100 businesses, several schools, a university, and other critical infrastructure. With this surge in urbanization, flooding problems have intensified for homes and businesses built close to the city's streams. Property losses, road and bridge closures, and life-threatening situations caused by flooding have increased. Major flood damage in the Hilo area occurred in February 2008, November 2000, August 1994, March 1980, February 1979, July 1966, and March 1939.

As described in the Study, an initial array of alternative plans was formulated through combinations of management measures. The alternatives were evaluated for completeness, effectiveness, efficiency, and acceptability as specified in the Council for Environmental Quality Principles and Guidelines (Paragraph 1.6.2(c)). Based on the results of the screening process, the following alternatives were carried forward as the final array:

1. No Action Alternative
2. Kupulau Ditch Levee/Floodwall with Detention
3. Hilo Municipal Golf Course Detention
4. Ainalako Diversion
5. Combination Plan (#2, #3, #4)

Recommended Plan: Combination of Kupulau Ditch Levee/Floodwall with Detention and Hilo Municipal Golf Course Detention

Evaluation and comparison of the final array of alternatives included an assessment of costs and benefits for each of the alternatives included in the final array as well as an evaluation of various combinations of these alternatives to identify the optimized plan that reasonably maximizes net benefits. After incorporating revisions following agency, technical, and public review, the combination plan alternative is the Kupulau Ditch Levee/Floodwall with Detention and Hilo Golf Course Detention was presented as the recommended plan. The recommended plan incorporates the following features:

1. Kupulau Ditch Levees (3)
2. Kupulau Ditch Floodwall
3. Kupulau Ditch Detention Basin
4. Kupulau Ditch Roadway
5. Kupulau Ditch Staging Area
6. Hilo Golf Detention Basin
7. Hilo Golf Roadway
8. Hilo Golf Staging Area

See also Figure 2: Recommended Plan Map.

Structures in the Area

Portions of Waiakea Stream within the Study area have previously been altered to reduce flood risk in the Hilo area. In 1965, the USACE built a flood control project that extends from the lower reaches of Waiakea Stream to Wailoa Pond (Figure 1: Study Area Map). This project, called Wailoa Stream Flood Control Project, consisted of channel improvements and levees to provide flood protection for the area of Hilo downstream of the University of Hawaii at Hilo. The project included channels and levees to divert the Kawili Stream flows into the Waiakea Stream, plus additional channels and levees to divert the combined flows of the Waiakea and Kawila Streams into Waiakea Pond. The project was designed for a discharge of 6,500 cubic feet per second (cfs) which at that time had a recurrence interval of 125 years.

Upstream, the County of Hawaii constructed the Waiakea-Uka channel in 1984. This channel consists of 3,460 feet of concrete-lined and unlined trapezoidal channel improvements extending from Kawailani Street to the intersection of Komohana and Puainako Streets. These improvements were designed for a discharge of 4,460 cfs. Further upstream, the County of Hawaii replaced the Kawailani Street Bridge with a new bridge having a larger opening and improved the channel upstream and downstream of the bridge. These bridge and channel improvements were completed after severe storm damage occurred in November 2000.

There are no federal flood risk management projects located on Palai Stream within the Study area. In 1971, the County of Hawaii constructed Kupulau Ditch. This ditch diverted storm water runoff from the Palai Stream basin to Waiakea Stream upstream of Kupulau Road. The ditch consists of a trapezoidal channel about 3,500 feet long with a 12-foot bottom width and 2:1 side slopes.

Staging Areas

Staging areas and site access must be established for the use and distribution of construction materials and equipment. The staging areas would contain contractor trailers, parking, fencing, and storage of equipment and materials.

The staging area for the Kupulau Ditch Levee/Floodwall with Detention Basin is located adjacent to the east containment levee, and the staging area for the Hilo Golf Course Detention Basin is located adjacent to the detention basin. Restoration of staging areas will be to pre-construction conditions. See also Figure 3: Kupulau Ditch Levee/Floodwall with Detention Project Feature Map and Figure 4: Hilo Golf Course Detention Project Feature Map.

Site Access

For Kupulau Ditch project feature construction, it is anticipated that personnel, equipment, and imported materials would access the proposed project area via Kupulau Road. For Hilo Golf Course project feature construction, it is anticipated that personnel, equipment, and imported materials would access the proposed project area via the maintenance yard and along the east side of the course.

Additionally, for continued operations and maintenance of the recommended plan, new roadway easements are required for both the Kupulau Ditch Levee/Floodwall with Detention Basin and Hilo Golf Course Detention Basin. For the Kupulau Ditch access road, the road is estimated to begin at Kupulau Road and terminate at the right bank of Kupulau Ditch. For the Hilo Golf Course access road, the road is estimated to run from the maintenance yard and along the east side of the course to the stream bank and then westward to the levee surrounding the detention basin. The widths of the access roads are estimated at 20 feet. See also Figure 3: Kupulau Ditch Levee/Floodwall with Detention Project Feature Map and Figure 4: Hilo Golf Course Detention Project Feature Map.

Ownership by Project Feature

The following table summarizes the area and interest required by project feature and ownership.

Feature	Tax Map Key (TMK)	Approximate Area (Acres)	Owner	Zoning/ Property Class	Interest Required
1. Kupulau Ditch Levees	3-2-4-065:036	1.00	Private	Agricultural/ Residential	Flood Protection Levee Easement
	3-2-4-076:044	0.18	Private	Agricultural/ Residential	Flood Protection Levee Easement
	3-2-4-065:035	0.44	Private	Residential	Flood Protection Levee Easement
	3-2-4-036:001	0.60	Private	Agricultural/ Church	Flood Protection Levee Easement
2. Kupulau Ditch Floodwall	3-2-4-036:001	0.40	Private	Agricultural/ Church	Flood Protection Levee Easement
	3-2-4-035:003	0.22	Private	Agricultural/ Residential	Flood Protection Levee Easement
	3-2-4-035:032	0.16		Agricultural/ Residential	
3. Kupulau Ditch Detention Basin	3-2-4-036:001	6.60	Private	Agricultural/ Church	Flowage Easement (occasional)
	3-2-4-065:036	3.83	Private	Agricultural/ Residential	Flowage Easement (occasional)
4. Kupulau Ditch Roadway	3-2-4-036:999	0.63	Public	Agricultural/ Residential	Road Easement
5. Kupulau Ditch Staging Area	3-2-4-036:001	0.70	Private	Agricultural/ Church	Temporary Work Area Easement
6. Hilo Golf Detention Basin	3-2-4-002:001	4.50	Public	Conservation	Flowage Easement (permanent)
	3-2-4-002:001	2.13	Public	Conservation	Flowage Easement (occasional)
7. Hilo Golf Roadway	3-2-4-002:001	0.60	Public	Conservation	Road Easement
8. Hilo Golf Staging Area	3-2-4-002:001	0.32	Public	Conservation	Temporary Work Area Easement

See also Figure 3: Kupulau Ditch Levee/Floodwall with Detention Project Feature Map and Figure 4: Hilo Golf Course Detention Project Feature Map.

4. SPONSOR'S REAL ESTATE INTERESTS

The Non-Federal Sponsor (NFS) for the Study is the County of Hawaii Department of Public Works (DPW). The District will coordinate with the County of Hawaii DPW. The County of Hawaii controls some lands identified for the Study area.

5. ESTATES TO BE ACQUIRED

The NFS will provide all LERRDs required for the construction, operation, and maintenance of the proposed project. The NFS is instructed to acquire the minimum real estate interest necessary for the proposed project. LERRDs to be acquired for the proposed project include:

Flood Protection Levee Easement

1. Kupulau Ditch Levees: 2.22 acres

2. Kupulau Ditch Floodwall: 0.78 acres

Flood Protection Levee Easement Standard Estate

A perpetual and assignable right and easement in (the land described in Schedule A) (Tracts Nos, ____, ____ and ____) to construct, maintain, repair, operate, patrol and replace a flood protection (levee) (floodwall)(gate closure) (sandbag closure), including all appurtenances thereto; reserving, however, to the owners, their heirs and assigns, all such rights and privileges in the land as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

Flowage Easement (Occasional Flooding)

3. Kupulau Ditch Detention Basin: 10.43 acres

6. Hilo Golf Detention Basin: 2.13 acres

Flowage Easement Standard Estate (Occasional Flooding)

The perpetual right, power, privilege and easement occasionally to overflow, flood and submerge (the land described in Schedule A) (Tracts Nos. ____, ____ and ____). (and to maintain mosquito control)in connection with the operation and maintenance of the project as authorized by the Act of Congress approved ________________________, together with all right, title and interest in and to the structure; and improvements now situate on the land, except fencing (and also excepting _________________ (here identify those structures not designed for human habitation which the District Engineer determines may remain on the land); provided that no structures for human habitation shall be constructed or maintained on the land, that no other structures shall be constructed or maintained on the land except as may be approved in writing by the representative of the United States in charge of the project, and that no excavation shall be conducted and no landfill placed on the land without such approval as to the location and method of excavation and/or placement of landfill; the above estate is taken subject to existing easements for public roads and highways, public utilities, railroads and pipelines; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges as may be used and enjoyed without interfering with the use of the project for the purposes authorized by Congress or abridging the rights and easement hereby acquired; provided further that any use of the land shall be subject to Federal and State laws with respect to pollution.

Flowage Easement (Permanent Flooding)

6. Hilo Golf Detention Basin: 4.50 acres

Flowage Easement Standard Estate (Permanent Flooding)

The perpetual right, power, privilege and easement permanently to overflow, flood and submerge (the land described in Schedule A) Tracts Nos. _____, _____ and _____), (and to maintain mosquito control) in connection with the operation maintenance of the project as authorized by the Act of Congress approved _______________, and the continuing right to clear and remove and brush, debris and natural obstructions which, in the opinion of the representative of the United States in charge of the project, may be detrimental to the project, together with all right, title and interest in and to the timber, structures and improvements situate on the land (excepting ____________________, (here identify those structures not designed for human habitation which the District Engineer determines may remain on the land)); provided that no structures for human habitation shall be constructed or maintained on the land, that no other structures shall be constructed or maintained on the land except as may be approved in writing by the representative of the United States in charge of the project, and that no excavation shall be conducted and no landfill placed on the land without such approval as to the location and method of excavation and/or placement of. landfill; the above estate is taken subject to existing easements for public roads and highways, public utilities, railroads and pipelines; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges as may be used and enjoyed without interfering with the use of the project for the purposes authorized by Congress or abridging the rights and easement hereby acquired; provided further that any use of the land shall be subject to Federal and State laws with respect to pollution.

Roadway Easement

4. Kupulau Ditch Roadway: 0.63 acres

7. Hilo Golf Roadway: 0.60 acres

Roadway Easement Standard Estate

A (perpetual [exclusive] [non-exclusive]and assignable) (temporary) easement and right of way in, on, over and across (the land described in Schedule A) (Tracts Nos. _____, _____ and _____) for the location, construction, operation, maintenance, alteration replacement of (a) road(s) and appurtenances thereto; together with the right to trim, cut, fell and remove therefrom all trees, underbrush, obstructions and other vegetation, structures, or obstacles within the limits of the right of way; (reserving, however, to the owners, their heirs and assigns, the right to cross over or under the right of way as access to their adjoining land at the locations indicated in Schedule B); subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

Temporary Work Area Easement

5. Kupulau Ditch Staging Area: 0.70 acres

8. Hilo Golf Staging Area: 0.32 acres

Temporary Work Area Easement Standard Estate

A temporary easement and right of way in, on, over and across (the land described in Schedule A) (Tracts Nos. _____, _____ and _____), for a period not to exceed ___________________, beginning with date of possession the land is granted to the United States, for use by the United States, its representatives, agents, and contractors as a (borrow area) (work area), including the right to (borrow and/or deposit fill, spoil and waste material thereon) (move, store and remove equipment and supplies, and erect and remove temporary structures on the land and to perform any other work necessary and incident to the construction of the ____________________ Project, together with the right to trim, cut, fell and remove therefrom all trees, underbrush, obstructions, and any other vegetation, structures, or obstacles within the limits of the right of way; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

Kupulau Ditch: The minimum estates required for the construction of levees, a floodwall, and detention basin are flood protection levee easements (3.00 acres), flowage easements for occasional flooding (10.43 acres), a roadway easement (0.63 acres), and a temporary work area easement (0.32 acres). According to the County of Hawaii Real Property Tax Office, the Kupulau Ditch project features are located within Tax Map Keys (TMKs) 3-2-4-035:003, 3-2-4-035:032, 3-2-4-065:035, 3-2-4-065:036, 3-2-4-076:044, 3-2-4-036:001, which are owned by private persons and entities, and TMK 3-2-4-036:999, which is under control of the County of Hawaii.

Hilo Golf Detention: The minimum estates required for the construction of a detention basin are a flowage easement for occasional flooding (2.13 acres), flowage easement for permanent flooding (4.50 acres), roadway easement (0.60 acres), and temporary work area easement (0.32 acres). According to the County of Hawaii Real Property Tax Office, the Hilo Golf Detention Basin project features are located within TMK 3-2-4-002:001, which is owned by the State of Hawaii.

The temporary work area easements for staging are estimated to be required for two (2) years during project construction. The road easements are estimated to be required in perpetuity for ongoing project feature operation and maintenance.

6. FEDERAL PROJECTS/OWNERSHIP

Within the general Study area, USACE previously completed the Wailoa Stream Flood Control Project that extends from the lower reaches of Waiakea Stream to Wailoa Pond.

The Wailoa Stream Flood Control Project included channel improvements and levees. However, the Wailoa Stream Flood Control Project does not overlap with the current Study project features. Additionally, there are no Federally owned lands within the LERRDs required for the Study.

7. NAVIGATION SERVITUDE

Lands required for the Study are not located within navigable waters and therefore, Navigation Servitude doctrine does not apply.

8. MAPS

Maps are intended as a preliminary tool to illustrate the Study area, LERRDs to be acquired, and lands within the navigation servitude. Detailed maps will be provided prior to the Notice to Acquire (NTA) Letter to the NFS. For the Study Area Map and Recommended Plan Map, refer to Figures 1-2. For the Kupulau Ditch Levee/Floodwall with Detention Project Feature Map and Hilo Golf Course Detention Project Feature Map, refer to Figures 3-4.

9. INDUCED FLOODING

The proposed project is not anticipated to induce flooding outside of the footprint of the proposed project features.

10. BASELINE COST ESTIMATE FOR REAL ESTATE

The baseline cost estimate for the NFS to acquire the Kupulau Ditch flood protection levee easements, flowage easements for occasional flooding, roadway easement, and temporary work area easement as well as the Hilo Golf Detention flowage easement for occasional flooding, flowage easement for permanent flooding, roadway easement, and temporary work area easement is estimated at $976,900.

Item	Size (Acres)	Cost Estimate
Kupulau Ditch Flood Protection Levee Easement	3.00	$66,700
Kupulau Ditch Flowage Easement (occasional)	10.43	$267,100
Hilo Golf Flowage Easement (permanent)	4.50	$150,200
Hilo Golf Flowage Easement (occasional)	2.13	$71,100
Kupulau Ditch Road Easement	0.63	$21,000
Hilo Golf Road Easement	0.60	$20,000

Kupulau Ditch Staging Area Temporary Work Area Easement	0.70	$23,400
Hilo Golf Staging Area Temporary Work Area Easement	0.32	$10,700
Improvements	--	$0
Hazard Removals	--	$0
Mineral Rights	--	$0
Kupulau Levee/Floodwall Damages		$37,800
Hilo Golf Couse Damages	--	$88,200
Facility/Utility Relocations	--	$0
Uniform Relocation Assistance	--	$0
Incremental Real Estate Costs	--	$94,600
Incidental Acquisition Costs: NFS	--	$106,100
Incidental Acquisition Costs: Government	--	$20,000
TOTAL	**--**	**$976,900**

CAP projects generally require a cost-estimate level of effort, determined by the complexity of the project. The real estate valuation effort should be commensurate with the level of detail performed by other elements for each of these CAP programs and projects. Simplified evaluation procedures are adopted for low-risk or low-cost projects. Real estate LERRD acquisition costs are estimated at 9% of total project costs.

In 2015, real estate cost estimates were prepared by USACE District Appraisal. The current real estate cost estimates were obtained from market research prepared by the District in June 2021. Incremental real estate costs are estimated at 15% of total real estate acquisition costs for risk-based contingencies. Incidental acquisition costs are estimated at 20% of total real estate acquisition costs and includes NFS costs incurred for title work, appraisals, review of appraisals, coordination meetings, review of documents, legal support, and other costs that are incidental to Project LERRDs as well as Government costs for staff monitoring and reviewing and approving LERRDs.

11. PUBLIC LAW 91-646 RELOCATION BENEFITS

The Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, PL 91-646, as amended, commonly called the Uniform Act, is the primary law for acquisition and relocation activities on Federal or federally assisted projects and programs. The NFS is required to follow the guidance of PL 91-646.

No displacement of towns or persons will occur, and there will be neither habitable nor commercial structures affected as a result of this Study. The Study is not eligible for the provisions of PL 91-646 related to relocation expenses.

12. MINERALS/TIMBER/CROP ACTIVITY

There are no known surface or subsurface minerals that would impact the proposed project features. Additionally, no known timber or crops will be permanently affected by the proposed project features.

13. ASSESSMENT OF SPONSOR'S ACQUISITION CAPABILITY

The NFS is considered moderately capable at present to acquire and provide the LERRDs necessary for the Study. The NFS has the financial capability and authority to hold title. However, the NFS will perform necessary LERRDs efforts, such as survey, appraisal, title work, negotiation, closing, and eminent domain, with contract support.

An Assessment of the NFS's Real Estate Acquisition Capability was conducted jointly with the NFS. A Sponsor's Acquisition Capability Assessment is included in Attachment 1. Additionally, the NFS was provided with a Local Sponsor Toolkit in June 2021.

14. ZONING

All LERRDs required for the proposed project features are zoned agricultural or residential and are being used in that manner. Therefore, no zoning change in lieu of acquisition is anticipated.

15. ACQUISITION MILESTONES

The following preliminary schedule estimates eighteen (18) months for NFS LERRDs planning and acquisition. The planned timeline below is mutually agreed upon by USACE District Real Estate, Project Management, and the NFS. The schedule starts from the Notice to Acquire Letter, which is estimated to occur when construction site plans are defined during the Pre-Construction, Engineering, and Design (PED) phase.

The NFS's preliminary acquisition planning is estimated at eight (8) months as follows:

Survey/Map/Title	90 Days
Legal Description	60 Days
Appraisal	90 Days

The NFS's LERRD acquisition is estimated at ten (10) months as follows:

Documentation	90 Days
Negotiation	90 Days
Payment	90 Days
LERRD Certification	30 Days

16. PUBLIC FACILITY OR UTILITY RELOCATIONS

No facility or utility relocations are planned as part of the Study. Hilo Golf Course Hole 10 is the only area with a temporary closure impact. Hole 10 is estimated to be closed for approximately two to three months during construction of the berm/levee. The berm will be designed during PED with a landscape architect to allow continued play of the hole. The bridge at Hole 10 is estimated to be replaced with a bridge on top of the planned culvert. The value of the temporary golf hole closure and redesign is estimated as severance damages, which are included in the baseline cost estimate (Section 10).

17. ENVIRONMENTAL IMPACTS

Potential environmental impacts resulting from the proposed project were considered, including investigation under NEPA/HEPA, HTRW Policy, National Historic Preservation Act, Clean Water Act, Endangered Species Act, Clean Air Act, Fish and Wildlife Coordination Act, Magnuson-Stevens Fishery Conservation and Management Act, Farmland Protection Policy Act, Migratory Bird Treaty Act, and Coastal Zone Management Act.

National Environmental Policy Act (NEPA) and Hawaii Environmental Policy Act (HEPA)
The NEPA (40 CFR 1500 et seq.) requires that environmental consequences and project alternatives be considered before a decision is made to implement a federal project. The NEPA established the requirements for an Environmental Impact Statement (EIS) for projects potentially having significant environmental impacts and an Environmental Assessment (EA) for projects with no significant environmental impacts.

In accordance with NEPA and USACE regulations and policies, the EA determined that the Proposed Action would not result in significant adverse impacts on either the man-made or natural environment. A FONSI is included with the final Study and EA.

Hazardous, Toxic, and Radioactive Waste Policy
In accordance with USACE HTRW policy, USACE Honolulu District conducted an HTRW Assessment in August 2005. The HTRW Assessment was based upon review of existing documentation, coordination with responsible agencies, and observations made during a visual site investigation. Based upon review of existing historical and current documentation, agency consultation and coordination, personal interviews, and on-site visual surveys, the HTRW Assessment found no HTRW sources or areas of HTRW contamination identified within or proximal to the proposed project site.

National Historic Preservation Act
Federal agencies are required under Section 106 of the National Historic Preservation Act of 1966 (NHPA, 54 USC Chapter 3001 et seq.), as amended, to “take into account the effects of their undertakings on historic properties” and consider alternatives “to avoid, minimize, or mitigate the undertaking’s adverse effects on historic properties.” In

accordance with Section 106 of the NHPA, the USACE has consulted with the Hawaii State Historic Preservation Division (SHPD) and other appropriate consulting parties.

Regarding cultural resources, according to the Hawaii SHPD, there are no Hawaii Register of Historic Places listed historic properties within the vicinity of the Study area. Additionally, according to archeological surveys, there is no evidence of archaeological or historic resources. The Hawaii SHPD, the Office of Hawaiian Affairs, and the Hawaiian Civic Club of Hilo were consulted on the findings of the Archaeological Survey and the potential for unknown historic and cultural resources in the Study area. This produced no further evidence of historic or cultural resources.

<u>Other Environmental Compliance</u>
Additionally, USACE has considered and investigated potential environmental impacts in accordance with the Clean Water Act, Endangered Species Act, Clean Air Act, Fish and Wildlife Coordination Act, Magnuson-Stevens Fishery Conservation and Management Act, Farmland Protection Policy Act, Migratory Bird Treaty Act, and Coastal Zone Management Act.

18. LANDOWNER CONCERNS

No landowner concerns are anticipated at this time.

19. NOTIFICATION TO SPONSOR

The NFS, County of Hawaii DPW, is involved in the planning process. The NFS was provided a Local Sponsor Toolkit and advised of the risks of acquiring LERRDs before the execution of the PPA. A Sample Letter Advising Against Early Acquisition is included in Attachment 2.

Additionally, once the LERRDs are finalized, a Notice to Acquire Letter will be transmitted to the NFS. The Notice to Acquire Letter serves as the formal instruction for the NFS to acquire the real estate interests needed for the Project. A Sample Notice to Acquire Letter is included in Attachment 3.

20. OTHER RELEVANT REAL ESTATE ISSUES

There are no other known relevant real estate issues in the Study area.

Figure 1: Study Area Map

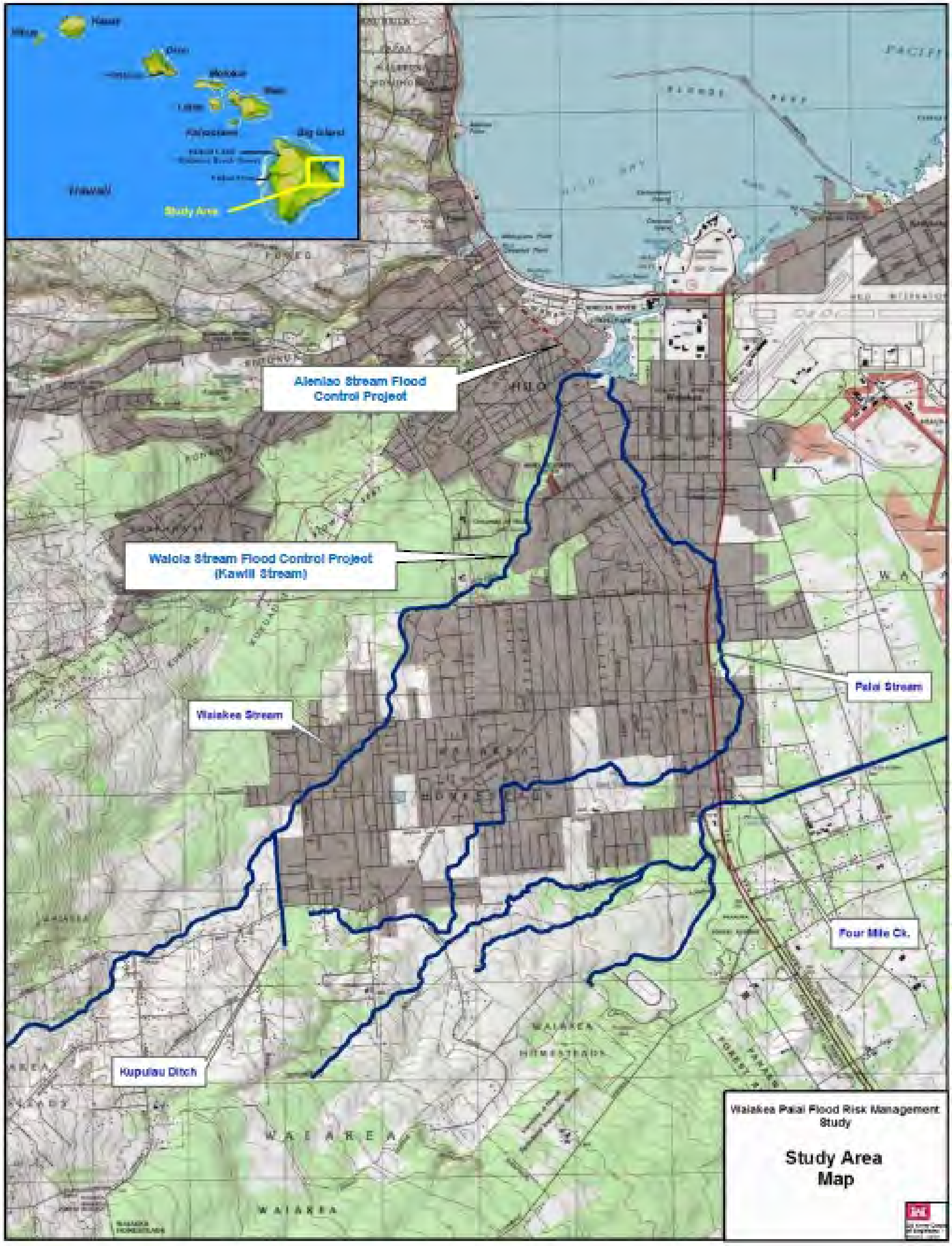

Figure 2: Recommended Plan Map

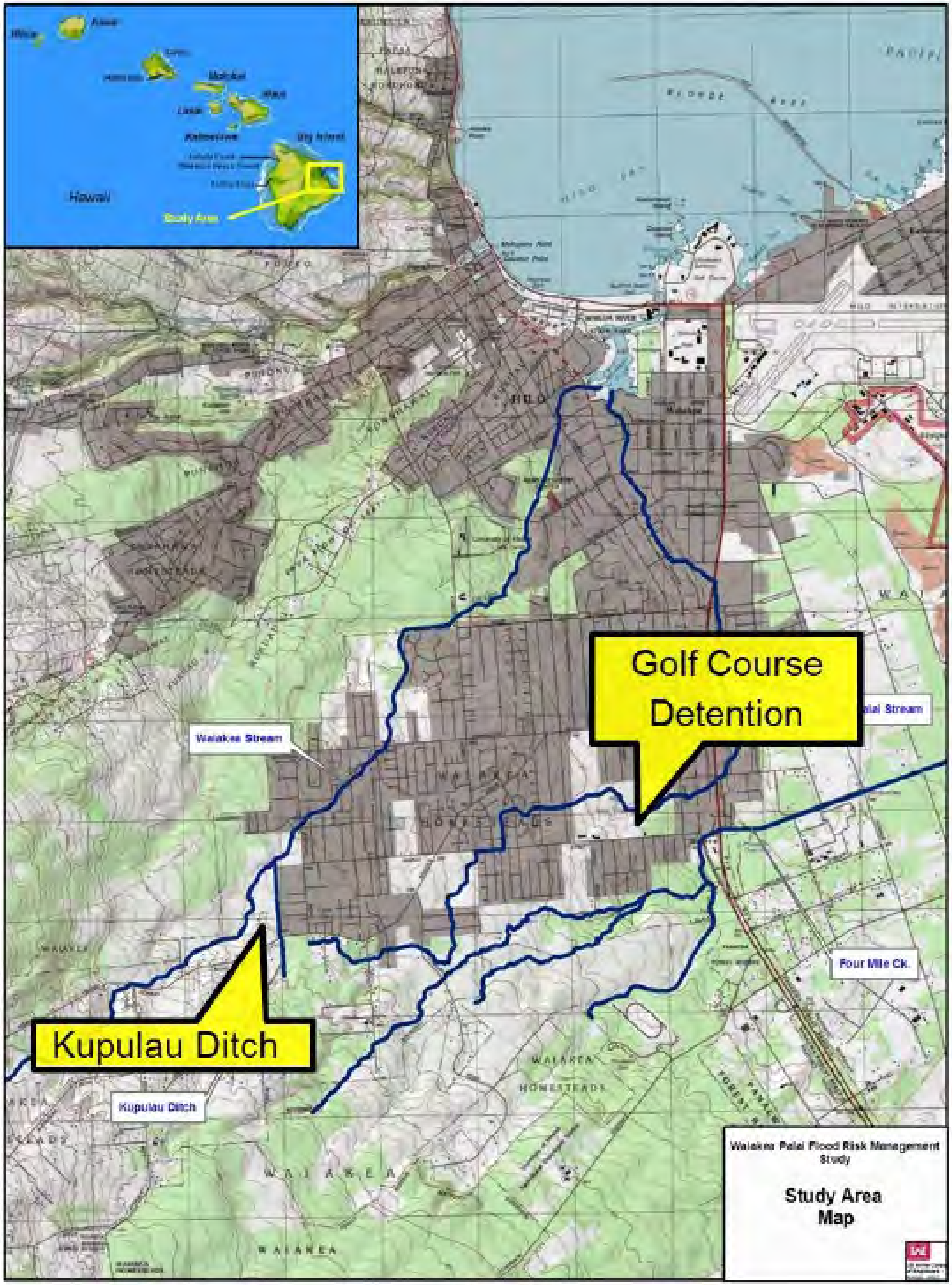

Figure 3: Kupulau Ditch Levee/Floodwall with Detention Project Feature Map

Figure 4: Hilo Golf Course Detention Project Feature Map

Attachment 1: Assessment of NFS's Real Estate Acquisition Capability

Assessment of Non-Federal Sponsor's Real Estate Acquisition Capability

Project: Waiakea-Palai Flood Control Project, Hilo, HI
Project Authority: Section 205 of the Flood Control Act of 1948
Non-Federal Sponsor: County of Hawaii, Department of Public Works
Steven Ikaika Rodenhurst, Director
Aupuni Center, 101 Pauahi Street, Suite 7, Hilo, Hawai'i 96720
808-961-8321, Ikaika.Rodenhurst@hawaiicounty.gov

Legal Authority	Yes	No
1. Does the NFS have legal authority to acquire and hold title to real property for project purposes? (Hawaii Revised Statutes, Chp. 46)	✓	
2. Does the NFS have the power of eminent domain for the project (Hawaii Revised Statutes, Chp. 101)	✓	
3. Does the NFS have "quick-take" authority for this project?		✓
4. Are there any lands/interests in land required for the project that are located outside the NFS's authority boundary?		✓
5. Are any of the lands/interests in land required for the project owned by an entity whose property the sponsor cannot condemn?		✓
6. Will the NFS's in-house staff require training to become familiar with the real estate requirements of Federal projects, such as PL 91-646, as amended?		✓
7. If #6 is yes, has a reasonable plan been developed to provide training?		NA

Willingness to Participate	Yes	No
8. Has the NFS stated its general willingness to participate in the project and its understanding of the general scope and role?	✓	
9. Is the NFS agreeable to signing a Project Partnership Agreement and supplying funding as stipulated in the agreement?	✓	
10. Was the NFS provided the Local Sponsor Toolkit? 06/02/2021	✓	

Acquisition Experience and Capability	Yes	No
11. Taking into consideration the project schedule and complexity, does the NFS have the capability, with in-house staffing or contract support, to provide the necessary services, including surveying, appraisal, title, negotiation, condemnation, closing, and relocation assistance, as required for the project?	✓	
12. Is the NFS's projected in-house staffing level sufficient considering its workload?	✓	
13. Can the NFS obtain contractor support, if required, in a timely manner?	✓	
14. Is the NFS's staff located within reasonable proximity to the project site?	✓	
15. Will the NFS likely request USACE assistance in acquiring real estate?		✓

Schedule Capability	Yes	No
16. Has the NFS approved the tentative project real estate schedule and indicated its willingness and ability to utilize its financial, acquisition, and condemnation capabilities to provide the necessary project LERRDs in accordance with the proposed project schedule so the Government can advertise and award a construction contract as required by overall project schedules and funding limitations? The anticipated NFS real estate acquisition timeframe for the project is eighteen (18) months. **NFS Initials:** [signature]	✓	

LERRD Crediting	Yes	No
17. Has the NFS indicating its understanding of LERRD credits and its capability and willingness to gather the necessary information to submit LERRD credits within six (6) months after possession of all real estate and completion of relocations so the project can be financially settled? **NFS Initials:**	✓	

Past Action and Coordination	Yes	No
1. Has the NFS performed satisfactorily on other USACE projects?	✓	
2. Has the assessment been coordinated with NFS?	✓	
3. Does the NFS concur with the assessment? (provide explanation if no)	✓	

With regard to the project, the NFS is anticipated to be:	Select One
Fully Capable: previous experience; financial capability; authority to hold title; in-house staff can perform necessary services (survey, appraisal, title, negotiation, closing, relocation assistance, condemnation) as required by the LERRDs.	
Moderately Capable: financial capability; authority to hold title; can perform, with contract support, necessary services (survey, appraisal, title, negotiation, closing, relocation assistance, condemnation) as required by the LERRDs.	✓
Marginally Capable: financial capability; authority to hold title; will rely on approved contractors to provide necessary services (survey, appraisal, title, negotiation, closing, relocation assistance, condemnation) as required by the LERRDs.	
Insufficiently Capable (provide explanation): financial capability; will rely on another entity to hold title; will rely on approved contractors to provide necessary services (survey, appraisal, title, negotiation, closing, relocation assistance, condemnation) as required by the LERRDs.	

USACE Prepared by:	NFS Reviewed by:
MURRAY.TIFFANY.MARIE.1384979013 Digitally signed by MURRAY.TIFFANY.MARIE.1384979013 Date: 2021.06.14 17:13:03 -10'00'	
Tiffany Murray Realty Specialist USACE Honolulu District	Steven Ikaika Rodenhurst Director County of Hawaii, Department of Public Works
Date: June 14, 2021	Date: JUN 14 2021

USACE Approved by:	
Considering the capability of the NFS and the ancillary support to be provided by contract services, it is my opinion that the risks associated with LERRDs acquisition and closeout of the project have been properly identified and mitigated.	
HIRIAMS.VERONICA.A.1117935783 Digitally signed by HIRIAMS.VERONICA.A.1117935783 Date: 2021.06.15 10:29:29 -05'00'	
Veronica A. Hiriams Acting Chief, Real Estate Branch U.S. Army Corps of Engineers Honolulu District	Date: June 15, 2021

Attachment 2: Sample Letter Advising Against Early Acquisition

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS, HONOLULU DISTRICT
FORT SHAFTER, HAWAII 96858-5440

June 14, 2021

Real Estate Division

SUBJECT: Waiakea-Palai Flood Risk Management Final Integrated Feasibility Report and Environmental Assessment, Risks of Early Acquisition

Name
Title
Office
Street
City, State Zip

Dear xx:

Reference is made to the Waiakea-Palai Flood Risk Management Final Integrated Feasibility Report and Environmental Assessment proposed project, as authorized by Section 205 of the Flood Control Act of 1948, as amended. The State of Hawaii Department of Public Works, as the non-Federal Sponsor, is responsible for ensuring that it possesses the authority to acquire and holds title for all real property required for the proposed project. The non-Federal sponsor shall provide one hundred percent (100%) of the lands, easements, rights-of-way, utility or public facility relocations, and dredged or excavated material disposal areas (LERRDs) as well as operation, maintenance, and repair required by the project.

The United States Army Corps of Engineers, Honolulu District, advises your office that there are risks associated with the acquisition of LERRDs prior to the execution of a Project Partnership Agreement (PPA) or Local Cooperation Agreement (LCA). The State of Hawaii will assume full and sole responsibility for any and all costs and liabilities arising out of premature acquisition. Project risks generally include, but are not limited to:

a. Congress may not appropriate funds to construct the proposed project;

b. The proposed project may otherwise not be funded or approved for construction;

c. A PPA/LCA mutually agreed to by the non-Federal sponsor and the Government may not be executed;

d. The non-Federal Sponsor may incur liability and expense by virtue of its ownership of contaminated lands, or interests therein, whether such liability should arise out of local, state, or Federal laws or regulations, including liability arising out of the

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended;

e. The non-Federal Sponsor may acquire interest or estates that are later determined by the Government to be inappropriate, inefficient, or otherwise no required for the project;

f. The non-Federal Sponsor may initially acquire insufficient or excessive real property acreage, which could result in additional negotiations and or/benefit payments under Public Law 91-646 or additional payment of fair market value to affected landowners;

g. The non-Federal Sponsor may incur costs or expenses in connection with its decision to acquire LERRDs in advance of the executed PPA/LCA and the Government's Notice to Acquire (NTA).

If you have further questions, please contact the USACE Honolulu District, Real Estate Branch, at (808) 835-4055.

Sincerely,

Veronica A. Hiriams
Chief, Real Estate Branch
U.S. Army Corps of Engineers
Honolulu District

Attachment 3: Sample Notice to Acquire Letter

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS, HONOLULU DISTRICT
FORT SHAFTER, HAWAII 96858-5440

June 14, 2021

Real Estate Division

SUBJECT: Waiakea-Palai Flood Risk Management Final Integrated Feasibility Report and Environmental Assessment, Notice to Acquire

Name
Title
Office
Street
City, State Zip

Dear xx:

This letter serves as your Notice to Acquire the real estate interests needed from the State of Hawaii Department of Public Works for the Waiakea-Palai Flood Risk Management Project, as authorized by Section 205 of the Flood Control Act of 1948, as amended. Enclosed are the final Authorization for Entry for Construction, Attorney's Certificate of Authority, and project real estate drawings. Also enclosed is the standard language to be used for the flood protection levee easement, flowage easement for occasional flooding, flowage easement for permanent flooding, roadway easement, and temporary work area easement conveyance documents between the State of Hawaii Department of Public Works, as the non-Federal Sponsor, and landowners.

In accordance with the Project Partnership Agreement (PPA) dated xx, the State of Hawaii Department of Public Works shall provide the real property interests and relocations required for the construction, operation, and maintenance of the project. As required by the PPA, the Government has determined the flood protection levee easements, flowage easements for occasional flooding, flowage easements for permanent flooding, roadway easements, and temporary work area easements as shown on the real estate drawings are required for project implementation. The PPA also requires the State of Hawaii Department of Public Works to comply with the Uniform Relocations and Assistance and Real Property Acquisition Policies Act. 42 U.S.C. § 4601, et. seq., and the Uniformed Regulations, 49 C.F.R. part 24. More information can be found at http://www.fhwa.dot.gov/realestate/realprop.

After acquisition of the required real estate interests, the State of Hawaii Department of Public Works shall complete and sign the Authorization for Entry for Construction and Attorney's Certificate of Authority. Please return the original signed authorization documents to the Corps of Engineers, Honolulu District Real Estate Branch, by mail to the address contained in the letterhead. In addition, the State of Hawaii, Department of Agriculture, shall provide copies of all conveyance documents for required real estate acquisitions to the Corps of Engineers. The Corps of Engineers requires the conveyance documents prior to advertising a construction contract. Copies of conveyance documents may be scanned and submitted electronically to the contact person below.

If you have any questions, please contact Tiffany Murray, Realty Specialist, at (808) 835-4065 or tiffany.murray@usace.army.mil.

Sincerely,

Veronica A. Hiriams
Chief, Real Estate Branch
U.S. Army Corps of Engineers
Honolulu District

Enclosures

References

U.S. Army Corps of Engineers, Honolulu District, *Waiakea Stream Flood Control Reconnaissance Study,* December 2001.

U.S. Army Corps of Engineers, Honolulu District, *Draft Hazardous, Toxic, and Radioactive Waste (HTRW) Assessment,* August 2005.

U.S. Army Corps of Engineers, Honolulu District, *Draft Environmental Assessment for the Proposed Waiakea Stream Flood Control Project,* September 2011.

U.S. Army Corps of Engineers, Honolulu District, *Waiakea-Palai CAP Section 204 Flood Risk Management Final Integrated Feasibility Report and Environmental Assessment,* March 2021.

WAIAKEA-PALAI STREAMS
Hilo, Island of Hawaii, Hawaii

CONTINUING AUTHORITIES PROGRAM SECTION 205
FLOOD RISK MANAGEMENT

Appendix E: Cost Estimate

MAY 2020

US Army Corps of Engineers
Honolulu District

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Cost Appendix

PN# 326040 Waiakea-Palai FRM, Hilo, Island of Hawaii, Hawaii

(6 September 19)

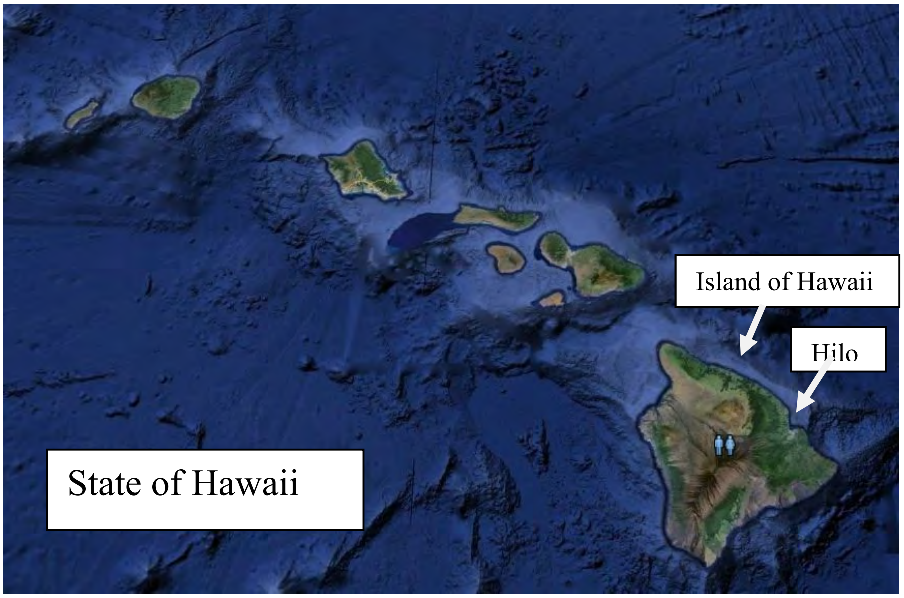
Contents

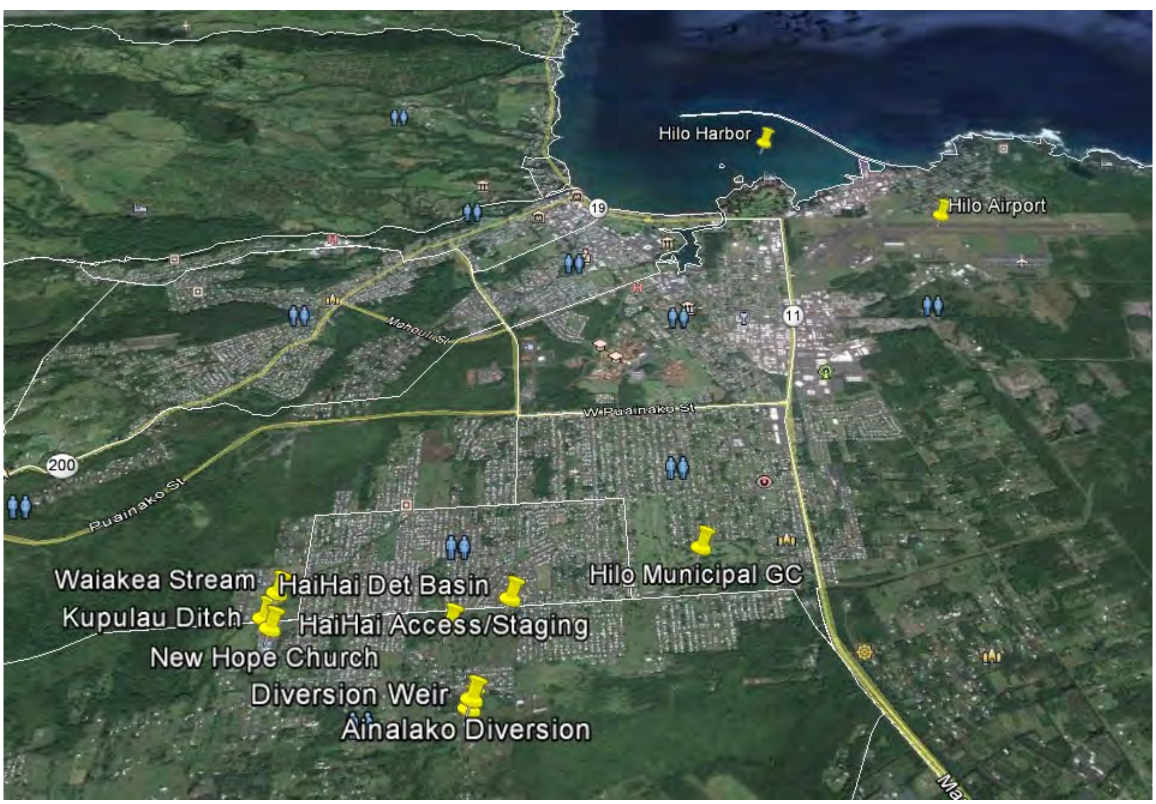
Tables:

Attachments:

1. PROJECT DESCRIPTION:

The project consists of various measures to reduce flood damage the Waiakea & Palai area of Hilo on the East side of the Island of Hawaii, State of Hawaii.





The following describes the measures included in the Viable Alternatives.

Table 1 Management Measures

Measure	Description	Location
Alternative 1: Kupulau Ditch Levee/Floodwall with Detention Area II (Base Plan – Reformulated @ 0. 1% AEP)	Detention Basin (Levees and Floodwalls) (Average height 4.3', 5.7', 6.7')	Kupulau Ditch and confluence of Waiakea Stream near Hope Church
	12'X 8' Box Culvert outlet with overflow spillway	Downstream end of Kupulau Ditch.
	Detention Basin Outlet, 4 Ea 4' Dia Culvert	Pipes thru Waiakea Stream Levee emptying into Waiakea Stream
Hilo Golf Course Detention Basin	Impoundment with side levees, in-channel barrier, uncontrolled outlet & overflow spillway, Avg. 20'H	Palai Stream within Hilo Municipal Golf Course
Hai Hai Detention Basin	Impoundment with in-channel barrier with an uncontrolled outlet (flume).	Upstream of Hai Hai Street on Palai Stream
Ainaloko Diversion	Diversion structure containment levee to divert excess flows into Four Mile Creek with in-channel barrier and uncontrolled outlet using pipes. Diversion weir and grassed swale.	Downstream of Ainalako Road on Palai Stream.
Combination of Measures (TSP)	* Kupulau Ditch Levee/Floodwall (Avg 4.3'H) * Hilo Golf Course Detention Basin (Avg 10'H)	See Above Locations

2. BASIS OF ESTIMATE AND QUANTITY

This feasibility cost estimate is based on the Feasibility Report and Environmental Assessment, dated January 2019 (Draft). Input for the estimate was obtained from the Project Delivery Team (PDT). Following ER 1110-2-1302, Engineering and Design Civil Works Cost Estimating, cost estimates were prepared at three levels:

a. Class 5 for screening of the initial viable array of alternatives which based the costs on historical cost data from similar projects.

b. Class 4 for the refinement of the final viable array of alternatives, which was based on a concept design. Cost was developed from rough quantity take-offs and supplemented with best professional judgment based on similar projects.

c. Class 3 for inclusion in the preliminary feasibility report which was based on a 35% level of design. Quantities for this level of design were calculated from 10-60% quality of project definition. Quantity calculations were aided by the use of Microstation, Google Earth, and Excel software. Major cost items were obtained from material suppliers.

3. ESTIMATED DESIGN AND CONSTRUCTION SCHEDULE

The estimate was initially based on the entire contract awarded to a single contractor with multiple contractors. The estimated schedule is:

Table 2 Project Schedule

Phase	Estimated Start	Estimated End	Estimated Midpoint
Real Estate Acquisition	April 2020	December 2020	September 2020
Planning, Engrg & Design	January 2020	December 2020	June 2020
Solict/Award	March 2021	April 2023	N/A

The Tentatively Selected Plan construction schedule is presented in this Appendix. The estimated construction time is based on the following:

a. Typical construction crew (1 shift) working 8 hr/day and 5 days per week.

b. An overall Production Efficiency Rate of 80% which is based on anticipated project difficulty, method of construction, labor availability, supervision, job conditions, weather and expected delays. Anticipated weather delays are included in the construction schedule.

Table 3 Estimated Construction Duration for the Initial TSP

	Initial TSP - Combination
Construction Start	March 2021
Construction End	April 2023
Midpoint of Construction	April 2022
Estimated Duration	25 months

CONSTRUCTION WINDOWS: None

OVERTIME
This estimate contains no overtime to complete the project.

4. ACQUISITION PLAN

a. The estimate is based on a single contract being awarded to one Prime Contractor with multiple subcontractors. The acquisition strategy is assumed as Full and Open Invitation for Bid. The prime contractor will be responsible for oversight of the contract the rest of the work is assumed performed by subcontractors.

b. Sub-Contracting: At the Class 4 Estimate level, the assumption of multiple subcontractors was used. A single subcontractor markup was used for any subcontractor effort. For the Tentatively Selected Plan estimate, the subcontractors are broken out as:

- Site work Subcontractor
- Survey Subcontractor
- Hauling Subcontractor
- Material Supplier (concrete, soil, rocks, Pipes)
- Disposal Cost (Landfill)
- Concrete Subcontractor
- Miscellaneous Subcontractor

5. PROJECT CONSTRUCTION

a. Mobilization, Demobilization & Preparatory Work

Mobilization/Demobilization: The estimate for this study assumed that the Prime Contractor will be from Oahu and Site work Contractor from the Island of Hawaii. This does not exclude contractors from other locations during the bidding process. Other sub-contractors are assumed from the Island of Hawaii.

Temporary Facilities: The estimate includes the assumption of office trailers and temporary utilities for the Prime Contractor and Government. The electricity will be supplemented by diesel generator.

b. Surveys: Assume site pre-construction survey and layout, and geotechnical surveys.

c. Disposal: Approved on-island landfill approximately 70 miles away on the West side of the Island of Hawaii.

d. Features & discussion

- SITE ACCESS: The sites are located in urban Hilo, Island of Hawaii. Access is readily available.

    - BORROW AREAS: The borrow sources is assumed from an on-island commercial source. Borrow areas for topsoil and fill is assumed to be from on-island.

    - CONSTRUCTION METHODOLOGY: The construction methodology will be industry standard.

    - UNUSUAL CONDITIONS (Soil, Water, and Weather): Actual dewatering plan will be determined by the Contractor performing the work after award of the construction project. The project schedule includes anticipated weather delays.

    - UNIQUE TECHNIQUES OF CONSTRUCTION: None

    - EQUIPMENT AND LABOR AVAILABILITY: The cost assumes equipment and labor is readily available on the Island of Hawaii or from the other locations.

    - ENVIRONMENTAL CONCERNS: None at this stage.

      Standard Best Management Practices such as silt fences, gravel entrances to the contractor's storage area are included in the estimate.

6. COST ESTIMATE ASSUMPTIONS

EFFECTIVE DATES FOR LABOR, EQUIPMENT, MATERIAL PRICING

a. Effective Price Level: Project costs are presented in July 2019(4Q2019) dollars.

b. The construction cost estimate was developed using MCACES 2nd Generation estimating software in accordance with EF 1110-2-1302, Civil Works Cost Engineering, 30 Jun 2016; UFC 3-740-05, Handbook: Construction Cost Estimating, 8 November 2010, Change 1, June 2011. The construction cost estimate was prepared using MII Version 4.4, and the latest 2016 English Cost Book and 2016 Equipment Library (Region 10).

c. The labor rates used is from the State of Hawaii Department of Labor & Industrial Wage Rate Schedule Bulletin#494 18 Feb 2019 effective until September 2019 for the State of Hawaii for Building, Heavy (Heavy and Dredging), Highway and Residential Construction Types for all counties in Hawaii Statewide.
Labor and Equipment Productivity: No overtime hours. The estimate includes an overall Production Index of 80% which is based on anticipated project difficulty, method of construction, labor availability, supervision, job conditions, weather and expected delays.

d. Escalation: Escalation has been included within the Total Project Cost Summary Sheet (TPCS) estimate. Price levels have been escalated from price levels of the construction cost estimate to the midpoint of construction indicated in the above Table 3.

e. Functional Costs: Functional costs using the Civil Works Breakdown Structure (CWBS) associated with this work were developed from quantity take-offs using CAD drawings, historical costs and input from PDT members as follows:

   1) 01 – Lands and Damages: This account covers Lands and Damages costs for Construction. The initial estimate for real estate costs were derived from the tax map key full replacement. Market cost will be determined at TSP level by an appraiser. Based on Real Estate's judgment, TMK costs are typically much lower than market costs.

   2) 11 - Levees and Floodwalls: This account covers cost for levees/berms and floodwalls. The levee/berm consists of compacted impermeable fill and grass.

   3) 30 – Planning, Engineering and Design (PED): This account covers planning, engineering and design to include topographic and geotechnical surveys. The Initial PED cost was based on a % of construction. PED cost will be refined in the TSP estimate.

4) 31 - Construction Management (CM): This account covers supervision and administration costs during construction. The initial cost for the viable array was based on a % of construction based on typical projects. CM costs will be further refined in the TSP estimate.

f. Estimate Assumptions: Key assumptions used for estimating the construction cost of the proposed alternative are as follows:

1) Analysis performed on major cost items based on a 10% level of design. The viable array conceptual design is at approximately 10% quality of project definition and the Tentatively Selected plan at approximately a 35% level of design effort.

2) Excavated material associated with the feature will be calculated for the structure. Areas of clear and grubbed material will be mulched and if possible left on the project area. Soil, rocks, and green waste will be hauled off site for either disposal or recycling.

3) The streams are normally dry. During storm events, it is assumed temporary storm drain pipes and sandbags will be used for stream flow thru the site during storm events.

4) Access to structures will be constructed and used as permanent access roads for O&M maintenance.

5) General % markups will be used for the initial estimate. Markups will be refined for Recommended Plan in the next phase.

g. Contingencies by Feature or Sub-Feature: Current Headquarters USACE guidance requires a formal analysis on all projects where the projected cost exceeds $40 million. In accordance with ER 1110-2-1302 and ECB 2007-17, 10 Sep 2007, Cost Risk Analysis was used to identify and measure the cost impact of project uncertainties within the estimated total project cost. The risk model used was an Abbreviated Cost Risk Analysis template created by the Cost MCX to determine the contingencies by Civil Works Features for the initial viable alternatives, incremental cost and optimized design cost prior to selection of the recommended plan.

An Abbreviated Cost Risk Analysis will be used to develop contingencies for the Recommended Plan since the Total Project Cost is less than $40,000,000.

Contingencies are added to the cost estimate based on results of cost risk analysis. Results yielded contingencies added to the total cost. Table 4 summarizes the contingency amounts.

Unknowns that could affect the project costs and design assumptions prior to the detailed design phase (PED) include the following:

- Additional features added to the design, increasing scope.
- Insufficient Topographic and Geotechnical survey.
- Insufficient sub-surface surveys (lava tubes, utilities, etc.)
- Under-designed floodwall footings.
- Variation in estimated quantities
- Changes in Acquisition strategy.
- Changes in bid schedule
- Unexpected geotechnical or ground water issues.
- Increased landfill disposal rates
- Increased fuel cost
- Further refinement of designs based on refinement of hydraulic models.
- Delays in real estate acquisition or funding.
- Availability of large quantities of suitable levee material.
- Increased permitting regulations affecting designs.
- Community opposition.
- Unseasonal weather delays during construction.
- Unanticipated phasing requirements.
- Single or multiple contracts over multiple years.
- Impact to Golf Course operations.
- Dam safety risk for impoundment of runoff water.

Real Estate Contingency was based on judgment by the Real Estate PDT member for the viable array. TMK costs are typically much lower than market costs. Real Estate Contingency will be refined in the TSP estimate.

h. Total Project Cost Summary: The Total Project Cost Summary Sheet (TPCS) includes the construction costs from the MCACES estimate, project markups, as well as costs for Lands and Damages, Planning, Engineering & Design, and Construction Management. The following in Table 4 were all previous measures evaluated.

Table 4 Management Measure Cost & Duration

Total Project Cost (Fully Funded) Budget Year 2016 based on 10% Level of (Class 4 Historical/Parametric)						
	Kupulau Levee/Floodwall Detention @ 4.3' Avg Floodwall/ Levee Height (50 Yr) (6/22/15)			Kupulau Levee/Floodwall Detention @ 5.7' Avg Floodwall /Levee Height (100 Yr) (6/18/15)		
CWBS Acct	Est Cost @ EPL 1 Oct 14 Incl. Cont ($K)		Fully Funded Total Proj Cost @ FY16 ($K)	Est Cost @ EPL 1 Oct 14 Incl. Cont ($K)		Fully Funded Total Proj Cost @ FY16 ($K)
01 Real Estate	$376		$399	$376		$399
Construction:						
11 Levees/ Floodwalls	$4,549		$5,001	$5,974		$6,567
19 Bldgs, Grounds & Utility (Flood Warning System)	$39		$43	$40		$44
Total Construction Cost	$4,588		**$5,044**	$6,014		**$6,611**
30 Planning, Engrg & Design	$1,260		$1,446	$1,654		$1,898
31 Construction Mgt	$666		$801	$874		$1,052
Project Cost Total	$6,890		**$7,690**	$8,918		**$9,960**
Contingency	29.6%			29.7%		
Fully Funded Cost	**$7,690,000.00**			**$9,960,000.00**		
Estimated Duration	Jul 2019 to Sep 2020 14 months			Jul 2019 to Sep 2020 14 months		

	Kupulau Levee/Floodwall Detention @ 6.7’ Avg Levee/Floodwall Height (200 Yr) (6/22/15)		Hilo Golf Course Detention (Avg 20’H) (6/22/15)	
CWBS Acct	Est Cost @ EPL 1 Oct 14 Incl. Cont ($K)	Fully Funded Total Proj Cost @ FY16 ($K)	Est Cost @ EPL 1 Oct 14 Incl. Cont ($K))	Fully Funded Total Proj Cost @ FY16 ($K)
01 Real Estate	$376	$399	$341	$362
Construction:				
11 Levees/ Floodwalls	$6,691	$7,356	$2,033	$2,235
19 Bldgs, Grounds & Utility (Flood Warning System)	$51	$56		
Total Construction Cost	$6,742	**$7,412**	$2,033	**$2,235**
30 Planning, Engrg & Design	$1,856	$2,131	$563	$647
31 Construction Mgt	$979	$1,178	$295	$355
Project Cost Total	$9,953	**$11,120**	$3,232	**$3,599**
Contingency	29.7%		30%	
Fully Funded Cost	**$11,120,000.00**		**$3,599,000.00**	
Estimated Duration	Jul 2019 to Sep 2020 14 months		Jul 2019 to Oct 2020 15 months	

	Hai Hai Detention (6/2215)		Ainalako Diversion (6/22/15)	
CWBS Acct	Est Cost @ EPL 1 Oct 14 Incl. Cont ($K)	Fully Funded Total Proj Cost @ FY16 ($K)	Est Cost @ EPL 1 Oct 14 Incl. Cont ($K)	Fully Funded Total Proj Cost @ FY16 ($K)
01 Real Estate	$266	$282	$121	$128
Construction:				
11 Levees/ Floodwalls	$2,555	$2,823	$1,707	$1,877
Total Construction Cost	$2,555	**$2,823**	$1,707	**$1,877**
30 Planning, Engrg & Design	$703	$808	$471	$541
31 Construction Mgt	$370	$449	$248	$299
Project Cost Total	$3,894	**$4,362**	$2,547	**$2,845**
Contingency	21.3%		24.3%	
Fully Funded Cost	**$4,362,000.00**		**$2,845,000.00**	

Estimated Duration	July 2019 to Jan 2021 16.76 months	July 2019 to July 2020 12 months

Note:

1. Estimated Cost is the initially developed cost estimate and includes contingencies. The effective price level date for the Estimated Cost is usually the date of preparation of the estimate.
2. Total Project Cost is the Constant Dollar Cost FULLY FUNDED WITH ESCALATION to the estimated midpoint of construction. Total Project Cost (is the cost estimate used in Project Partnership Agreements and Integral Determination Reports. Total Project Cost is the cost estimate provided non-Federal sponsors for their use in financial planning as it provides information regarding the overall non-Federal cost sharing obligation.

3. Constant Dollar Cost (Price Level) is the Estimated Cost BROUGHT TO THE EFFECTIVE PRICE LEVEL (EPL). The effective price level for Constant Dollar Cost is the date of the common point in time of the pricing used in the cost estimate. Constant Dollar Cost does not include inflation. Constant Dollar Cost at current price levels is the cost estimate used in feasibility reports and Chief's Report.

4. Abbreviations:

- Est = Estimated
- Cont = Contingency
- Proj = Project
- $K = X $1,000.00
- CWBS = Civil Works Breakdown Structure, cost accounting feature codes in accordance with ER 1110-2-1302.

7. INITIAL TENTATIVELY SELECTED PLAN COST (TSP)

Each measure was estimated starting with the base measure, Kupulau Levee/Floodwall Detention. Following the base measure, Hai Hai Detention, Ainalako Diversion and the Golf Course Detention were estimated. Economic and hydraulic analysis determined which measures were incrementally justified in addition to the base measure. This combination consists of the base measure, Kupulau Levee/Floodwall Detention with an average 4.3' high floodwall/levee height and an average height 10' Golf Course Detention. For further explanation, refer to the Economic Appendix. Contingencies used were developed for each measure. The Contingencies will be refined once the Recommended Plan design is completed.

Table 5 Proposed Tentatively Selected Alternative / NED

Kupulau Levee/Floodwall Detention (Avg 4.3'H) & Golf Course Detention (Avg. 10'H) (Class 4 Estimate)			
CWBS Acct	Est Cost @ EPL 1 Jul 19 (FY19) Including Contingency ($K)		Total Proj Cost @ Budget Year FY20 ($K)
01 Real Estate	$937		$984
Construction:			
11 Levees/ Floodwalls	$6,621		$7,317
Total Construction Cost	$6,621		$7,317
30 Planning, Engrg & Design	$2,015		$2,159
31 Construction Mgt	$960		$1,091
Project cost Total (Shown on the TPCS)	$10,533		$11,552
Contingency	30%		

Note:
1. Contingency (Cont) determined by Cost Risk Analysis
2. Planning, Engineering & Design (PED)
3. Construction Management (CM)
4. Total Project Cost (TPC) – includes contingency & escalation of a fully funded project. The Alternative cost was refined using preliminary designs after screening of the initial viable array of alternatives.
5. $K = $100,000
6. TSP design and cost will be refined following the Concurrent Review.
7. Total Project Cost Summary (TPCS)

a. <u>Total Project Cost Summary for the Initial Tentatively Selected Plan</u>

The Total Project Cost Summary Sheet (TPCS) includes the construction costs from the MCACES estimate, project markups, as well as costs for Lands and Damages, Planning, Engineering & Design, and Construction Management. The following table summarizes the TPCS.

Estimated Cost (EPL Jul 2019, FY19)	Project First Cost (1 Oct 19)	Total Project Cost (Fully Funded)
$10,533,000	$10,816,000	$11,552,000

Based on 1 Jul 2019 price levels, the estimated project first cost is $10,533,000. In accordance with the cost share provisions in Section 103(c) of the Water Resources Development Act (WRDA) of 1986, as amended (33 U.S.C. 2213(c)), the Federal Share of the Total Project Cost (Fully Funded) is estimated to be $7,509,000 which equates to 65% of the Total Project Cost (Fully Funded). The non-Federal share is estimated to be $4,043,000 which equates to 35% of the Total Project Cost (Fully Funded). The non-Federal costs include the value of lands, easements, rights-of-way, relocations (LERRD) estimated to be $984,000.

---- End of Project Notes ---

Cost Appendix Attachments

WALLA WALLA COST ENGINEERING
MANDATORY CENTER OF EXPERTISE

COST AGENCY TECHNICAL REVIEW CERTIFICATION STATEMENT

For Project No. 326040

POH – Waiakea-Palai Streams Section 205
Flood Risk Management

The Waiakea-Palai Streams Section 205 – Flood Risk Management project as presented by Honolulu District, has undergone a successful Cost Agency Technical Review (Cost ATR), performed by the Walla Walla District Cost Engineering Mandatory Center of Expertise (Cost MCX) team. The Cost ATR included study of the project scope, report, cost estimates, schedules, escalation, and risk-based contingencies. This certification signifies the products meet the quality standards as prescribed in ER 1110-2-1150 Engineering and Design for Civil Works Projects and ER 1110-2-1302 Civil Works Cost Engineering.

As of August 20, 2019, the Cost MCX certifies the estimated total project cost:

FY20 Project First Cost:	$10,816,000
Fully Funded Total Project Cost:	$11,552,000
Federal Cost of Project:	$7,709,000

It remains the responsibility of the District to correctly reflect these cost values within the Final Report and to implement effective project management controls and implementation procedures including risk management through the period of Federal participation.

FOR: Michael P. Jacobs, PE, CCE
Chief, Cost Engineering MCX
Walla Walla District

**** TOTAL PROJECT COST SUMMARY ****

PROJECT: **Waiakea-Palai Flood Risk Mgmt Project**
PROJECT NO: **P2 326040**
LOCATION: **Hilo, Island of Hawaii, Hawaii**

DISTRICT: **Honolulu District** PREPARED: **8/19/2019**
POC: **CHIEF, COST ENGINEERING, Alex M. Tseng**

This Estimate reflects the scope and schedule in report; Waiakea-Palai Flood Risk Mgmt Project

Civil Works Work Breakdown Structure		**ESTIMATED COST**				**PROJECT FIRST COST (Constant Dollar Basis)**						**TOTAL PROJECT COST (FULLY FUNDED)**			
							Program Year (Budget EC):			2020					
							Effective Price Level Date:			1-Oct- 19					
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	REMAINING COST ($K)	Spent Thru: 1-Oct-18 ($K)	TOTAL FIRST COST ($K)	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
11	LEVEES & FLOODWALLS	$5,071	$1,550	31%	$6,621	2.4%	$5,194	$1,587	$6,781		$6,781	7.9%	$5,605	$1,713	$7,317
	#N/A			-		-						-			
				-		-						-			
				-		-						-			
	CONSTRUCTION ESTIMATE TOTALS:	$5,071	$1,550		$6,621	2.4%	$5,194	$1,587	$6,781		$6,781	7.9%	$5,605	$1,713	$7,317
01	LANDS AND DAMAGES	$766	$171	22%	$937	2.4%	$785	$175	$960		$960	2.5%	$805	$179	$984
30	PLANNING, ENGINEERING & DESIGN	$1,543	$472	31%	$2,015	3.4%	$1,596	$488	$2,083		$2,083	3.7%	$1,654	$506	$2,159
31	CONSTRUCTION MANAGEMENT	$735	$225	31%	$960	3.4%	$760	$232	$992		$992	9.9%	$835	$255	$1,091
	PROJECT COST TOTALS:	$8,116	$2,417	30%	$10,533		$8,334	$2,482	$10,816		**$10,816**	6.8%	$8,899	$2,653	$11,552

ESTIMATED TOTAL PROJECT COST:		**$11,552**
ESTIMATED FEDERAL COST:	65%	$7,509
ESTIMATED NON-FEDERAL COST:	**35%**	$4,043
22 - FEASIBILITY STUDY (CAP studies):		**$400**
ESTIMATED FEDERAL COST:	50%	$200
ESTIMATED NON-FEDERAL COST:	50%	$200
ESTIMATED FEDERAL COST OF PROJECT		**$7,709**

________________ CHIEF, COST ENGINEERING, Alex M. Tseng

________________ PROJECT MANAGER, Jeffrey A. Herzog

________________ CHIEF, REAL ESTATE, Carrie-Ann Chee

________________ CHIEF, PLANNING, Stephen Cayetano

________________ CHIEF, ENGINEERING, Todd C. Barnes

________________ CHIEF, OPERATIONS, XXX

________________ CHIEF, CONSTRUCTION, Jamie M. Hagio

________________ CHIEF, CONTRACTING, Leigh Ann Lucas

________________ CHIEF, PM-PB, Roxanne E. Iseri

________________ CHIEF, DPM, Stephen Cayetano

**** TOTAL PROJECT COST SUMMARY ****

**** CONTRACT COST SUMMARY ****

PROJECT: Waiakea-Palai Flood Risk Mgmt Project
LOCATION: Hilo, Island of Hawaii, Hawaii
This Estimate reflects the scope and schedule in report; Waiakea-Palai Flood Risk Mgmt Project

DISTRICT: Honolulu District
POC: CHIEF, COST ENGINEERING, Alex M. Tseng

PREPARED: 8/19/2019

WBS Structure		**ESTIMATED COST**				**PROJECT FIRST COST (Constant Dollar Basis)**				**TOTAL PROJECT COST (FULLY FUNDED)**				
		Estimate Prepared:			**6-May-16**	Program Year (Budget EC):			2020					
		Estimate Price Level:			1-Oct-18	Effective Price Level Date:			1 -Oct-19					
				RISK BASED										
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Mid-Point Date	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*P*	*L*	*M*	*N*	*O*
	Kupulau Levee/Fld Wall (Det) (4.3"H/50yr, Rev 2/22/19)													
11	LEVEES & FLOODWALLS	$3,647	$1,094	30.0%	$4,741	2.4%	$3,735	$1,120	$4,855	2022Q3	7.9%	$4,031	$1,209	$5,240
				30.0%										
	CONSTRUCTION ESTIMATE TOTALS:	$3,647	$1,094	30.0%	$4,741		$3,735	$1,120	$4,855			$4,031	$1,209	$5,240
01	LANDS AND DAMAGES	$365	$83	22.8%	$448	2.4%	$373	$85	$458	2020Q4	2.5%	$383	$87	$470
30	PLANNING, ENGINEERING & DESIGN													
2.5%	Project Management	$91	$27	30.0%	$118	3.4%	$94	$28	$122	2020Q4	2.9%	$97	$29	$126
1.0%	Planning & Environmental Compliance	$36	$11	30.0%	$47	3.4%	$37	$11	$48	2020Q4	2.9%	$38	$11	$50
15.0%	Engineering & Design	$547	$164	30.0%	$711	3.4%	$566	$170	$735	2020Q4	2.9%	$582	$175	$756
1.0%	Reviews, ATRs, IEPRs, VE	$36	$11	30.0%	$47	3.4%	$37	$11	$48	2020Q4	2.9%	$38	$11	$50
1.0%	Life Cycle Updates (cost, schedule, risks)	$36	$11	30.0%	$47	3.4%	$37	$11	$48	2020Q4	2.9%	$38	$11	$50
1.0%	Contracting & Reprographics	$36	$11	30.0%	$47	3.4%	$37	$11	$48	2022Q3	9.9%	$41	$12	$53
3.0%	Engineering During Construction	$109	$33	30.0%	$142	3.4%	$113	$34	$147	2022Q3	9.9%	$124	$37	$161
2.0%	Planning During Construction	$73	$22	30.0%	$95	3.4%	$75	$23	$98	2020Q4	2.9%	$78	$23	$101
3.0%	Adaptive Management & Monitoring	$109	$33	30.0%	$142	3.4%	$113	$34	$147	2020Q3	1.9%	$115	$34	$149
1.0%	Project Operations	$36	$11	30.0%	$47	3.4%	$37	$11	$48	2020Q3	1.9%	$38	$11	$49
31	CONSTRUCTION MANAGEMENT													
10.0%	Construction Management	$365	$110	30.0%	$475	3.4%	$377	$113	$491	2022Q3	9.9%	$415	$124	$539
2.0%	Project Operation:	$73	$22	30.0%	$95	3.4%	$75	$23	$98	2022Q3	9.9%	$83	$25	$108
2.5%	Project Management	$91	$27	30.0%	$118	3.4%	$94	$28	$122	2022Q3	9.9%	$103	$31	$134
	CONTRACT COST TOTALS:	$5,650	$1,669		$7,318		$5,802	$1,714	**$7,516**			$6,203	$1,833	**$8,037**

**** CONTRACT COST SUMMARY ****

PROJECT: Waiakea-Palai Flood Risk Mgmt Project
LOCATION: Hilo, Island of Hawaii, Hawaii
This Estimate reflects the scope and schedule in report; Waiakea-Palai Flood Risk Mgmt Project

DISTRICT: Honolulu District
POC: CHIEF, COST ENGINEERING, Alex M. Tseng

PREPARED: 8/19/2019

****** TOTAL PROJECT COST SUMMARY ******

WBS Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
		Estimate Prepared: 6-May-16 Estimate Price Level: 1-Oct-18				Program Year (Budget EC): 2020 Effective Price Level Date: 1 -Oct-19								
WBS NUMBER *A*	Civil Works Feature & Sub-Feature Description *B*	COST ($K) *C*	CNTG ($K) *D*	RISK BASED CNTG (%) *E*	TOTAL ($K) *F*	ESC (%) *G*	COST ($K) *H*	CNTG ($K) *I*	TOTAL ($K) *J*	Mid-Point Date *P*	ESC (%) *L*	COST ($K) *M*	CNTG ($K) *N*	FULL ($K) *O*
	Ainalako Diversion													
11	LEVEES & FLOODWALLS			24.0%										
	CONSTRUCTION ESTIMATE TOTALS:													
01	LANDS AND DAMAGES			30.0%										
30	PLANNING, ENGINEERING & DESIGN													
2.5%	Project Management			24.0%										
1.0%	Planning & Environmental Compliance			24.0%										
15.0%	Engineering & Design			24.0%										
1.0%	Reviews, ATRs, IEPRs, VE			24.0%										
1.0%	Life Cycle Updates (cost, schedule, risks)			24.0%										
1.0%	Contracting & Reprographics			24.0%										
3.0%	Engineering During Construction			24.0%										
2.0%	Planning During Construction			24.0%										
3.0%	Adaptive Management & Monitoring			24.0%										
1.0%	Project Operations			24.0%										
31	CONSTRUCTION MANAGEMENT													
10.0%	Construction Management			24.0%										
2.0%	Project Operation:			24.0%										
2.5%	Project Management			24.0%										
	CONTRACT COST TOTALS:													

****** CONTRACT COST SUMMARY ******

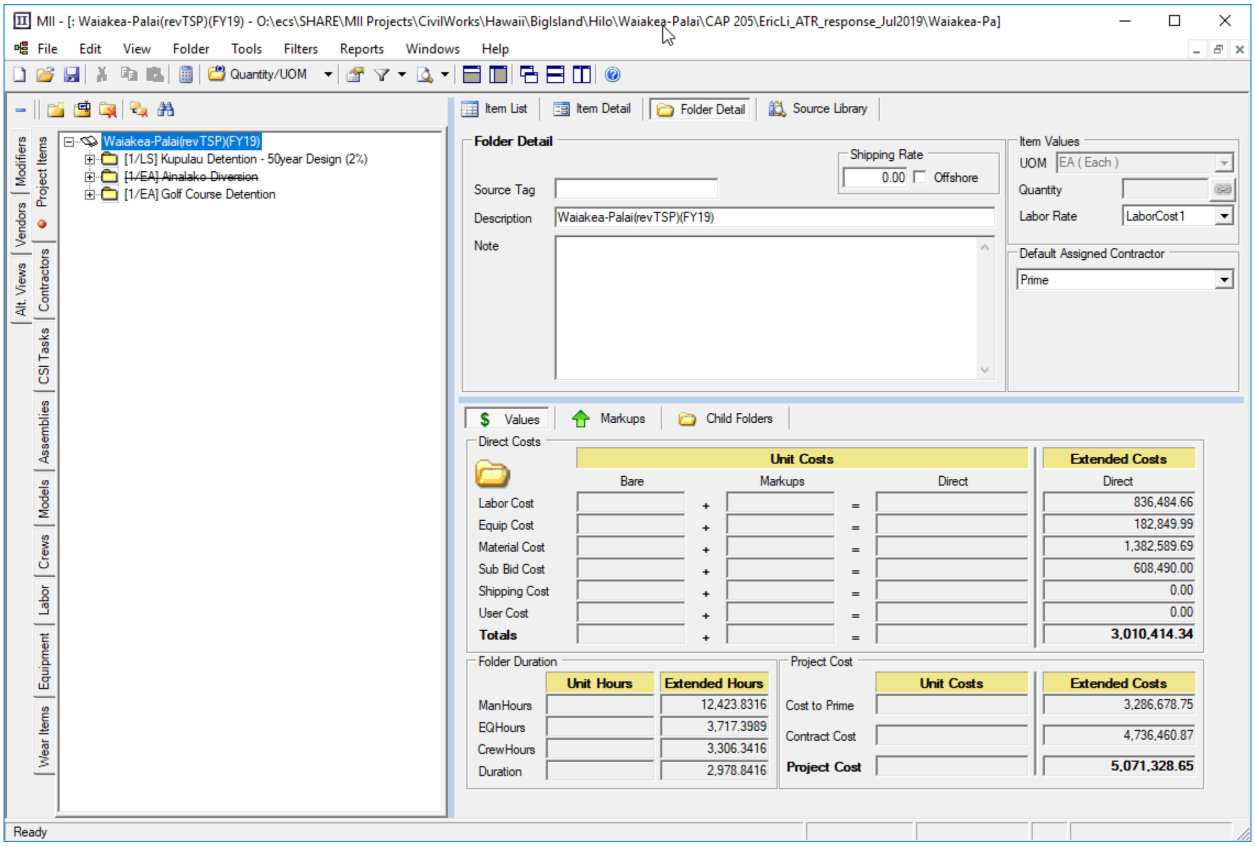
PROJECT: Waiakea-Palai Flood Risk Mgmt Project
LOCATION: Hilo, Island of Hawaii, Hawaii
This Estimate reflects the scope and schedule in report; Waiakea-Palai Flood Risk Mgmt Project

DISTRICT: Honolulu District
POC: CHIEF, COST ENGINEERING, Alex M. Tseng
PREPARED: 8/19/2019

WBS Structure	ESTIMATED COST	PROJECT FIRST COST (Constant Dollar Basis)	TOTAL PROJECT COST (FULLY FUNDED)
	Estimate Prepared: 6-May-16 Estimate Price Level: 1-Oct-18 RISK BASED	Program Year (Budget EC): 2020 Effective Price Level Date: 1 -Oct-19	

**** TOTAL PROJECT COST SUMMARY ****

WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Mid-Point Date	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*P*	*L*	*M*	*N*	*O*
	Golf Course Detention													
11	LEVEES & FLOODWALLS	$1,424	$456	32.0%	$1,880	2.4%	$1,459	$467	$1,925	2022Q3	7.9%	$1,574	$504	$2,078
	CONSTRUCTION ESTIMATE TOTALS:	$1,424	$456	32.0%	$1,880		$1,459	$467	$1,925			$1,574	$504	$2,078
01	LANDS AND DAMAGES	$402	$88	21.8%	$490	2.4%	$412	$90	$501	2020Q4	2.5%	$422	$92	$514
30	PLANNING, ENGINEERING & DESIGN													
2.5%	Project Management	$36	$12	32.0%	$48	3.4%	$37	$12	$49	2020Q4	2.9%	$38	$12	$51
1.0%	Planning & Environmental Compliance	$14	$4	32.0%	$18	3.4%	$14	$5	$19	2020Q4	2.9%	$15	$5	$20
15.0%	Engineering & Design	$214	$68	32.0%	$282	3.4%	$221	$71	$292	2020Q4	2.9%	$228	$73	$300
1.0%	Reviews, ATRs, IEPRs, VE	$14	$4	32.0%	$18	3.4%	$14	$5	$19	2020Q4	2.9%	$15	$5	$20
1.0%	Life Cycle Updates (cost, schedule, risks)	$14	$4	32.0%	$18	3.4%	$14	$5	$19	2020Q4	2.9%	$15	$5	$20
1.0%	Contracting & Reprographics	$14	$4	32.0%	$18	3.4%	$14	$5	$19	2022Q3	9.9%	$16	$5	$21
3.0%	Engineering During Construction	$43	$14	32.0%	$57	3.4%	$44	$14	$59	2022Q3	9.9%	$49	$16	$65
2.0%	Planning During Construction	$28	$9	32.0%	$37	3.4%	$29	$9	$38	2020Q4	2.9%	$30	$10	$39
3.0%	Adaptive Management & Monitoring	$43	$14	32.0%	$57	3.4%	$44	$14	$59	2020Q3	1.9%	$45	$15	$60
1.0%	Project Operations	$14	$4	32.0%	$18	3.4%	$14	$5	$19	2020Q3	1.9%	$15	$5	$19
31	CONSTRUCTION MANAGEMENT													
10.0%	Construction Management	$142	$45	32.0%	$187	3.4%	$147	$47	$194	2022Q3	9.9%	$161	$52	$213
2.0%	Project Operation:	$28	$9	32.0%	$37	3.4%	$29	$9	$38	2022Q3	9.9%	$32	$10	$42
2.5%	Project Management	$36	$12	32.0%	$48	3.4%	$37	$12	$49	2022Q3	9.9%	$41	$13	$54
	CONTRACT COST TOTALS:	$2,466	$748		$3,214		$2,532	$768	**$3,300**			$2,696	$820	**$3,515**



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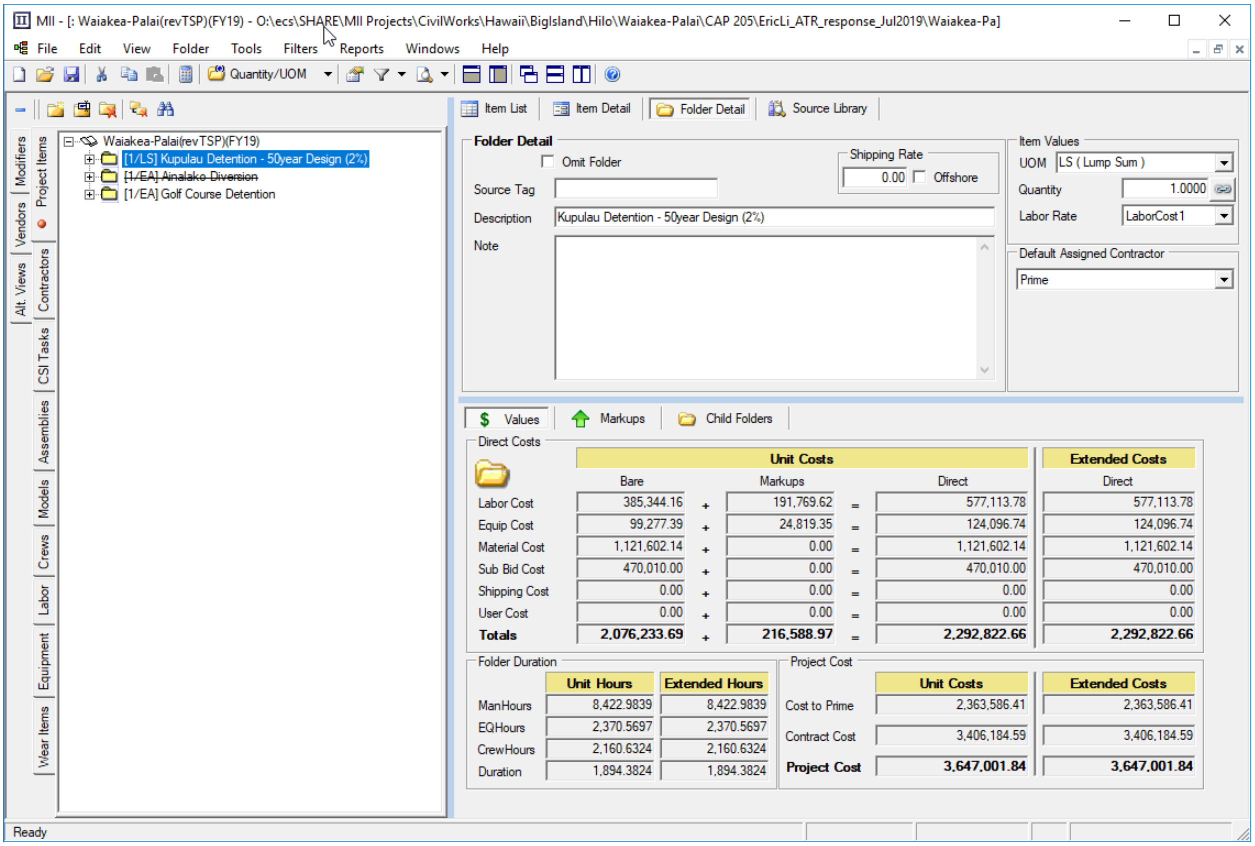
File Edit View Folder Tools Filters Reports Windows Help
Quantity/UOM
Item List
Item Detail
Folder Detail
Source Library
Waiakea-Palai(revTSP)(FY19)
[1/LS] Kupulau Detention - 50year Design (2%)
[1/EA] Ainalako Diversion
[1/EA] Golf Course Detention
Folder Detail
Shipping Rate
0.00
Offshore
Source Tag
Description
Waiakea-Palai(revTSP)(FY19)
Note
Item Values
UOM
EA (Each)
Quantity
Labor Rate
LaborCost1
Default Assigned Contractor
Prime
Values
Markups
Child Folders
Direct Costs
Unit Costs
Extended Costs
Bare
Markups
Direct
Direct
Labor Cost 836,484.66
Equip Cost 182,849.99
Material Cost 1,382,589.69
Sub Bid Cost 608,490.00
Shipping Cost 0.00
User Cost 0.00
Totals 3,010,414.34
Folder Duration
Unit Hours
Extended Hours
ManHours 12,423.8316
EQHours 3,717.3989
CrewHours 3,306.3416
Duration 2,978.8416
Project Cost
Unit Costs
Extended Costs
Cost to Prime 3,286,678.75
Contract Cost 4,736,460.87
Project Cost 5,071,328.65
Modifiers
Project Items
Vendors
Alt. Views
Contractors
CSI Tasks
Assemblies
Models
Crews
Labor
Equipment
Wear Items
Ready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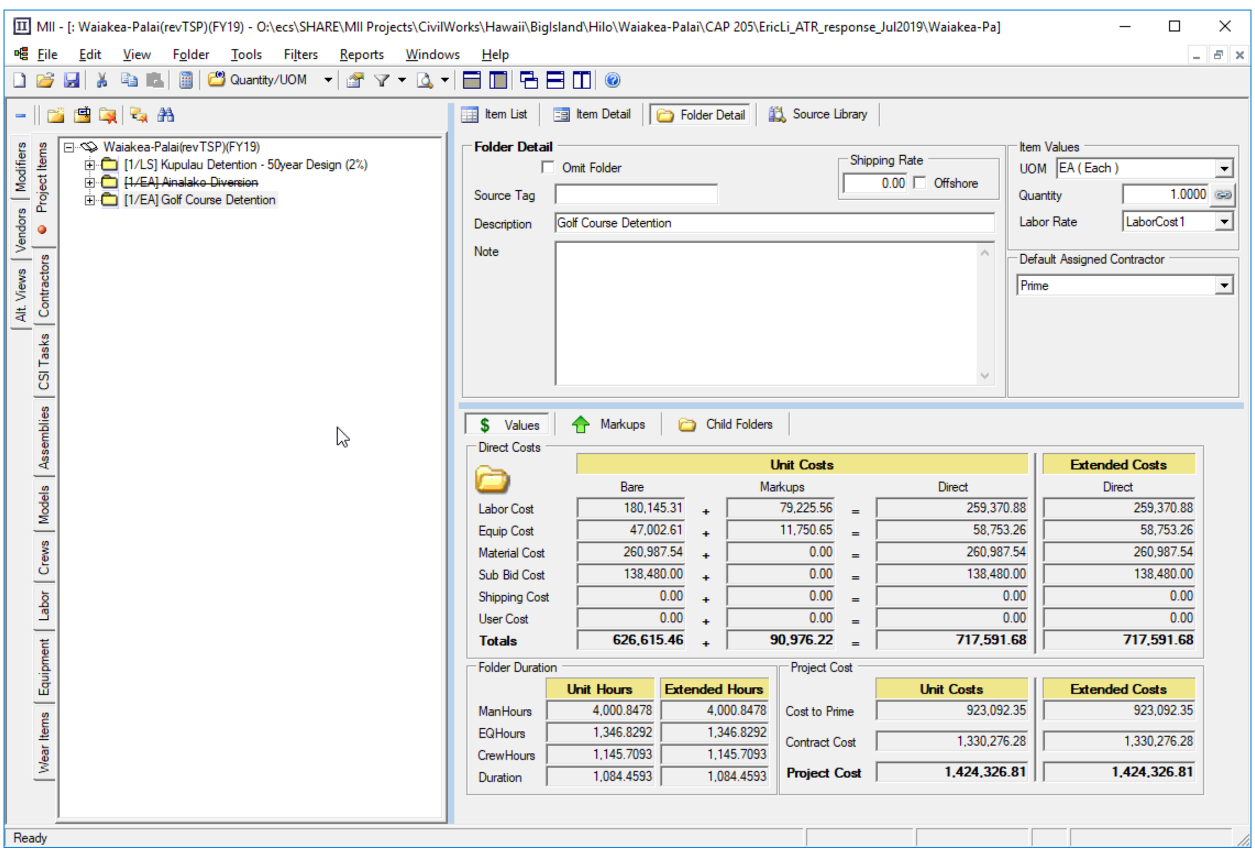
Quantity/UOM
Item List Item Detail Folder Detail Source Library
Waiakea-Palai(revTSP)(FY19)
[1/LS] Kupulau Detention - 50year Design (2%)
[1/EA] Ainalako Diversion
[1/EA] Golf Course Detention
Modifiers Project Items Vendors Alt. Views Contractors CSI Tasks Assemblies Models Crews Labor Equipment Wear Items
Folder Detail
Omit Folder
Shipping Rate 0.00 Offshore
Source Tag
Description Kupulau Detention - 50year Design (2%)
Note
Item Values
UOM LS (Lump Sum)
Quantity 1.0000
Labor Rate LaborCost1
Default Assigned Contractor
Prime
Values Markups Child Folders
Direct Costs
Unit Costs Extended Costs
Bare Markups Direct Direct
Labor Cost 385,344.16 + 191,769.62 = 577,113.78 577,113.78
Equip Cost 99,277.39 + 24,819.35 = 124,096.74 124,096.74
Material Cost 1,121,602.14 + 0.00 = 1,121,602.14 1,121,602.14
Sub Bid Cost 470,010.00 + 0.00 = 470,010.00 470,010.00
Shipping Cost 0.00 + 0.00 = 0.00 0.00
User Cost 0.00 + 0.00 = 0.00 0.00
Totals 2,076,233.69 + 216,588.97 = 2,292,822.66 2,292,822.66
Folder Duration
Unit Hours Extended Hours
ManHours 8,422.9839 8,422.9839
EQHours 2,370.5697 2,370.5697
CrewHours 2,160.6324 2,160.6324
Duration 1,894.3824 1,894.3824
Project Cost
Unit Costs Extended Costs
Cost to Prime 2,363,586.41 2,363,586.41
Contract Cost 3,406,184.59 3,406,184.59
Project Cost 3,647,001.84 3,647,001.84
Ready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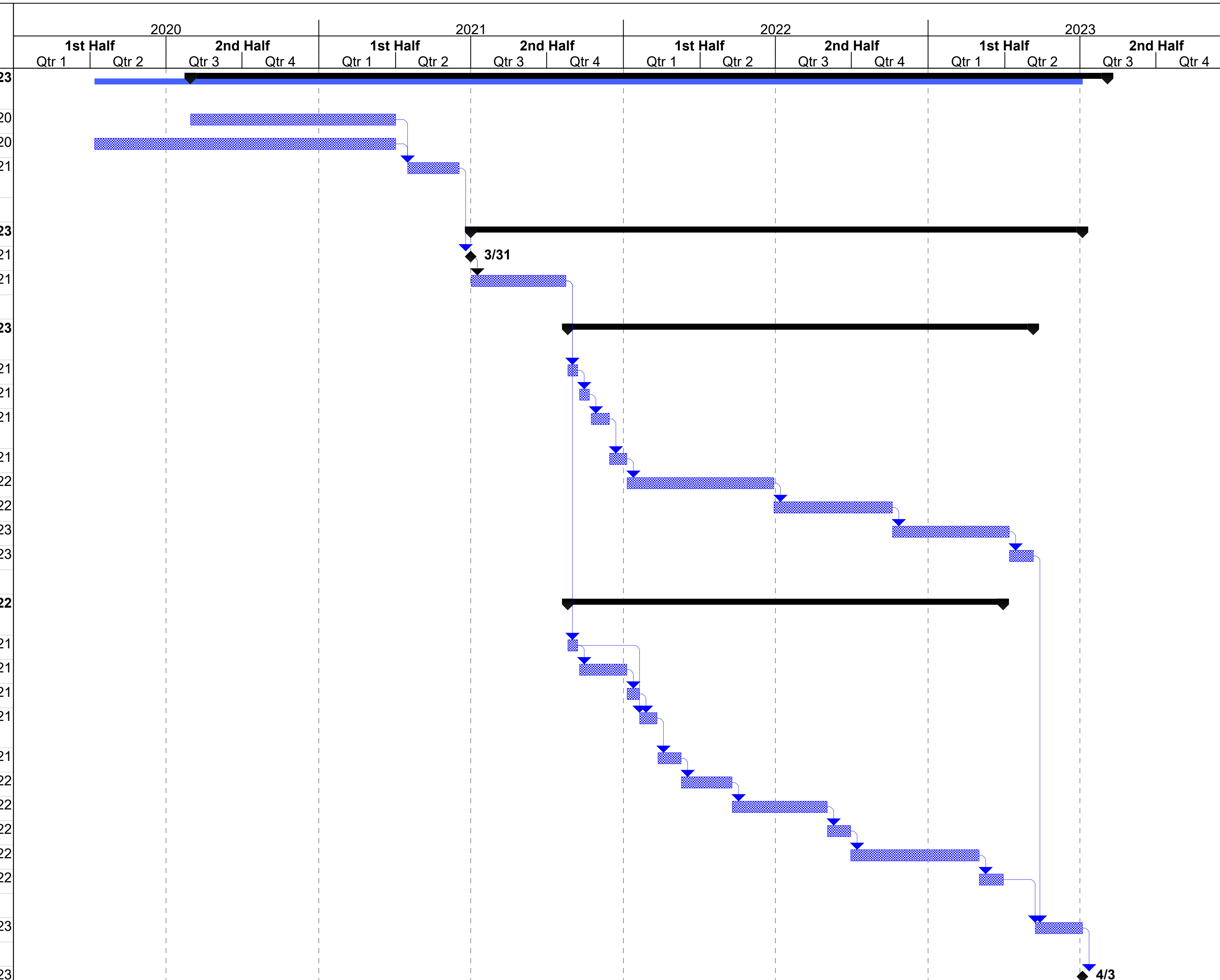
File Edit View Folder Tools Filters Reports Windows Help
Quantity/UOM
Item List Item Detail Folder Detail Source Library
Waiakea-Palai(revTSP)(FY19)
[1/LS] Kupulau Detention - 50year Design (2%)
[1/EA] Ainalako Diversion
[1/EA] Golf Course Detention
Modifiers Project Items Vendors Alt. Views Contractors CSI Tasks Assemblies Models Crews Labor Equipment Wear Items
Folder Detail
Omit Folder
Shipping Rate 0.00 Offshore
Source Tag
Description Golf Course Detention
Note
Item Values
UOM EA (Each)
Quantity 1.0000
Labor Rate LaborCost1
Default Assigned Contractor
Prime
Values Markups Child Folders
Direct Costs
Unit Costs Extended Costs
Bare Markups Direct Direct
Labor Cost 180,145.31 + 79,225.56 = 259,370.88 259,370.88
Equip Cost 47,002.61 + 11,750.65 = 58,753.26 58,753.26
Material Cost 260,987.54 + 0.00 = 260,987.54 260,987.54
Sub Bid Cost 138,480.00 + 0.00 = 138,480.00 138,480.00
Shipping Cost 0.00 + 0.00 = 0.00 0.00
User Cost 0.00 + 0.00 = 0.00 0.00
Totals 626,615.46 + 90,976.22 = 717,591.68 717,591.68
Folder Duration
Unit Hours Extended Hours
ManHours 4,000.8478 4,000.8478
EQHours 1,346.8292 1,346.8292
CrewHours 1,145.7093 1,145.7093
Duration 1,084.4593 1,084.4593
Project Cost
Unit Costs Extended Costs
Cost to Prime 923,092.35 923,092.35
Contract Cost 1,330,276.28 1,330,276.28
Project Cost 1,424,326.81 1,424,326.81
Ready

P/N 326040 Waiakea-Palai Combo

ID	Task Name	Duration	Start	Finish
1	**P/N# 326040 Waiakea-Palai FRM, Hilo, Island of Hawaii (Combo) Class 3**	**755.94 days**	**Thu 4/30/20**	**Wed 5/3/23**
2	Real Estate Acquisition	168.88 days	Thu 4/30/20	Thu 12/31/20
3	Design	249.88 days	Mon 1/6/20	Thu 12/31/20
4	Solicit/Award (Full & Open, Single Contract)	42 days	Fri 1/15/21	Wed 3/17/21
5				
6	**Construction Start**	**504 days**	**Wed 3/31/21**	**Mon 4/3/23**
7	NTP	0 days	Wed 3/31/21	Wed 3/31/21
8	Submittals, Permits	4 mons	Thu 4/1/21	Fri 7/23/21
9				
10	**Kupulau Ditch Levee/Floodwall Detention**	**384 days**	**Mon 7/26/21**	**Fri 2/3/23**
11	Survey & layout	10 days	Mon 7/26/21	Fri 8/6/21
12	Mob	10 days	Mon 8/9/21	Fri 8/20/21
13	BMPs / Contractor's Storage Area/ Haul Road	15 days	Mon 8/23/21	Mon 9/13/21
14	Clear & Grub	3 wks	Tue 9/14/21	Mon 10/4/21
15	Levees/ Access Road	6 mons	Tue 10/5/21	Tue 3/29/22
16	Floodwall	5 mons	Wed 3/30/22	Thu 8/18/22
17	Rain Delay	94 days	Fri 8/19/22	Thu 1/5/23
18	Cleanup & Demob	20 days	Fri 1/6/23	Fri 2/3/23
19				
20	**Golf Course Detention**	**360 days**	**Mon 7/26/21**	**Thu 12/29/22**
21	Survey & layout	10 days	Mon 7/26/21	Fri 8/6/21
22	Golf Course Coordination	2 mons	Mon 8/9/21	Mon 10/4/21
23	Mob	10 days	Tue 10/5/21	Tue 10/19/21
24	BMPs / Contractor's Storage Area/ Haul Road	15 days	Wed 10/20/21	Tue 11/9/21
25	Clear & Grub	4 wks	Thu 11/11/21	Wed 12/8/21
26	Culvert & Weir	2 mons	Thu 12/9/21	Mon 2/7/22
27	Levees	4 mons	Tue 2/8/22	Wed 6/1/22
28	Restore damaged areas	1 mon	Thu 6/2/22	Wed 6/29/22
29	Rain Delay	105 days	Thu 6/30/22	Wed 11/30/22
30	Cleanup & Demob	20 days	Thu 12/1/22	Thu 12/29/22
31				
32	Final Submittals/Closeout Contract	2 mons	Mon 2/6/23	Mon 4/3/23
33				
34	Project Construction Complete	0 days	Mon 4/3/23	Mon 4/3/23



P/N 326040: Waiakea-Palai Combo
Hilo, Island of Hawaii
Date: Fri 9/6/19

Task
Critical Task
Milestone
Summary
Rolled Up Task
Rolled Up Critical Task
Rolled Up Milestone
Rolled Up Progress
Split
External Tasks
Project Summary
External MileTask
Progress
Inactive Milestone
Inactive Summary
Manual Task
Duration-only
Manual Summary Rollup
Manual Summary
Start-only
Finish-only
External Tasks
External Milestone
Progress
Critical Task

WAIAKEA-PALAI STREAMS
Hilo, Island of Hawaii, Hawaii

CONTINUING AUTHORITIES PROGRAM SECTION 205

FLOOD RISK MANAGEMENT

Appendix F: Public Involvement

May 2020

US Army Corps of Engineers®
Honolulu District

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Table of Contents

1 Introduction

This document responds to comments received on the Waiakea-Palai Streams Draft Feasibility Report and Integrated Environmental Assessment (FR/EA) by the U.S. Army Corps of Engineers (Corps). The documents were available for public review at the Hilo Public Library beginning on May 23, 2019 and also posted on the following website: http://oeqc2.doh.hawaii.gov/EA_EIS_Library/2019-06-23-HA-DEA-Waiakea-Palai-Streams-Flood-Control.pdf. The official public comment period was from June 23, 2019 through July 23, 2019. Comments were received in writing through letters and electronic mail. A total of 12 comment submittals were received and are enclosed; and include comments from two public meetings and the official public review period.

2 Public Meetings

There were three public meetings outside of the public review period. The first meeting occurred on April 30, 2019 with the impacted homeowners in the project area. The second meeting occurred on May 21, 2019 with the entire community of Hilo invited to hear the Corp's recommendation for flood risk management in the Waiakea Palai project area. This meeting was well attended and generated most of the comments in Appendix F. The final meeting occurred September 12, 2019 after the public and Agency review periods were complete and the updates to the recommended plan was presented to the community. It was at this meeting that the recommended plan without Ainalako Diversion was presented to the community as a result of a change in conditions, public comments, and collaboration with the County of Hawaii. A second 30 day public review period was determined unnecessary due to the overall impacts of the change being less than the originally presented plan.

3 Document Organization and List of Commenters

This document contains copies of comments received during the comment period followed by the Corps' responses to those comments. A total of 12 comment submittals were received on the Draft FR/EA, including comments from a public information session held on April 30, 2019, email submittals, and letters. Each comment submittal was given a comment identification code. Each comment submittal is listed below in Table 1.

Table 1: Public Comment Submittals received on the Waiakea-Palai CAP Section 205 Project

Comment Identification	Date on Letter/Email	Commenter	Organization/Affiliation
1	April 30, 2019	Joyce Anderson	Landowner
2	April 30, 2019	Shugeng Cao	University of Hawaii, Hilo
3	April 30, 2019	Steve Correia	Property Owner
4	April 30, 2019	Harvey Llantero	Property Owner

5	April 30, 2019	Leila and Jeremy Spain	N/A
6	April 30, 2019	Robert Williams	Waiakea Fairways
7	April 30, 2019	Alex Way-Wong	Homeowner
8	April 30, 2019	Malar Yip	N/A
9	May 2, 2019	Clyde Nagata	Local Resident
10	May 22, 2019	Clyde Miyamura	Clyde's Realty
11	May 28, 2019	Dennis Onishi	N/A
12	July 1, 2019	Patsy Matsuo	Local Resident

4 Individual Comments and Responses

4.1 Comment 1 – Joyce Anderson – Landowner

US Army Corps of Engineers

Waiakea-Palai Flood Risk Management Study

Homeowners' meeting– April 30, 2019

Comment Sheet

Point of contact for comments: Jeff Herzog
DUE BY June 21, 2019
Bldg 230, Ft Shafter
Ft Shafter, HI 96858
Jeffrey.a.herzog@usace.army.mil

Name	Organization	Phone	e-mail
Joyce Anderson	landowner	(808) 959-3814	jhanderson@hawaiiantel.net

****PLEASE PRINT CLEARLY****

Comment(s): Will farmer on Kupulau be willing to have water overflow [illegible] on his property? How do the landowners feel about grassed swales and berms on their property? Do they have any "say" in this plan? Does county/Army Corp of Engineers have "power" to purchase affected lands?

(Ainalako Subdivision)

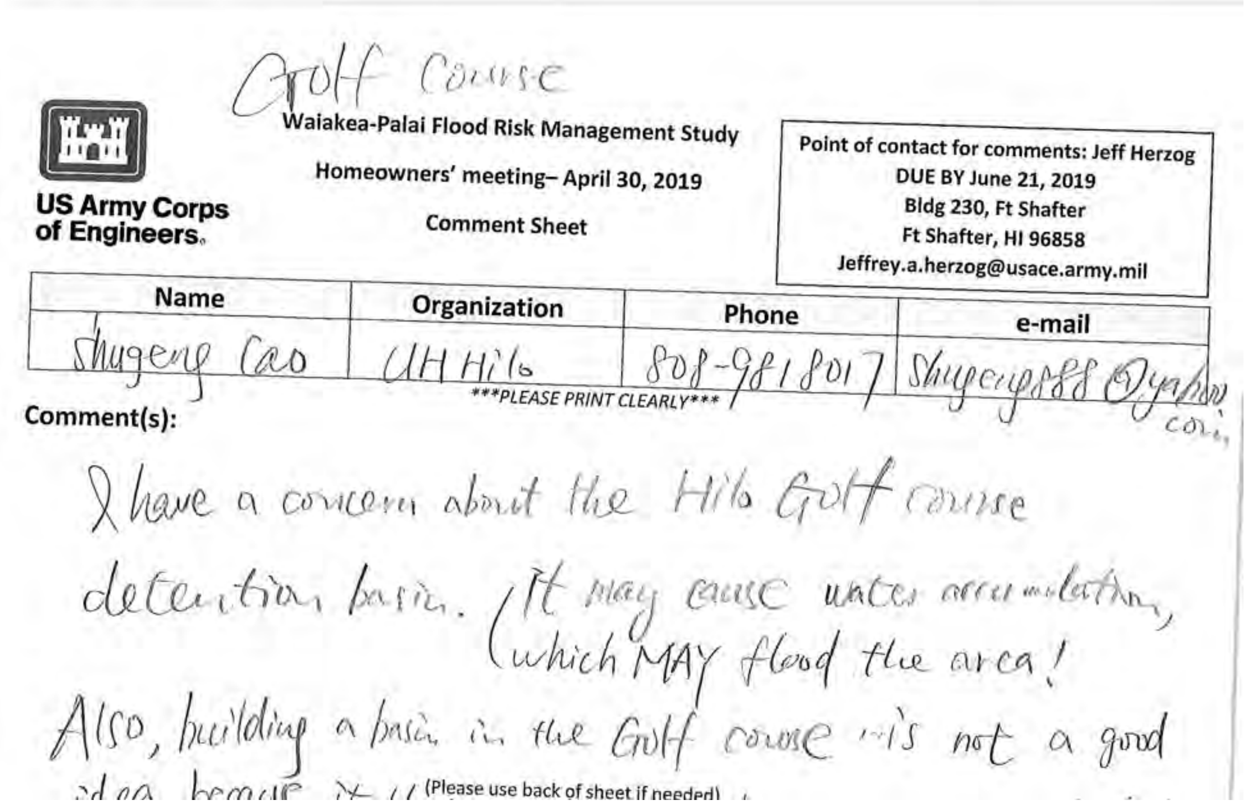
(Please use back of sheet if needed)

4.1.1 Response to Comment 1

Landowner willingness is a key component of this flood risk management project. Based on feedback from landowners during public review of the Draft Feasibility Report/Environmental Assessment, the Ainalako Diversion project has been removed from the recommended plan.

Landowner outreach will continue during the Design and Implementation phase of the project. During this phase, the Corps and County will continue to work to refine the project designs in coordination with landowners and stakeholders. If there are landowners who are unwilling to negotiate with the study sponsor to provide necessary property, individual project sites will be modified and/or removed from the proposed flood risk management plan.

4.2 Comment 2 – Shugeng Cao – University of Hawaii, Hilo



Golf Course

US Army Corps of Engineers

Waiakea-Palai Flood Risk Management Study

Homeowners' meeting– April 30, 2019

Comment Sheet

Point of contact for comments: Jeff Herzog
DUE BY June 21, 2019
Bldg 230, Ft Shafter
Ft Shafter, HI 96858
Jeffrey.a.herzog@usace.army.mil

Name	Organization	Phone	e-mail
Shugeng Cao	UH Hilo	808-9818017	Shugeng888@yahoo.com

PLEASE PRINT CLEARLY

Comment(s):

I have a concern about the Hilo Golf course detention basin. It may cause water accumulation, which MAY flood the area!

Also, building a basin in the Golf course is not a good idea because it ... (Please use back of sheet if needed)

4.2.1 Response to Comment 2

During the Design and Implementation phase, additional hydrology and hydraulic modeling will further evaluate how the recommend plan interacts with local flood channels. Based on updated modeling, project features may be refined to minimize any impacts from induced flooding.

4.3 Comment 3 – Steve Correia – Property Owner

US Army Corps of Engineers

Waiakea-Palai Flood Risk Management Study

Homeowners' meeting– April 30, 2019

Comment Sheet

GOLF COURSE S/D, HILO

Point of contact for comments: Jeff Herzog
DUE BY June 21, 2019
Bldg 230, Ft Shafter
Ft Shafter, HI 96858
Jeffrey.a.herzog@usace.army.mil

Name	Organization	Phone	e-mail
Steve Correia	OWNER TMK'S: 2-4-084-029 2-4-084-026 2-4-084-024	(808) 896-3500	steve.a.correia @hotmail.com

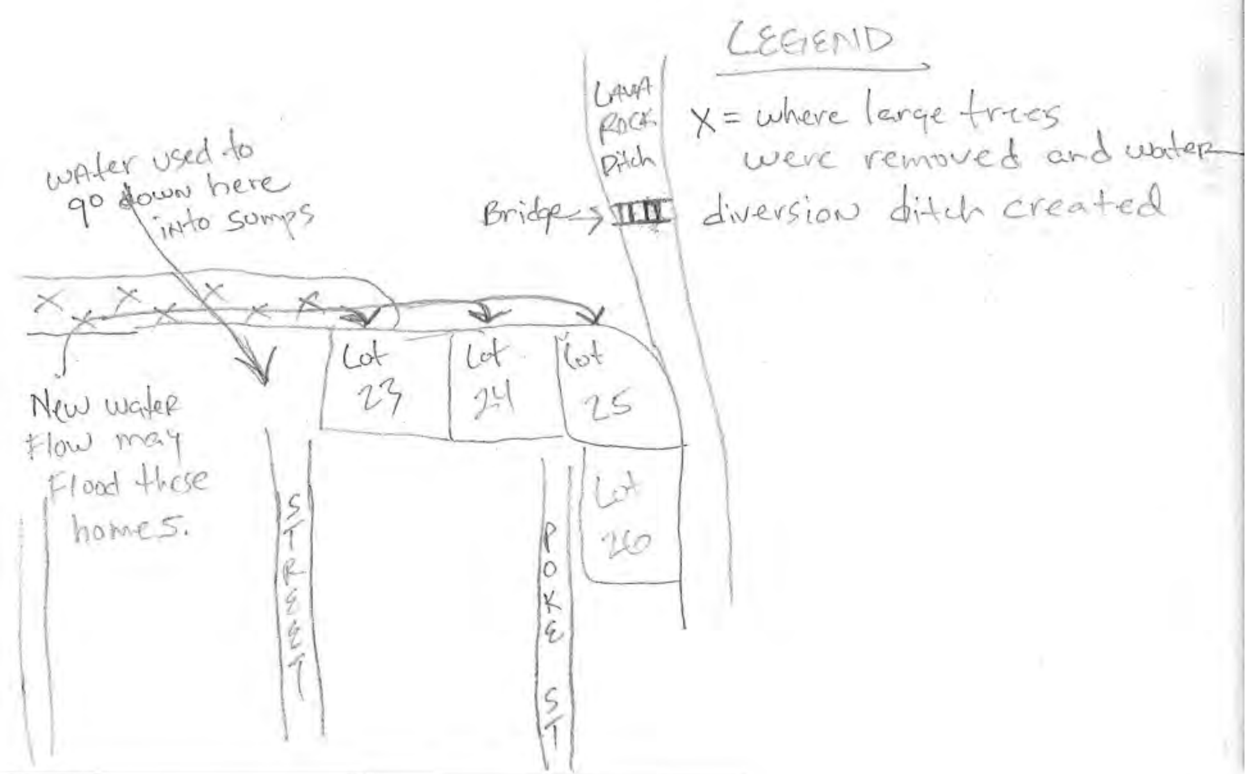
PLEASE PRINT CLEARLY

Comment(s):

Re-iterating on Sunshine Carters question tonight, In the last 2-3 weeks, the county cleared an enormous amount of trees and appeared to create a ditch or diversion of natural water flow on the makai (ocean) side of hole # 11. It appears this will divert more water towards Hamakua direction towards the lava rock gulch. Problem is this may cause flooding over a small bank along lot (2-4-084-024) and adjacent parcels which never flooded before. County did this without any notice to homeowners. WAS FEMA notified and was this done with permission and/or permits?

(Please use back of sheet if needed)

OVER FOR MAP



4.3.1 Response to Comment E3

This comment has been provided to the County for local coordination and follow-up.

4.4 Comment 4 – Harvey Llantero – Property Owner

US Army Corps of Engineers

Waiakea-Palai Flood Risk Management Study

Homeowners' meeting– April 30, 2019

Comment Sheet

Point of contact for comments: Jeff Herzog
DUE BY June 21, 2019
Bldg 230, Ft Shafter
Ft Shafter, HI 96858
Jeffrey.a.herzog@usace.army.mil

Name	Organization	Phone	e-mail
Harvey Llantero	Property owner w/ ag land w/ berm-	808 961-3270 222-1645 (cell)	Harvey.llantero@gmail.com

PLEASE PRINT CLEARLY

Comment(s): - With a 6 ft berm blocking the berm to the road, how would you address the area between the berm and road from flooding? The properties around the road & the road itself drains toward these areas without any visible outlet in your plan. mentioned earlier area floods but clears up in a day or two.
- How will you address the access of agricultural land on the opposite side of the berm @ Kupulau & access to additional property across the stream?
- Is there still plans to extend the Haihai St westward, as shown for road easement. If so, the berm becomes useless as it cuts the berm and the detention area into two.

(Please use back of sheet if needed)

4.4.1 Response to Comment 4

During the Design and Implementation phase, additional hydrology and hydraulic modeling will further evaluate how the recommend plan interacts with local flood channels. Based on updated modeling, project features may be refined to minimize any impacts from induced flooding. In addition, landowner outreach will continue during the Design and Implementation phase of the project. During this phase, the Corps and County will continue to work to refine the project designs in coordination with landowners and stakeholders. If there are landowners who are unwilling to negotiate with the study sponsor to provide necessary property, individual project sites will be modified and/or removed from the proposed flood risk management plan.

4.5 Comment Letter 5 – Leila and Jeremy Spain

US Army Corps of Engineers.

Waiakea-Palai Flood Risk Management Study

Homeowners' meeting– April 30, 2019

Comment Sheet

Point of contact for comments: Jeff Herzog
DUE BY June 21, 2019
Bldg 230, Ft Shafter
Ft Shafter, HI 96858
Jeffrey.a.herzog@usace.army.mil

Name	Organization	Phone	e-mail
LEILA & JEREMY SPAIN	—	(808) 937.0617 (808) 895.5618	leila_girl57@yahoo jspain@teamdeluz.com

PLEASE PRINT CLEARLY

Comment(s): RE: 3002 LAU ST HILO HI 96720
(WAIAKEA FAIRWAYS) - GOLF COURSE

PLEASE INCLUDE US IN ANY FUTURE PROPERTY OWNER MEETINGS. WE DID NOT RECEIVE ANY NOTIFICATION, BUT WERE INFORMED BY OTHER PROPERTY OWNERS W/IN OUR NEIGHBORHOOD.

MAILING ADDRESS IS: PO BOX 10413
HILO HI 96721

THANK YOU!

(Please use back of sheet if needed)

4.5.1 Response to Comment 5

Thank you for your comment. Your contact information has been added to the project's distribution and contact list. Landowner outreach will continue during the Design and Implementation phase of the project. During this phase, the Corps and County will continue to work to refine the project designs in coordination with landowners and stakeholders.

4.6 Comment 6 – Robert Williams – Waiakea Fairways

US Army Corps of Engineers

Waiakea-Palai Flood Risk Management Study

Homeowners' meeting– April 30, 2019

Comment Sheet

Point of contact for comments: Jeff Herzog
DUE BY June 21, 2019
Bldg 230, Ft Shafter
Ft Shafter, HI 96858
Jeffrey.a.herzog@usace.army.mil

Name	Organization	Phone	e-mail
Robert Williams	WaiKea Fairways	987-3320	rwilliams@clarkhawaii.com

PLEASE PRINT CLEARLY

Comment(s):

Great presentation. Include a drainage ditch on the golf course from Haihai to Palai Stream. Water flowing from golf course into sections of Waiakea Fairways -

(Please use back of sheet if needed)

4.6.1 Response to Comment 6

During the Design and Implementation phase, additional hydrology and hydraulic modeling will further evaluate how the recommend plan interacts with local flood channels. Based on updated modeling, project features may be refined to minimize any impacts from induced flooding.

4.7 Comment 7 – Alex Way-Wong – Homeowner

US Army Corps of Engineers

Waiakea-Palai Flood Risk Management Study

Homeowners' meeting– April 30, 2019

Comment Sheet

Point of contact for comments: Jeff Herzog
DUE BY June 21, 2019
Bldg 230, Ft Shafter
Ft Shafter, HI 96858
Jeffrey.a.herzog@usace.army.mil

Name	Organization	Phone	e-mail
Alex Way-Wong	Homeowner	808-217-5134	alexanderrway@gmail.com

PLEASE PRINT CLEARLY

Comment(s):

personally affects me – lot located in Waiakea Fairways subdivision

4.7.1 Response to Comment 7

Thank you for your comment. Landowner outreach will continue during the Design and Implementation phase of the project. During this phase, the Corps and County will continue to work to refine the project designs in coordination with landowners and stakeholders. If there are landowners who are unwilling to negotiate with the study sponsor to provide necessary property, individual project sites will be modified and/or removed from the proposed flood risk management plan.

4.8 Comment 8 – Malar Yip

US Army Corps of Engineers

Waiakea-Palai Flood Risk Management Study

Homeowners' meeting– April 30, 2019

Comment Sheet

Point of contact for comments: Jeff Herzog
DUE BY June 21, 2019
Bldg 230, Ft Shafter
Ft Shafter, HI 96858
Jeffrey.a.herzog@usace.army.mil

Name	Organization	Phone	e-mail
MALAR YIP	–	917-846-2223	malar.yip@gmail.com

PLEASE PRINT CLEARLY

Comment(s):

KUPULAU DITCH LEVEE / FLOODWALL W/ DETENTION

Detention Pond Outlet 4ft Diameter CMP culvert – need to understand impact to property on the left.

4.8.1 Response to Comment 8

During the Design and Implementation phase, additional hydrology and hydraulic modeling will further evaluate how the recommend plan impacts individual properties/parcels. Based on updated modeling, project features may be refined to minimize any impacts from induced flooding.

4.9 Comment 9 – Clyde Nagata – Local Resident

-----Original Message-----
From: Clyde Nagata [mailto:clyde.nagata@gmail.com]
Sent: Tuesday, May 21, 2019 11:49 AM
To: Herzog, Jeffrey A CIV USARMY CEPOH (USA) <Jeffrey.A.Herzog@usace.army.mil>
Cc: 'Nancy Aoki' <aokine45@gmail.com>; Mesko, Rachel C CIV USARMY CEMVP (US) <Rachel.C.Mesko@usace.army.mil>; 'Joyce Anderson' <jhanderson@hawaiiantel.net>
Subject: [Non-DoD Source] Waiakea-Palai Streams COE Landowners Meeting on April 30, 2019 Follow-up Questions (UNCLASSIFIED) May 21 Additional Questions/Comments

Mr. Herzog,
I missed the following question:
In considering the access to the residential house on property 002, what does your records show of flooding of the access road within the property and how does it compare to the COE studies as a result of the proposed diversion wall and weir? Since the diversion wall will probably hold back the normal flow of water, I would expect the water level at the lowest point of traverse on the access road will be higher than pre diversion conditions.
Please confirm and if that is the case, could the COE include improving the access road for the resident as part of the diversion wall/weir proposal?

-----Original Message-----
From: Clyde Nagata [mailto:clyde.nagata@gmail.com]
Sent: Tuesday, May 21, 2019 11:15 AM
To: 'Herzog, Jeffrey A CIV USARMY CEPOH (USA)'
Cc: 'Nancy Aoki'; 'Mesko, Rachel C CIV USARMY CEMVP (US)'; 'Joyce Anderson'
Subject: RE: [Non-DoD Source] Waiakea-Palai Streams COE Landowners Meeting on April 30, 2019 Follow-up Questions (UNCLASSIFIED)

Thank you for your responses. Following are additional questions/comments:
1. Not withstanding the proposal itself to encumber the properties, of primary concern is your responses to 2d, 2e, 2f. The landowner is left open to possible future post construction suits related to injury to trespassers checking out the diversion/weir structures and/or failure of the proposed remedies with subsequent damages to facilities downstream. This brings up the Kauai situation where the landowner was sued for the failure of his filed dam system and subsequent jail time. If any of the 3 landowners agree to these proposed remedies on their properties, there must be some means of indemnifying the landowners and all costs (legal and supplemental) related to any resulting suit be the responsibility of the COE or COH.
2. What does the FEMA Flood Insurance Rate Maps show for the 4 listed properties and what does it mean/impacts?
3. Thank you for the additional maps and upcoming presentation. The 4 mile creek seems to cut property 112 in half and at the corner of property 113. Please show how the Palai stream runs on this photo. With the proposed diversion just above properties 112 and 113, the water level in the 4 mile creek will rise. Based on current information, what does the flooding footprint look like on properties 112 and 113. If the proposed

diversion/weir are installed, what will the resulting flooding footprint be?
4. The second photo enclosed shows the location of the diversion on the road access to properties 112 and 113.....this rendering is different from the
photo shown on the public presentation for May 21.   Please explain the
discrepancy.

Thank you.

-----Original Message-----
From: Herzog, Jeffrey A CIV USARMY CEPOH (USA) [mailto:Jeffrey.A.Herzog@usace.army.mil]
Sent: Tuesday, May 21, 2019 8:42 AM
To: Clyde Nagata
Cc: 'Nancy Aoki'; Mesko, Rachel C CIV USARMY CEMVP (US); 'Joyce Anderson'
Subject: RE: [Non-DoD Source] Waiakea-Palai Streams COE Landowners Meeting on April 30, 2019 Follow-up Questions (UNCLASSIFIED)

CLASSIFICATION: UNCLASSIFIED

Clyde, et al.,

Good morning. I do apologize that it's taken so long to get full responses to your original inquiries, but they are attached. They were great questions, and deserved full attention and response.

Also attached is a copy of the presentation for tonight's public meeting at the Golf Course. I hope you will be in attendance. Tomorrow, my entire team and I will be available to meet with you at your properties to discuss the feature, the real estate, as well as answer questions. Then you will have until July 8, 2019 to make formal comments on our draft report. We do hope that you will make comments and express concerns so that we can incorporate it into the final report due out in September.

Thanks,

Jeff Herzog

V/R

Jeffrey A. Herzog
Project Manager
CEPOH-PPC
O: 808-835-4029
C: 808-202-7204
E: jeffrey.a.herzog@usace.army.mil

Building 230, Room 307
Fort Shafter, HI 96858

-----Original Message-----
From: Clyde Nagata [mailto:clyde.nagata@gmail.com]
Sent: Friday, May 3, 2019 8:45 AM
To: Herzog, Jeffrey A CIV USARMY CEPOH (USA) <Jeffrey.A.Herzog@usace.army.mil>
Cc: 'Nancy Aoki' <aokine45@gmail.com>; 'Joyce Anderson'
<jhanderson@hawaiiantel.net>
Subject: RE: [Non-DoD Source] Waiakea-Palai Streams COE Landowners Meeting on April 30, 2019 Follow-up Questions

Thank you for your reply/confirmation. My responses below in red.

From: Herzog, Jeffrey A CIV USARMY CEPOH (USA) [mailto:Jeffrey.A.Herzog@usace.army.mil]
Sent: Thursday, May 2, 2019 10:06 PM
To: Clyde Nagata
Cc: 'Nancy Aoki'; 'Joyce Anderson'
Subject: Re: [Non-DoD Source] Waiakea-Palai Streams COE Landowners Meeting on April 30, 2019 Follow-up Questions

Clyde,

Both were received. I have my team working on answers to your first email. I fully plan to have a response to you prior to our next Visit on the 21-23, that way you can have time to read over it and discuss in person. Thank you.

Curious about this latest email, would you be suggesting a full diversion of Palai under the property or a partial diversion as we are currently showing?
An underground system like that will always be more expensive, currently we estimate the diversion at $2.8 Million, underground diversion of Palai could triple that. As noted below, either from the culvert that goes below Ainalako Rd or above it, place the culvert underground below Ainalako Road and take it to the closest point to the 4 Mile Creek then direct it into it.
Not sure if the Ainalako Road now crosses the 4 Mile Creek or not but there must be a point that is closest to the Ainalako Rd. With this option there should be minimum impact of above grade infrastructures on the two properties but I understand that it may be more costly that the present proposed option. What would be the benefit to cost ratio. The benefit should include possible future residential subdivision on the 4 properties or 3 properties if possible.

How would you all feel about the project helping Mother Nature develop the stream by actually creating the stream's channel and directing it into four mile creek? Doing so would potentially keep the cost down and still reduce the flooding. Certainly we wouldn't consider a concrete channel, it would likely be a natural stream channel with armor rock similar to many other stream beds on the island. Geologically, the stream bed will likely form anyway, we would be expediting the process and directing it into four mile creek. Nancy Aoki and Joyce Anderson would need to evaluate this as installing permanent concrete channel will leave an above grade structure on their properties which will impact future use of the land. On Joyce Anderson's property, the COE will need to consider how the residents on Joyce Anderson's property will cross this open channel (require a bridge) to get to their home. Personally, though, I would prefer a permanent concrete channel sized for more than the present level of "#years storm".
At least some development could possibly occur in its proximity. However, if it is determined that no development can be done, then the government should purchase the whole 5 acre lot (Nancy Aoki at fair market value), otherwise she would not be able to do any land improvements and still be required to pay the COH land taxes....which I think is unfair. The present COE proposal uses her land as a ponding/catchment area to drain

through the open weir and spillway. This option also takes away her option for any land improvements.

The difference between your email and my channel concept is the idea that it remains open to sunlight and the opportunity for natural habitat such as flora, fauna, birds and insects to flourish in a natural stream channel.

This is merely brainstorming and would require much more analysis as to the economic and environmental impacts. We appreciate you staying engaged and participating.

Finally, was there a plan to develop that property into a home or was the risk of flooding a prohibitive factor? When my parents purchased the property (20+ acres at that time - one lot), there was always the thought of the children living on the land or later develop into a residential subdivision. As years passed, it became apparent that more and more water came onto the property. In fact I recall the property to the south (the one you showed on your slide that was not developed previously) had a creek or so and water flowed in that area. Now that whole area is developed and the water perhaps now flows onto our property.

Aloha nui loa, have a great weekend,

Jeff Herzog

Sent via the Samsung Galaxy S8, an AT&T 5G Evolution smartphone

-------- Original message --------

From: Clyde Nagata <clyde.nagata@gmail.com>

Date: 5/2/19 21:46 (GMT-10:00)

To: "Herzog, Jeffrey A CIV USARMY CEPOH (USA)" <Jeffrey.A.Herzog@usace.army.mil>

Cc: 'Nancy Aoki' <aokine45@gmail.com>, 'Joyce Anderson' <jhanderson@hawaiiantel.net>

Subject: [Non-DoD Source] Waiakea-Palai Streams COE Landowners Meeting on April 30, 2019 Follow-up Questions

Mr. Herzog:

Got another idea to eliminate the flood water on Nancy Aoki's property.
Has the COE looked at placing the portion of the Palai stream on Aoki's property underground through a large culvert/tunnel system? Say perhaps starting from the upper side of where the existing culvert goes under the road or further upstream, build it under the road and take it to the closest point of the 4 Mile Creek? Let me know if this was considered? If not, can it be an option that is added to the study?

Please confirm receipt of this e-mail and the earlier e-mail dated May 1, 2019.

Thank you.

Clyde H. Nagata

808-7316245

462 Kaanini Street

Hilo, HI 96720

4.9.1 Response to Comment 9

Responses to this comment are contained in the email communications presented above. Ultimately, based on feedback from landowners during public review of the Draft Feasibility Report/Environmental Assessment, the Ainalako Diversion project has been removed from the recommended plan. Evaluations of flood risk management problems and opportunities on Four Mile Creek may occur under a separate study.

4.10 Comment 10 – Clyde Miyamura – Clyde's Realty

-----Original Message-----
From: C M [mailto:clydesreal@yahoo.com]
Sent: Wednesday, May 22, 2019 8:01 AM
To: Herzog, Jeffrey A CIV USARMY CEPOH (USA) <Jeffrey.A.Herzog@usace.army.mil>
Subject: [Non-DoD Source] Waiakea-Palai Streams Hilo, Island of Hawaii (Meeting on 21May19) and follow up questions on replaced "Kawailani Bridge"

Attended meeting. Was very informative.

Have follow up questions and concerns about replaced "Kawailani Bridge" project.

Subject: Flood of 2000?
Subject Property: 3-2-4-63-2
1365 Mailani St.
Question: Why is subject property and neighbors (3-2-4-63-3 & 4 etc.) still in flood zone.

I managed the property at time of flooding and still manage property for owner.

After flooding, I had one on one interview with person from (Corp of Engineer??)

Told them that prior to flooding, construction work was done on Kawailani St. on the pasture side across on Mailani St. intersection and it seemed like the pasture fencing was changed from what existed and was replaced by "chain linked fencing". At time of flooding, the run off debris got caught in the chain linked fence; therefore, the fence acted like a dam and held back the run off water. In past heavy rains we had no problems with water backing up on Mailani St.. When you look at the slope of the environment, the pasture is the lowest point, than Kawailani St., then Mailani St..

Several months later the chain linked fence was replaced. I was really surprised that someone listened to my input and did something constructive.

There were several meetings for realtors regarding the FEMA flood insurance and flood maps and I noticed that the maps were changed. They told us that we could appeal the changes; however, it seemed like a done deal.

Spoke with Bryson at county and he told me that the county can't do anything and that someone (I) would need to hire an engineer to do flood study and resubmit for review. I inquired with several engineering firms and the cost would be prohibitive because they would have to start from ground zero.

The source of the flood water still exists. The Kawailani Bridge was replaced, and the fencing replaced; therefore, was the cause of the flooding corrected? The most obvious and easiest conclusion is that the area is in a flood zone because the properties flooded once before.

I asked Bryson if he could provide the report that supported the conclusion that the properties are in a flood zone.

Question:

1. Was the flood study updated after completion of Kawailani Bridge replacement?

2. Can the Corp of Engineers do an update because they have all the data?

3. What alternatives does a property owner have to change flood zoning?

Thank you for your assistance

Clyde Miyamura

Cel (808)854-6316

Office: Clyde's Realty (808) 935-4611

email: clydesreal@yahoo.com

4.10.1 Response to Comment 10

Hydraulic modeling included blocked obstructions and partial bridge blockages to represent the accumulation of stream bed material under bridges that were observed during past site visits. During the Design and Implementation phase, additional hydrology and hydraulic modeling will further evaluate how the recommend plan interacts with local flood channels, bridges, etc. Based on updated modeling, project features may be refined to minimize any impacts from induced flooding.

The Corps recommends further coordination with the County and FEMA to discuss flood zoning.

4.11 Comment 11 – Dennis Onishi

-----Original Message-----
From: Poppin Fresh [mailto:fresh19@msn.com]
Sent: Tuesday, May 28, 2019 7:40 AM
To: Herzog, Jeffrey A CIV USARMY CEPOH (USA) <Jeffrey.A.Herzog@usace.army.mil>
Subject: [Non-DoD Source] Comments to Waiakea-Palai Flood Risk Management Report

Good morning Mr. Herzog,

I have a few questions concerning the proposed plans for Waiakea-Palai streams.

1. You mentioned, from Palai Stream, once it get down by a certain area, a portion of the water will be diverted into the 4-mile bridge stream. By doing so, someone asked about the vegetation right now and you mentioned, all the vegetation will be removed. The question is, "who will maintain the stream once the vegetation is removed and will the removal of vegetation be done to Kanoelehua Avenue bridge?"
2. Because of all the diversions, will the existing channels along Kinoole Street and Kilauea Avenue be able to handle the flows?
3. There are 2 flood channel along side the Machado Acres Walking Park in the Waiakea district which empties into the stream with a bridge at Maunakai Street. The vegetation along the walking park is overgrown and needs to be cleaned.

I see the plans are to limit the amount of flow to a minimum capacity so the old infrastructure we have in the lower areas will be able to handle the increase due to development.

Thank you,

Dennis Onishi
CLASSIFICATION: UNCLASSIFIED

4.11.1 Response to Comment 11

Based on feedback from landowners during public review of the Draft Feasibility Report/Environmental Assessment, the Ainalako Diversion project has been removed from the recommended plan. Vegetation removal on Four Mile Creek near the Kanoelehua Avenue bridge will not be included as part of the Federal (Corps) project. Vegetation management in other areas is being coordinated with the County of Hawaii.

During the Design and Implementation phase, additional hydrology and hydraulic modeling will further evaluate how the recommend plan interacts with local flood channels. Based on updated modeling, project features may be refined to minimize any impacts from induced flooding.

4.12 Comment 12 – Patsy M. Matsuo – Local Resident

July 1, 2019

Mr. Jeffrey A. Herzog
U. S. Army Corps of Engineers
Building 230
Attn.: CEPOH-PPC
Fort Shafter, HI 96858

Dear Mr. Herzog:

Subject: Waiakea-Palai Streams, Hilo, Island of Hawaii,
CAP Section 205

My neighbor attended your public meeting on May 21,2019 on the above subject and gave me a copy of the handout. I was away on an extended trip and, therefore, did not attend the meeting.

I noticed the Public Review period is from June 8 to July 8, 2019 and would like to submit a comment.

I am concerned about Alternative 6: Ainalako Diversion. I live at the end of Kupaa Street and my property is right next to Four Mile Creek.

During heavy rains, water in the creek become a river 1 to 2 feet high and 50 feet wide. A few years ago, after several days of heavy rain, water in the creek reached the top of my 4-foot high wall and also flowed over the top. Fortunately, the wall is constructed of 12-inch wide hollow tile with a concrete base 3 feet below ground. Otherwise, the water would have destroyed the wall.

I believe your plan to (1) construct diversion structure to divert flow into Four Mile Creek or (2) have grassed swale direct overflow from weir into Four Mile Creek will cause water to rise higher than 4 feet and possibly damage Four-Mile Bridge making it unusable.

I would appreciate your considering my comments. If you have any questions, you may reach me at (808) 640-8269.

Sincerely,

Patsy M. Matsuo

Patsy M. Matsuo
175 Kupaa Street
Hilo, Hawaii 96720-5736
(Cell: (808) 640-8269

4.12.1 Response to Comment 12

Based on feedback from landowners during public review of the Draft Feasibility Report/Environmental Assessment, the Ainalako Diversion project has been removed from the recommended plan.