Harry Kim
Mayor

Wil Okabe
Managing Director

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JUN 2 3 2019

David Yamamoto, P.E.
Director

Allan G. Simeon, P.E.
Deputy Director

County of Hawaiʻi
DEPARTMENT OF PUBLIC WORKS

Aupuni Center
101 Pauahi Street, Suite 7 · Hilo, Hawaiʻi 96720-4224
(808) 961-8321 · Fax (808) 961-8630
public_works@hawaiicounty.gov

May 23, 2019

Scott Glenn, Director
Office of Environmental Quality Control
235 South Beretania Street, Suite 702
Honolulu HI 96813

SUBJECT: **Draft Environmental Assessment and Draft 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 draft environmental assessment and anticipated finding of no significant impact (DEA-AFONSI) for the subject project in Waiakea and Palai Streams located in Hilo, Island of Hawaii, Hawaii for publication in the next available edition of the Environmental Notice.

Enclosed is a completed OEQC Publication Form, four (4) digital copies of the DEA-AFONSI and an electronic copy of the publication form in MS Word.

Should you have any questions, please contact Bryce Harada of DPW at (808) 961-8042.

David Yamamoto, P.E.
Director

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Enclosures: (as noted above)

cc: Bryce Harada (COH-DPW)

19-384

AGENCY
PUBLICATION FORM

Project Name:	Waiakea-Palai Flood Control Project
Project Short Name:	Waiakea-Palai Flood Control Project
HRS §343-5 Trigger(s):	Use of County lands and funds
Island(s):	Hawaii Island
Judicial District(s):	South Hilo
TMK(s):	(3) 2-4-002:001 (3) 2-4-004:072a (3) 2-4-030:002 (3) 2-4-030:112 (3) 2-4-030:113 (3) 2-4-035:003 (3) 2-4-035:032 (3) 2-4-036:001 (3) 2-4-036:999 (3) 2-4-051:004 (3) 2-4-065:035 (3) 2-4-065:036 (3) 2-4-076:044 (3) 2-4-081:007 (3) 2-4-081:011
Permit(s)/Approval(s):	Compliance with NEPA (National Environmental Policy Act) and associated statutory requirements Endangered Species Act, Fish and Wildlife Coordination Act, Magnuson-Stevens Fishery Conservation and Management Act, National Historic Preservation Act, Clean Air Act, Coastal Zone Management Act (Federal Consistency Determination), Clean Water Act (Section 404-Discharges in Waters of the U.S. Department of the Army permit, Section 402-National Pollutant Discharge Elimination System, Section 401-Water Quality Certification) Historic Sites Review (Chapter 6e, HRS) Stream Channel Alteration Permit (potential) Special Management Area Permit (potential) Conservation District Use Permit (potential) Community Noise Control Permit (potential) Work in County Right-of-Way (potential) Grading, Grubbing, Excavating and Stockpiling Permits (potential) Executive Order 12898-Environmental Justice, Executive Order 11988-Floodplain Management
Proposing/Determining Agency:	County of Hawaii, Department of Public Works
Contact Name, Email, Telephone, Address	Bryce Harada County of Hawaii, Department of Public Works, Engineering Division 101 Pauahi Street, Suite 7 Hilo, HI 96720 Bryce.Harada@hawaiicounty.gov (808) 961-8042
Accepting Authority:	n/a
Contact Name, Email, Telephone, Address	n/a
Consultant:	n/a
Contact Name, Email, Telephone, Address	n/a

Status (select one) **Submittal Requirements**

__X__	DEA-AFNSI	Submit 1) the proposing agency notice of determination/transmittal letter on agency letterhead, 2) this completed OEQC publication form as a Word file, 3) a hard copy of the DEA, and 4) a searchable PDF of the DEA; a 30-day comment period follows from the date of publication in the Notice.
____	FEA-FONSI	Submit 1) the proposing agency notice of determination/transmittal letter on agency letterhead, 2) this completed OEQC publication form as a Word file, 3) a hard copy of the FEA, and 4) a searchable PDF of the FEA; no comment period follows from publication in the Notice.
____	FEA-EISPN	Submit 1) the proposing agency notice of determination/transmittal letter on agency letterhead, 2) this completed OEQC publication form as a Word file, 3) a hard copy of the FEA, and 4) a searchable PDF of the FEA; a 30-day comment period follows from the date of publication in the Notice.
____	Act 172-12 EISPN (“Direct to EIS”)	Submit 1) the proposing agency notice of determination letter on agency letterhead and 2) this completed OEQC publication form as a Word file; no EA is required and a 30-day comment period follows from the date of publication in the Notice.
____	DEIS	Submit 1) a transmittal letter to the OEQC and to the accepting authority, 2) this completed OEQC publication form as a Word file, 3) a hard copy of the DEIS, 4) a searchable PDF of the DEIS, and 5) a searchable PDF of the distribution list; a 45-day comment period follows from the date of publication in the Notice.
____	FEIS	Submit 1) a transmittal letter to the OEQC and to the accepting authority, 2) this completed OEQC publication form as a Word file, 3) a hard copy of the FEIS, 4) a searchable PDF of the FEIS, and 5) a searchable PDF of the distribution list; no comment period follows from publication in the Notice.
____	FEIS Acceptance Determination	The accepting authority simultaneously transmits to both the OEQC and the proposing agency a letter of its determination of acceptance or nonacceptance (pursuant to Section 11-200-23, HAR) of the FEIS; no comment period ensues upon publication in the Notice.
	FEIS Statutory Acceptance	Timely statutory acceptance of the FEIS under Section 343-5(c), HRS, is not applicable to agency actions.
____	Supplemental EIS Determination	The accepting authority simultaneously transmits its notice to both the proposing agency and the OEQC that it has reviewed (pursuant to Section 11-200-27, HAR) the previously accepted FEIS and determines that a supplemental EIS is or is not required; no EA is required and no comment period ensues upon publication in the Notice.
____	Withdrawal	Identify the specific document(s) to withdraw and explain in the project summary section.
____	Other	Contact the OEQC if your action is not one of the above items.

Project Summary

The Honolulu District, U.S. Army Corps of Engineers (Corps) is evaluating flood risk management problems and opportunities on the Waiakea and Palai Streams near Hilo, Hawaii. The enclosed Integrated Feasibility Report and Environmental Assessment documents the planning process for evaluating potential streambank protection alternatives to demonstrate consistency with Corps planning policy and compliance with the National Environmental Policy Act and the State of Hawaii Chapter 343, Hawaiʻi Revised Statutes.

The Corps is the lead federal agency conducting this study. The non-Federal sponsor is the County of Hawaii, Department of Public Works.

The study area encompasses the Palai and Waiakea Stream watersheds. Waiakea Stream, Palai Stream, and Four Mile Creek are three of the five tributaries within the Wailoa River system, draining about 160 square miles into Hilo Bay. The study will assist in identifying flood risk management measures and will evaluate and compare the benefits, costs, and impacts to the human environment of study alternatives including the No Action Alternative.

The purpose of the study is to reduce flood risks to structures, property, and critical infrastructure. The tentatively selected plan includes construction of detention basins, a diversion channel, levees, and floodwalls to reduce flood risk in the study area.

WAIAKEA-PALAI STREAMS
Hilo, Island of Hawaii, Hawaii

CONTINUING AUTHORITIES PROGRAM SECTION 205
FLOOD RISK MANAGEMENT

DRAFT INTEGRATED FEASIBILITY REPORT
AND ENVIRONMENTAL ASSESSMENT

MAY 2019

US Army Corps
of Engineers®
Honolulu District

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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

ACE	Annual Chance of Exceedance
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 streambank protection 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 (*).

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.

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.

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 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 160 square miles and empties into Hilo Bay.

Waiakea Stream has a drainage area of about 35.6 square miles and is classified as intermittent 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. 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 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.

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.

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 tentatively selected plan includes construction of detention basins, a diversion channel, levees, and floodwalls to reduce flood risk in the study area.

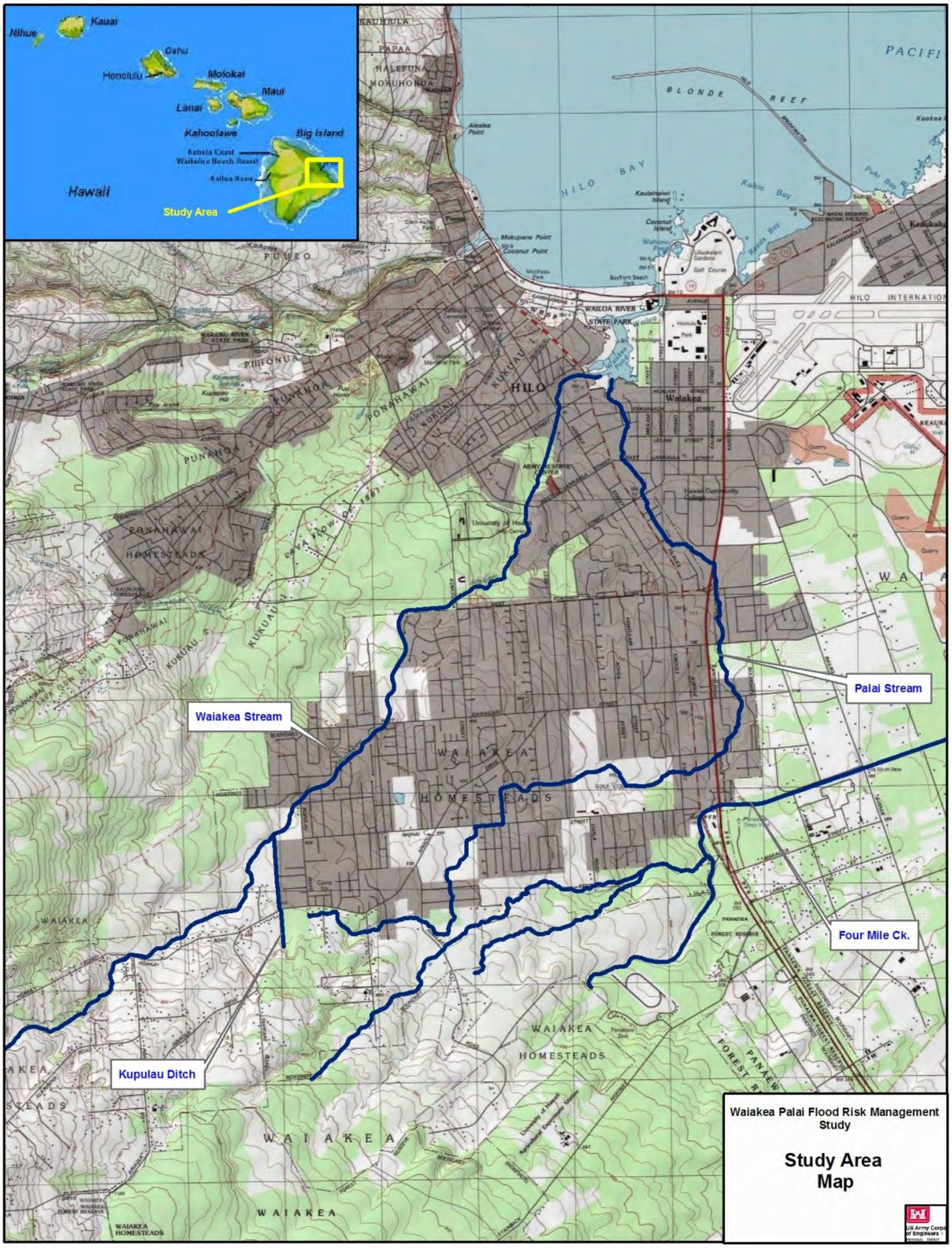

Figure 1-1. Study Area

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. The Tentatively Selected Plan is needed in order to reduce the risks to life, safety and property through the watershed resulting from flooding.

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.

Figure 2-1. Floodwater at Kupulau Ditch

In addition, the City of Hilo has experienced significant growth over recent decades. With this surge in urbanization, flooding problems have intensified for homes and businesses built close to the city's streams (Figure 2-3). Property losses, road and bridge closures, and life-threatening situations caused by flooding have become an everyday 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 43 inches of rain was recorded in a 4-day period resulting from Hurricane Lane.
- 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 Kupulau Road in 2008

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

- The Waiakea and Palai Streams 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:

- The project area has experienced earthquakes and tsunamis in the past. The study area is outside the limits of the tsunami evacuation zone; however, downstream portions of Waiakea and Palai Streams are within the tsunami evacuation zone. In addition, seismic considerations will be included in formulation, evaluation, and design of alternatives.

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.
- **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 they 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.

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 and would not address the study objective of reducing repair and maintenance to existing flood risk management features 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 Tentatively Selected 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 $6.6 million and expected annual cost (EAC) of $402,000, but it also yields the highest expected annual benefits (EAB) of $1,910,000. Ainalako Diversion is marginally more expensive than the Hilo Golf Course Detention and has an EAC of $132,000 and expected annual benefits of $350,000. Finally, the Hilo Golf Course Detention measure is marginally less expensive than the Ainalako Diversion at $2.8M and EAC of $182,000, but also produces the least amount of expected annual benefits of $280,000. While all three measures could be added as pairs as shown in Table 3-4, the net benefits are maximized when combined together.

Table 3-3. Costs and Benefits of Alternatives
$1000s; FY 2019 Discount Rate (2.875%)

	Kupulau Ditch Levee/Floodwall with Detention	Ainalako Diversion	Hilo Golf Course Detention
Plans & Specs	$1,301	$556	$505
Construction Management	$600	$264	$240
Lands	$402	$129	$365
Construction Contract	$4,061	$1,800	$1,637
Total First Cost	$6,364	$2,749	$2,747
Interest During Construction	$275	$80	$80
Total Investment	$6,639	$2,829	$2,827
Equivalent Annual Cost	$252	$107	$107
Annual O&M	$150	$25	$75
Expected Annual Cost (EAC)	$402	$132	$182
Expected Annual Benefits (EAB)	$1,910	$350	$280
Incremental Net Benefits	$1,508	$218	$98
Inc. Benefit/Cost Ratio	4.8	2.6	1.5

* 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.

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 2019 Price Level; FY 2019 Federal Discount Rate (2.875%)

Project Alternatives - Possible Combinations	Expected Annual Benefits	Expected Annual Cost	Net Benefits	Benefit-to-Cost Ratio
Kupulau Ditch Levee/Floodwall with Detention	$1,910	$402	$1,508	4.8
Ainalako Diversion	$350	$132	$218	2.6
Hilo Golf Course Detention	$280	$182	$98	1.5
Kupulau Ditch + Ainalako Diversion	$2,260	$534	$1,726	4.2
Kupulau Ditch + Hilo Golf Course Detention	$2,190	$584	$1,605	3.7
Ainalako Diversion + Hilo Golf Course Detention	$630	$315	$316	2.0
Kupulau Ditch + Ainalako Diversion + Hilo Golf Course Detention	$2,540	$717	$1,822	3.5

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 (Figure 3-1), which maximizes annualized net benefits at $1.8 million. This plan is the Tentatively Selected Plan (TSP) and National Economic Development (NED) Plan. At the FY 2019 discount rate of 2.875 percent, the benefit cost ratio for the TSP and NED Plan is 3.5 The TSP is considered complete, effective, efficient, and acceptable.

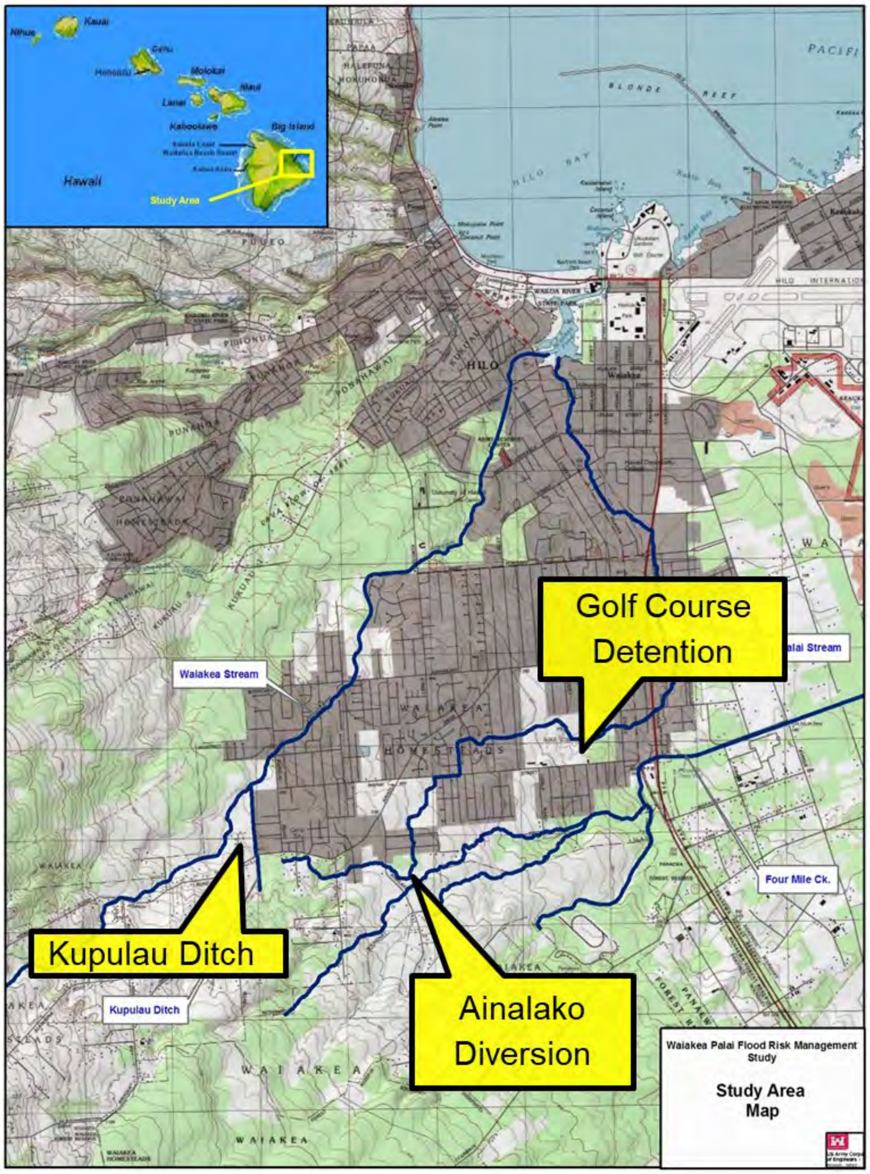

Figure 3-1. Tentatively Selected Plan

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 implementing any of the alternatives 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 Tentatively Selected Plan (TSP). The TSP presented in this chapter represents the largest combined footprint of the three sites included in the final array: Kupulau Ditch, Hilo Golf Course, and Ainalako Diversion. This chapter only presents the results of the evaluation of the Tentatively Selected Plan (all three sites) in order to disclose the greatest possible environmental effects associated with the alternatives evaluated in this study. Appendix C presents a more detailed evaluation of the effects of each individual site included in the Tentatively Selected Plan as standalone alternatives (e.g., Kupulau Ditch Alternative, Hilo Golf Course Alternative, and Ainalako Diversion Alternative) as well as the Tentatively Selected Plan that combines all three 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 – Tentatively Selected Plan

The TSP includes the Kupulau Ditch Detention, Hilo Municipal Golf Course Detention, and Ainalako Diversion.

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

Waiakea and Palai Streams and Four Mile Creek are three of five streams that form the larger Wailoa River system. Waiakea and Palai Streams drain into Waiakea Pond, which is contiguous with Hilo Bay and the

Pacific Ocean. Four Mile Creek drains into undeveloped low lands near the Hilo Drag Strip south of Hilo International Airport (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 (Figure 4-3). The channel bed is composed of lava rock and the overbanks are highly vegetated. The high velocities dislodge rock and vegetation and transport them downstream.

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.

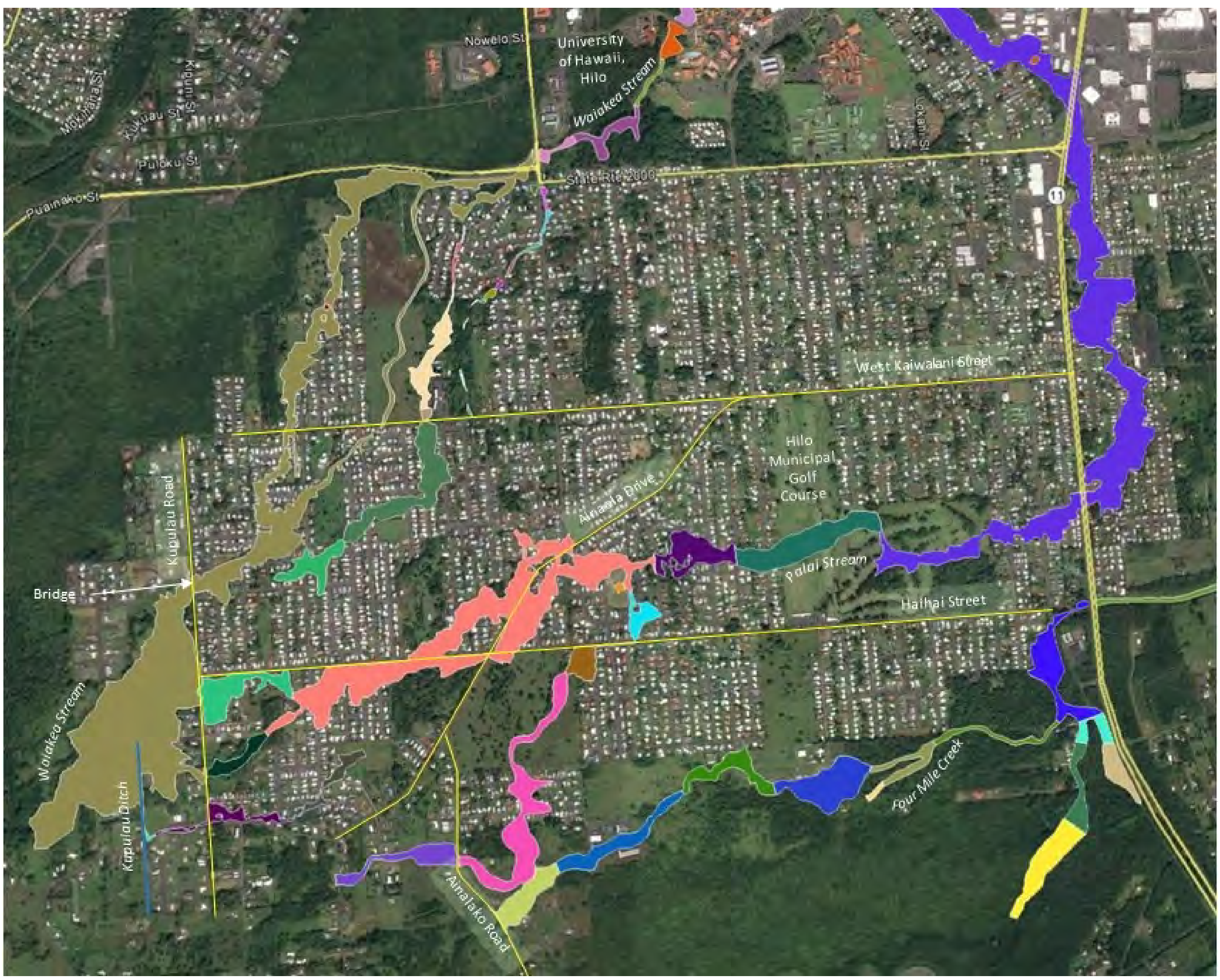

Figure 4-1. Study Area 0.2% Annual Exceedance Probability (AEP) Event

Floodwater from the overtopping of Kupulau Ditch 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.

Wetlands

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.

Wetlands

No wetlands associated with Waiakea Stream, Palai Stream, and Four Mile Creek 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 – Tentatively Selected 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. Similarly, the Ainalako Diversion feature would divert peak floodwater flows to Four Mile Creek, increasing the flow and length of time the creek is inundated.

For each of the three features included in the TSP, 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, the storm water 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.

In addition to the detention impacts addressed above, the Ainalako Diversion would result in higher floodwater flows being diverted into Four Mile Creek. Similar to the other alternatives, the increased flows would have the same effect on Four Mile Creek. Stage and flows of Four Mile Creek would increase as it incorporates the additional flows from the Waiakea watershed. However, because the stream bed consists of lava bedrock, the probability of erosion of the stream channel would be low and the temporal increase of released flows would not be considered a significant impact on the stream resources.

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 and excavation. Best Management Practices (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 TSP 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 and Palai Stream and Hilo Bay. The 404 (b)(1) analysis for the TSP is included in Appendix C.

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 TSP (AECOS, 2005; AECOS, 2010a;

and AECOS, 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 AECOS (2005, 2010a, 2010b).

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 (AECOS, 2005; AECOS, 2010a; and AECOS, 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 AECOS (2005, 2010a, 2010b).

Threatened and Endangered Species

Three ESA-listed species were identified in an 8 June 2018 informal consultation letter from the USFWS (Appendix C). A response letter from USFWS 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. During field investigations, no threatened or endangered species were observed within the study area (AECOS 2005, 2010a, 2010b).

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 – Tentatively Selected 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 impact vegetation on the golf course. Finally, at the Ainalako Diversion, the proposed levees and swale are located in a maintained pasture and would require the conversion of approximately 0.7 acres of pasture to construct the feature. Overall, the TSP would not have any substantial adverse impacts on vegetation within the project area.

Aquatic Resources

The footprint of the TSP occurs within the intermittent portions of the Waiakea and Palai Streams and Four Mile Creek. The flood risk management features included in the TSP 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. No long-term adverse impacts to aquatic resources are expected.

Terrestrial Resources

Implementation of the TSP 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.

There is a chance that Hawaiian hoary bats could utilize native and non-native woody plant species in 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 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 the TSP "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 the TSP "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 the TSP 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 would have "no effect" on the Hawaiian Coot.

4.4 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 19^{th} and early 20^{th} centuries (Pacific Legacy, 2005).

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 at the study area.

4.4.2 Alternative 2 – Tentatively Selected Plan

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 TSP would not impact any of these resources. Appendix C includes additional information regarding Cultural Resources coordination.

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 – Tentatively Selected Plan

Based on the U.S. Census data and field observations, the implementation of the TSP 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 – Tentatively Selected Plan

In the short-term, the TSP may generate solid waste from the clearing of vegetation and unused construction materials in the proposed project area. During construction of the TSP, the contractor would be responsible for such solid waste disposal. In the long-term, the TSP would require infrequent solid waste disposal of cleared debris, in accordance with applicable regulations. Overall, implementation of the TSP 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 TSP, 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 TSP 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 – Tentatively Selected 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 TSP 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 TSP is passive, with no further contribution of GHG.

5 Tentatively Selected Plan

This chapter discusses the details of the Tentatively Selected 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 Tentatively Selected Plan

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

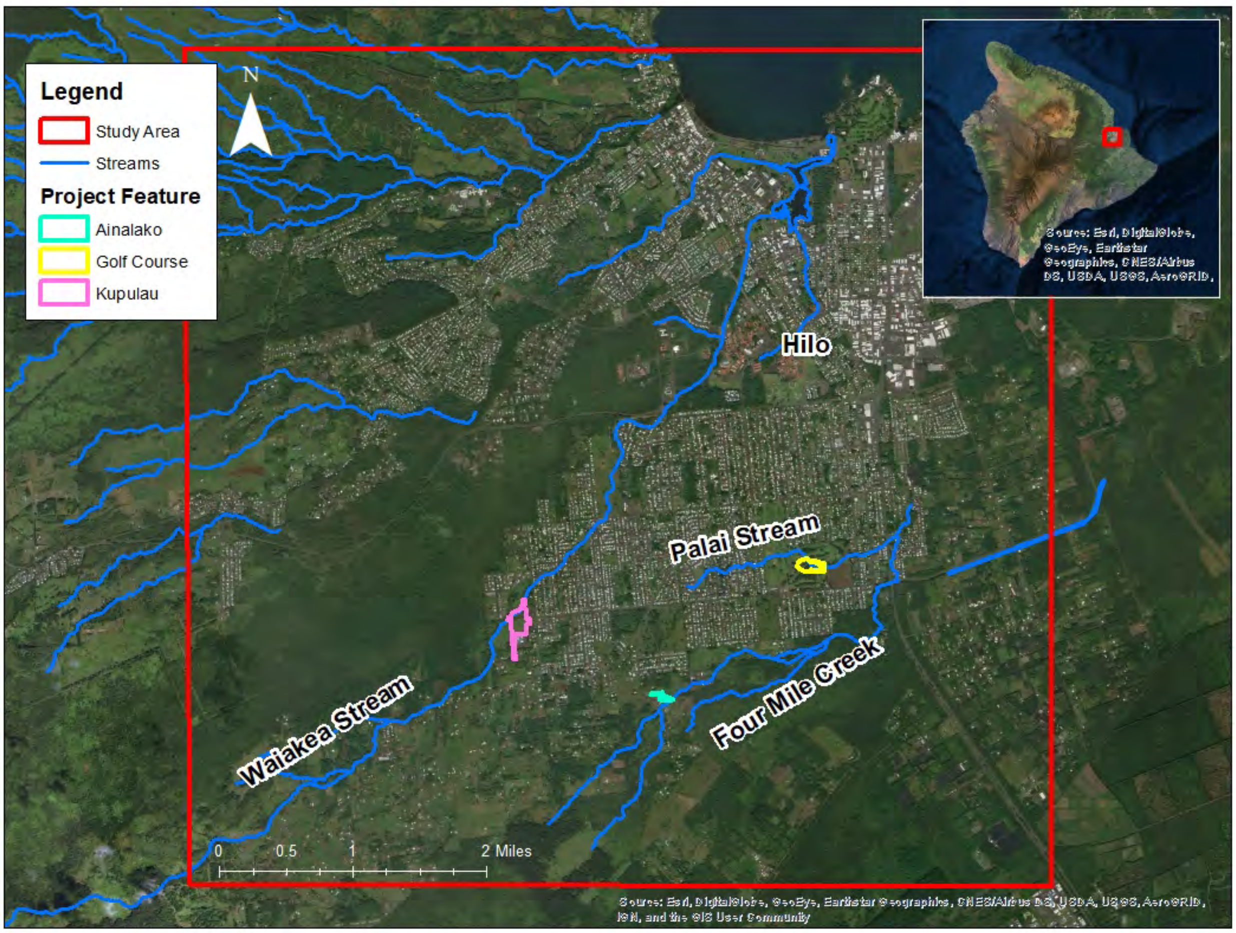

Figure 5-1. Tentatively Selected Plan

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%.

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.

5.1.3 Ainalako Diversion

The main component of this feature is the construction of a diversion structure to divert excess flows into Four Mile Creek (Figure 5-4). 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.

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. The “saddle” has a minimum elevation of 514.0 feet. At that elevation, the weir is 200 feet in length. Under without-project conditions, the overflow is covered with scrub brush and tall grasses, making the overflow very inefficient. Increasing its efficiency will allow an increase in flow over the weir. 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 feet in length and an average of about 182 feet in width, resulting in an area of about 1.2 acres.

Figure 5-2. Kupulau Ditch Detention

Figure 5-3. Hilo Municipal Golf Course Detention

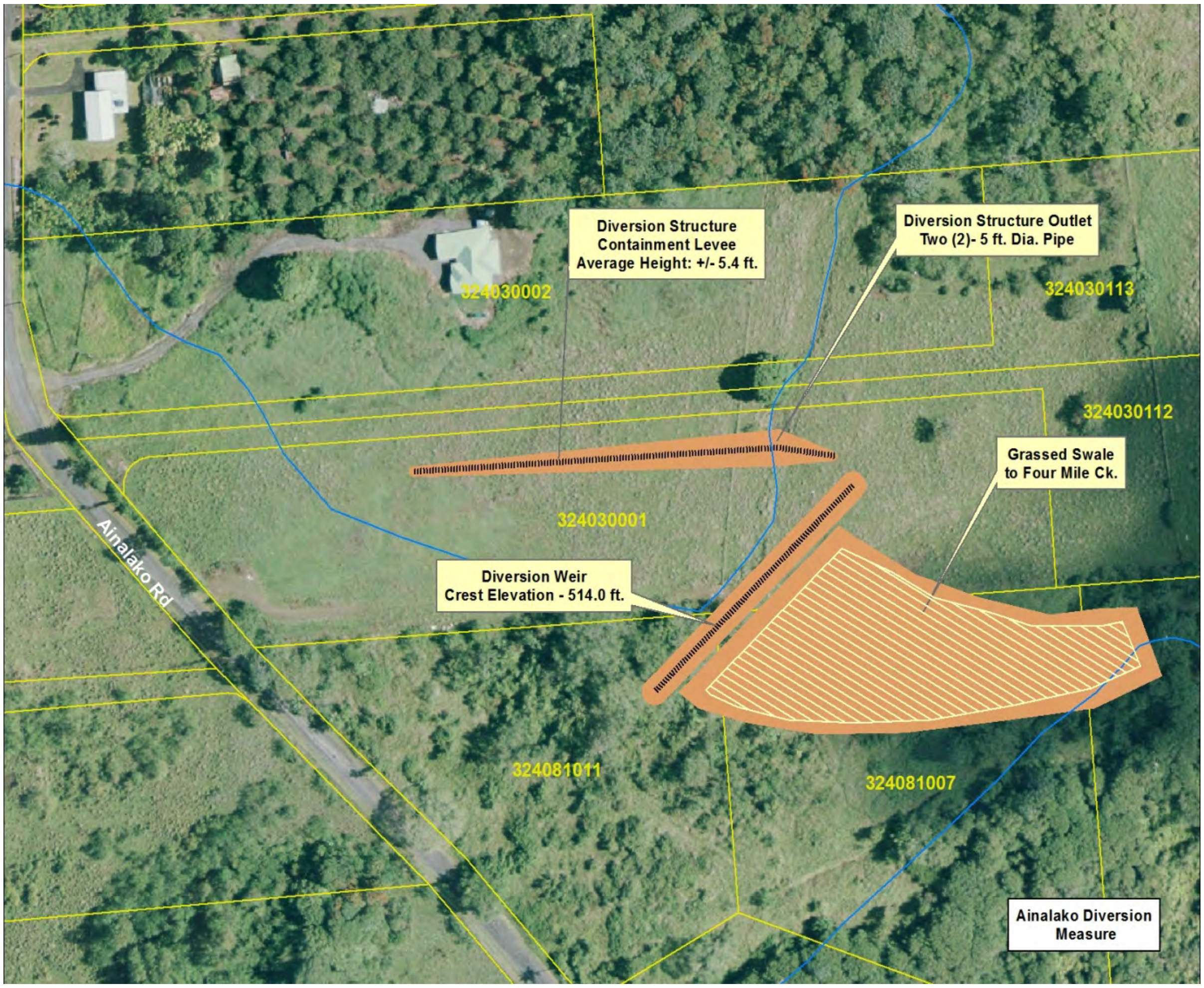

Figure 5-4. Ainalako Diversion

5.2 Cost Estimate and Economic Summary

The total project first cost (Constant Dollar Cost at FY19 price levels) of the Tentatively Selected Plan is $11,860,000. The fully funded total project cost (Constant Dollar Cost) for the Tentatively Selected Plan is $13,000,000, 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 $7,126,000 and the non-Federal share (35%) is estimated to be $4,734,000, which includes $896,000 in lands, easements, rights-of-way, relocations, and disposal (LERRD). Table 5-1 provides the cost breakdown for total project first cost. Detailed information on Project costs can be found in Appendix E.

Table 5-1. Estimated Project First Cost and Cost-Share

Item	Project First Cost (FY19 Price Level)	Federal Cost	Non-Federal Cost
Construction	7,537	4,899	2,638
LERRDs (non-cash contribution)	896	0	896
Preconstruction Engineering and Design	2,322	1,509	813
Construction Management	1,105	718	387
Total ($1000s)	**11,860**	**7,126**	**4,734**

5.3 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, four parcels are affected for the Hilo Golf Course Detention, and eight parcels are affected for the Ainalako Diversion. Additional details of the real estate requirements for this project are presented in Appendix D.

5.4 Implementation 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 all three sites, clearing of accumulated debris at all three 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 $250,000, 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.

6 Compliance with Environmental Statutes*

This chapter provides documentation of how the Tentatively Selected 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 TSP may affect, but is not likely to adversely affect the Hawaiian bat and Hawaiian hawk and would have no effect on the Hawaiian coot.

6.2 Clean Water Act of 1972

A Section 404(b)(1) analysis was conducted for the Waiakea-Palai Stream FRM study and reviewed by the Honolulu District. Before construction, the Corps, or its contractors, will obtain a National Pollutant Discharge Elimination System (NPDES) construction activities permit from DOH. The Section 404(b)(1) analysis was provided to DOH and the agency will provide the water quality certification for the study in accordance with Section 401 of the CWA.

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

The TSP is considered compatible, consistent, and does not conflict with any of the objectives of the Coastal Zone Management program. The TSP would not impact coastal recreation opportunities, impede economic uses, increase coastal hazards, or conflict with development within the coastal zone. A federal consistency determination was prepared in accordance with 15 CFR Part 930. This section and Appendix C will be updated when a response from the Hawaii State Office of Planning is received.

6.5 National Historic Preservation Act of 1966

Section 106 of the NHPA consultation is ongoing pending completion of the archaeological survey. Copies of all correspondence documenting the Section 106 consultation conducted will be included in Appendix C of the final report.

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. Consultation with the USFWS is ongoing to assure that the TSP would not adversely impact important fish and wildlife resources within the affected environment.

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.*). Consultation with NOAA has been initiated to identify potential impacts to EFH from the tentatively selected plan. All correspondence and determinations will be incorporated in the final decision document.

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 TSP 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 TSP 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 TSP. 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 tentatively selected plan on the overall floodplain management of the study area.

Implementation of the Tentatively Selected Plan would avoid, to the extent possible, long- and short-term adverse impacts associated with the occupancy and modification of the base floodplain. The TSP 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 TSP be assessed and publicly disclosed. Throughout the planning process, the District has been coordinating with other Federal, state, and regional agencies, and Native American Tribes. The draft Feasibility Report and Environmental Assessment will be released for a 30-day public review and comment period.

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
- Hawaii Division of Aquatic Resources
- Hawaii Division of Forestry and Wildlife
- Hawaii State Historic Preservation Office
- National Marine Fisheries Service
- U.S. Fish and Wildlife Service

8 Recommendations

I have considered all significant aspects of this project, including environmental, social and economic effects; and engineering feasibility. I recommend that the tentatively selected 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 tentatively selected plan is $11,860,000. Operations, maintenance, repair, rehabilitation, and replacement (OMRR&R) expenses are estimated to be approximately $250,000 per year at this time. The Federal portion of the estimated first cost is $7,126,000. The non-Federal sponsors' portion of the required 35 percent cost share of total project first costs is $4,734,000. 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-Sb), and Section l03G) 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. Consequently, the recommendations may be modified before they are transmitted to Congress for authorization and/or implementation funding.

However, prior to transmittal to Congress, the State of Hawaii, interested Federal agencies, and other parties will be advised of any significant modifications in the recommendations and will be afforded an opportunity to comment further.

KATHRYN SANBORN
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 **DATE OF IFR/EA**, for the Waiakea-Palai Streams addresses Flood Risk Management opportunities and feasibility in Hilo, Island of Hawaii, Hawaii. The final recommendation is contained in the report of the Chief of Engineers, dated **DATE OF CHIEF'S REPORT**.

The Final IFR/EA, incorporated herein by reference, evaluated various alternatives that would reduce flood risk in the study area. The recommended plan is the National Economic Development (NED) Plan and 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;
- The 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;
- and the construction of a 200 foot long weir and 276 foot long grass swale along the right bank of Palai Stream to divert water into Four Mile Creek.

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 **DATE DRAFT EA AND FONSI REVIEW PERIOD ENDED**. 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 will have no effect on federally listed species or their 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 discharge of dredged or fill material associated with the recommended plan has been found to be compliant with section 404(b)(1) Guidelines (40 CFR 230). The Clean Water Act Section 404(b)(1) Guidelines evaluation is found in Appendix C of the IFR/EA.

CLEAN WATER ACT SECTION 401 COMPLIANCE:

401 WQC OBTAINED:

A water quality certification pursuant to section 401 of the Clean Water Act was obtained from the **NAME OF ISSUING AUTHORITY.** All conditions of the water quality certification shall be implemented in order to minimize adverse impacts to water quality.

401 WQC WAIVED:

The **NAME OF ISSUING AUTHORITY** has waived water quality certification pursuant to section 401 of the Clean Water Act, as follows. **DESCRIBE DOCUMENTATION OF THE WAIVER OF THE WQC.**

401 WQC PENDING:

A water quality certification pursuant to section 401 of the Clean Water Act will obtained from the **NAME OF ISSUING AUTHORITY** prior to construction. In a letter dated **DATE OF LETTER**, the **STATE, TERRITORY, OR TRIBE** stated that the recommended plan appears to meet the requirements of the water quality certification, pending confirmation based on information to be developed during the pre-construction engineering and design phase. All conditions of the water quality certification will be implemented in order to minimize adverse impacts to water quality.

COASTAL ZONE MANAGEMENT ACT

CZMA CONSISTENCY ISSUED:

A determination of consistency with the **STATE OR TERRITORY NAME** Coastal Zone Management program pursuant to the Coastal Zone Management Act of 1972 was obtained from the **NAME OF CZM ISSUING AUTHORITY**. All conditions of the consistency determination shall be implemented in order to minimize adverse impacts to the coastal zone.

CZMA CONSISTENCY WAIVED:

A determination of consistency with the **STATE OR TERRITORY NAME** Coastal Zone Management program was provided to **NAME OF CZM ISSUING AUTHORITY** on **DATE OF SUBMITTAL** pursuant to Section 307 of the Coastal Zone Management Act of 1972. Due to the lack of response of **STATE OR TERRITORY NAME** within six months of the Corps' submittal, consistency is presumed under 16 U.S.C. 1456(c)(3)(A).

CZMA CONSISTENCY PENDING:

A determination of consistency with the **STATE OR TERRITORY NAME** Coastal Zone Management program pursuant to the Coastal Zone Management Act of 1972 will be obtained from the **NAME OF CZM ISSUING AUTHORITY** prior to construction. In a letter dated **DATE OF LETTER**, the State of Hawaii stated that the recommended plan appears to be consistent with state Coastal Zone Management plans, pending confirmation based on information to be developed during the pre-construction engineering and design phase. All conditions of the consistency determination shall be implemented 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, Tribes, 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.

____________________	____________________
Date	Kathryn Sanborn Lieutenant Colonel, Corps of Engineers District Commander

WAIAKEA-PALAI STREAMS
Hilo, Island of Hawaii, Hawaii

CONTINUING AUTHORITIES PROGRAM SECTION 205
FLOOD RISK MANAGEMENT

Appendix A: Economics

MAY 2019

US Army Corps of Engineers
Honolulu District

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

May 2019

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 profiles associated with the different probability events. The economic analysis utilizes FY19 price levels and a 2.875 percent discount rate. Net benefits and benefit-cost ratios (BCR) are provided for three project increments: the Kupulau Ditch Levee/Floodwall with Detention, the Ainalako Diversion, 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 ACE 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 ACE event. When the stream overflows floodwaters travel east to enter Kupulau Ditch. At the 1 percent annual chance exceedance (ACE) 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 ACE 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 ACE floodplain, and about that many people again live between the 0.2 percent ACE 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 FY2019 price levels from 2014 using Hawaii based RS Means index factors.

Table 2
Number of Structures and Average Depreciated Replacement Value
by Occupancy Type
FY2019 Price Levels

Structure Category	Number	Avg. Depreciated Replacement Value
Single Family Residential 1-story	1,362	$139,000
Single Family Residential 2-story	101	$236,000
Single Family Residential Split	101	$184,000
Multi-Family Residential 1-story	30	$123,000
Multi-Family Residential 2-story	10	$2,578,000
Warehouse	35	$253,000
Church	10	$183,000
Convenience Store	2	$235,000
Commercial 2 story	1	$429,000
Office	29	$2,643,000
Retail Store	2	$21,757,000
Restaurant	3	$356,000
Garage	2	$396,000
Hospital	9	$951,000
Bank	1	$634,000
Public Building 1-story	3	$97,000

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 degree 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.

Given the variety of sources of ground and first floor elevations and inherent uncertainty involved with each, an expected normal distribution with a standard deviation of 0.5 feet was used to calculate the uncertainty surrounding the first floor elevation of all of the structure categories.

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. 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.

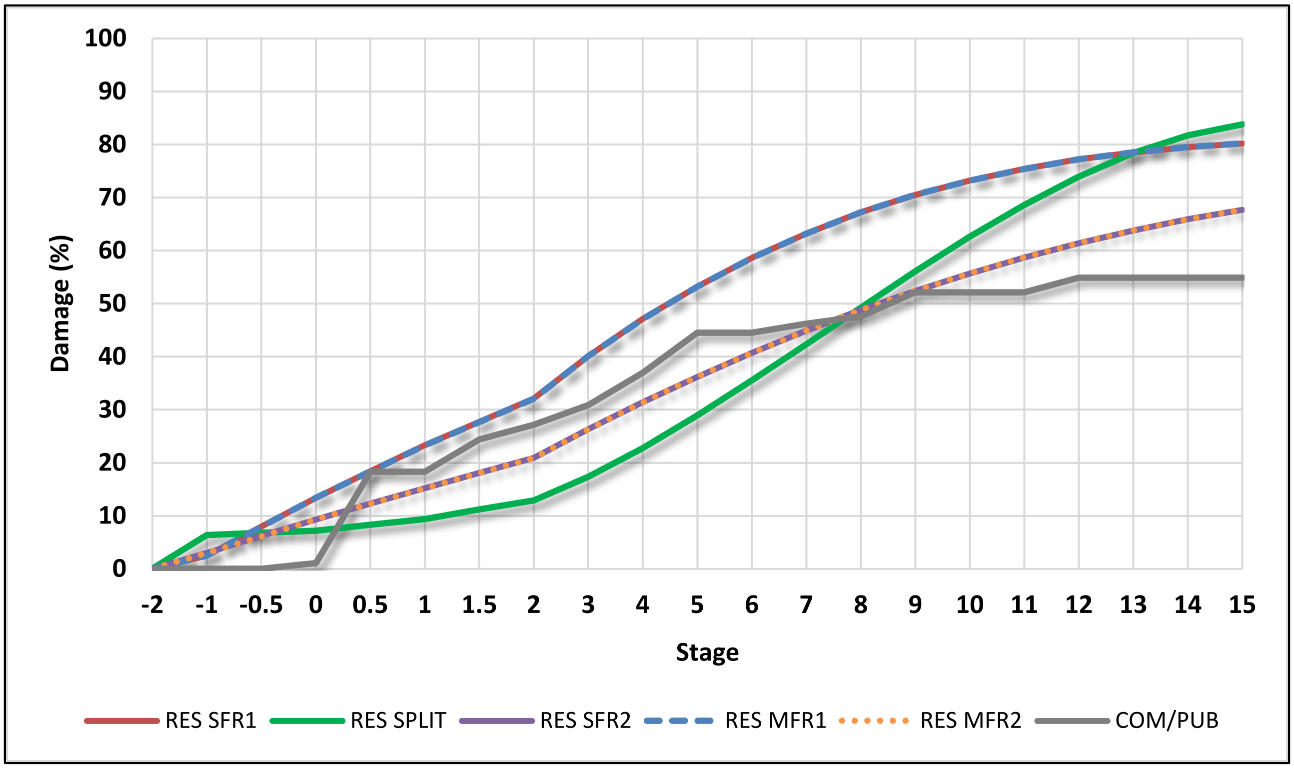

Figure 1. Waiakea-Palai Depth-Damage Relationships

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 profiles were based on the following eight annual chance exceedance (ACE) 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. 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 simulation 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 FY2019 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
Expected Annual Damages by Probability Event
Without-Project Condition
($1,000s)

Annual Chance Exceedance Event (ACE)	Residential	Commercial	Public	Total
0.5 (2 yr)	991	0	0	991
0.20 (5 yr)	4,290	228	0	4,518
0.10 (10 yr)	6,510	2,472	0	8,983
0.04 (25 yr)	11,927	3,112	0	15,039
0.02 (50 yr)	14,793	3,398	0	18,191
0.01 (100 yr)	17,920	3,706	0	21,626
0.005 (200 yr)	22,745	4,714	455	27,913
0.002 (500 yr)	27,464	6,504	580	34,548

Table 5
Structures Damaged by Probability Event
Without-Project Condition

Annual Chance Exceedance Event (ACE)	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.

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 2019 Price Level
FY 2019 Federal Discount Rate 2.875%

Project Alternatives - Possible Combinations	Expected Annual Benefits	Expected Annual Cost	Net Benefits	Benefit-to-Cost Ratio
Kupulau Ditch (2% AEP Plan)	$1,910	$402	$1,508	4.8
Ainalako Diversion	$350	$132	$218	2.6
Golf Course Detention	$280	$182	$98	1.5
Kupulau Ditch + Ainalako Diversion	$2,260	$534	$1,726	4.2
Kupulau Ditch + Golf Course Detention	$2,190	$584	$1,605	3.7
Ainalako Diversion + Golf Course Detention	$630	$315	$316	2.0
Kupulau Ditch + Ainalako Diversion + Golf Course Detention	$2,540	$717	$1,822	3.5

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 $1.9 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 2019 Federal Discount Rate 2.875%

	Kupulau Ditch	Ainalako Diversion	Golf Course Detention	TSP/ NED Plan
Plans & Specs	$1,301	$556	$505	$2,322
Construction Management	$600	$264	$240	$1,105
Lands	$402	$129	$365	$896
Construction Contract	$4,061	$1,800	$1,637	$7,498
Total First Cost	$6,364	$2,749	$2,747	$11,821
Interest During Construction	$275	$80	$80	$514
Total Investment	$6,639	$2,829	$2,827	$12,335
Equivalent Annual Cost	$252	$107	$107	$468
Annual O&M	$150	$25	$75	$250
Expected Annual Cost (EAC)	$402	$132	$182	$718
Expected Annual Benefits (EAB)	$1,910	$350	$280	$2,540
Incremental Net Benefits	$1,508	$218	$98	$1,822
Inc.Benefit/Cost Ratio	4.8	2.6	1.5	3.5

* 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.

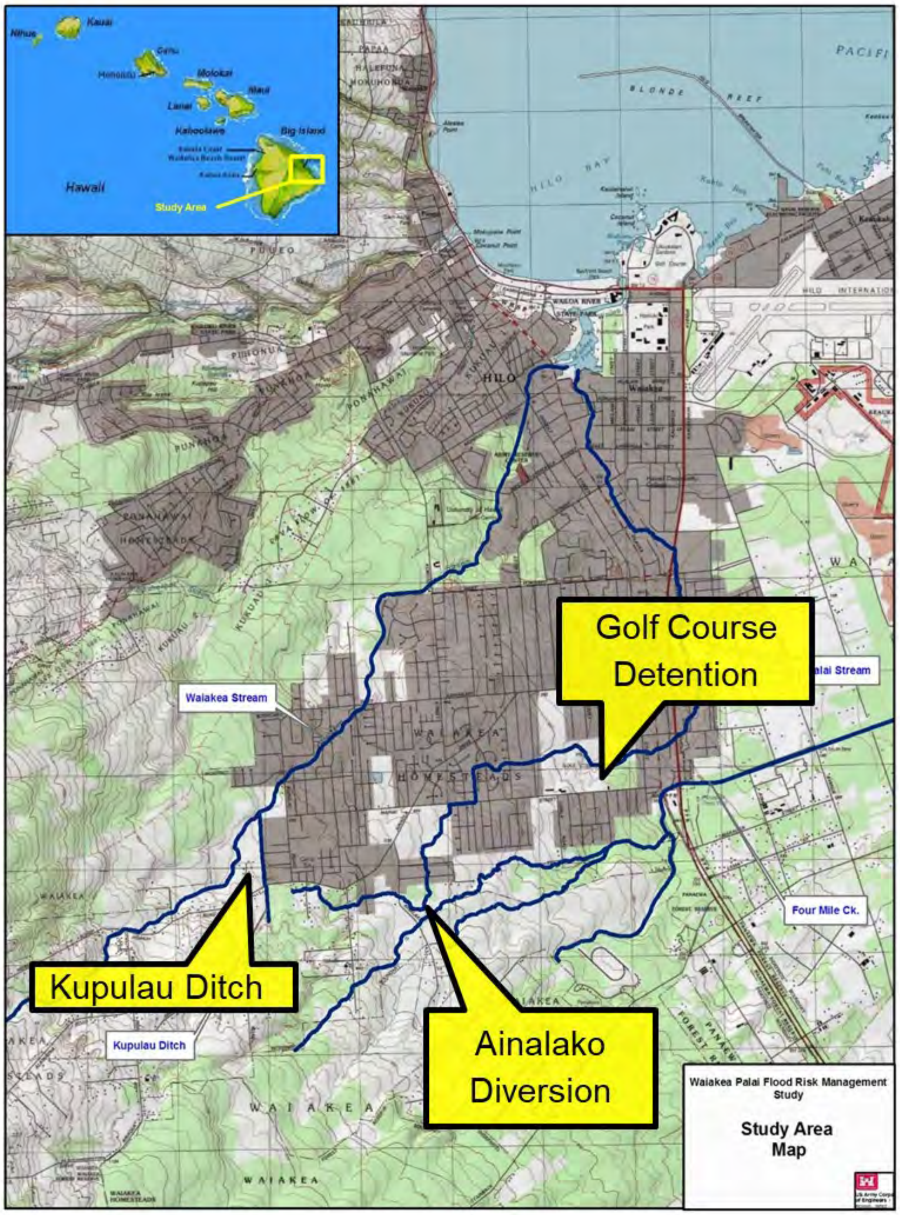

Figure 3. Location of the Combination Plan

Project Benefits. Table 9 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 $6.6 million and expected annual cost (EAC) of $402,000, but it also yields the highest benefit cost ratio (BCR) of 4.8. Incrementally, Ainalako Diversion, with an EAC of $132,000, has a BCR of 2.6, and produces net benefits of $218,000. The Golf Course Detention measure has a total cost of $2.8M, and $182,000 expected annual cost, and produces the least amount of expected annual benefits of $98,000. 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 2019 Price Level
FY 2019 Federal Discount Rate 2.875%

Project Alternatives	Expected Annual Benefits	Expected Annual Cost	Net Benefits	Benefit-to-Cost Ratio
Kupulau Ditch - 2% ACE Plan	$1,910	$402	$1,508	4.8
Ainalako Diversion - 1% ACE Plan	$350	$132	$218	2.6
Reconfigured Golf Course Detention - 1% ACE Plan	$280	$182	$98	1.5
Combination Plan (TSP)	$2,540	$718	$1,822	3.5

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 2019 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 2019 Federal discount rate of 2.875 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 FY19 Federal discount rate of 2.875 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 $1,822,000 were calculated by subtracting the average annual costs from the expected annual benefits. The benefits and costs are displayed FY 2019 price levels. At the prescribed FY 2019 discount rate of 2.875 percent, the benefit cost ratio for the TSP is 3.5.

Net benefits for the Kupulau Ditch alternative are reasonably maximized at the 4.3-foot average height (roughly equivalent to a 2 percent ACE flood). 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 ACE flood), and further declines with a 6.7-foot average height (roughly equivalent to a 0.5 percent ACE flood). Thus, the levee/floodwalls of varying heights were specifically designed to safely pass the 2 percent, 1 percent or 0.2 percent ACE events. The crests were raised an additional 2.5 feet in order to achieve a conditional non-exceedance probability (CNP) of at least 95 percent.

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 the diversion or 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 ACEs. These changes in ACEs 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. There are residual expected annual damages of approximately $2.3 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 three TSP measures that reduces the risk of flooding to properties along Waiakea.

Project Effectiveness. Table 9 shows that there is a greater than 75 percent chance that expected annual benefits will exceed $1.6 million. Compared with the current expected annual cost estimate of $718K 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 9
EAD Probability Distribution ($1,000s)
FY 2019 Price Level
FY 2019 Federal Discount Rate 2.875%

Project Alternatives	Expected Annual Benefits	Probability Damage Reduced Exceeds Indicated Values		
		75%	50%	25%
Kupulau Ditch - 2% ACE Plan	$1,910	1,236	1,917	2,699
Ainalako Diversion - 1% ACE Plan	$350	212	329	495
Reconfigured Golf Course Detention - 1% ACE Plan	$280	169	263	396
Combination Plan (TSP)	$2,540	1,618	2,509	3,590

WAIAKEA-PALAI STREAMS
Hilo, Island of Hawaii, Hawaii

CONTINUING AUTHORITIES PROGRAM SECTION 205
FLOOD RISK MANAGEMENT

Appendix B-1: Hydrology

MAY 2019

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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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 209 of the Rivers and Harbors Act of 1962, Public Law 87-874, as amended (76 U.S.C. 1197s; hereinafter Section 209). Section 209 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.

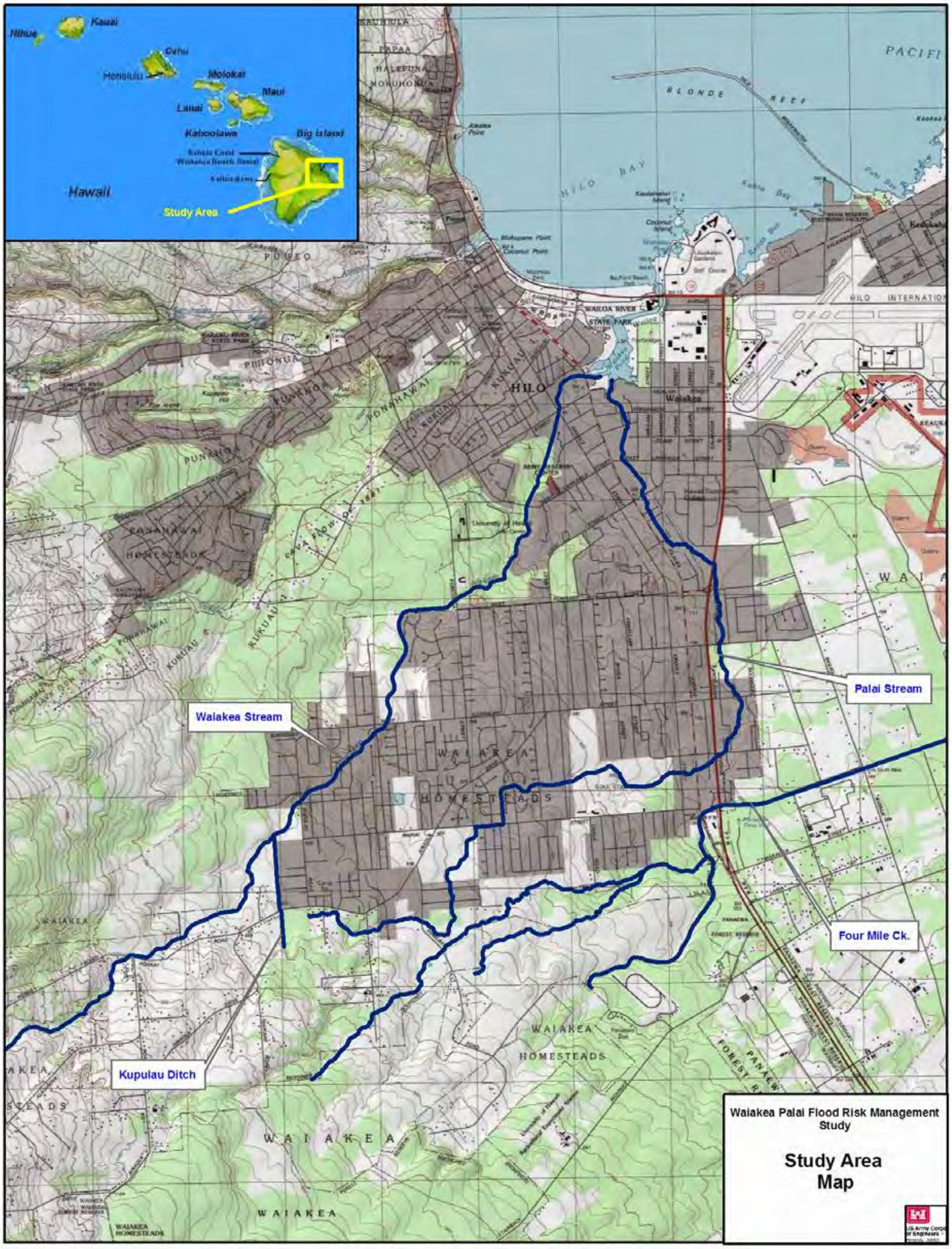


Figure 1. Study Area/Location Map

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 2). The drainage pattern in the upper watershed area is not very well defined and the poorly defined water courses are subject to changes with time. 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 (Figures 2a and 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.

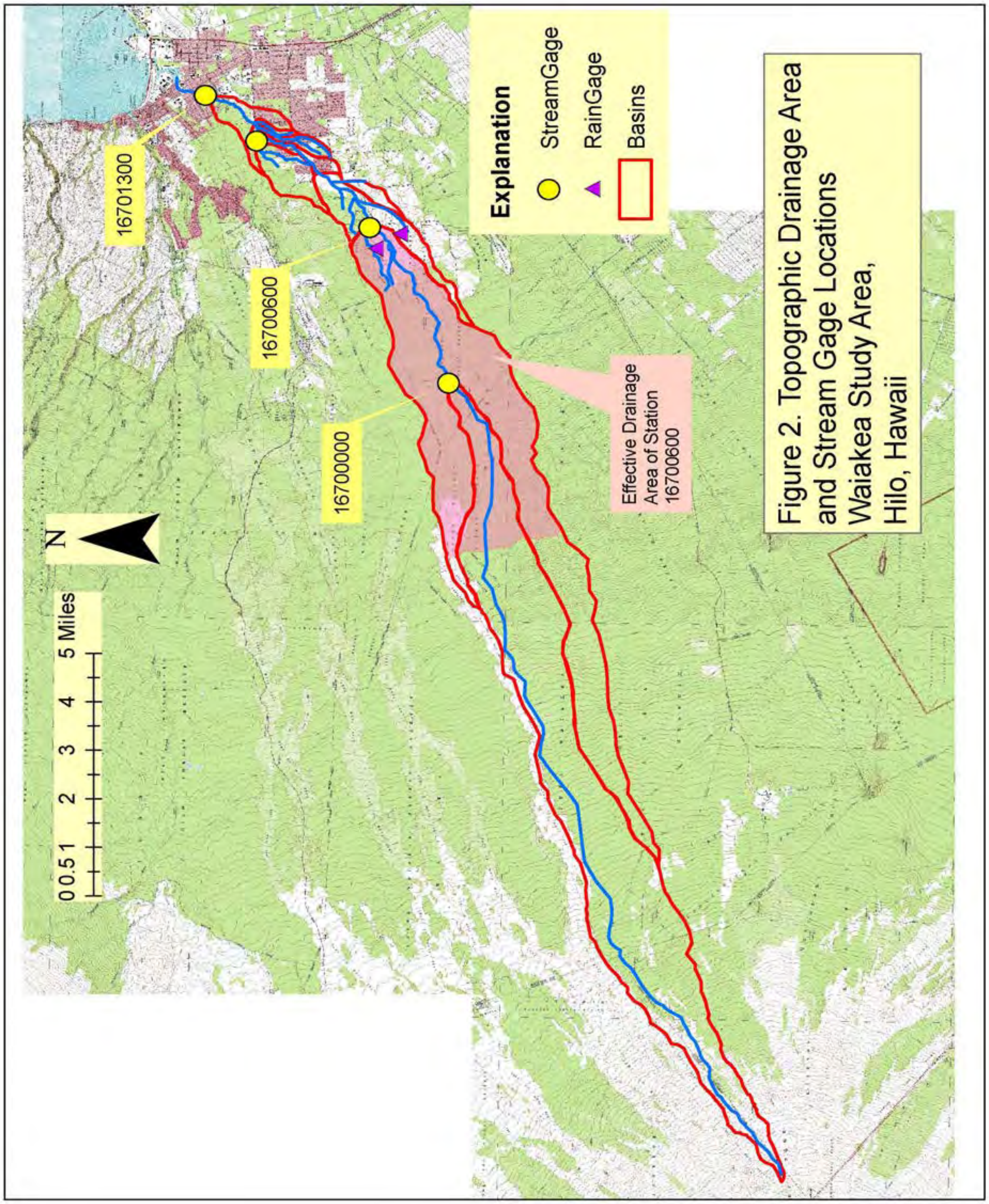


Figure 2. Waiakea Stream Drainage Basin

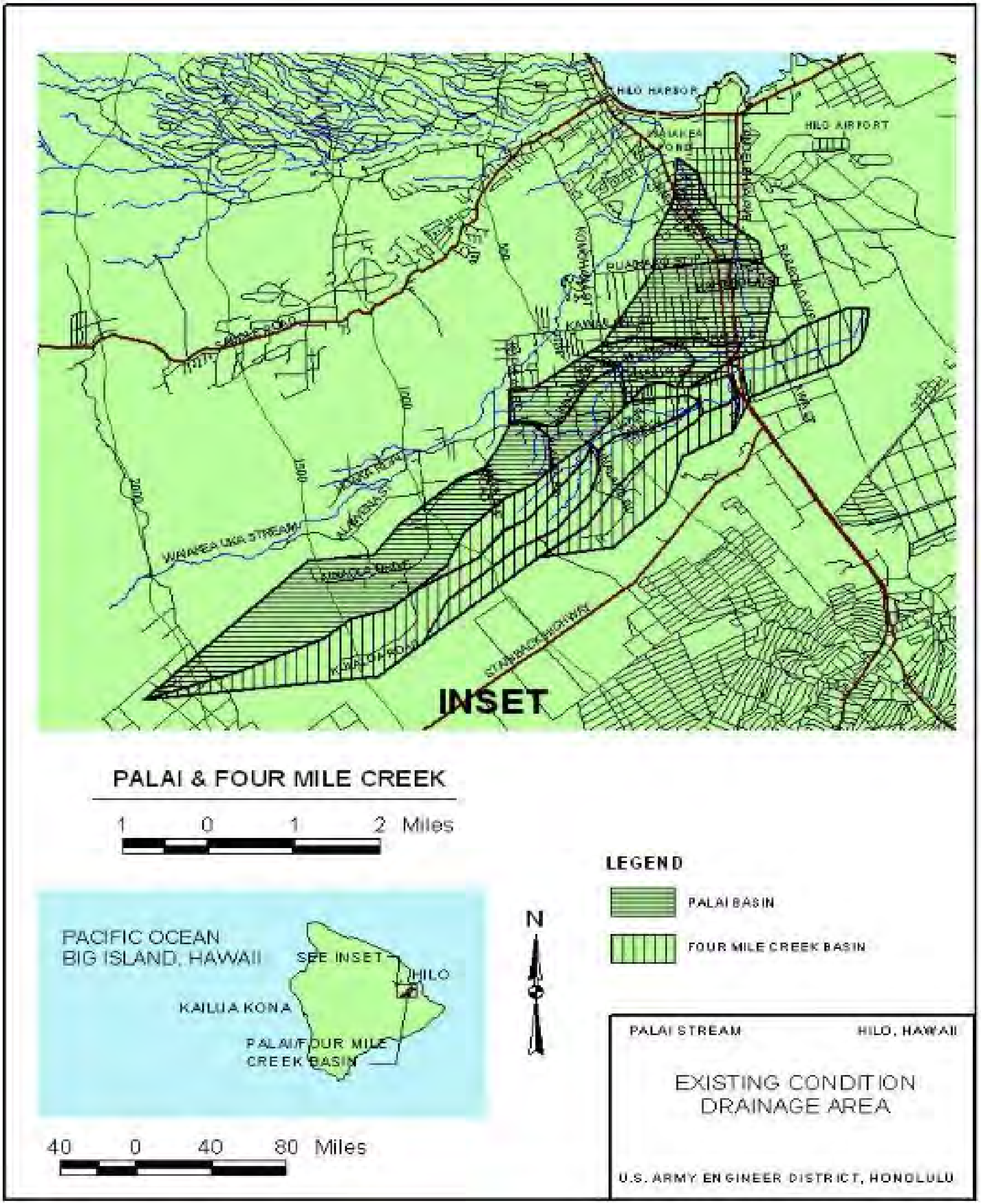


Figure 2a. Drainage Area map for Palai Stream and Four Mile Creek, Hilo, Hawaii

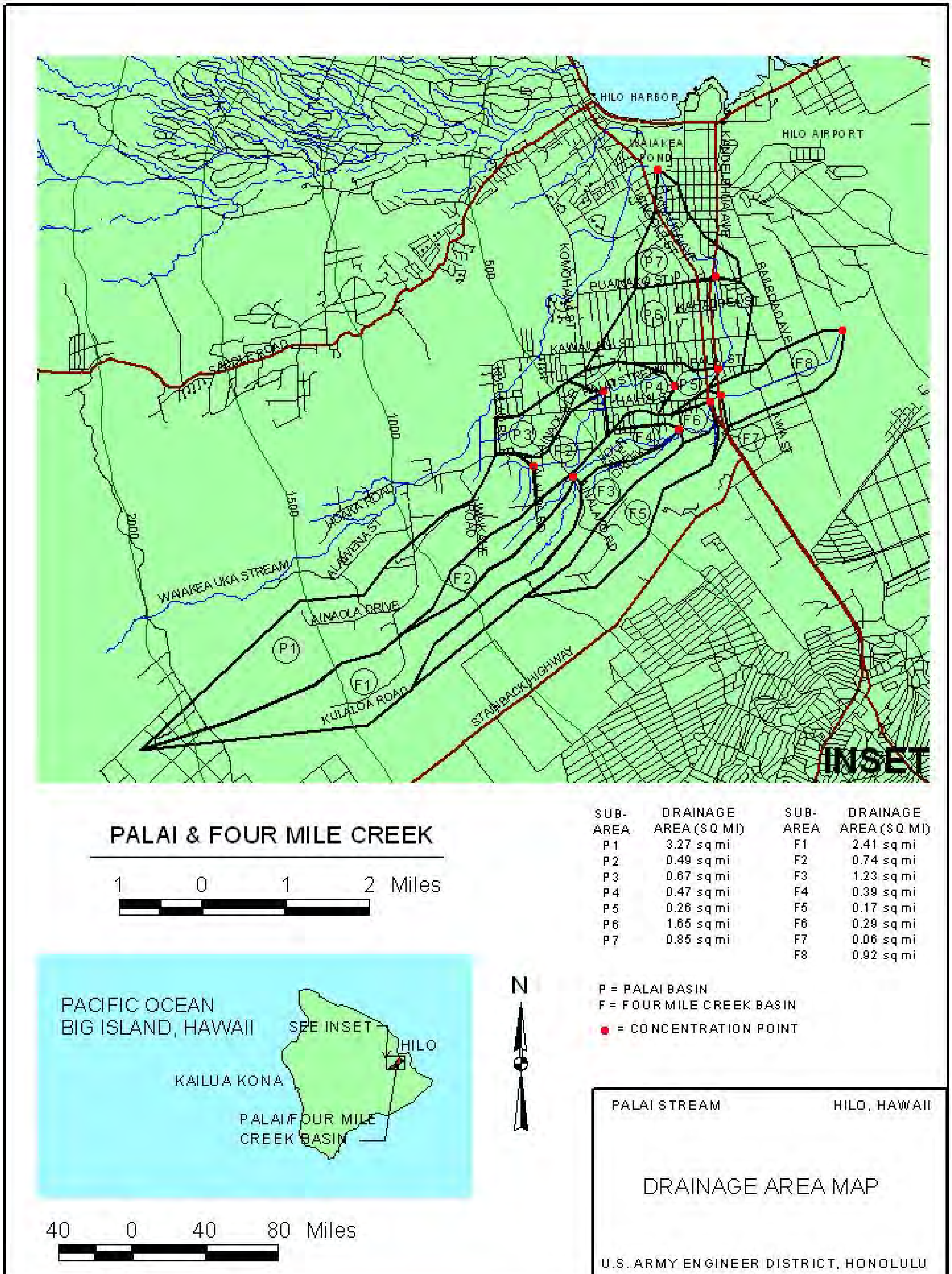


Figure 2b. Sub-Basin Areas for Palai Stream and Four Mile Creek, Hilo, Hawaii

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

1.6 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. This storm produced 15.66 inches of rain at Hilo airport on that day according to the NWS. In the 72 hour period from 16 to 19 March, 25.36 inches of rain was recorded. Damages totaled $3.8 million on the island of Hawaii. No peak flow data is available at station 16701300. The Palai stream gage recorded a peak flow of 1,070 cubic feet per second.

12 August 1994. This storm produced 4.10 inches of rainfall at Hilo airport on that day according to the NWS. Damages totaled $3 million on the island of Hawaii, about $1 million in the Waiakea area (Natural Resources Conservation Service, 1999). Gage station 16701300 recorded a peak flow of 3,670 cubic feet per second, the second highest on record. The Palai stream gage recorded a peak flow of 575 cubic feet per second.

1-2 November 2000. A severe and intense rainfall storm produced significant flooding and damage on the eastern side of the Island of Hawaii. A total of 26.89 inches of rainfall at the Hilo airport gage and 29.11 inches of rainfall at the Waiakea-Uka rain gage over a 24 hour period were recorded for this storm (Fontaine and Hill, 2002). Rainfall intensities of 2.57 to 3.24 inches per hour occurred during a 4 hour period from 2200 hours on November 1 to 0200 hours on November 2 at the Waiakea-Uka rain gage. The peak of record (1968-2004) was recorded at the USGS gage on Waiakea Stream, station 16701300. This peak was 5,760 cubic feet per second recorded on November 2, 2000 and assigned a recurrence interval of about 70 years (Fontaine and Hill, 2002). 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.

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 3). 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.

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 Chance Exceedance or ACE (100-year) 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% ACE the 2-, 5-, 10-, 25-, 50-, 100-, 200-, and 500-year) 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).

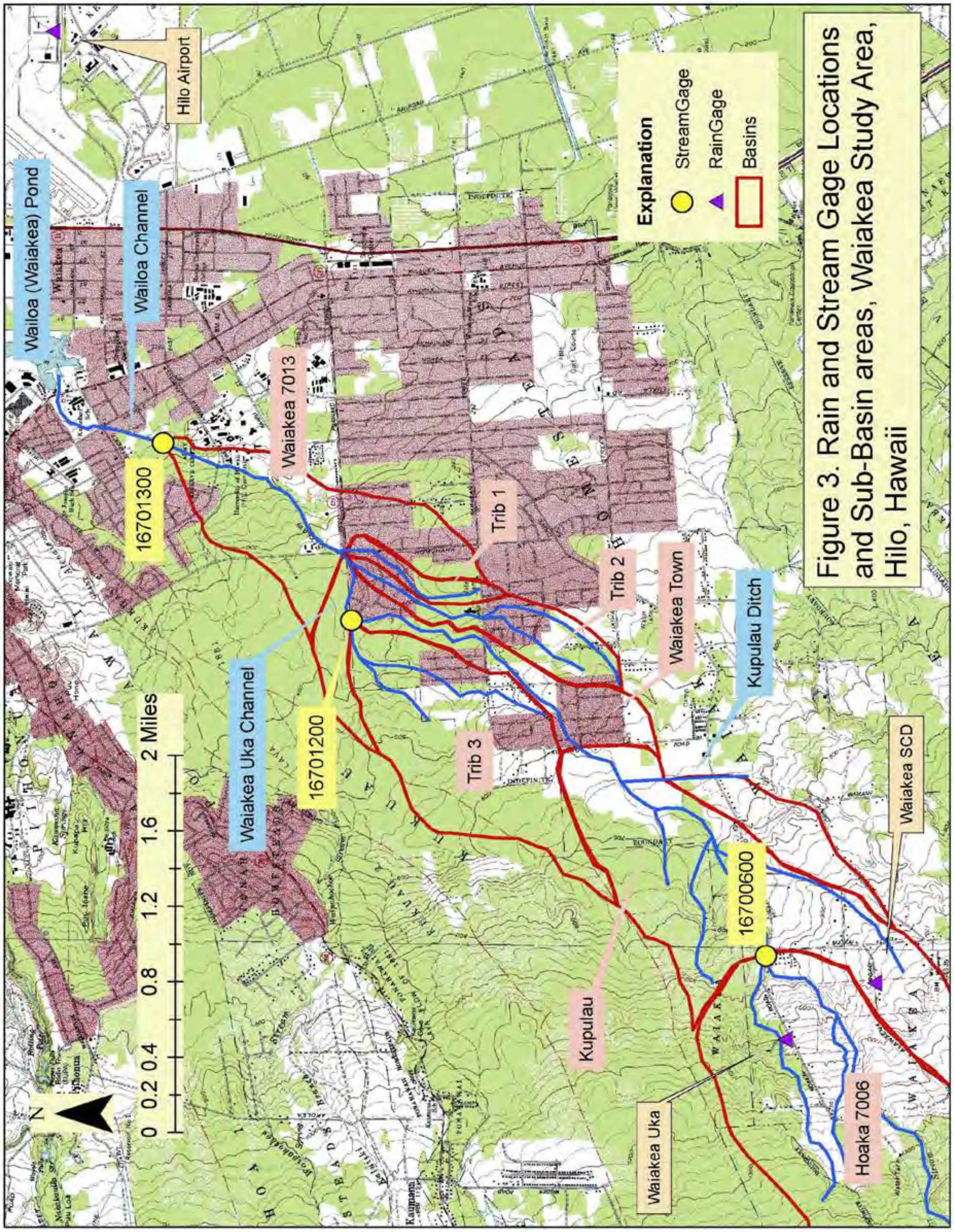


Figure 3. Waiakea Stream Rain and Stream Gage Stations

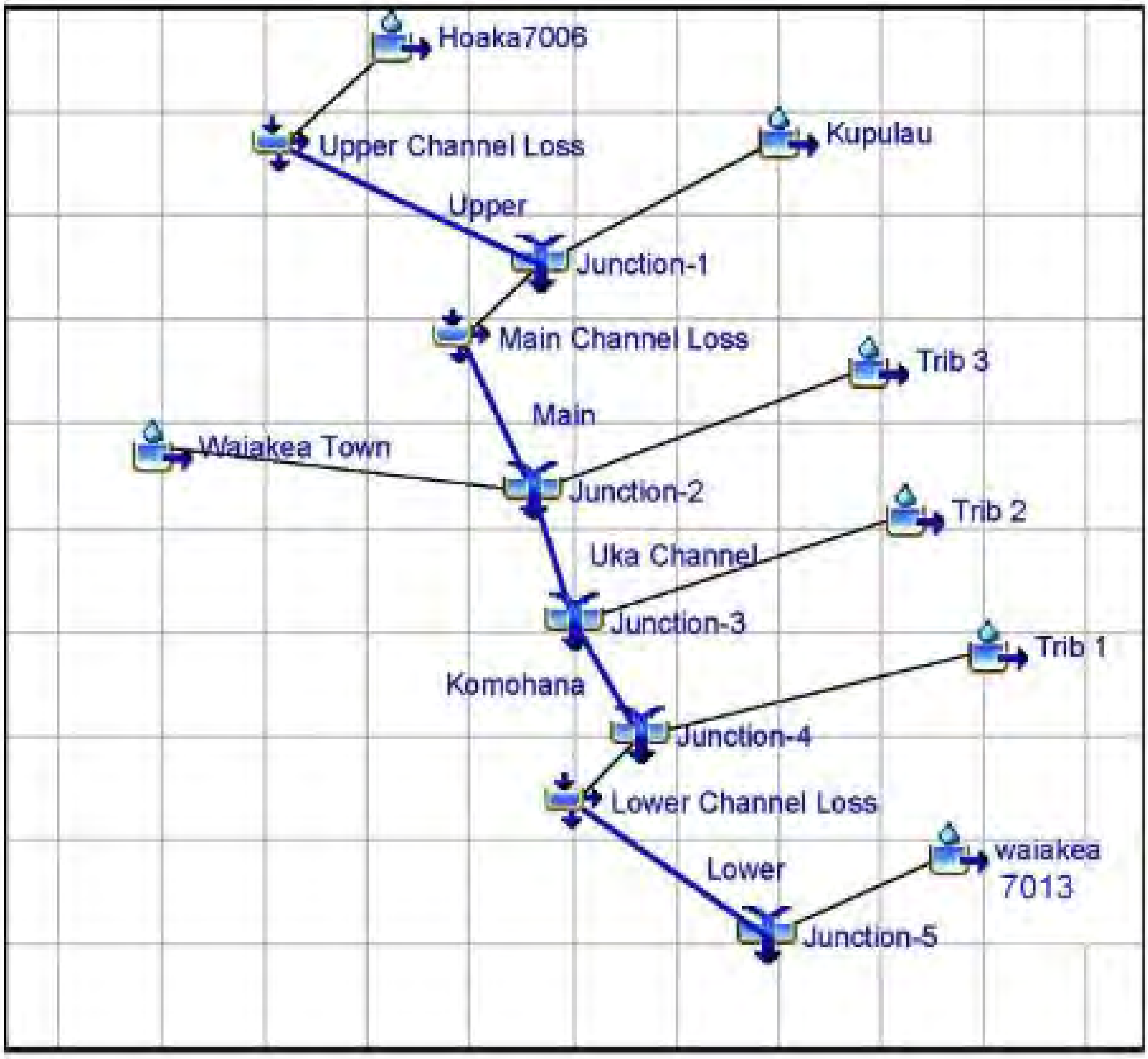


Figure 4. Waiakea Stream HEC-HMS Model Layout

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

Gage Location, Elevation, or Storm Date	Rain Gage Daily Total Data Rain fall values in inches			Stream Gage Peak Flow Data		
	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 (mi^2)**	**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

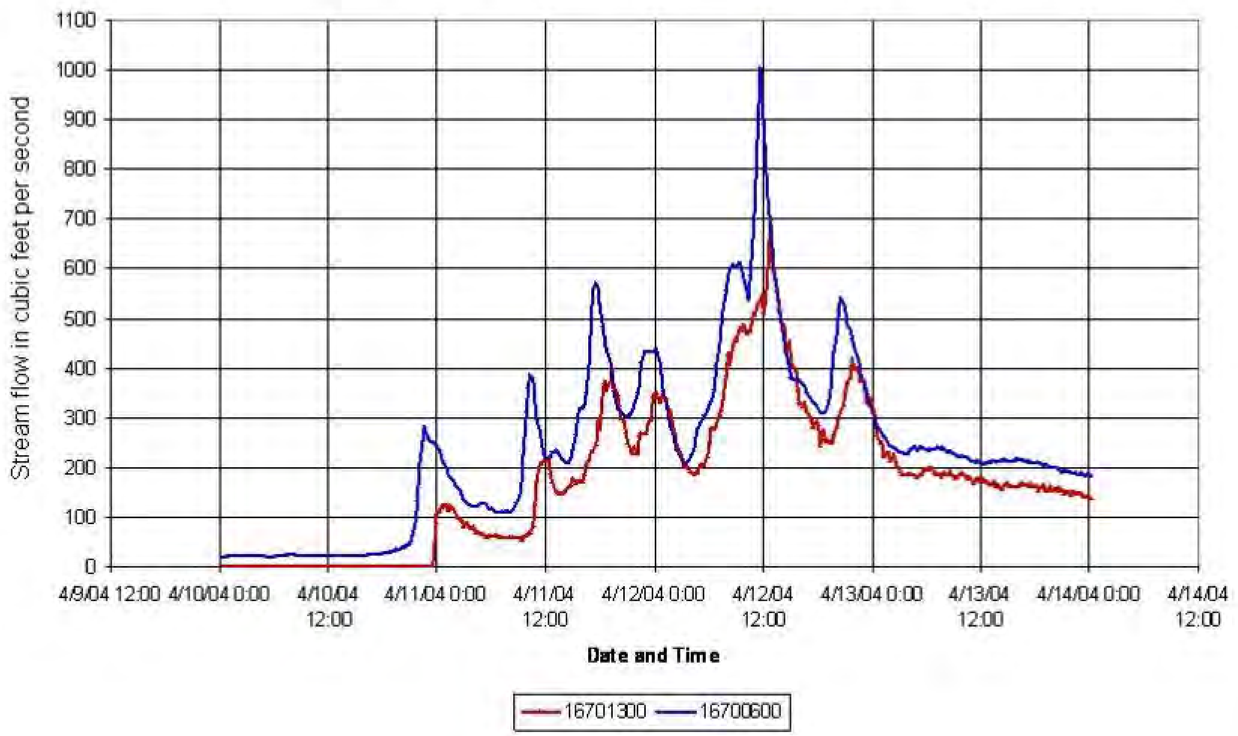


Figure 5. – Stream Flow Hydrographs, April 10-13, 2004, at USGS Stations 16700600 and 16701300 on Waiakea Stream

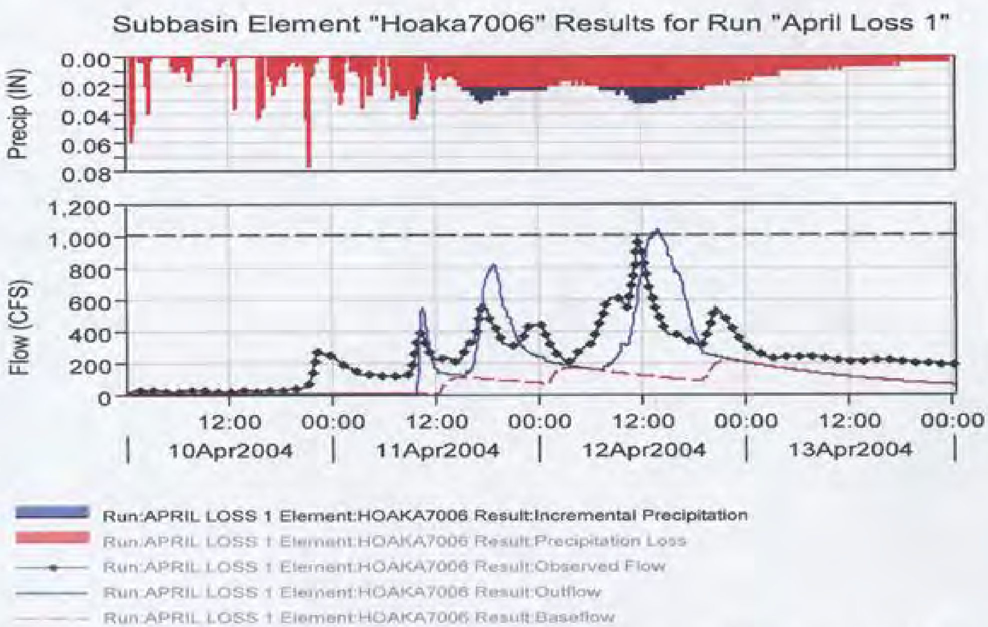


Figure 6. HEC-HMS Model Results versus Observed Data at USGS Station 16700600, Waiakea Stream near Hoaka Road, upstream end of Waiakea Stream Study Area, Hilo, Hawaii

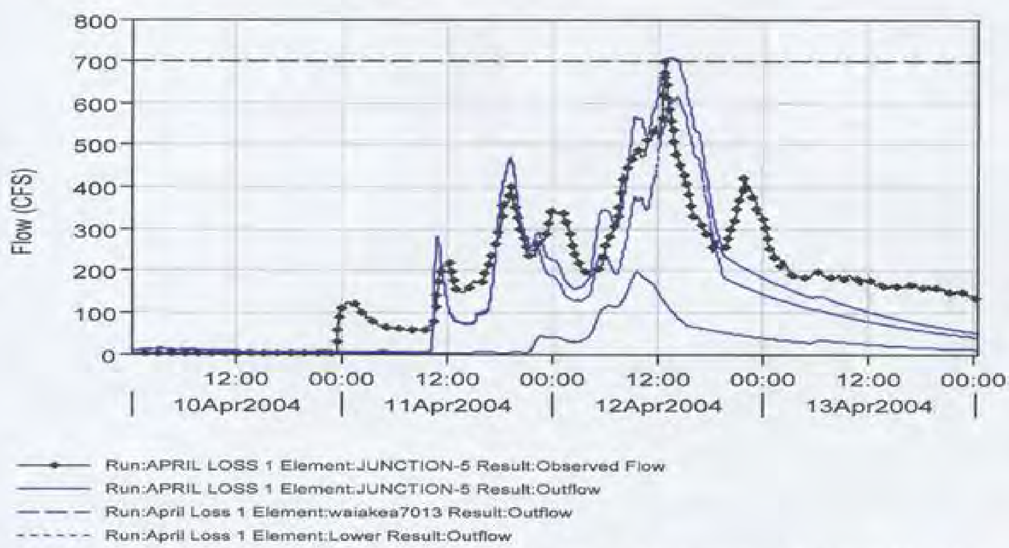


Figure 7. HEC-HMS Model Results versus Observed Data at USGS Station 16701300, Waiakea Stream near Hilo, downstream end of Waiakea Stream Study Area, Hilo, Hawaii

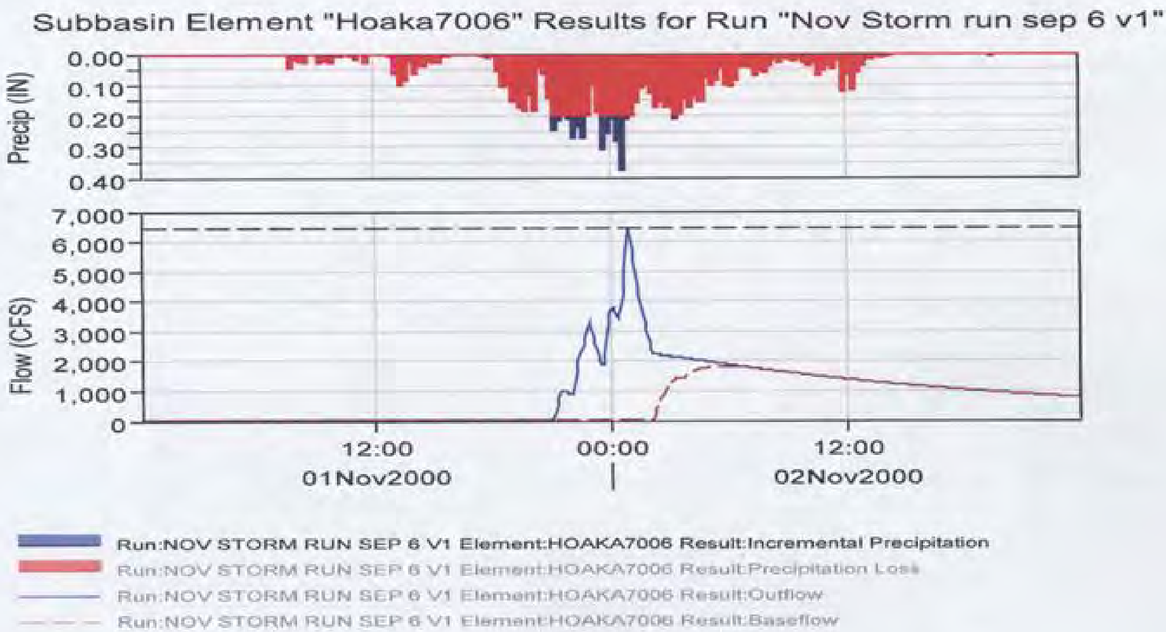


Figure 8. HEC-HMS Model Results at USGS Station 16700600, Waiakea Stream near Hoaka Road, upstream end of Waiakea Stream Study Area, Hilo, Hawaii for November 1-2, 2000 Storm Event

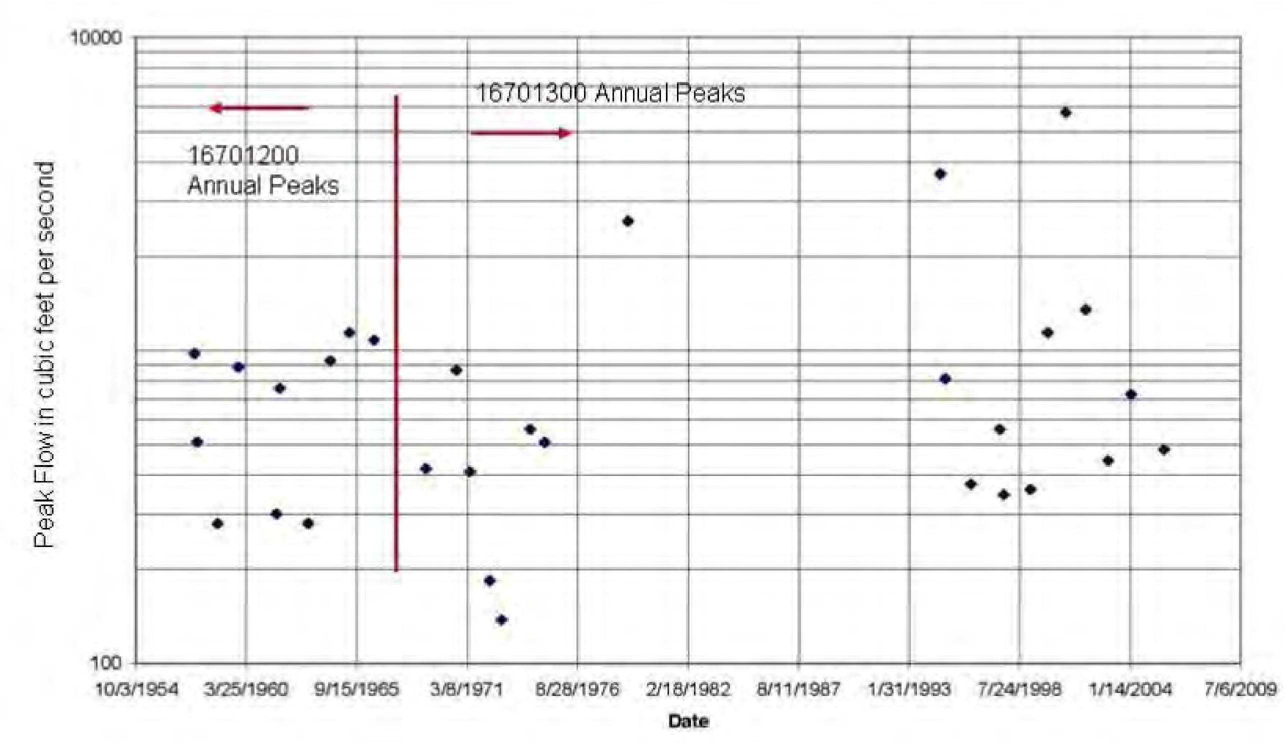


Figure 9. Annual Peak Flow Data at USGS Gage Stations 16701200 and 16701300, Waiakea Stream

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.

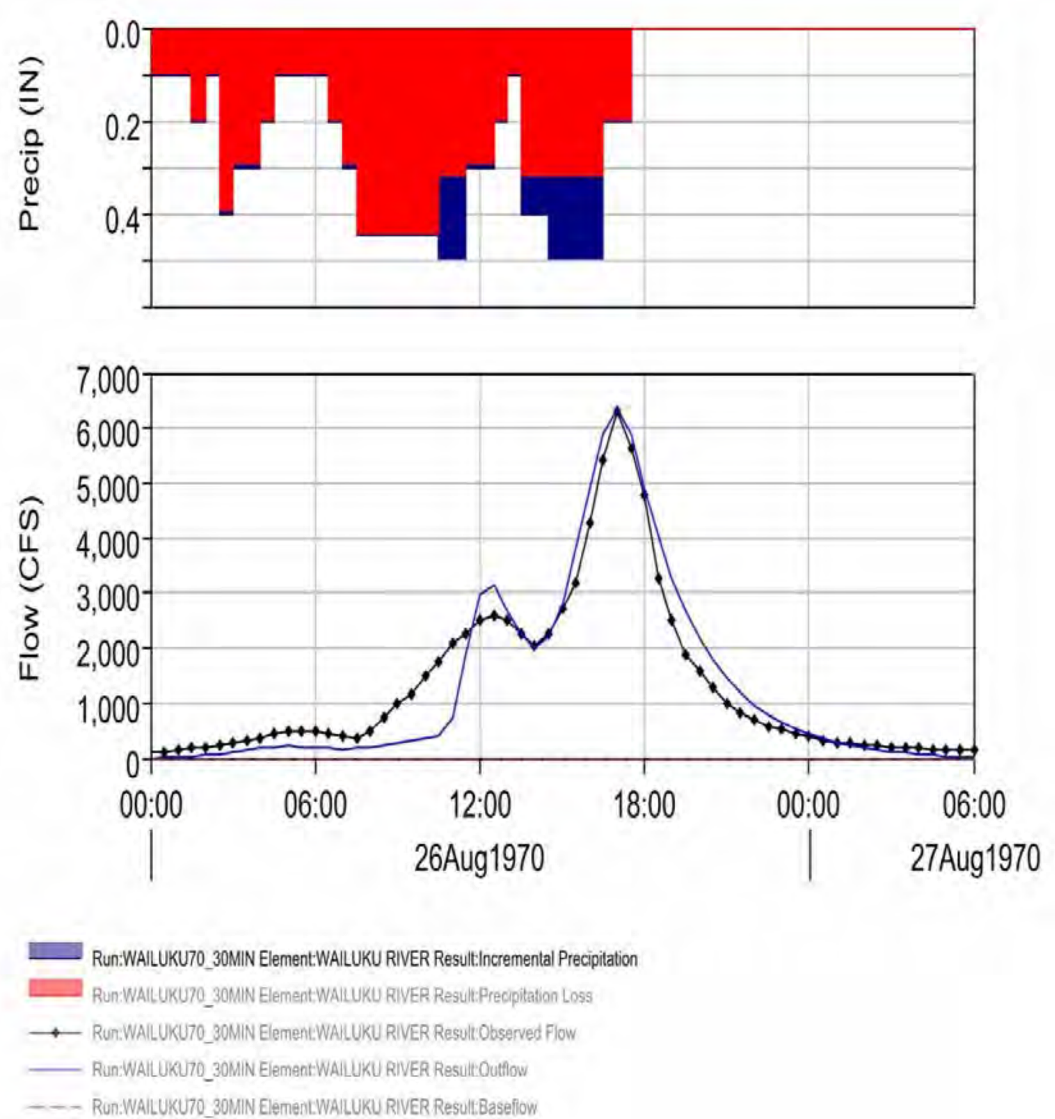
Table 10. Wailuku River Reconstitution: Input for 1970 and 1979 Storms

			Rainfall Runoff Parameters			Snyder Hydrograph Parameters from Alenaio Report March 1990	
Gage	**Date**	**Area (Sq mi)**	**Initial Loss (in)**	**Constant Loss (in)**	**% Impervious**	**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 (ft³/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.

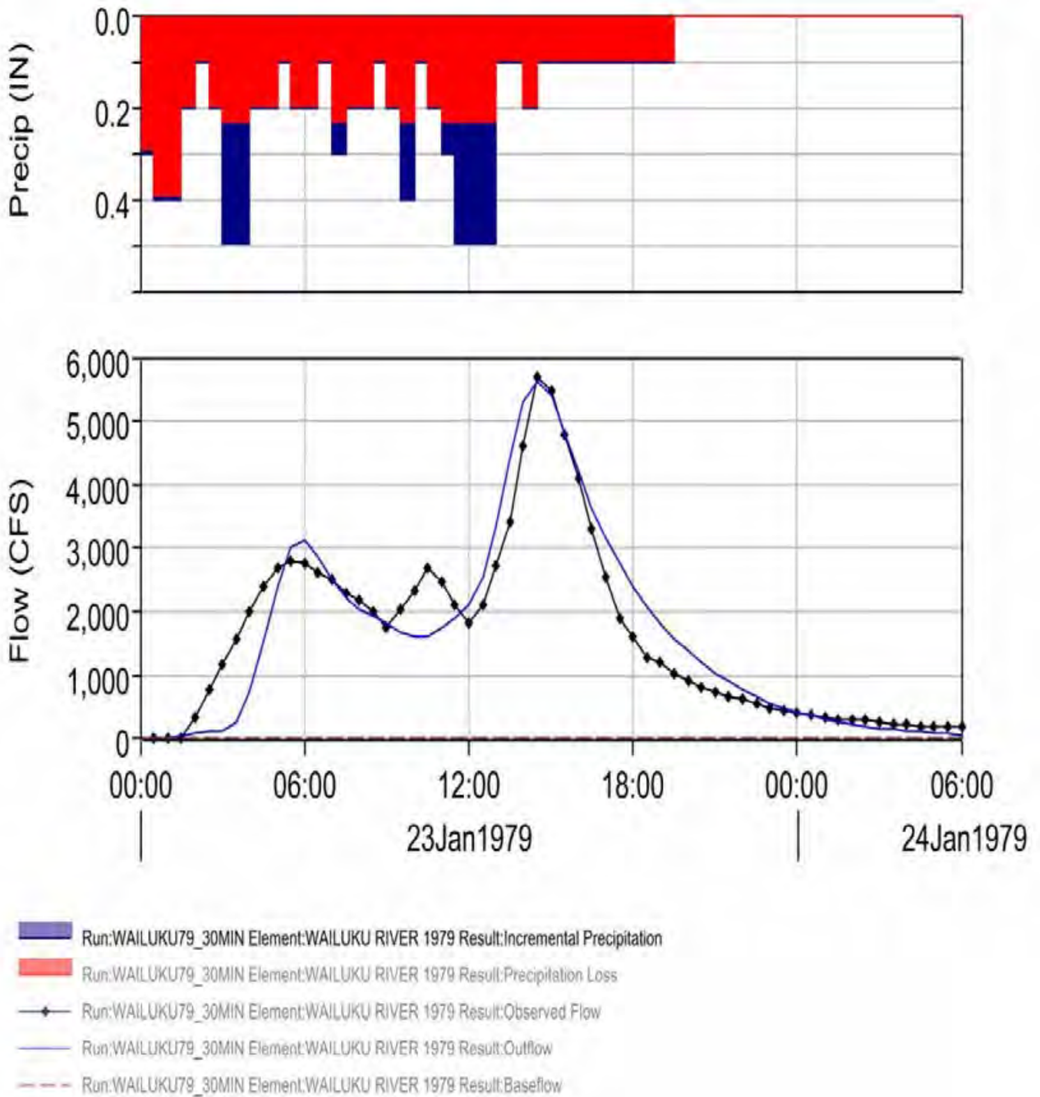


PALAI STREAM HILO, HAWAII

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- % ACE 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.

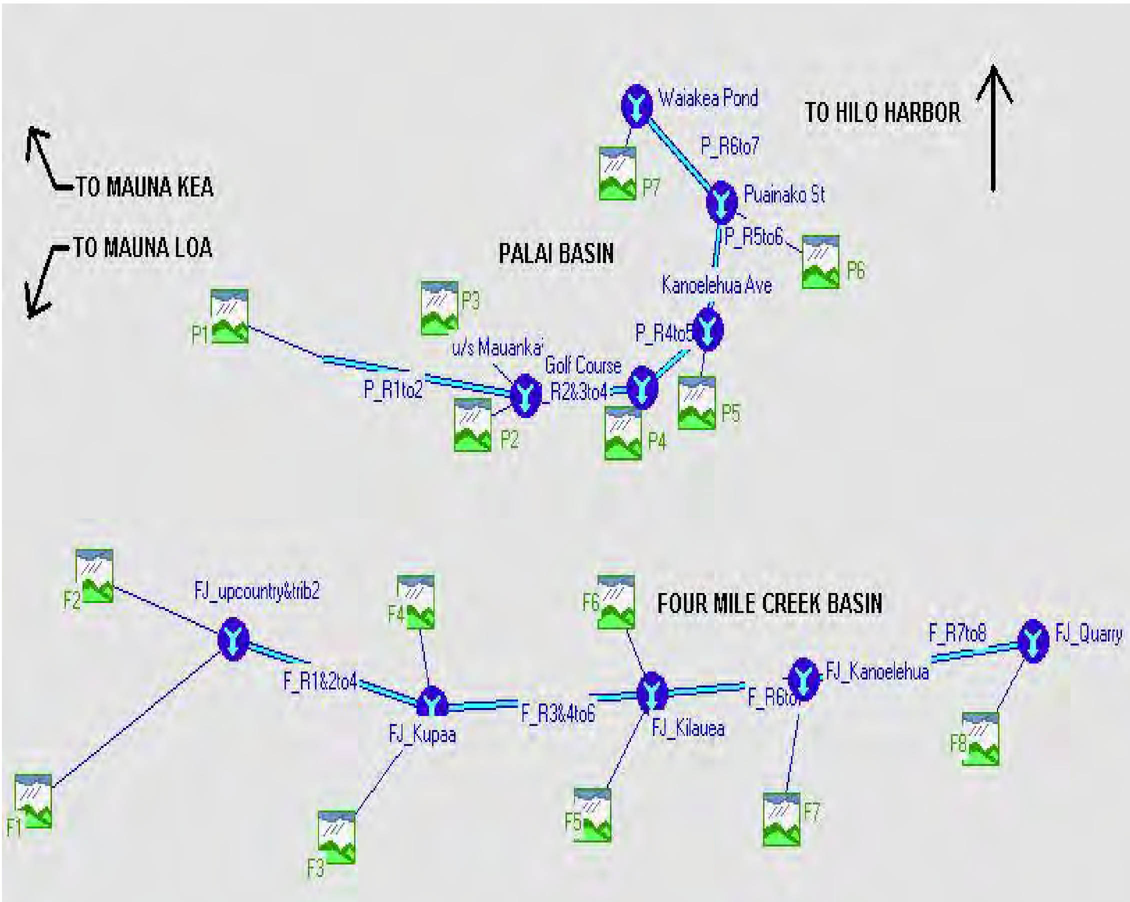
Once the Palai Basin (summation of P1 to P7) input matches output values for the USGS gage station 16701400, the same initial and constant loss rates are applied to Four Mile Creek. Baseflow is considered negligible as runoff occurs only as a direct response to high intensity rainfall. See Table 19 and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

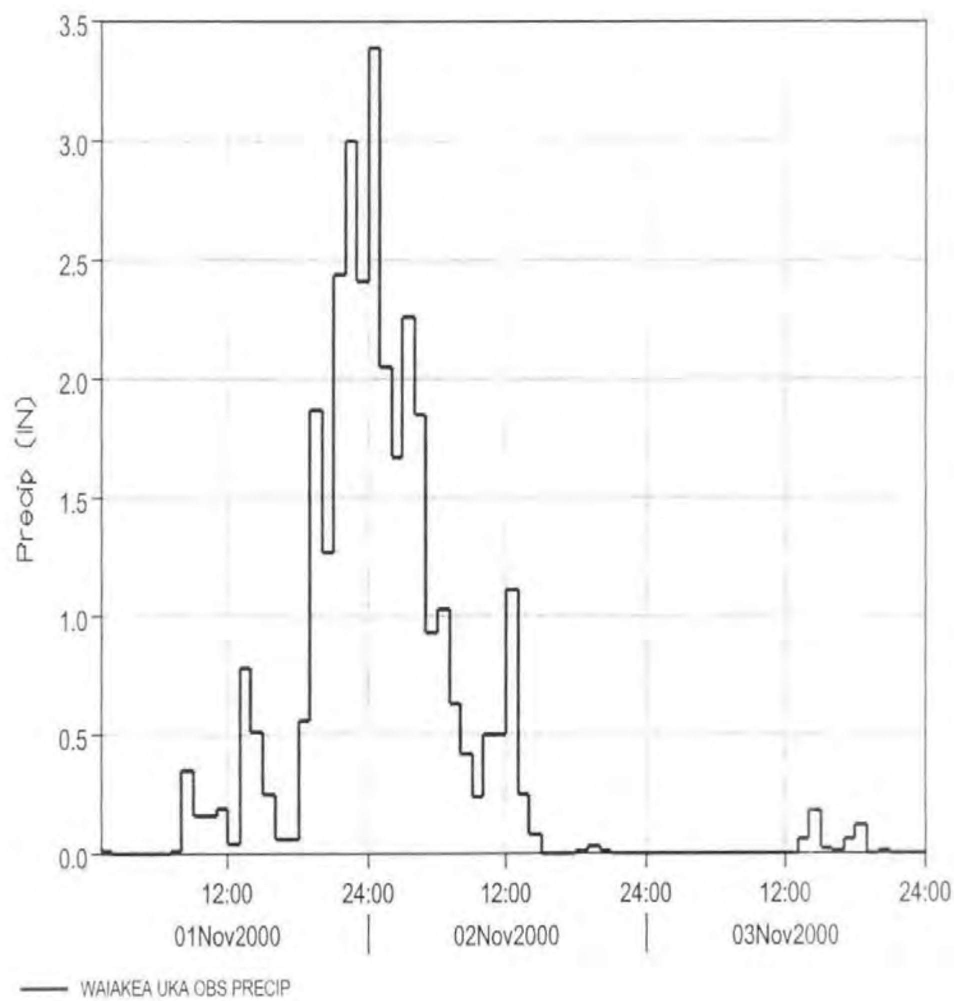
Description	Hypothetical Storm Frequency Flood					Nov 2000 Flood
	1%	2%	4%	10%	50%	
All Palai Sub-Areas Constant Loss Rate (in/hr)	5.14 in/hr	4.96 in/hr	4.64 in/hr	4.45 in/hr	3.28 in/hr	2.36 in/hr
J_Kanoelehua Ave Peak Flows (ft^3/s) DA=5.16 sq. mi.	1,860 ft^3/s	1,600 ft^3/s	1,360 ft^3/s	1,070 ft^3/s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

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% ACE (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% ACE (1-year) event in rainfall magnitude and about a 50% ACE (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% ACE (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% ACE 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% ACE 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% ACE 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% ACE (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% ACE 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 (mi^2)	Topographic Drainage Area (in 100 acres)	Plate 6 Discharge (ft^3/s)	Effective Drainage Area (mi^2)	Effective Drainage Area (in 100 acres)	Plate 6 Discharge (ft^3/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 (mi^2)	Topographic Drainage Area (in 100 acres)	Plate 6 Discharge (ft^3/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 (mi^2)	Topographic Drainage Area (in 100 acres)	Plate 6 Discharge (ft^3/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% ACE) but fit well with the 4% and 2% ACE events, and underestimated the other methods for the higher recurrence intervals. However, with the exception of the 50% ACE 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

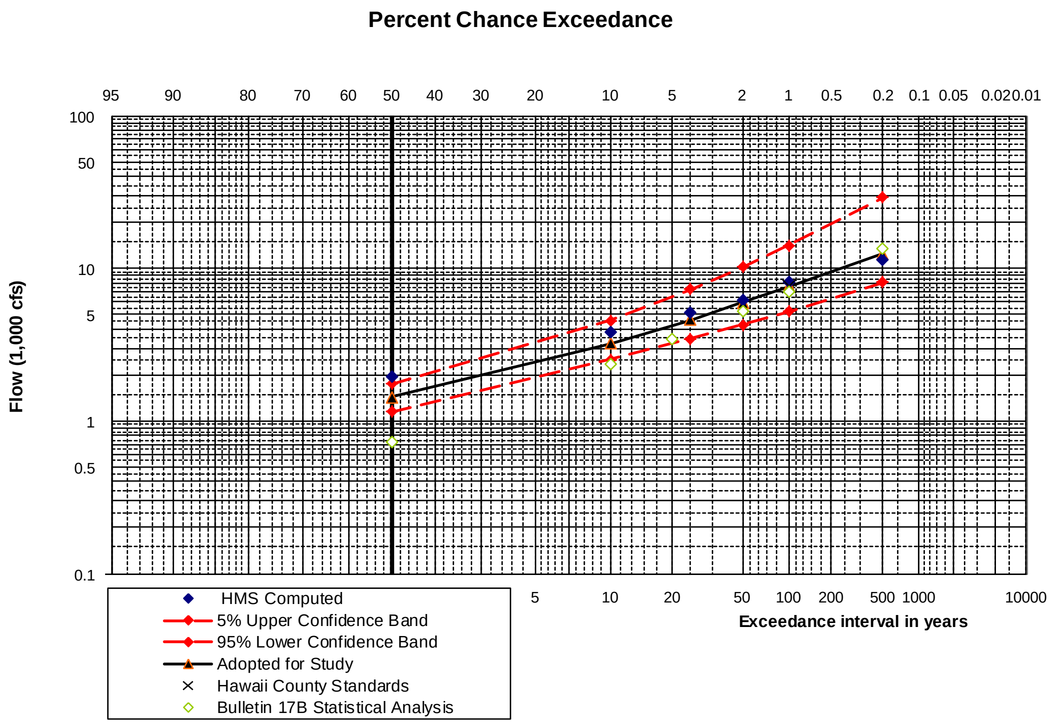
Table 33. Peak Flow Frequency comparison between Bulletin 17B analysis and HEC-HMS model at Station 16701300 Waiakea Stream, Hilo, Hawaii

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% ACE 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 of. 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).



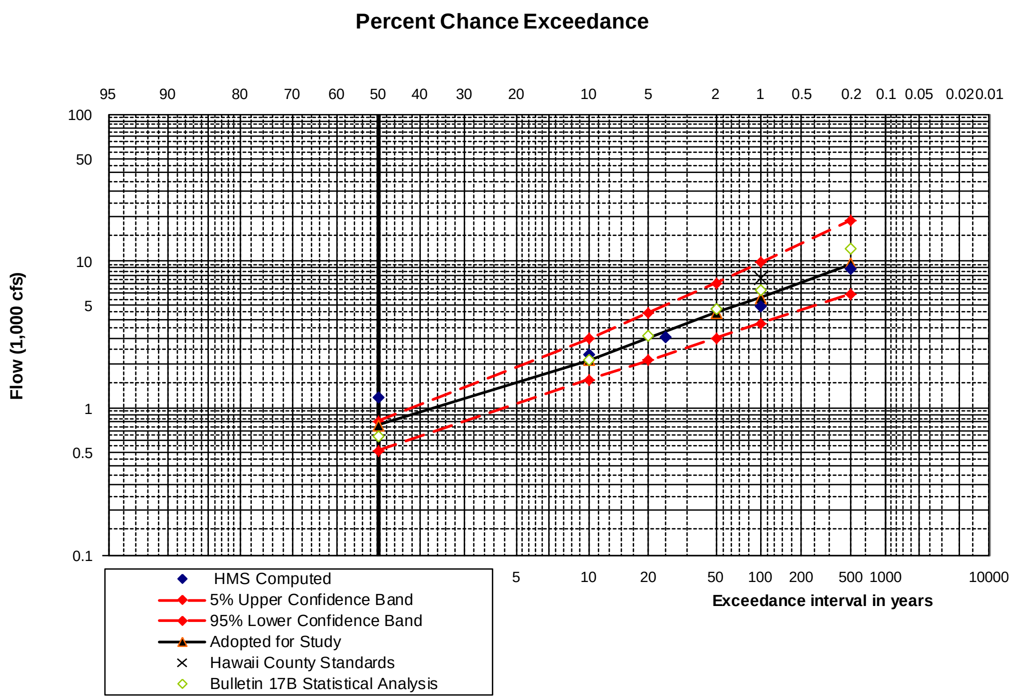
<u>HEC-HMS Conditional Probability Statistics</u>
logMean: 3.187
Skew: 0.839
log Std Dev: 0.238
HEC-HMS 90% confidence band statistics
computed with equations in Appendix 5, Bulletin 17B
(Interagency Committee on Water Data, 1982)

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



<u>HEC-HMS Conditional Probability Statistics</u>
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

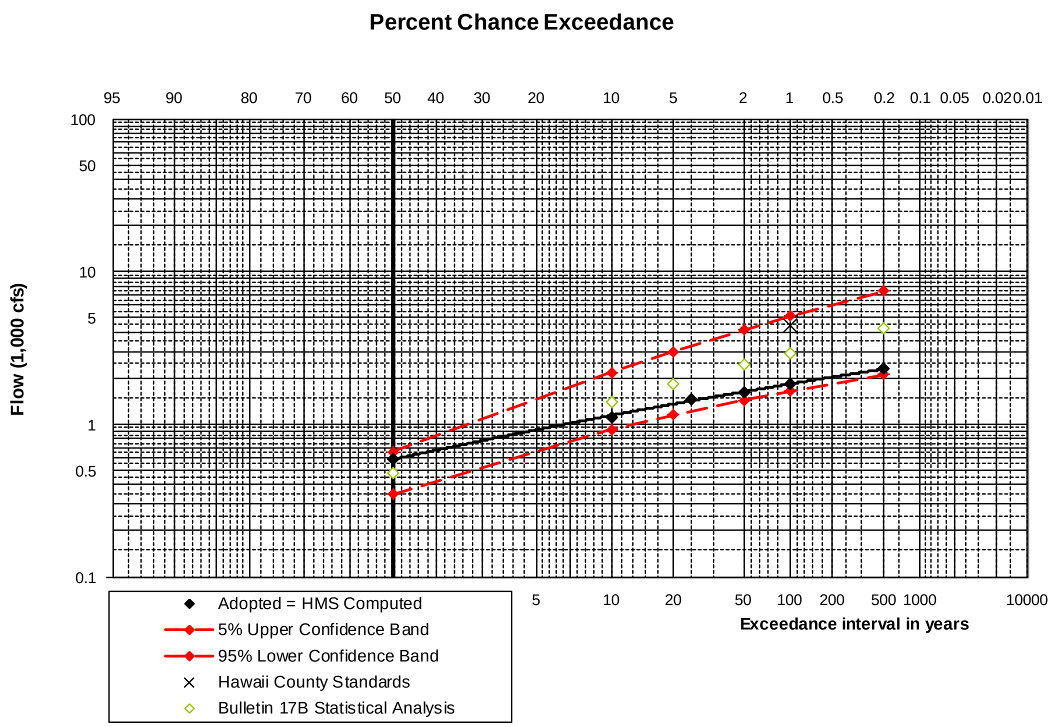
Figure 15. Waiakea Stream USGS Gage Station 16701300 Discharge Frequency Curve Comparison

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 ACE 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.



<u>HEC-HMS Conditional Probability Statistics</u>
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 16701400

U.S. ARMY CORPS OF ENGINEERS
HAWAII ENGINEER DISTRICT

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

Gage	DA (sq. mi.)	25-Jan-04		
		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

Gage	DA (sq. mi.)	12-Apr-04		
		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% ACE (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.

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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 2019

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 (ACE). 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 three measures that produce the most benefits. The TSP simulation is based on the 2% ACE (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 and the resulting hydraulic output data (flow rates, elevations, depths, inundation) could differ enough from the values presented in this report that modification to the extents and elevations of project measures (increases or decreases) may be necessary to maintain the 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 (ACE) 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 209 of the Rivers and Harbors Act of 1962, Public Law 87-874, as amended (76 U.S.C. 1197s; hereinafter Section 209). Section 209 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.

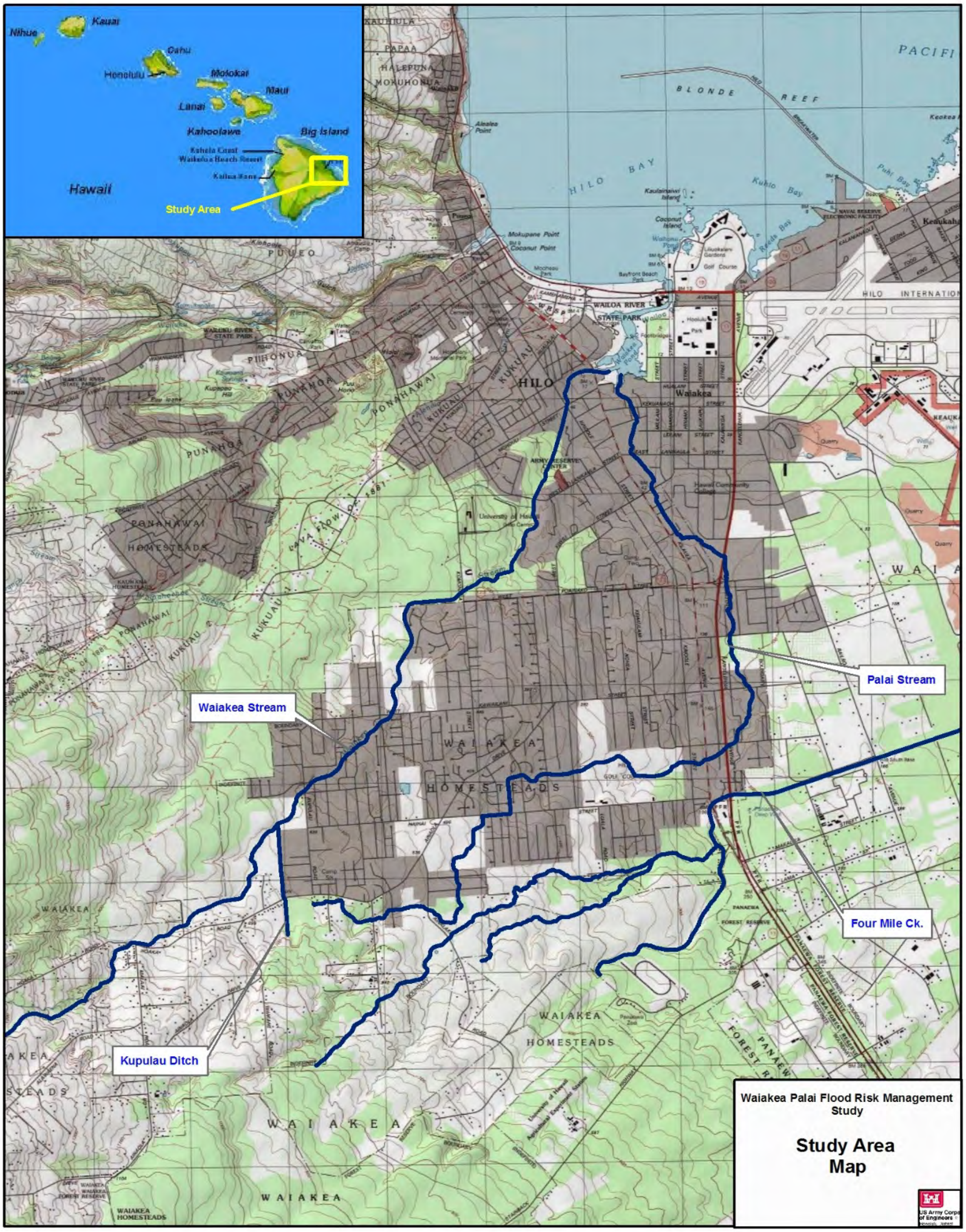

Figure 1. Study Area/Location Map

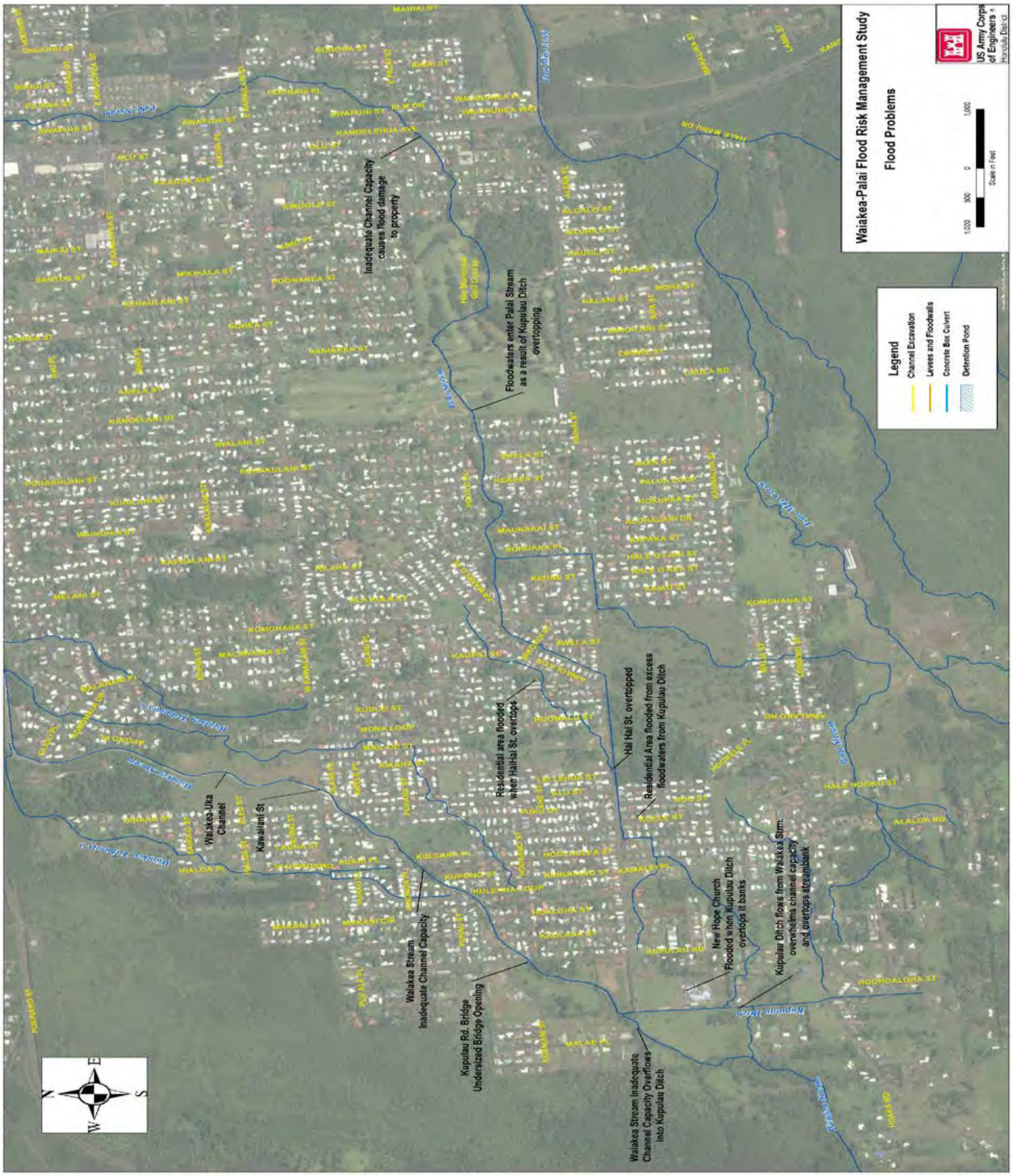

Figure 2. Flood Problem Locations

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.

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.

<u>2.4.1 Terrain Data</u>. 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% ACE (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.

Table1. 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
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.

2.5.3 Boundary Conditions. 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.

Table 3.
Flow Comparison at USGS Stream gage 16701400

Event	Model Results		Adopted Flows from Hydrologic Analysis
ACE	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

ACE=Annual Chance Exceedance
Elev. = elevation
cfs = cubic feet per second

Table 4.
Flow Comparison at USGS Stream gage 16701300

Event	Model Results		Adopted Flows from Hydrologic Analysis
ACE	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

ACE=Annual Chance Exceedance
Elev. = elevation
cfs = cubic feet per second

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.

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
ACE	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

ACE=Annual Chance Exceedance
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
ACE	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

ACE=Annual Chance Exceedance
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% ACE 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% ACE 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% ACE storm event. Flows greater than the 20% ACE 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% ACE storm with some areas capable of containing a 4% ACE 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

Figure15.
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% ACE storm event. However, the ditch is subject to significant backwater from Waiakea Stream which reduces the effective channel capacity to approximately a 20% ACE 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 routs 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 from Station XX

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% ACE 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% ACE event where it receives flow that overtops the right bank of Kupulau Ditch. At the 0.2% ACE 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 1 and 38). 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% ACE 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% ACE events are shown in figures 40-42.

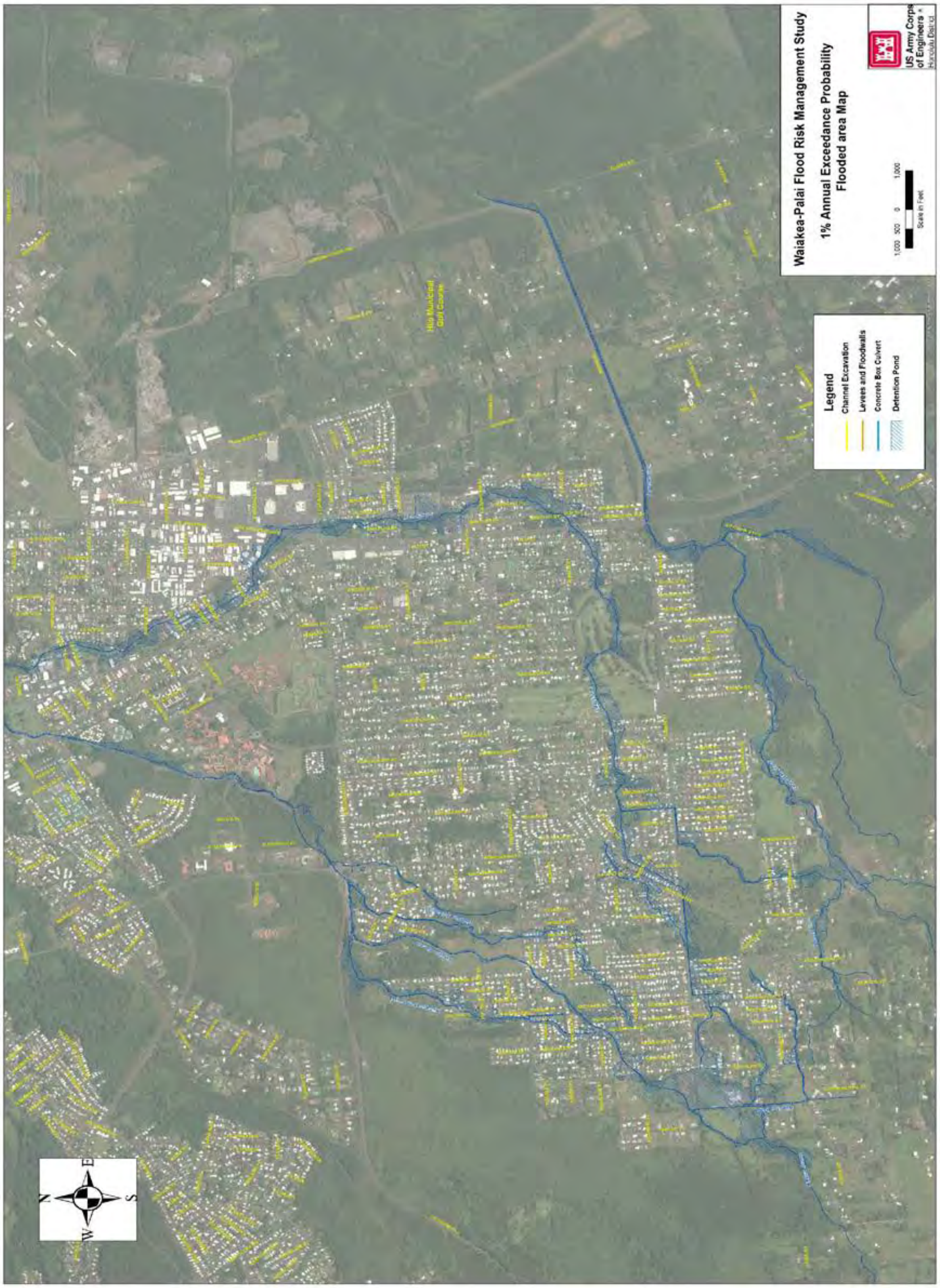

Figure 38. 1% ACE Without Project Flooded Area Map

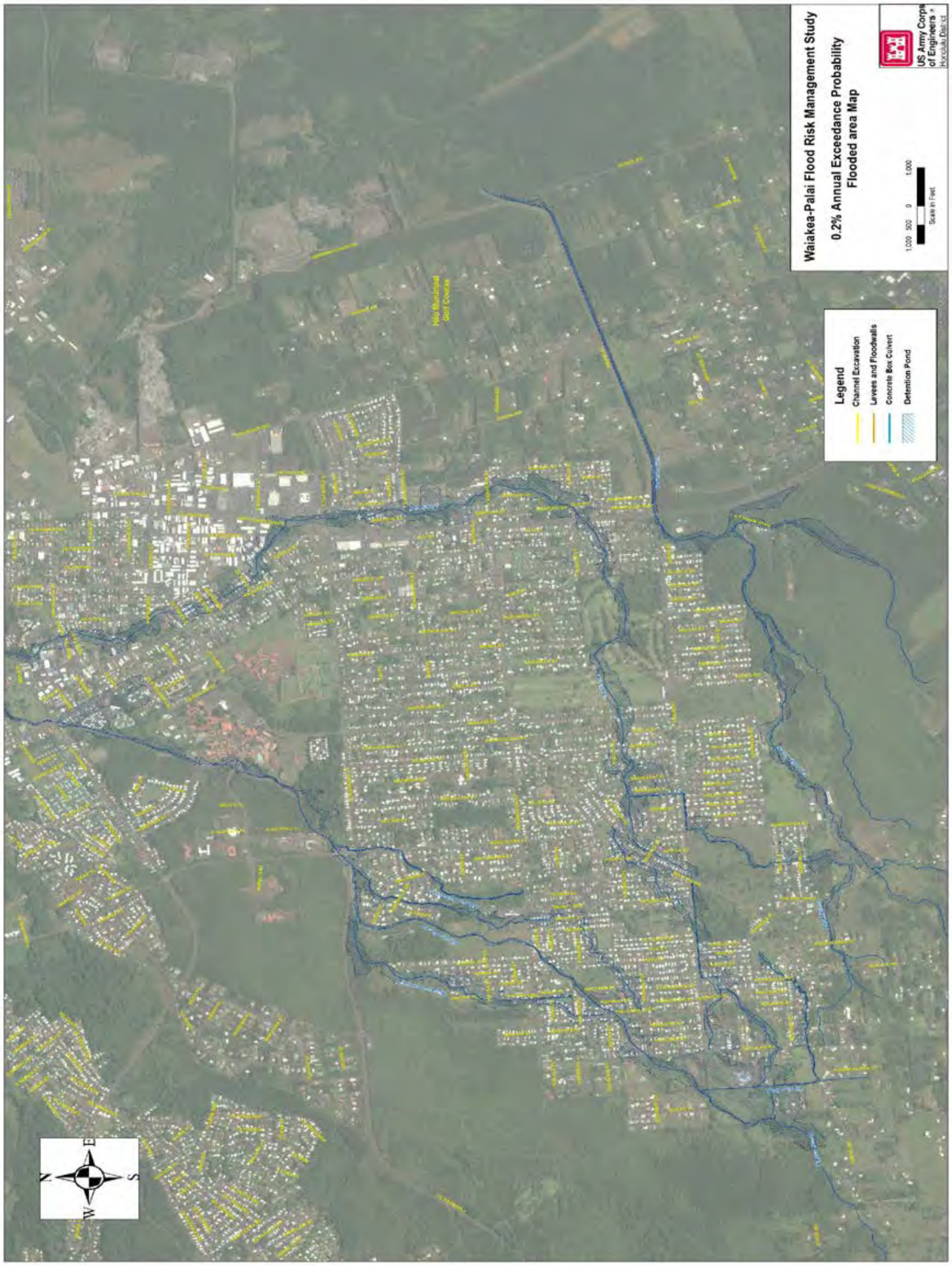

Figure 39. 0.2% ACE Without Project Flooded Area Map

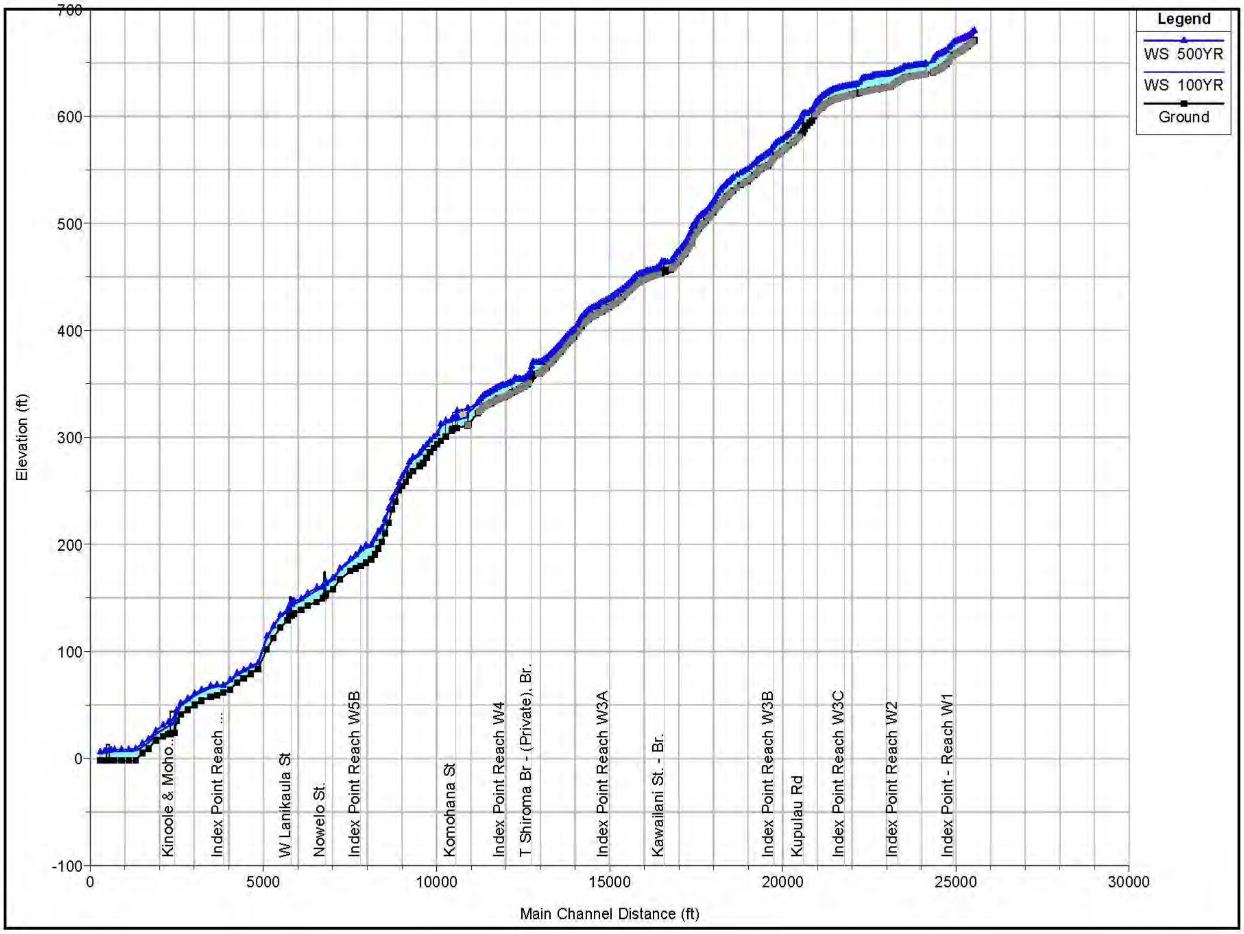

Figure 40. Waiakea Stream Without Project Profile

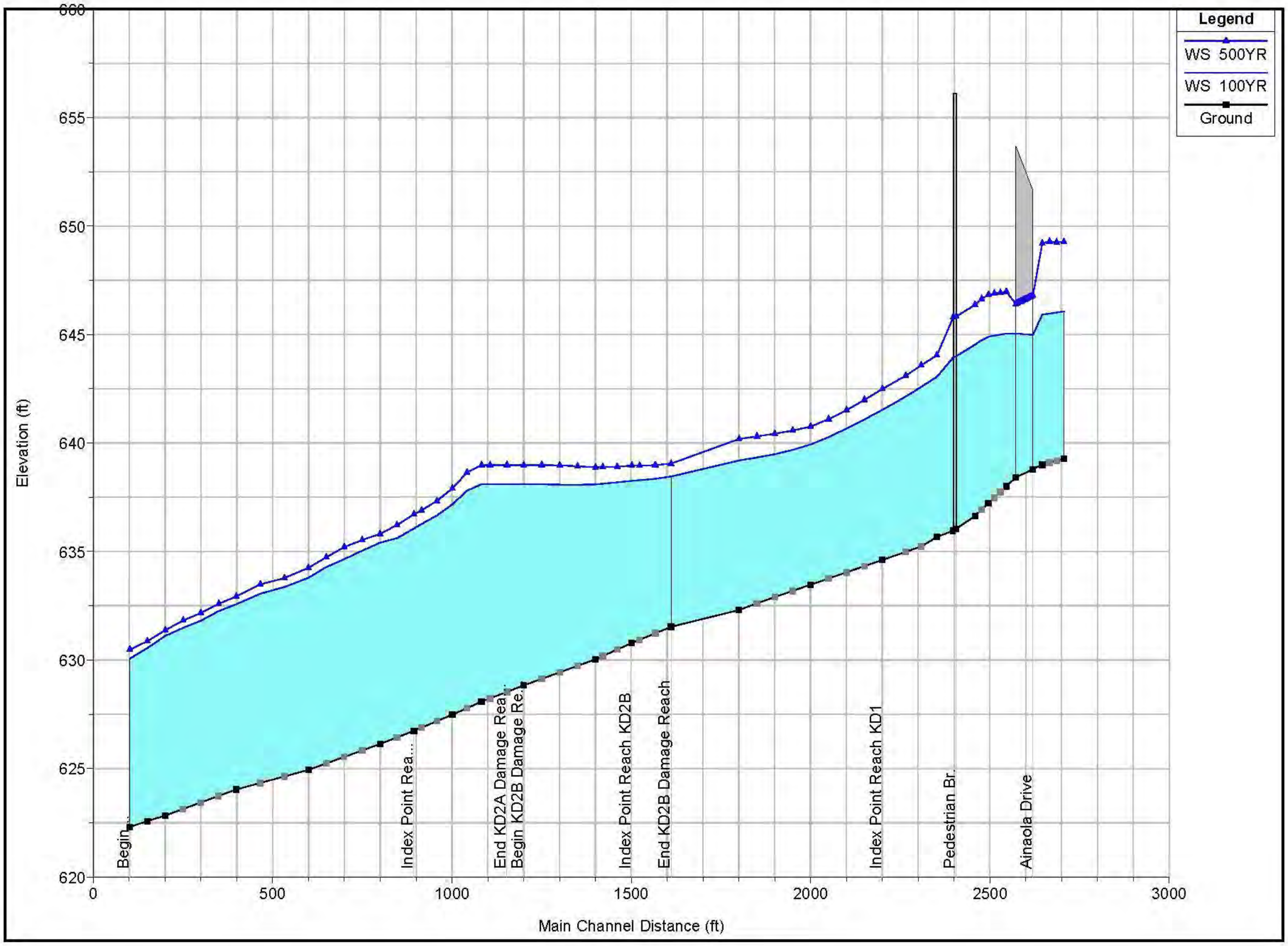

Figure 41. Kupulau Ditch Without Project Profile

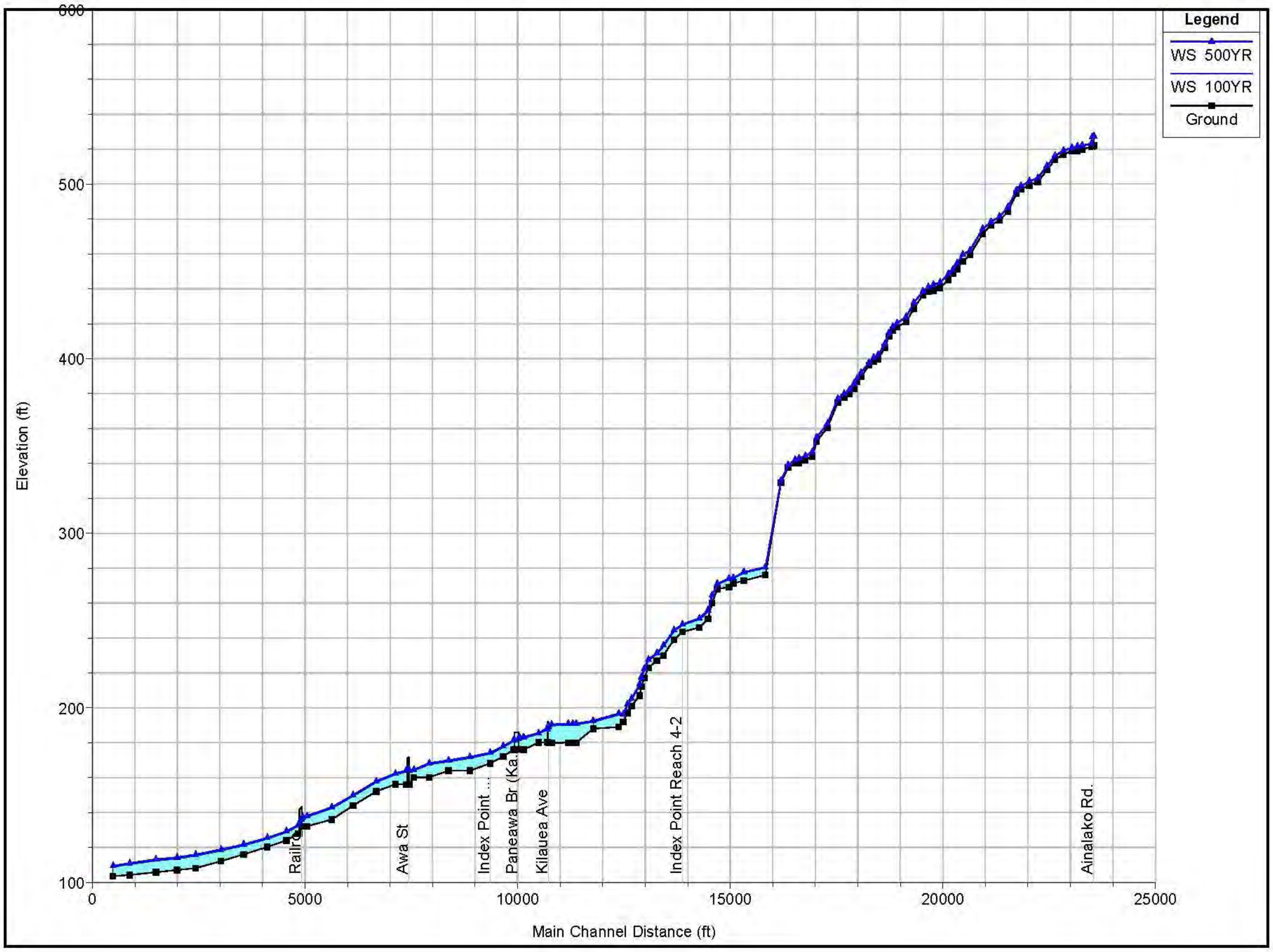

Figure 42. Four Mile Creek Without Project Profile

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					
ACE	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.

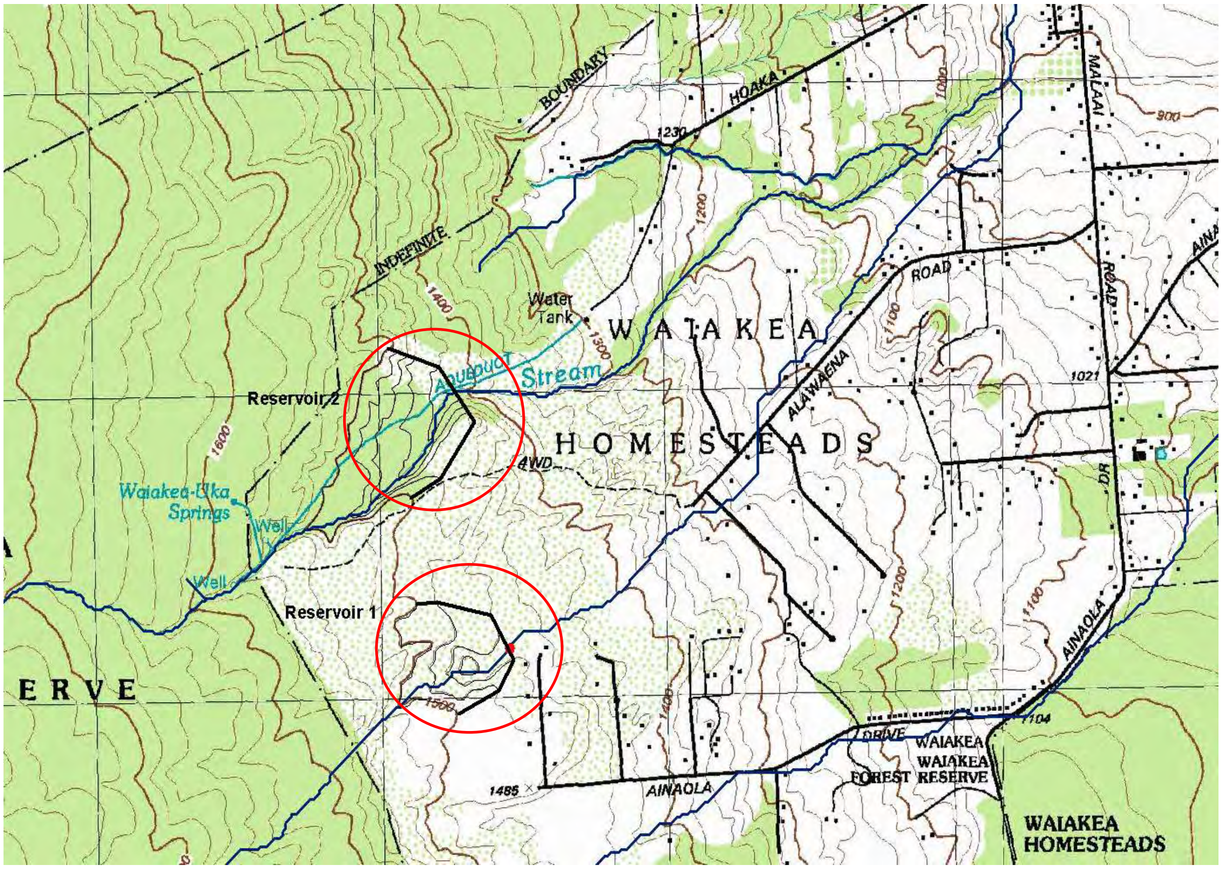

Figure 43. Upper Waiakea Basin Detention Basins Location

<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% ACE 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.

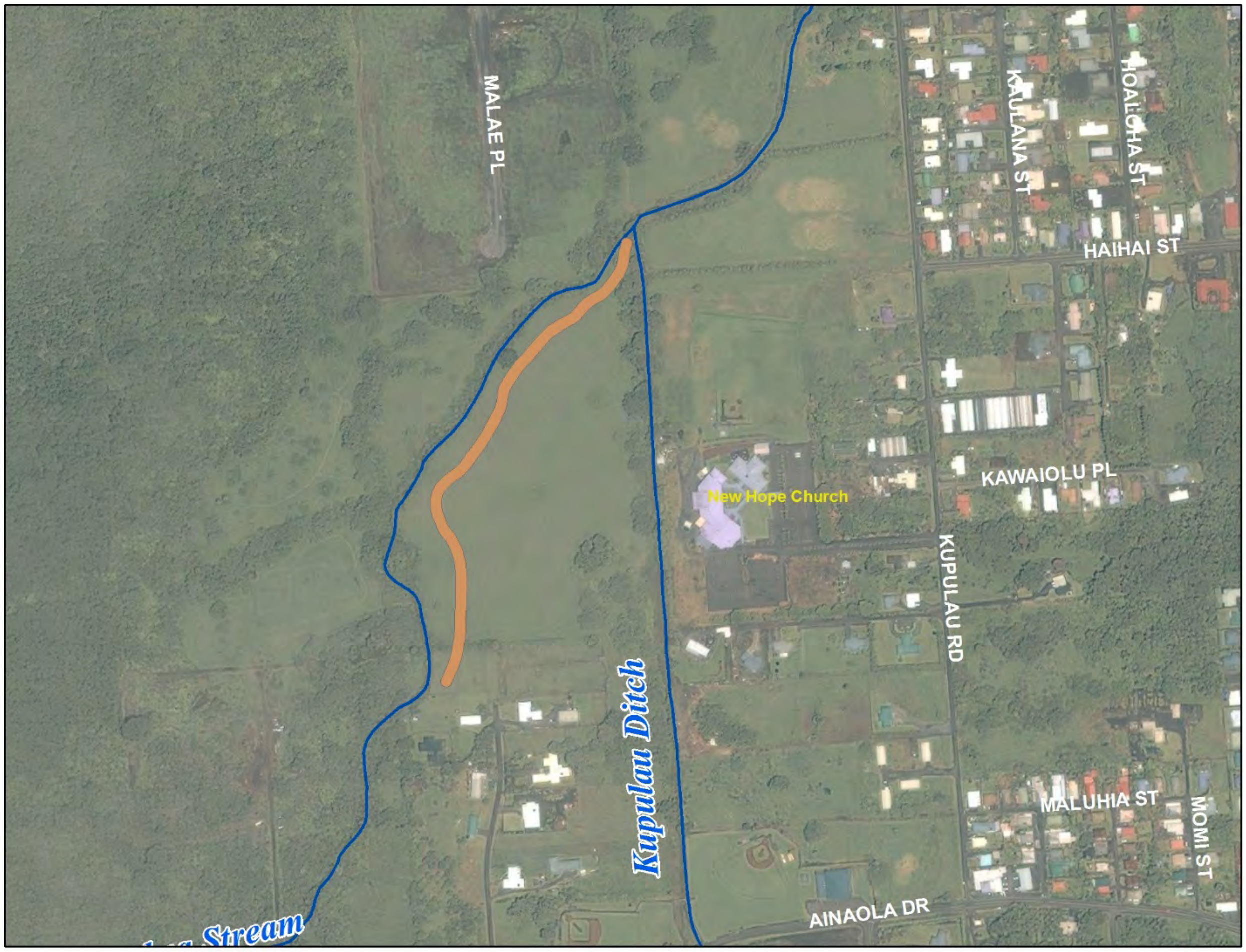

Figure 44: Location of Upper Waiakea Levee #1

<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.

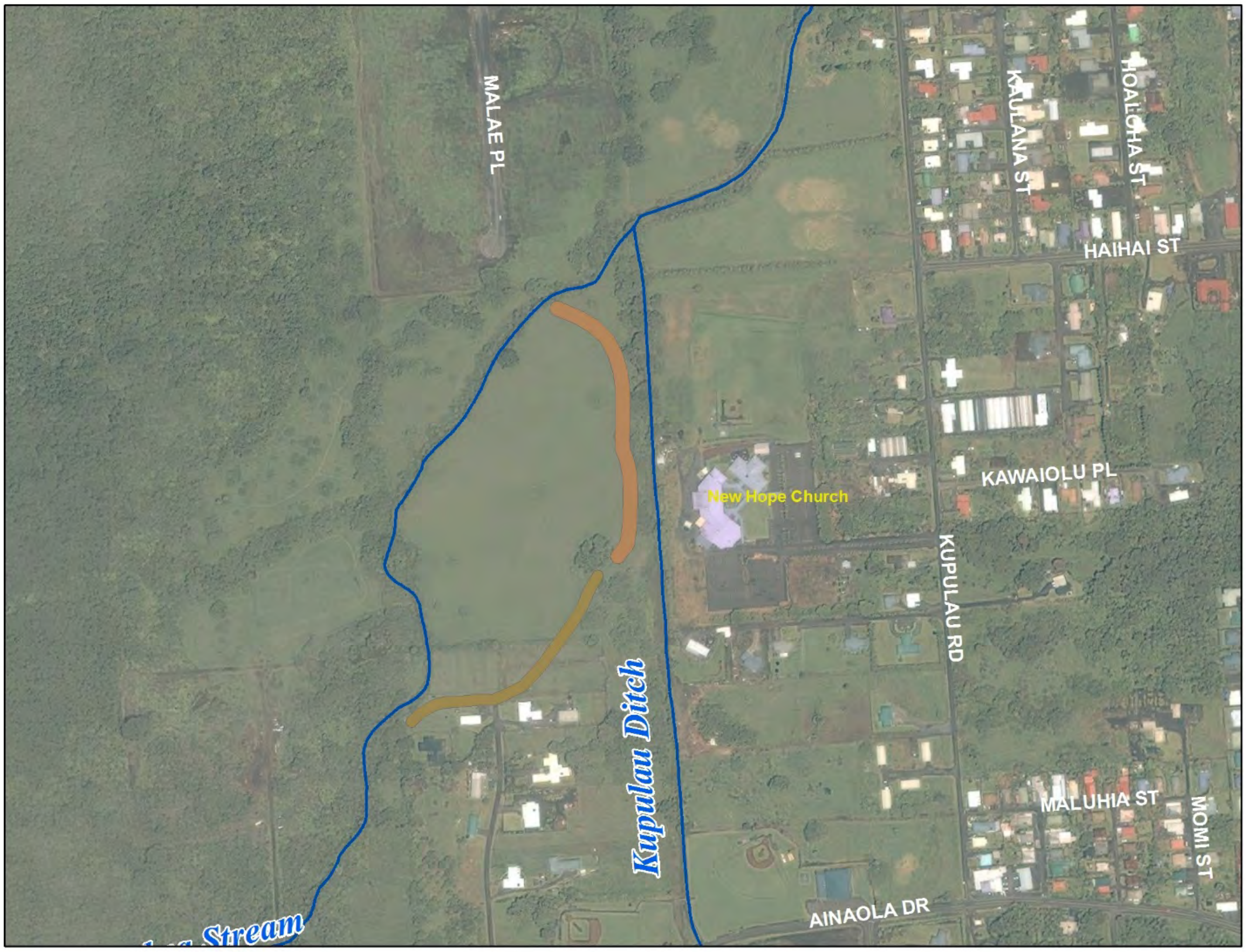

Figure 45. Location of upper Waiakea Levee #2

<u>6.2.4 Kupulau Ditch Channel Enlargement</u>. 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% ACE 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% ACE 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% ACE 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% ACE 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 begining 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% ACE 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.

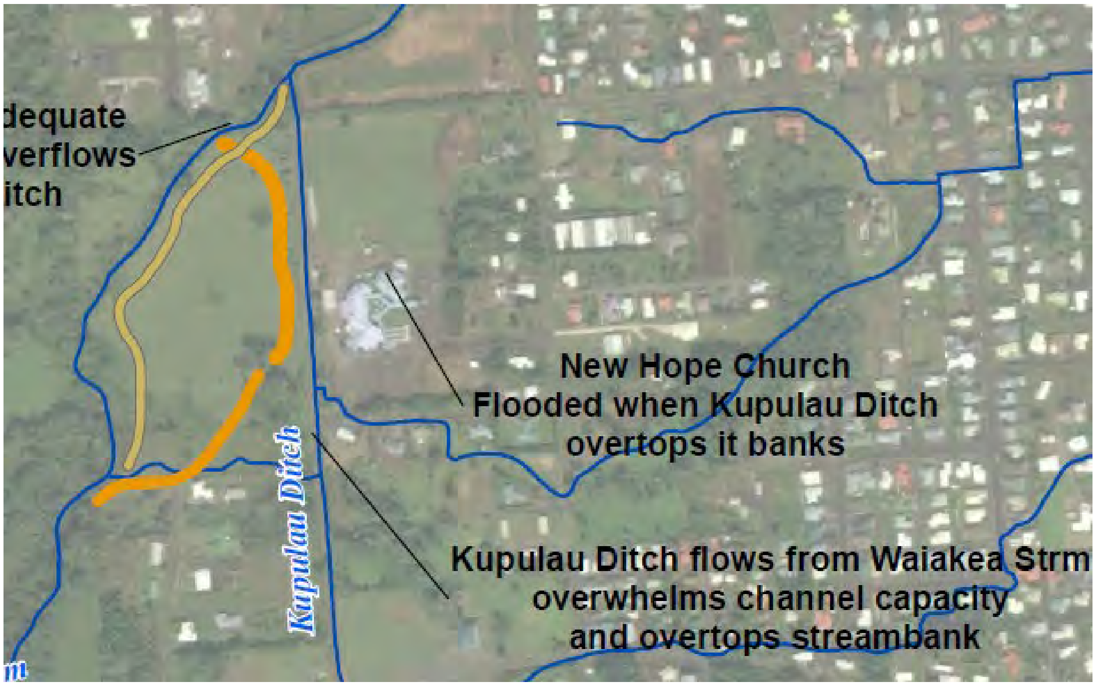

Figure 47. Location of Kupulau Ditch Detention I

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

<u>6.2.10 Waiakea Stream Floodwalls</u>. 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.

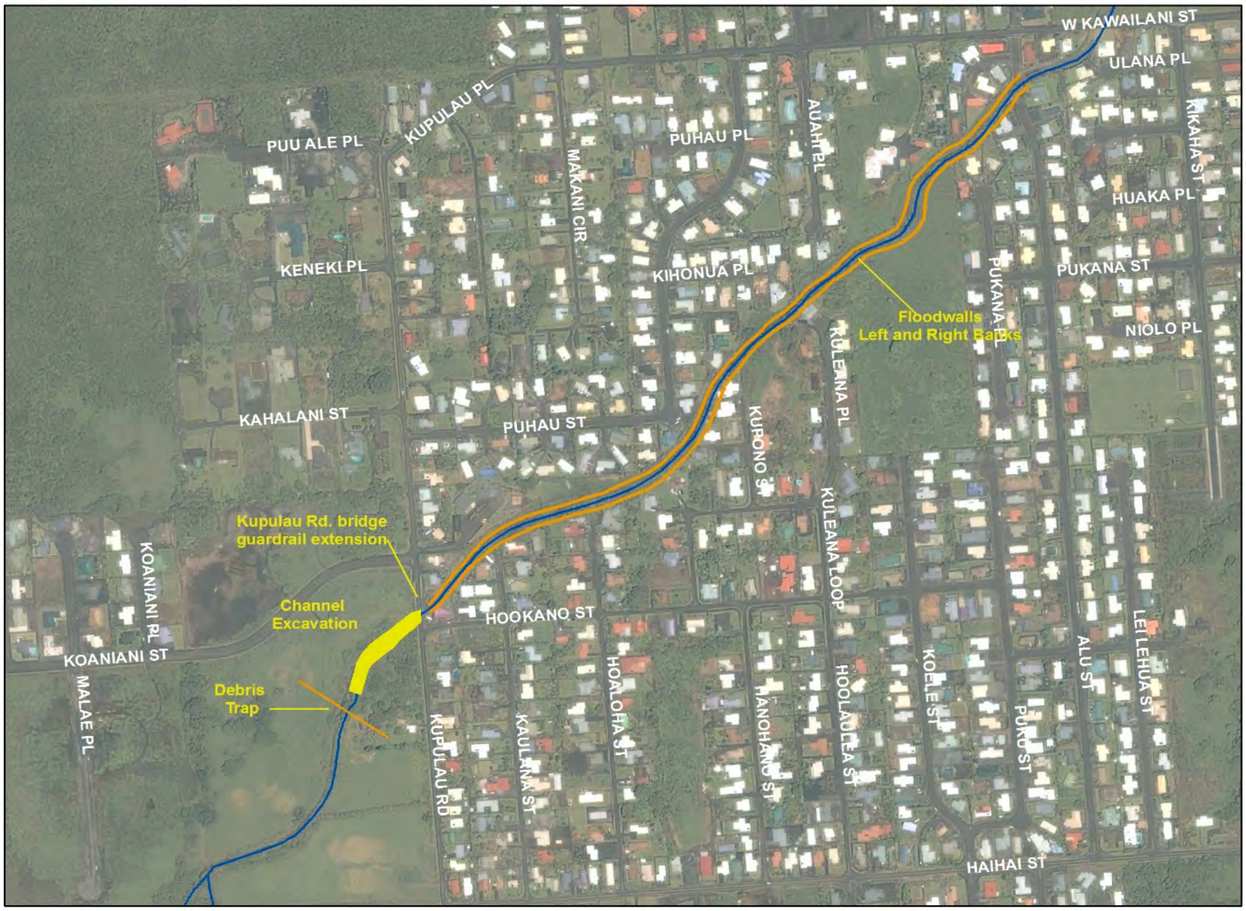

Figure 52. Location of Waiakea Stream Floodwalls

<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.

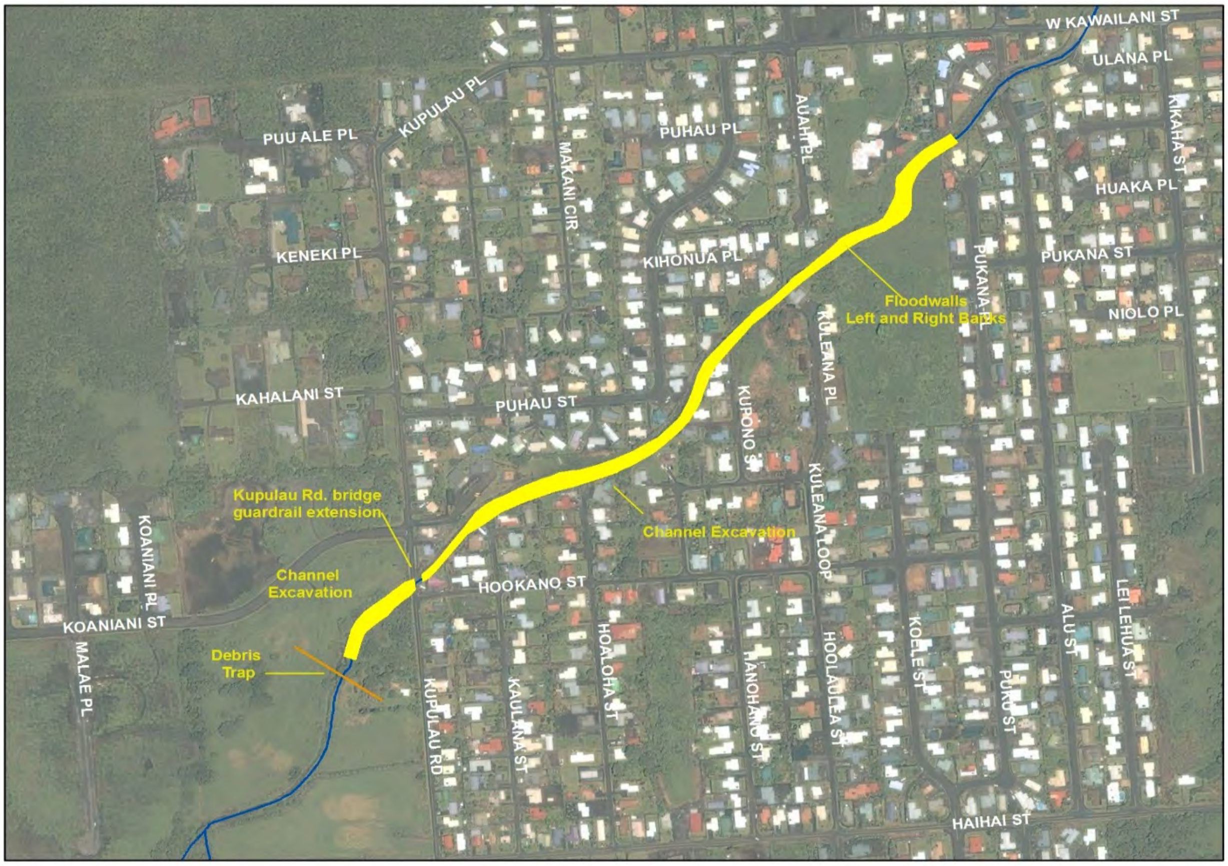

Figure 53. Location of Waiakea Stream Combination of Floodwalls and Channelization

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.

6.3.1 Hilo Municipal Golf Course Diversion. 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% ACE 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% ACE 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% ACE 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% ACE 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% ACE 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.

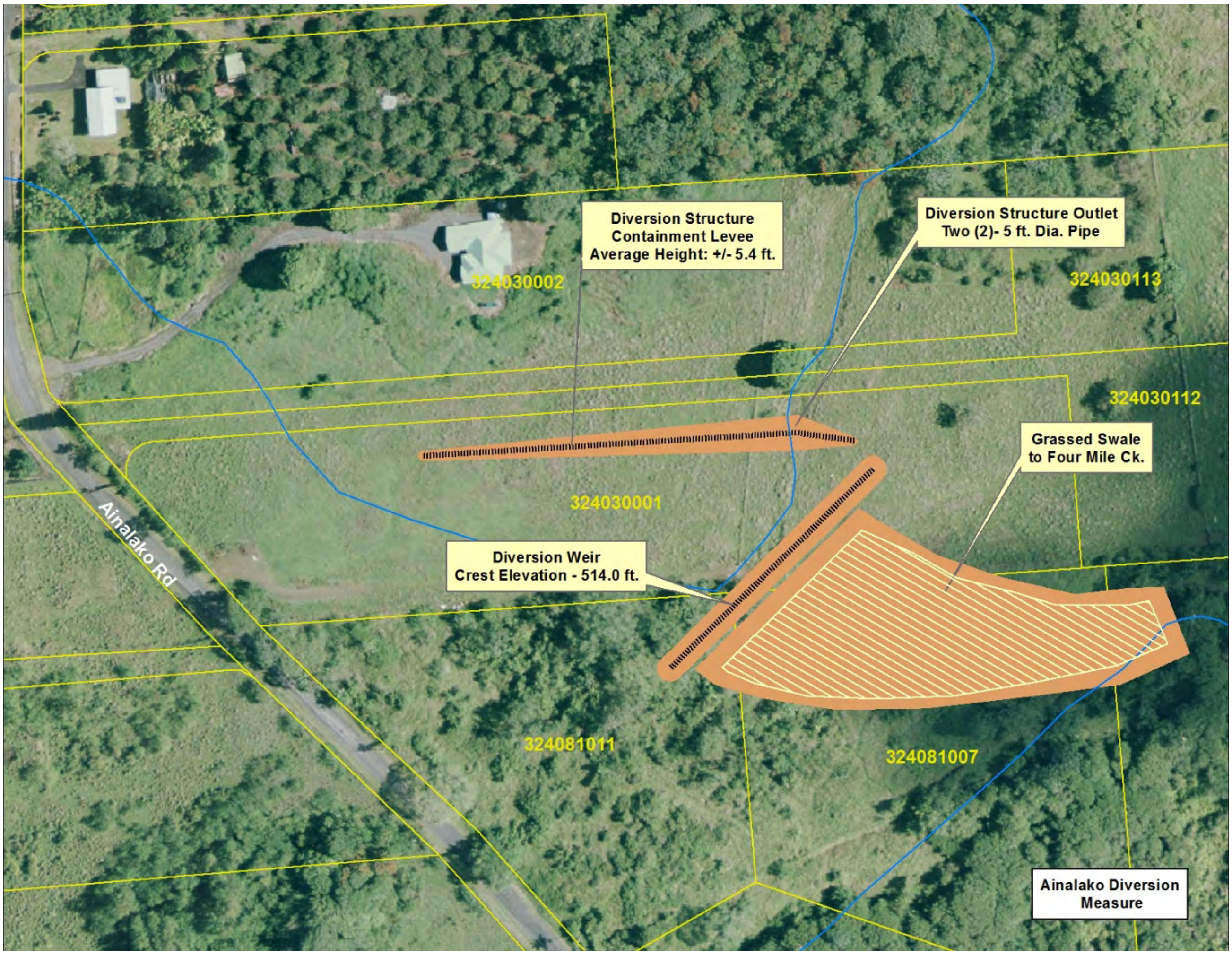

Figure 57. Location of Ainalako Rd Diversion

<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% ACE 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.

Four Mile Creek Impacts

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 not 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% ACE 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% ACE 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.

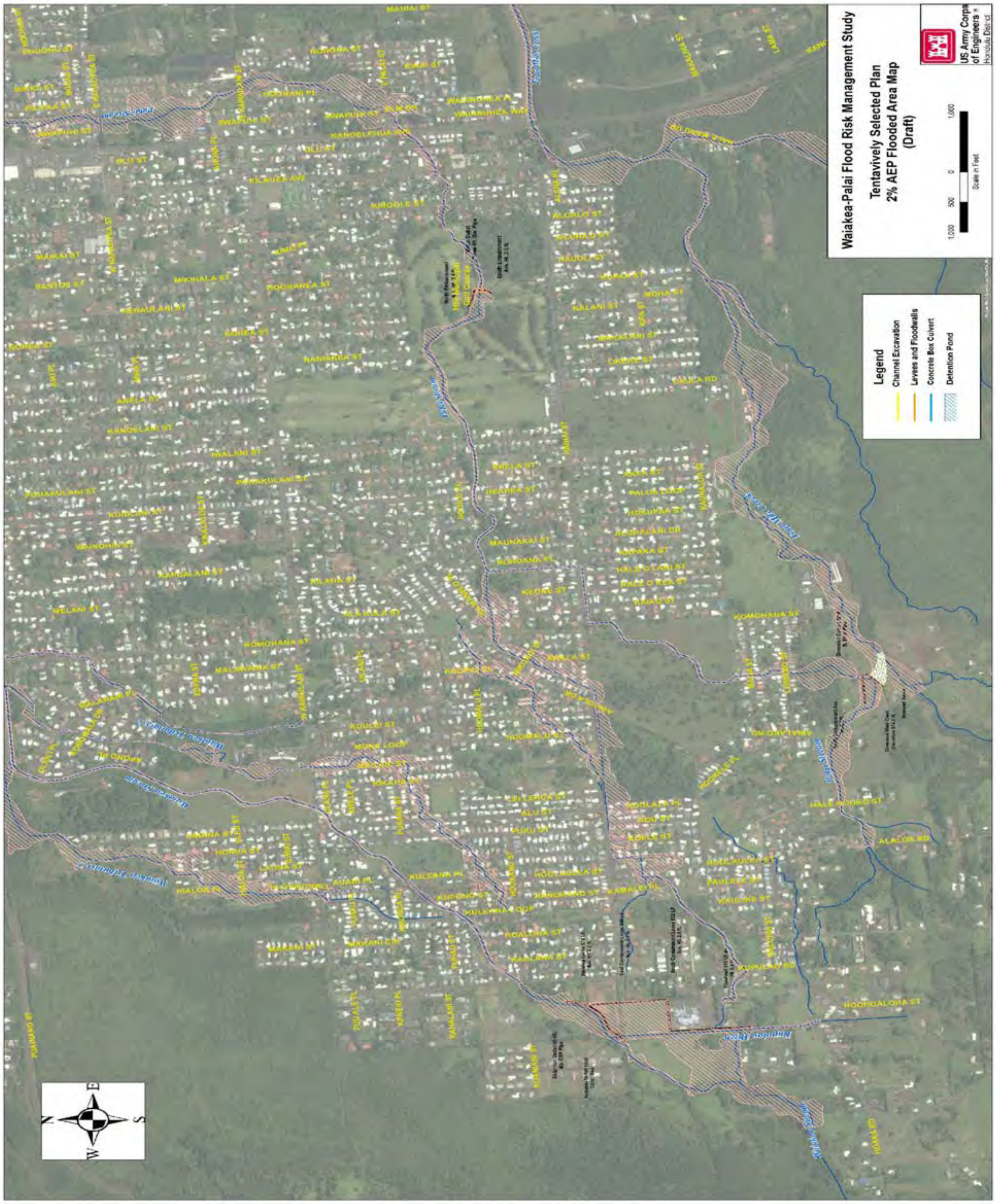

Figure 58. With Project Flooded Area Map (Draft)

7.5 WITH PROJECT WATER SURFACE PROFILES (Preferred Alternative)

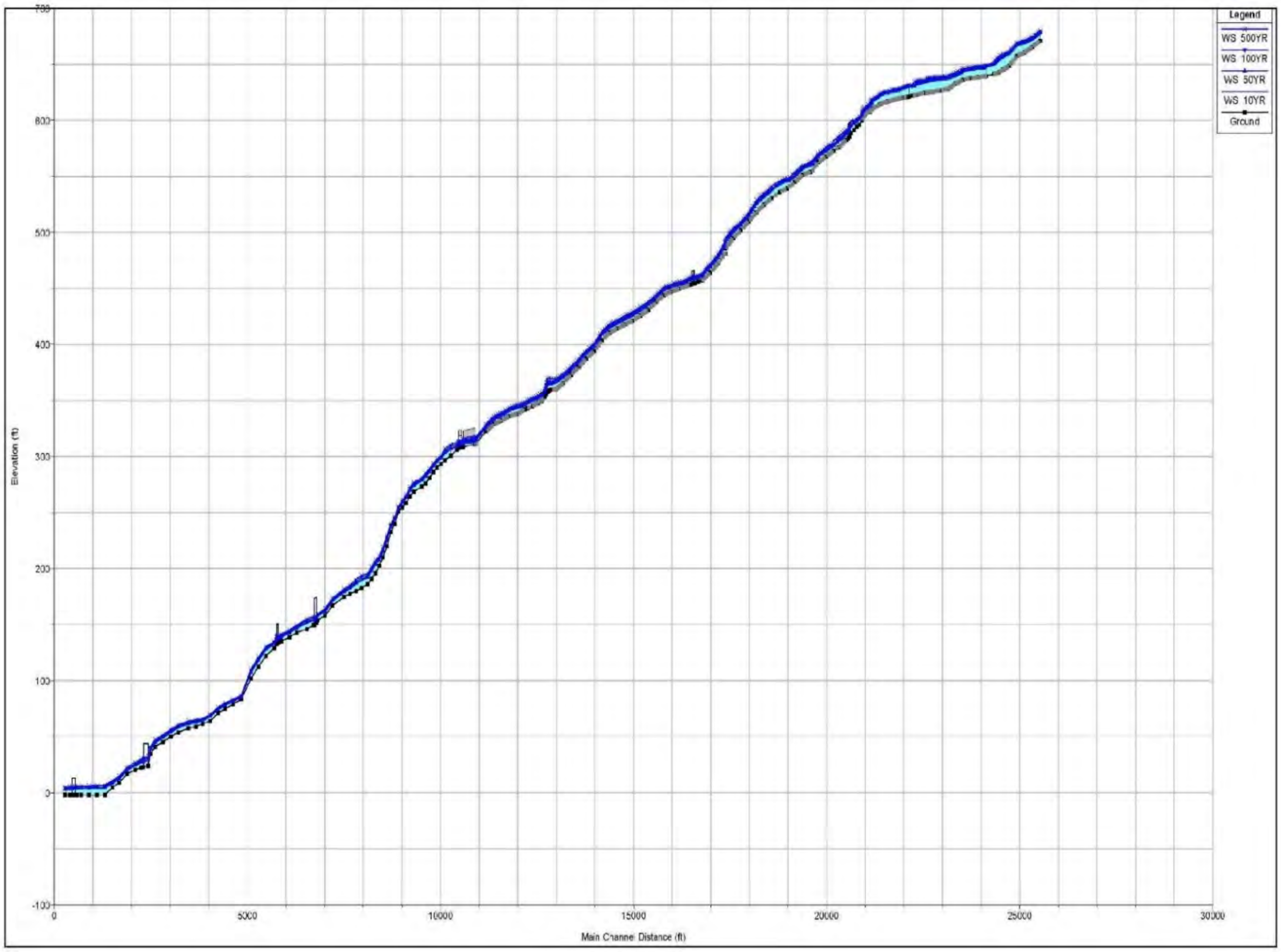

Figure 59. With Project Waiakea Stream Water Surface Profiles

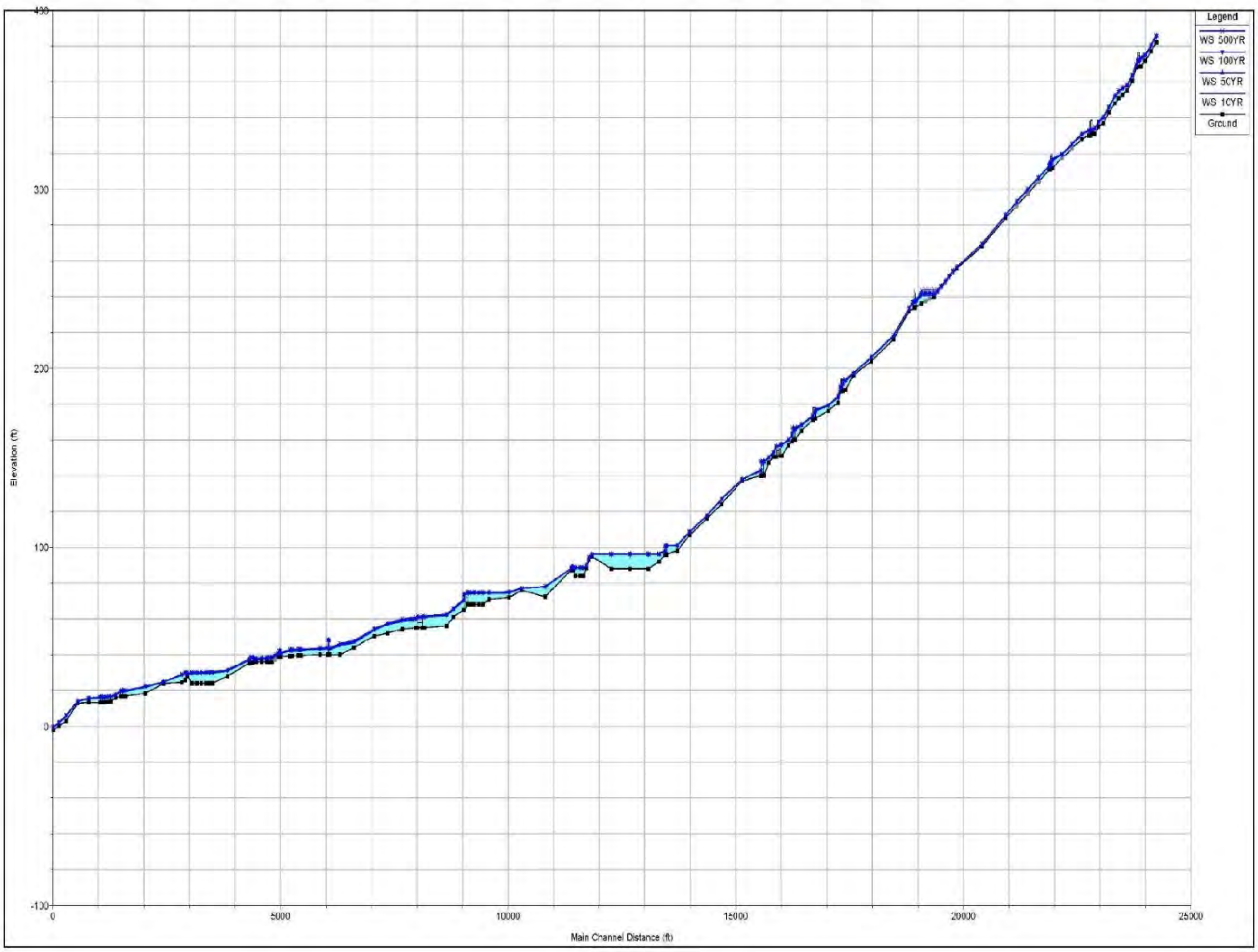

Figure 60. With Project Palai Stream Water Surface Profiles

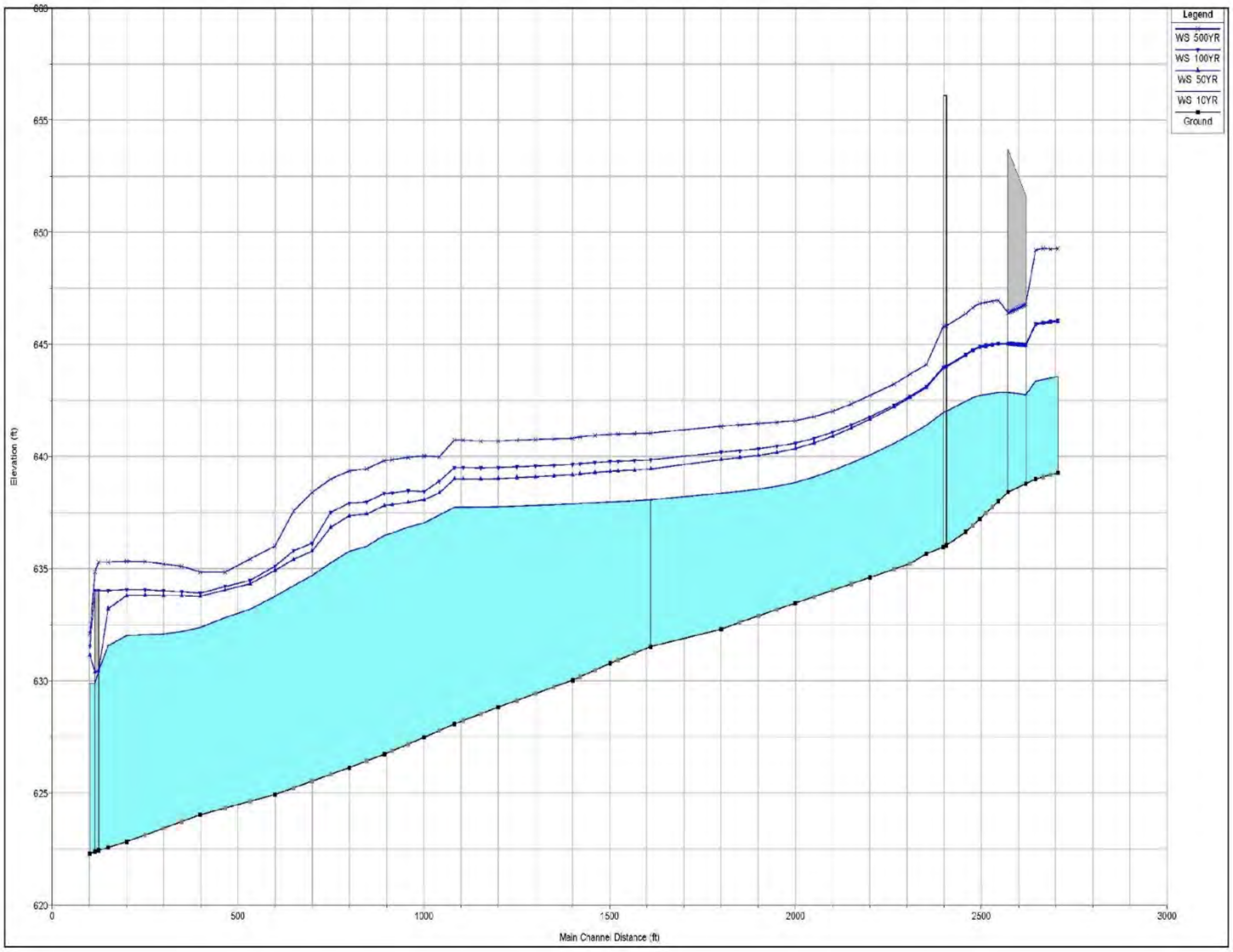

Figure 61. With Project Kupulau Ditch Water Surface Profile

8. SUMMARY

This appendix presented a discussion on creating a HEC-RAS model of the study area to simulate the flood problem that would result from rainfall storm events over the Waiakea Palai, Four Mile Streams and their tributaries drainage basin. This model shows the impact of flooding would have on the Waiakea and Palai Streams and their tributaries, and overflow areas. This study examines the flood inundation resulting from eight flood frequency events.

Discharge estimates from eight frequency storms – the 50%, 20%, 10%, 4%, 2%, 1%, 0.5%, and 0.2% Annual Chance Exceedance (ACE) events were analyzed with HEC-RAS. Input discharge data for the model was obtained from the results of the Hydrologic Appendix and field observations. The model was used to develop reasonable estimates of the flood magnitude depths and damages that would result.

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.

A number of flood risk management measures were created and analyzed with the HEC-RAS model. Combinations of measures (or alternatives) were analyzed, model results were used 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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WAIAKEA-PALAI STREAMS
Hilo, Island of Hawaii, Hawaii

CONTINUING AUTHORITIES PROGRAM SECTION 205
FLOOD RISK MANAGEMENT

Appendix C: Environmental Resources

MAY 2019

US Army Corps of Engineers®
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Appendix C: Environmental Appendix

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

May 2019

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.

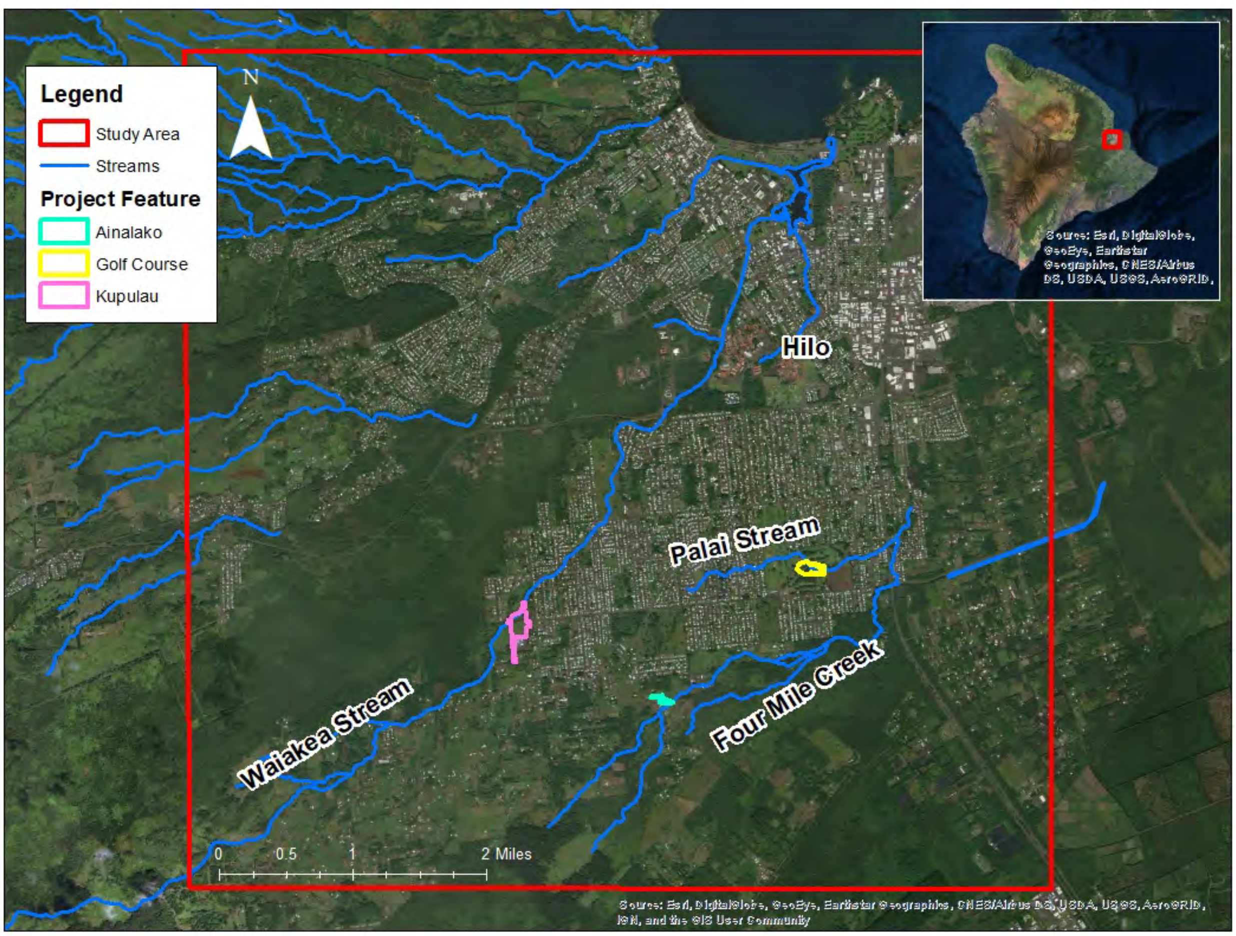
1 INTRODUCTION

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). 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 three stand-alone alternative measures (Kupulau Ditch Levee/Floodwall, Hilo Municipal Golf Course Detention, and Ainalako Diversion) and an alternative combining all the three 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

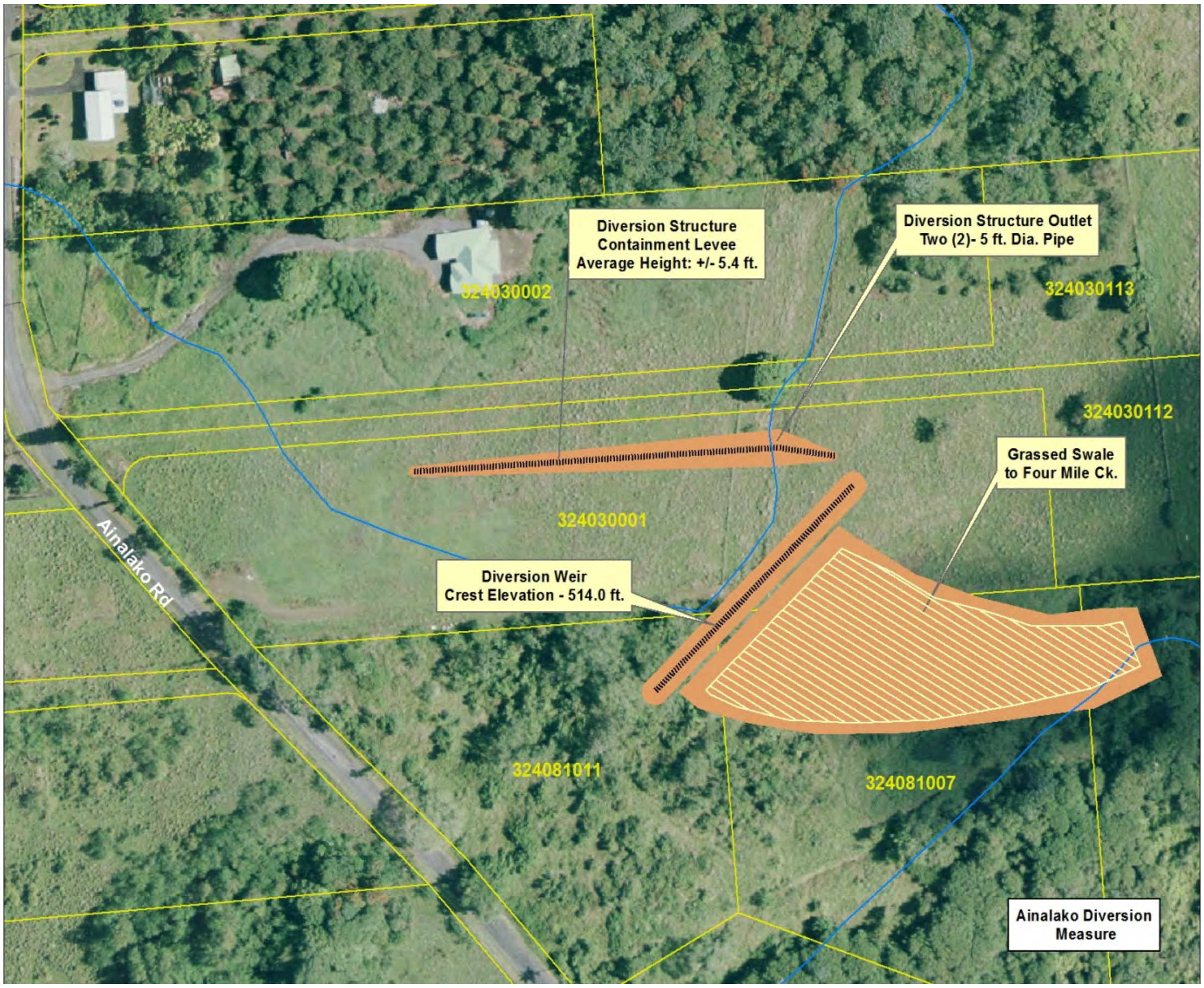
The golf course alternative includes the construction of a detention basin in the Hilo Municipal Golf Course to attenuate flow and reduce damage to properties in the downstream reaches of Palai Stream (***Figure 3***). A 21 acre-foot detention pond would be constructed at the Hilo Municipal Golf Course 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

3.3 AINALAKO DIVERSION

The main component of this FRM feature is the construction of a diversion structure to divert excess flows into Four Mile Creek (***Figure 4***). 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.

Figure 4: Aianalako Diversion



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. Four Mile Creek drains into the undeveloped low lands near the Hilo Drag Strip south of Hilo International Airport.

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*.) requires Federal agencies to protect waters of the U.S. The regulation implementing the Act disallows the placement of dredged or fill material into waters of the U.S. The Sections of the CWA that apply to this study include Section 401 regarding discharges to waterways and Section 404 regarding fill material in waters or wetlands.

The Clean Water Rule defines Jurisdictional Waters of the U.S. (WOTUS) as:

- Navigable waters,
- Interstate waters,
- Territorial seas,
- Impoundments,
- Tributaries to the traditional navigable waters (water features with beds, banks, and ordinary high water mark (OHWM) , and flow downstream, except for wetlands and open waters without beds, banks, or OHWMs, which will be evaluated for adjacency),
- Adjacent wetlands/waters (includes waters adjacent to WOTUS within a minimum of 100 feet and within the 100-year floodplain to a maximum of 1,500 feet from the OHWM), and
- Isolated or “other” waters, which includes specific waters as defined in the Final Rule and waters with a significant nexus within the 100-year floodplain of a traditional navigable water, interstate water, or territorial seas, as well as waters with a significant nexus within 4,000 feet of jurisdictional water.

The definition excludes ditches, groundwater, gullies, rills, non-wetlands swales, and constructed components of stormwater conveyance systems, water delivery/reuse, or erosional features. The Waiakea study area encompasses the watersheds of three streams: Waiakea Stream, Palai Stream, and Four Mile Creek.

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.

4.5.3 FOUR MILE CREEK

Four Mile Creek is an intermittent stream that drains into undeveloped low lands near the Hilo Drag Strip south of the Hilo International Airport. The creek flows away from Hilo through an unlined flood control channel that was constructed by Hawaiʻi County. The 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 through a mix of residential and agricultural lands.

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 Hawai'i (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 Hawai'i 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 Hawai'i 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, Hawai'i'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 Hawai'i State Department of Health (HSDOH), Clean Water Branch as the agency in Hawai'i 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 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 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 2*** 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%	-	

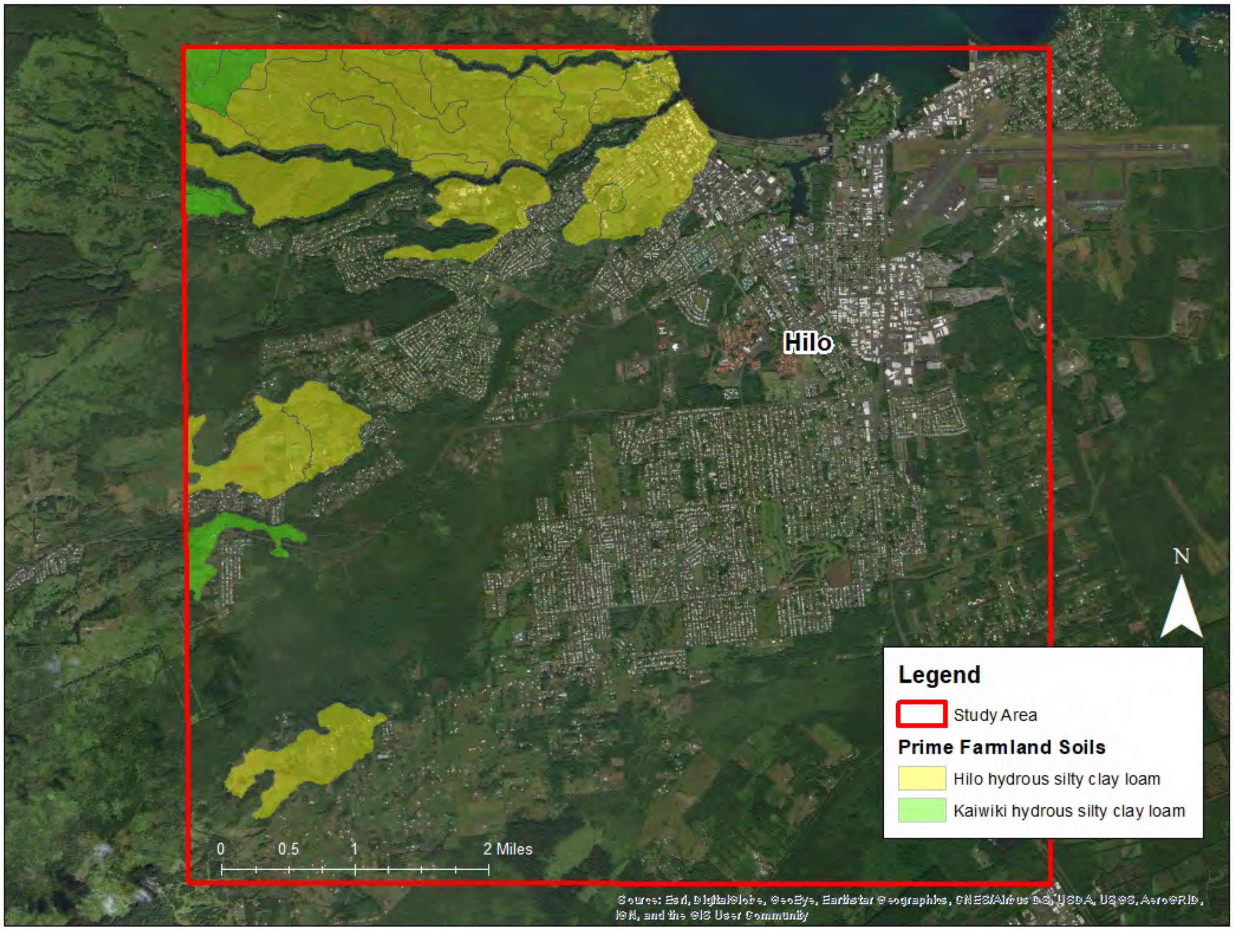
Source: NRCS Soil Data Mart (2019)

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 6***).

Figure 5: 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 (AECOS, 2005; AECOS, 2010a; and AECOS, 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 AECOS (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 AECOS (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 AECOS (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 (AECOS, 2005; AECOS, 2010a; and AECOS, 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 found within the study area. During field investigations, no threatened or endangered species were observed within the study area (AECOS 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. The EFH within the study area includes:

- Hawaiian Coral Reef Ecosystem
- Amberjack (*Seriola dumerli*)/blackjack (*Caranx lugubris*)/sea bass (*Etelis quernus*)
- Blue stripe snapper (*Lutjanus kasmira*)/gray jobfish (*Aprion virescens*)
- Giant trevally (*Caranx ignobilis*)
- Pink snapper (*Pristipomoides filamentosus*)
- Red snapper (*E. carbunculus*)/long tail snapper (*E. coruscans*)/yellow tail snapper (*P. auriculla*)/pink snapper/snapper (*P. zonatus*)
- Silver jaw jobfish (*Aphareus rutilans*)/thicklip trevally (*Pseudocaranx dentex*)

Descriptions, habitat, and potential impacts to EFH can be found in the EFH Assessment (***Attachment 2***).

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 3***. 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 4***.

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 5***.

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 4*** and ***Table 5*** 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

(Insert Mike Desilets write-up here)

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 6*** (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 7*** 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 four 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. Ainalako Diversion (Ainalako)
5. Combination of the Alternatives 2, 3, and 4 (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.

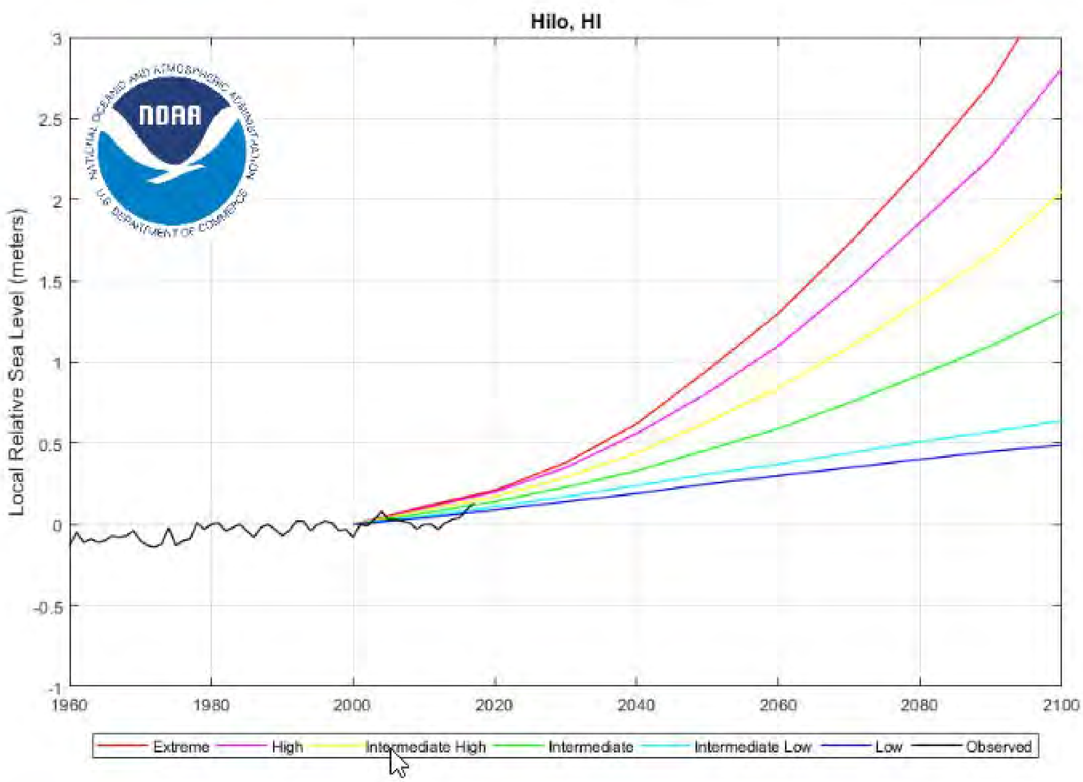
5.4 CLIMATE

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 7***). 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 6: 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. Similarly, the Ainalako Alternative would divert peak floodwater flows to Four Mile Creek, increasing the flow and length of time the creek is inundated. 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. The 404(b)(1) analysis is include in ***Attachment 3***.

Kupulau and Golf Course Alternatives: Under the Kupulau Alternative, the storm water 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.

Ainalako Alternative: In addition to the detention impacts addressed above, the Ainalako Diversion would result in higher floodwater flows being diverted into Four Mile Creek. Similar to the other alternatives, the increased flows would have the same effect on Four Mile Creek. Stage and flows of Four Mile Creek would increase as it incorporates the additional flows from the Waiakea watershed. 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 and Palai Stream and Hilo Bay. The 404 (b)(1) analysis for the Proposed Action is included in ***Attachment 3***.

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 and Ainalako Alternatives are 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.

Ainalako: The Ainalako Diversion would consist of the construction of two levees to divert flow from the Palai Stream into a grass swale that funnels into Four Mile Creek. The proposed levees and swale are located in a maintained pasture and would require the conversion of approximately 0.7 acres of pasture to FRM features. The grass swale would incorporate approximately two acres of pasture; however, the vegetation associated with the swale area would be maintained under current conditions. The proposed alternative would not have any substantial adverse impacts to 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 and Four Mile Creek. 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 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 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 would have "no effect" on 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 (AECOS, 2010a). With the exception of the Pacific Golden-plover, all bird species were not native to Hawai'i 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. 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. Therefore, no substantial adverse impacts to EFH is anticipated.

6.9.4 COASTAL ZONE MANAGEMENT

The action alternatives would be considered compatible, consistent, and not conflict with any of the objectives of the CZM program. The action alternatives would not impact coastal recreation opportunities, impede economic uses, increase coastal hazards, or conflict with development within the coastal zone. A federal consistency determination was prepared in accordance with 15 CFR Part 930 (***Attachment 4***) and concurrence was received from the Hawai'i State Office of Planning on [Insert Date when concurrence is received].

6.10 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.

Ainalako 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 nearest areas where children might congregate near the Ainalako Alterantive is the Panaewa Recreation Center and Panaewa Rainforest Zoo located approximately one mile east of the project area. Because the project area is not located near these facilities and is in a rural pasture, children should not be adversely exposed to harmful conditions as long as the mitigative measures identified 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.

6.11 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.

6.12 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.

6.13 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.

6.14 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.

Ainalako Alternative: There are no recreational features within the project area of the Ainalako Alternative. Therefore, the alternative does not impact 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 TSP. 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 Tentatively Selected Plan (TSP), 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 8***). 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 5***
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**
Coastal Barrier Resources Act of 1982, as amended	Not Applicable	
Coastal Zone Management Act of 1972, as amended	Compliant/In Progress	**Section 5.9.4, *Attachment 4***
Endangered Species Act of 1973, as amended	Compliant/In progress	**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 6***
Magnuson-Stevens Fisheries Conservation and Management Act of 1976, as amended	Compliant	**Section 5.9.3, *Attachment 2***
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 5***
Native American Graves Protection and Repatriation Act of 1990	Not Applicable	**Section 7.1.3, *Attachment 5***

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(B)(1)

USACE, under the direction of Congress, regulates the discharge of dredged and fill materials into waters of the U.S., including wetlands. USACE does not issue itself permits for construction activities affecting waters of the U.S., but must meet the legal requirements of the Act. A Section 404(b)(1) analysis was conducted for the Waiakea-Palai Stream FRM study and reviewed by the Honolulu District (***Attachment 3***). Before construction, USACE, or its contractors, will obtain a National Pollutant Discharge Elimination System (NPDES) construction activities permit from DOH. The Section 404(b)(1) analysis was provided to DOH and the agency will provide the water quality certification (***Attachment 7*****)** for the study in accordance with Section 401 of the CWA.

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.

8.1.2 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 5***).

[Summary to be provided by Mike Desilets]

8.1.4 ENDANGERED SPECIES ACT

Informal consultation was conducted with the USFWS and NMFS regarding potential impacts to threatened and endangered species within the project area. [Insert summary of results from consultation].

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. [Insert summary of FWCA actions/documentation].

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 [ADDITIONAL CORRESPONDENCE/CONSULTATION DOCUMENTS WILL BE ADDED FOR FINAL REPORT]

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: EFH ASSESSMENT (IN PROGRESS, EFH CONSULTAITON DOCUMENTS WILL BE ADDED ONCE CONSULTATION IS COMPLETE)

Attachment 3: SECTION 404(b)(1) ANALYSIS (SIGNED COPY WILL BE INSERTED ONCE RECEIVED)

EVALUATION OF SECTION 404(b)(1) GUIDELINES
(SHORT FORM)

PROPOSED PROJECT: Waiakea-Palai FRM Feasibility Study

	Yes	No*
1. Review of Compliance (230.10(a)-(d))		
A review of the proposed project indicates that:		
a. The placement represents the least environmentally damaging practicable alternative and, if in a special aquatic site, the activity associated with the placement must have direct access or proximity to, or be located in the aquatic ecosystem, to fulfill its basic purpose (if no, see section 2 and information gathered for EA alternative).	X	
b. The activity does not appear to:		
1) Violate applicable state water quality standards or effluent standards prohibited under Section 307 of the Clean Water Act;	X	
2) Jeopardize the existence of Federally-listed endangered or threatened species or their habitat; and	X	
3) Violate requirements of any Federally-designated marine sanctuary (if no, see section 2b and check responses from resource and water quality certifying agencies).	X	
c. The activity will not cause or contribute to significant degradation of waters of the U.S. including adverse effects on human health, life stages of organisms dependent on the aquatic ecosystem, ecosystem diversity, productivity and stability, and recreational, aesthetic, an economic values (if no, see values, Section 2)	X	
d. Appropriate and practicable steps have been taken to minimize potential adverse impacts of the discharge on the aquatic ecosystem (if no, see Section 5)	X	

Documentation of 230.10(a-d) is provided in the Waiakea-Palai FRM Environmental Appendix of the IFR/EA

	Not Applicable	Not Significant	Significant*
2. Technical Evaluation Factors (Subparts C-F) (where a 'Significant' category is checked, add explanation below.)			
a. Physical and Chemical Characteristics of the Aquatic Ecosystem (Subpart C)			
1) Substrate impacts		**X**	
2) Suspended particulates/turbidity impacts		**X**	
3) Water column impacts		**X**	
4) Alteration of current patterns and water circulation		**X***	
5) Alteration of normal water fluctuation/hydroperiod		**X***	
6) Alteration of salinity gradients	**X**		
b. Biological Characteristics of the Aquatic Ecosystem (Subpart D)			
1) Effect on threatened/endangered species and their habitat		**X**	
2) Effect on the aquatic food web		**X**	
3) Effect on other wildlife (mammals, birds, reptiles and amphibians)		**X**	

	Not Applicable	Not Significant	Significant*
2. Technical Evaluation Factors (Subparts C-F) (where a 'Significant' category is checked, add explanation below.)			
c. Special Aquatic Sites (Subpart E)			
1) Sanctuaries and refuges	**X**		
2) Wetlands	**X**		
3) Mud flats	**X**		
4) Vegetated shallows	**X**		
5) Coral reefs	**X**		
6) Riffle and pool complexes		**X**	
d. Human Use Characteristics (Subpart F)			
1) Effects on municipal and private water supplies		**X**	
2) Recreational and Commercial fisheries impacts		**X**	
3) Effects on water-related recreation		**X**	
4) Aesthetic impacts		**X**	
5) Effects on parks, national and historical monuments, national seashores, wilderness areas, research sites, and similar preserves		**X**	

2(a)(4): The Ainalako Diversion Ditch would funnel the higher flows from storm water events and divert the overflow into Four Mile Creek. Because the diversion would only be utilized during the less frequent and more intense precipitation events, the impacts on the water pattern and circulation was considered insignificant.

2(a)(5): Each of the alternatives include levees and/or detention basins which would alter the natural flows and hydroperiod by detaining flood flows downstream. However, these features would only be utilized during the less frequent and more intense precipitation events. The base flows and hydroperiod of more

frequent precipitation events would not be changed as the detention structures would be designed to allow the more frequent flows.

Documentation of Subparts C-F is provided in the Waiakea-Palai FRM Environmental Appendix of the IFR/EA

	Yes
3. Evaluation of Dredged or Fill Material (Subpart G)	**n/a**
a. The following information has been considered in evaluating the biological availability of possible contaminants in dredged or fill material (check only those appropriate)	
1) Physical characteristics	**n/a**
2) Hydrography in relation to known or anticipated sources of contaminants	**n/a**
3) Results from previous testing of the material or similar material in the vicinity of the project	**n/a**
4) Known, significant sources of persistent pesticides from land runoff or percolation	**n/a**
5) Spill records for petroleum products or designated (Section 311 of Clean Water Act) hazardous substances	**n/a**
6) Other public records of significant introduction of contaminants from industries, municipalities or other sources	**n/a**
7) Known existence of substantial material deposits of substances which could be released in harmful quantities to the aquatic environment by man-induced discharge activities	**n/a**

As documented in the Waiakea-Palai FRM IFR/EA and the Environmental Appendix of that document, the proposed action includes the construction of levees and detention basins. There is no excavation requiring disposal of materials.

	Yes	**No**
b. An evaluation of the appropriate information in 3a above indicates that there is reason to believe the proposed dredged or fill material is not a carrier of contaminants, or that levels of contaminants are substantively similar at extraction and placement sites and not likely to degrade the placement sites, or the material meets the testing exclusion criteria.	**n/a**	

As documented in the Waiakea-Palai FRM IFR/EA and the Environmental Appendix of that document, the proposed action includes the construction of levees and detention basins. There is no excavation requiring disposal of materials.

	Yes
4. Placement Site Delineation (230.11(f))	**n/a**
a. The following factors as appropriate, have been considered in evaluating the placement site:	
1) Depth of water at placement site	**n/a**
2) Current velocity, direction, and variability at placement site	**n/a**
3) Degree of turbulence	**n/a**
4) Water column stratification	**n/a**
5) Discharge vessel speed and direction	**n/a**
6) Rate of discharge	**n/a**
7) Fill material characteristics (constituents, amount, and type of material, settling velocities)	**n/a**
8) Number of discharges per unit of time	**n/a**
9) Other factors affecting rates and patterns of mixing (specify)	**n/a**

As documented in the Waiakea-Palai FRM IFR/EA and the Environmental Appendix of that document, the proposed action includes the construction of levees and detention basins. There is no excavation requiring disposal of materials.

	Yes	No
b. An evaluation of the appropriate factors in 4a above indicates that the placement site and/or size of mixing zone are acceptable.	**n/a**	**n/a**

As documented in the Waiakea-Palai FRM IFR/EA and the Environmental Appendix of that document, the proposed action includes the construction of levees and detention basins. There is no excavation requiring disposal of materials.

	Yes	No
5. Actions to Minimize Adverse Effects (Subpart H)		
All appropriate and practicable steps have been taken, through application of recommendations of 230.70-230.77 to ensure minimal adverse effects of the proposed discharge.	**n/a**	

As documented in the Waiakea-Palai FRM IFR/EA and the Environmental Appendix of that document, the proposed action includes the construction of levees and detention basins. There is no excavation requiring disposal of materials.

	Yes	No*
6. Factual Determination (230.11)		
A review of appropriate information as identified in items 2-5 above indicates that there is minimal potential for short- or long-term environmental effects of the proposed discharge as related to:		
a. Physical substrate at the placement site (review Sections 2a. 3, 4, and 5 above)	**n/a**	
b. Water circulation, fluctuation and salinity (review Sections 2a. 3, 4, and 5)	**X**	
c. Suspended particulates/turbidity (review Sections 2a. 3, 4, and 5)	**X**	
d. Contaminant availability (review Sections 2a. 3, and 4)	**X**	
e. Aquatic ecosystem structure and function (review Sections 2b and c, 3, and 5)	**X**	
f. Placement site (review Sections 2, 4, and 5)	**n/a**	
g. Cumulative impacts on the aquatic ecosystem	**X**	
h. Secondary impacts on the aquatic ecosystem	**X**	

Documentation of 230.11(a-h) is provided in the Waiakea-Palai FRM Environmental Appendix of the IFR/EA

7. Evaluation Responsibility
a. This evaluation was prepared by: Daniel Allen Position: Wildlife Biologist, CESWF-PEC-CC

8. Findings	**Yes**
a. The proposed placement site for discharge of or fill material complies with the Section 404(b)(1) Guidelines.	**X**
b. The proposed placement site for discharge of dredged or fill material complies with the Section 404(b)(1) Guidelines with the inclusion of the following conditions:	X

List of conditions:

c. The proposed placement site for discharge of dredged or fill material does not comply with the Section 404(b)(1) Guidelines for the following reason(s):	**n/a**
1) There is a less damaging practicable alternative	**n/a**
2) The proposed discharge will result in significant degradation of the aquatic ecosystem	**n/a**
3) The proposed discharge does not include all practicable and appropriate measures to minimize potential harm to the aquatic ecosystem	**n/a**

______________________ Date	____

NOTES:

* A negative, significant, or unknown response indicates that the permit application may not be in compliance with the Section 404(b)(1) Guidelines.

Negative responses to three or more of the compliance criteria at the preliminary stage indicate that the proposed projects may not be evaluated using this “short form” procedure. Care should be used in assessing pertinent portions of the technical information of items 2a-e before completing the final review of compliance.

Negative response to one of the compliance criteria at the final stage indicates that the proposed project does not comply with the Guidelines. If the economics of navigation and anchorage of Section 404(b)(2) are to be evaluated in the decision-making process, the “short form” evaluation process is inappropriate.

Attachment 4: COASTAL ZONE MANAGEMENT DETERMINATION (ADDITIONAL DOCUMENTATION WILL BE INSERTED ONCE RECEIVED)

HAWAII CZM PROGRAM
FEDERAL CONSISTENCY ASSESSMENT FORM

RECREATIONAL RESOURCES

Objective: Provide coastal recreational opportunities accessible to the public.

Policies:

1) Improve coordination and funding of coastal recreational planning and management.
2) Provide adequate, accessible, and diverse recreational opportunities in the coastal zone management area by:
   a) Protecting coastal resources uniquely suited for recreational activities that cannot be provided in other areas.
   b) Requiring replacement of coastal resources having significant recreational value including, but not limited to surfing sites, fishponds, and sand beaches, when such resources will be unavoidably damaged by development; or requiring reasonable monetary compensation to the State for recreation when replacement is not feasible or desirable.
   c) Providing and managing adequate public access, consistent with conservation of natural resources, to and along shorelines with recreational value.
   d) Providing an adequate supply of shoreline parks and other recreational facilities suitable for public recreation.
   e) Ensuring public recreational uses of county, state, and federally owned or controlled shoreline lands and waters having recreational value consistent with public safety standards and conservation of natural resources.
   f) Adopting water quality standards and regulating point and non-point sources of pollution to protect, and where feasible, restore the recreational value of coastal waters.
   g) Developing new shoreline recreational opportunities, where appropriate, such as artificial lagoons, artificial beaches, and artificial reefs for surfing and fishing.
   h) Encouraging reasonable dedication of shoreline areas with recreational value for public use as part of discretionary approvals or permits by the land use commission, board of land and natural resources, and county authorities; and crediting such dedication against the requirements of Hawaii Revised Statutes, section 46-6.

RECREATIONAL RESOURCES (continued)

Check either Yes or No for each of the following questions, and provide an explanation or information for Yes responses in the Discussion section:

	Yes	No
1. Will the proposed action occur in or adjacent to a dedicated public right-of-way, e.g., public beach access, hiking trail, shared-use path?	☑	☐
2. Will the proposed action affect public access to and along the shoreline?	☐	☑
3. Does the project site abut the shoreline?	☐	☑
4. Is the project site on or adjacent to a sandy beach?	☐	☑
5. Is the project site in or adjacent to a state or county park?	☐	☑
6. Is the project site in or adjacent to a water body such as a stream, river, pond, lake, or ocean?	☑	☐
7. Will the proposed action occur in or affect an ocean recreation area, swimming area, surf site, fishing area, or boating area?	☐	☑

Discussion: (If more space is needed, attach a separate sheet.)

1) The Hilo Municipal Golf Course is a public golf course. The design of the levees and detention basin would be designed to be compatible with this recreation feature.

6) The proposed action entails the construction of a floodwall, levees and a detention basin for flood waters flowing into Waiakea Stream, levees and a detention basin on the Waiakea Stream at the Municipal Golf Course, and a diversion of Palai Steam to Four Mile Creek off of Aialako Road.

HISTORIC RESOURCES

Objective: Protect, preserve, and, where desirable, restore those natural and manmade historic and prehistoric resources in the coastal zone management area that are significant in Hawaiian and American history and culture.

Policies:

1) Identify and analyze significant archaeological resources.
2) Maximize information retention through preservation of remains and artifacts or salvage operations.
3) Support state goals for protection, restoration, interpretation, and display of historic resources.

Check either Yes or No for each of the following questions, and provide an explanation or information for Yes responses in the Discussion section:

	Yes	No
1. Is the project site within a designated historic or cultural district?	☐	☑
2. Is the project site listed on or nominated to the Hawaii or National Register of Historic Places?	☐	☑
3. Has the project site been surveyed for historic or archaeological resources?	☑	☐
4. Does the project parcel include undeveloped land which has not been surveyed by an archaeologist?	☑	☐
5. Is the project site within or adjacent to a Hawaiian fishpond or historic settlement area?	☐	☑

Discussion: (If more space is needed, attach a separate sheet.)

3) A Cultural Impact Study report was produced in March 2005 detailing the records research and interviews with local cultural resource experts. This study was followed up with a Cultural Resource Survey in July and August of 2015. The reports determined that there are no known culturally significant traditional properties and resources in the project area. The project site does not appear to support any traditional cultural practices. Based on the absence of any known TCPs and any traditional prtactices associated with the project area, the determination was made that no adverse impact to cultural resources activities or resources would occur from the implementation of the federal action.

4) Five property tracts of the project area were inaccessible as right-of-entry could not be attained for all properties. USACE and the Hawaii State Historic Preservation Division (SHDP) that for these areas, construction would be monitored by a qualified archaeologist to ensure that no unidentified historic properties would be impacted. An Archaeological Monitoring Plan will be prepared and approved by SHPD prior to the initiation of construction activities at these locations.

SCENIC AND OPEN SPACE RESOURCES

Objective: Protect, preserve, and, where desirable, restore or improve the quality of coastal scenic and open space resources.

Policies:

1) Identify valued scenic resources in the coastal zone management area.
2) Ensure that new developments are compatible with their visual environment by designing and locating such developments to minimize the alteration of natural landforms and existing public views to and along the shoreline.
3) Preserve, maintain, and, where desirable, improve and restore shoreline open space and scenic resources.
4) Encourage those developments that are not coastal dependent to locate in inland areas.

Check either Yes or No for each of the following questions, and provide an explanation or information for Yes responses in the Discussion section:

	Yes	No
1. Will the proposed action alter any natural landforms or existing public views to and along the shoreline?	☐	☑
2. Does the proposed action involve the construction of a multi-story structure?	☐	☑
3. Is the project site located on or adjacent to an undeveloped parcel, including a beach or oceanfront land?	☑	☐
4. Does the proposed action involve the construction of a structure visible between the nearest coastal roadway and the shoreline?	☐	☑
5. Will the proposed action involve constructing or placing a structure in waters seaward of the shoreline?	☐	☑

Discussion: (If more space is needed, attach a separate sheet.)

3) The Kupulau Ditch and Ainalako Diversion alternatives are located in and adjacent to pastureland.

COASTAL ECOSYSTEMS

Objective: Protect valuable coastal ecosystems, including reefs, from disruption and minimize adverse impacts on all coastal ecosystems.

Policies:

1) Exercise an overall conservation ethic, and practice stewardship in the protection, use, and development of marine and coastal resources.
2) Improve the technical basis for natural resource management.
3) Preserve valuable coastal ecosystems, including reefs, of significant biological or economic importance.
4) Minimize disruption or degradation of coastal water ecosystems by effective regulation of stream diversions, channelization, and similar land water uses, recognizing competing water needs.
5) Promote water quantity and quality planning and management practices that reflect the tolerance of fresh water and marine ecosystems and maintain and enhance water quality through the development and implementation of point and nonpoint source water pollution control measures.

Check either Yes or No for each of the following questions, and provide an explanation or information for Yes responses in the Discussion section:

	Yes	No
1. Does the proposed action involve dredge or fill activities?	☐	☑
2. Is the project site within the Special Management Area (SMA) or the Shoreline Setback Area?	☐	☑
3. Is the project site within the State Conservation District?	☐	☑
4. Will the proposed action involve some form of discharge or placement of material into a body of water or wetland?	☑	☐
5. Will the proposed action require earthwork, grading, clearing, or grubbing?	☑	☐
6. Will the proposed action include the construction of waste treatment facilities, such as injection wells, discharge pipes, or septic systems?	☐	☑
7. Is an intermittent or perennial stream located on or adjacent to the project parcel?	☑	☐
8. Does the project site provide habitat for endangered species of plants, birds, or mammals?	☐	☑
9. Is any such habitat located in close proximity to the project site?	☐	☑

COASTAL ECOSYSTEMS (continued)

	Yes	No
10. Is a wetland located on the project site or parcel?	☐	☑
11. Is the project site situated in or abutting a Natural Area Reserve, a Marine Life Conservation District, or an estuary?	☐	☑
12. Will the proposed action occur on or in close proximity to a reef or coral colonies?	☐	☑

Discussion: (If more space is needed, attach a separate sheet.)

4) The proposed action for the alternatives that include FRM measures on the Hilo Municipal Golf Course would require the construction of a levee across Waiakea Stream. This structure would impound peak flood flows resulting from low frequency storm events; base flows and flood flows from more frequent events would be allowed through the structure unimpeded.

5) The construction of the flood wall and levees would would require grading, clearing and grubbing.

7) Within the project areas, Waiakea and Palai Streams and Four Mile Creek are intermittent.

ECONOMIC USES

Objective: Provide public or private facilities and improvements important to the State's economy in suitable locations.

Policies:

1) Concentrate coastal development in appropriate areas.
2) Ensure that coastal dependent development such as harbors and ports, and coastal related development such as visitor industry facilities and energy generating facilities, are located, designed, and constructed to minimize adverse social, visual, and environmental impacts in the coastal zone management area.
3) Direct the location and expansion of coastal dependent developments to areas presently designated and used for such development and permit reasonable long-term growth at such areas, and permit coastal dependent development outside of presently designated areas when:
   a) Use of presently designated locations is not feasible;
   b) Adverse environmental effects are minimized; and
   c) The development is important to the State's economy.

Check either Yes or No for each of the following questions, and provide an explanation or information for Yes responses in the Discussion section:

	Yes	No
1. Does the proposed action involve a harbor or port?	☐	☑
2. Is the proposed action a visitor industry facility or a visitor industry related activity?	☐	☑
3. Does the project site include agricultural lands or lands designated for such use?	☑	☐
4. Does the proposed action relate to commercial fishing or seafood production?	☐	☑
5. Is the proposed action related to energy production or transmission?	☐	☑
6. Is the proposed action related to seabed mining?	☐	☑

Discussion: (If more space is needed, attach a separate sheet.)

3) The Kupulau Ditch and Ainalako Diversion alternatives would be located within and adjacent to pastureland.

COASTAL HAZARDS

Objective: Reduce hazard to life and property from tsunami, storm waves, stream flooding, erosion, subsidence, and pollution.

Policies:

1) Develop and communicate adequate information about storm wave, tsunami, flood, erosion, subsidence, and point and nonpoint source pollution hazards.
2) Control development in areas subject to storm wave, tsunami, flood, erosion, hurricane, wind, subsidence, and point and nonpoint source pollution hazards.
3) Ensure that developments comply with requirements of the Federal Flood Insurance Program.
4) Prevent coastal flooding from inland projects.

Check either Yes or No for each of the following questions, and provide an explanation or information for Yes responses in the Discussion section:

	Yes	No
1. Is the project site on or abutting a sandy beach?	☐	☑
2. If "Yes" to question no. 1, has the project parcel or adjoining shoreline areas experienced erosion?	☐	☐
3. Is the project site within a potential tsunami inundation area? Refer to tsunami evacuation maps at http://www.scd.hawaii.gov	☐	☑
4. Is the project site within a flood hazard area according to a FEMA Flood Insurance Rate Map (https://msc.fema.gov)?	☑	☐
5. Is the project site within a subsidence hazard area?	☐	☑

Discussion: (If more space is needed, attach a separate sheet.)

4) The proposed action is a Flood Risk Management project to alleviate flooding hazard peaks to downstream communities. The proposed action will not increase flood risk, but will decrease flood risk for properties located in the floodplain.

MANAGING DEVELOPMENT

Objective: Improve the development review process, communication, and public participation in the management of coastal resources and hazards.

Policies:

1) Use, implement, and enforce existing law effectively to the maximum extent possible in managing present and future coastal zone development.
2) Facilitate timely processing of applications for development permits and resolve overlapping or conflicting permit requirements.
3) Communicate the potential short and long-term impacts of proposed significant coastal developments early in their life cycle and in terms understandable to the public to facilitate public participation in the planning and review process.

Check either Yes or No for each of the following questions, and provide an explanation or information for Yes responses in the Discussion section:

	Yes	No
1. List the permits or approvals required for the proposed action and provide the status of each in the Discussion section below.		
2. Does the proposed action conform with state and county land use designations for the site?	☑	☐
3. Has the public been notified of the proposed action?	☑	☐
4. Has an environmental impact statement or environmental assessment been prepared for the proposed action?	☐	☑

Discussion: (If more space is needed, attach a separate sheet.)

1) [To be filled in]

2) The feasibility study of the project has been under different stages since 2004. Over that time the local people have been made aware of the proposed project.

4) An Integrated Feasibility Report/Environmental Assessment (EA) is currently being prepared. The CZM federal consistency determination is required to complete the EA.

PUBLIC PARTICIPATION

Objective: Stimulate public awareness, education, and participation in coastal management.

Policies:

1) Promote public involvement in coastal zone management processes.
2) Disseminate information on coastal management issues by means of educational materials, published reports, staff contact, and public workshops for persons and organizations concerned with coastal issues, developments, and government activities.
3) Organize workshops, policy dialogues, and site-specific mediations to respond to coastal issues and conflicts.

Check either Yes or No for each of the following questions, and provide an explanation or information for Yes responses in the Discussion section:

	Yes	No
1. Has information about the proposed action been disseminated to the public?	☑	☐
2. Has the public been provided an opportunity to comment on the proposed action?	☐	☑
3. Has or will a public hearing or public informational meeting be held?	☐	☑

Discussion: (If more space is needed, attach a separate sheet.)

1) The feasibility study of the project has been under different stages since 2004. Over that time the local people have been made aware of the proposed project.

2) The public has currently not been afforded the opportunity to comment on the project; however, the public will be provided a 30-day comment period upon release of the Draft EA.

3) Due to the support of the proposed action, USACE does not currently plan on holding a public hearing or information meeting.

BEACH PROTECTION

Objective: Protect beaches for public use and recreation.

Policies:

1) Locate new structures inland from the shoreline setback to conserve open space, minimize interference with natural shoreline processes, and minimize loss of improvements due to erosion.
2) Prohibit construction of private erosion-protection structures seaward of the shoreline, except when they result in improved aesthetic and engineering solutions to erosion at the sites and do not interfere with existing recreational and waterline activities.
3) Minimize the construction of public erosion-protection structures seaward of the shoreline.
4) Prohibit private property owners from creating a public nuisance by inducing or cultivating the private property owner's vegetation in a beach transit corridor.
5) Prohibit private property owners from creating a public nuisance by allowing the private property owner's unmaintained vegetation to interfere or encroach upon a beach transit corridor.

Check either Yes or No for each of the following questions, and provide an explanation or information for Yes responses in the Discussion section:

	Yes	No
1. Will the proposed action occur on or adjacent to a beach?	☐	☑
2. Is the proposed action located within the shoreline setback area?	☐	☑
3. Will the proposed action affect natural shoreline processes?	☐	☑
4. Will the proposed action affect recreational activities?	☐	☑
5. Will the proposed action affect public access to and along the shoreline?	☐	☑

Discussion: (If more space is needed, attach a separate sheet.)

MARINE RESOURCES

Objective: Promote the protection, use, and development of marine and coastal resources to assure their sustainability.

Policies:

1) Ensure that the use and development of marine and coastal resources are ecologically and environmentally sound and economically beneficial.
2) Coordinate the management of marine and coastal resources and activities to improve effectiveness and efficiency.
4) Assert and articulate the interests of the State as a partner with federal agencies in the sound management of ocean resources within the United States exclusive economic zone.
5) Promote research, study, and understanding of ocean processes, marine life, and other ocean resources to acquire and inventory information necessary to understand how ocean development activities relate to and impact upon ocean and coastal resources.
6) Encourage research and development of new, innovative technologies for exploring, using, or protecting marine and coastal resources.

Check either Yes or No for each of the following questions, and provide an explanation or information for Yes responses in the Discussion section:

	Yes	No
1. Will the proposed action involve the use or development of marine or coastal resources?	☐	☑
2. Will the proposed action affect the use or development of marine or coastal resources?	☐	☑
3. Does the proposed action involve research of ocean processes or resources?	☐	☑

Discussion: (If more space is needed, attach a separate sheet.)

Attachment 5: CULTURAL RESOURCES APPENDIX (IN PROGRESS, WILL BE INSERTED ONCE COMPLETE)

Attachment 6: FISH AND WILDLIFE COORDINATION ACT REPORT (IN PROGRESS, DOCUMENTATION TO BE INSERTED WHEN RECEIVED)

Attachment 7: WATER QUALITY CERTIFICATION (IN PROGRESS, WILL BE INSERTED ONCE RECEIVED)

Attachment 8: RESOURCE AGENCY CORRESPONDENCE (RESPONSES TO AGENCY REVIEW WILL BE ATTACHED WHEN RECEIVED)

WAIAKEA-PALAI STREAMS
Hilo, Island of Hawaii, Hawaii

CONTINUING AUTHORITIES PROGRAM SECTION 205
FLOOD RISK MANAGEMENT

Appendix D: Real Estate Plan

MAY 2019

US Army Corps
of Engineers
Honolulu District

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Real Estate Planning Report

Waiakea-Palai Flood Control Project
Waiakea & Palai Stream, Hilo, Hawaii

Authorized under
Section 205 of the Flood Control Act of 1948,
As amended

Prepared for
Honolulu District, USACE

Prepared by:

5 April 19

Patrick Dwyer **Date**
Realty Specialist
Honolulu District, Pacific Ocean Division

Reviewed by:

8 Apr 19

Lon G. Larson **Date**
Acting Chief of Real Estate Branch
Honolulu District, Pacific Ocean Division

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1. AUTHORITY/PURPOSE

The Project 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 purpose of the proposed Federal action is to reduce flood risks to life, property, and critical infrastructure in the Palai Stream watershed and the Waiakea Stream watershed as well as a portion of Four Mile Creek near Hilo, Hawaii.

2. DESCRIPTION

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. 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 and empties into Hilo Bay.

Waiakea Stream has a drainage area of about 35.6 square miles and is classified as intermittent 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.

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 Hawaii County. 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.

Alternatives Include:

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.

The following parcel owners are identified in the proposed project.

Kupulau Ditch Levee / Flood Wall / Detention Basin - Real Estate Requirements

TMK	Ownership	Area (Acres)	Estate
324036001	Church	6.6	Flowage Easement (occasional flooding)
324065036	Private	3.83	Flowage Easement (occasional flooding)
324065036	Private	1.00	Flood Protection Levee Easement
324036999	Public	0.63	Road Easement
324076044	Private	0.18	Flood Protection Levee Easement
324065035	Private	0.44	Flood Protection Levee Easement
324036001	Church	1.00	Flood Protection Levee Easement
324035003	Private	0.22	Flood Protection Levee Easement
324035032	Private	0.16	Flood Protection Levee Easement
324036001	Church	0.70	Staging Area

Alternative 2: 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.

The following parcel owners are identified in the proposed project.

Hilo Municipal Golf Course Detention - Real Estate Requirements

TMK	Ownership	Area (Acres)	Estate
240020010000	Public	4.5	Flowage Easement (Perpetual)
240020010000	Public	2.13	Flowage Easement (occasional flooding)
240020010000	Public	0.60	Road Easement
240020010000	Public	0.32	Temporary Staging Area

Alternative 3: Ainalako Diversion
The main component 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.

The following parcel owners are identified in the proposed project.

Ainalako Diversion - Real Estate Requirements

TMK	Ownership	Area (Acres)	Estate
240300010000	Private	6.6	Flowage Easement (Perpetual)
240300020000	Private	3.83	Flowage Easement (Perpetual)
240301120000	Private	0.20	Flood Protection Levee Easement
240301130000	Private	0.63	Road Easement
240810070000	Private	0.18	Flood Protection Levee Easement
240810110000	Private	0.44	Staging
240510040000	Private	1.00	Flowage Easement (Perpetual)
240040720000a	Private	0.22	Flowage Easement (Perpetual)

3. SPONSOR'S REAL ESTATE INTERESTS

The non-federal sponsor, the County of Hawaii, owns some lands identified for this project. All Non Federal Sponsor lands have been under control of County of Hawaii since the original project was constructed.

As shown above, the feature sites are either wholly or partially owned by the local sponsor. These sites will not require acquisitions but all the remaining feature sites will require acquisition from private parties and/or a provision for making the property available from the City and County of Honolulu.

The County of Hawaii will have to transfer the requisite interest in their ownerships to make their lands available for the project. The County of Hawaii as local sponsor will have to provide evidence that they have the required interest in order to receive credit for the LERRD value.

To my knowledge, none of the properties were acquired using federal funds. None of the sponsor owned parcels were acquired in anticipation of the proposed project.

4. ESTATES TO BE ACQUIRED

Project features consist of earthen berms in the stream channel, flood protection levees and floodwalls, road access, flowage easements, and temporary work areas. For general purposes, the recommended estates are as follows,

Flowage Easement (occasional flooding)
Flowage Easement (Perpetual)
Channel Improvement Easement
Flood Protection Levee Easement
Road Easement
Temporary Work Area Easement

FLOWAGE EASEMENT (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 [1](and also excepting _________________ (here identify those structures not designed for human habitation which the District Engineer determines may remain on the land)) [2]; 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; [3] 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)

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 [4] (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; [5] 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.

____

CHANNEL IMPROVEMENT EASEMENT

A perpetual and assignable right and easement to construct, operate, and maintain channel improvement works on, over and across (the land described in Schedule A) (Tracts Nos. _____, _____ and _____) for the purposes as authorized by the Act of Congress approved_______________, including the right to clear, cut, fell, remove and dispose of any and all timber, trees, underbrush, buildings, improvements and/or other obstructions therefrom; to excavate: dredge, cut away, and remove any or all of said land and to place thereon dredge or spoil material; and for such other purposes as may be required in connection with said work of improvement; reserving, however, to the owners, 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 far public roads and highways, public utilities, railroads and pipelines.

FLOOD PROTECTION LEVEE EASEMENT

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.

ROAD EASEMENT

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)[6]; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

TEMPORARY WORK AREA EASEMENT

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 12 months, beginning with date possession of 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, therefore 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.

5. FEDERAL PROJECTS/OWNERSHIP

The Waiakea-Palai Flood Control Project is a federal cost share project, the Government has never held federal real estate interest in the flood control project. There are no federal owned lands in the immediately vicinity.

6. NAVIGATION SERVITUDE

Lands required for the channel repairs project are not located within navigable waters and no lands are available by navigation servitude.

7. MAPS

Real Estate mapping is not typically provided by the District at this stage of the project. Detailed mapping will be provided prior to the notification to the sponsor to provide the required LERRDs. Preliminary Real Estate mapping is provided as an ADDENDUM.

8. INDUCED FLOODING

The purpose of the project is to reduce damages caused by flood waters. The project is not anticipated to induce flooding outside of the footprint of the proposed flood control features

9. REAL ESTATE PGL NO. 31-REAL ESTATE SUPPORT TO CIVIL WORKS

PGL 31 discusses the level of detail for Real Estate cost estimates. A quick summary follows:

For projects in which the value of real estate (lands, improvements, and severance damages) are not expected to exceed ten percent of total project costs (total cost to implement project), a cost estimate (or rough order of magnitude) will be acceptable for purposes of the feasibility phase.

For projects in which the value of real estate (lands, improvements, and severance damages) do not exceed 30 percent of total project costs (total cost to implement project), a brief gross appraisal will be acceptable for purposes of the feasibility phase. A brief gross appraisal will follow format issued by Chief Appraiser.

For projects in which the value of real estate (lands, improvements, and severance damages) exceed 30 percent of total project costs (total cost to implement project), a full gross appraisal will be prepared in accordance with the appraisal regulation and guidance provided by EC 405-1-04 and the Chief Appraiser.

10. BASELINE COST ESTIMATE FOR REAL ESTATE

The initial cost estimate for real estate cost was derived from the tax map key at 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. Even considering this level of the TMK cost the cost is still not expected to exceed ten percent of total project costs limit referenced in PGL 31.

Available lands cost estimate is from 2015 level then escalated at a rate of 6.9% to 2019 price levels, as follows.

Kupulau Levee/Floodwall	$341,000
Hilo Golf Course Detention	$376,000
Ainalako Diversion	$121,000
October 2014 level	$838,000
Escalation	6.9%
Estimated Total	$895,822

For the Waiakea-Palai project, the existing LERRDs estimate ($896,000) is less than 10% of total project first costs ($13,051,000). A gross appraisal or brief gross appraisal is not required at this time.

11. PL 91-646 RELOCATION BENEFITS

Public Law 91-646, The Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, 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 non-federal sponsor is required to follow the guidance in this public law. The sponsor is aware of this and has experience in the Uniform Act policies. As the project is currently laid out it appears that there will be no displaced families or businesses.

12. MINERALS

There are no known surface or subsurface minerals known that would impact the project.

The State of Hawaii owns all mineral rights within the state and there are no surface or subsurface minerals that would impact the project or acquisition.

13. ASSESSMENT OF SPONSOR'S ACQUISITION CAPABILITY

An assessment of the sponsor's acquisition capabilities to acquire the land necessary for this project has not been done as of the writing of this REP. However, the local sponsors have partnered in other projects on the island. The County of Hawaii is considered fully capable and have Eminent Domain authority. In compliance with the Water Resources Development Act of 1986 (WRDA 86), Pub. L. 99-662, the Uniform Act and 49 CFR Part 24, Real Estate will request that the sponsor provide an assessment of their acquisition capability when the design is finalized.

14. ZONING

All lands involved in the project features are currently zoned as residential. No impacts of this project will result in a taking of a real property interest due to enactment or enforcement of the zoning ordinance.

15. MILESTONES

The following real estate milestones have been coordinated with Real Estate, and the Project Manager. For those parcels that are currently owned in fee by the local sponsor, they will need to demonstrate possession of the title prior to construction execution. For the private parcels that will be acquired, the sponsor will have to accomplish the acquisition prior to advertisement of the construction contract.

Real Estate Acquisition Schedule

Estimated Start	Estimated End	Estimated Midpoint
April 2020	Oct 2020	July 2020

16. PUBLIC UTILITIES RELOCATIONS

There are no known public utilities that are impacted by the project.

Two types of Relocations:

1) Temporary relocations in which all work will be commenced and resolved under construction contract(s) within the same footprint; and

2) Permanent relocations which require action on the part of the Non-Federal Sponsor in advance of the project to acquire lands for a permanent resettlement of the utility(s) on a different footprint.

The LERRDs crediting on the costs of the relocations which fall into the two above categories will be provided in the Attorney's Opinion of Compensability, which is scheduled to be completed later in the Design Phase of this Project. Any conclusions or categorization contained in this report that an item is a utility or facility relocation to be performed by the Non-Federal Sponsor as part of its LERRD responsibilities is preliminary only. The Government will make a final determination of the relocations necessary for the construction, operation, or maintenance of the project after further analysis and completion and approval of Final Attorney's Opinions of Compensability for each of the impacted utilities and facilities.

A description of the facility or utility relocations, i.e. the golf course facility, pipelines etc. that must be performed including information regarding the general nature of the impact to each facility or utility; the identity of the owners of the affected facilities and utilities; and the purpose of the affected facilities and utilities will be detailed in a future Draft Utility/Facility Assessment Report.

17. ENVIRONMENTAL IMPACTS

Environmental impacts, if any, are discussed in other sections of the Project Information Report. A supplemental Environmental Assessment is being prepared to address any environmental concerns but none are anticipated. A cultural assessment is also ongoing for this project.

18. ATTITUDES OF LANDOWNERS

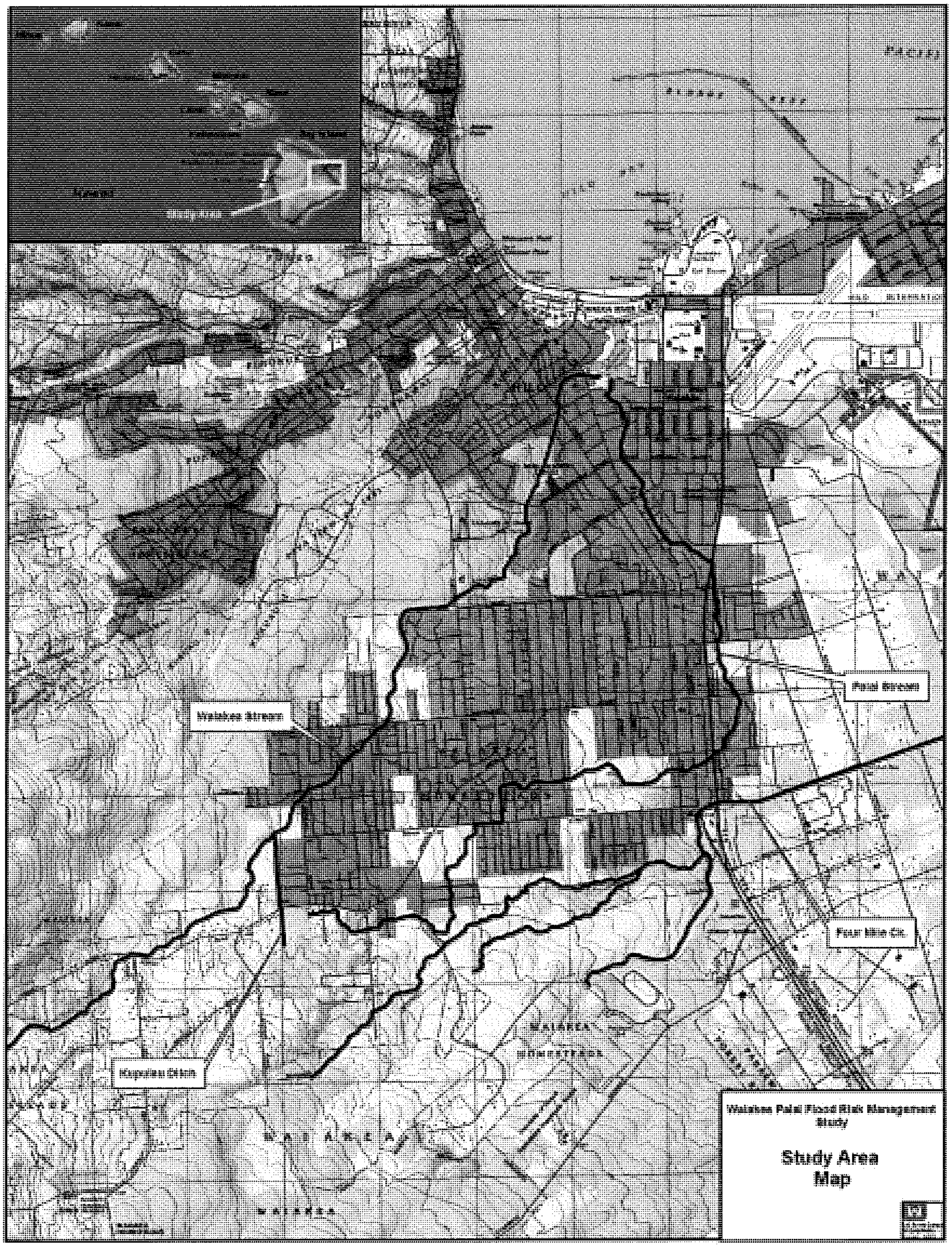
There is no known opposition to the project.

19. SPONSOR INVOLVEMENT

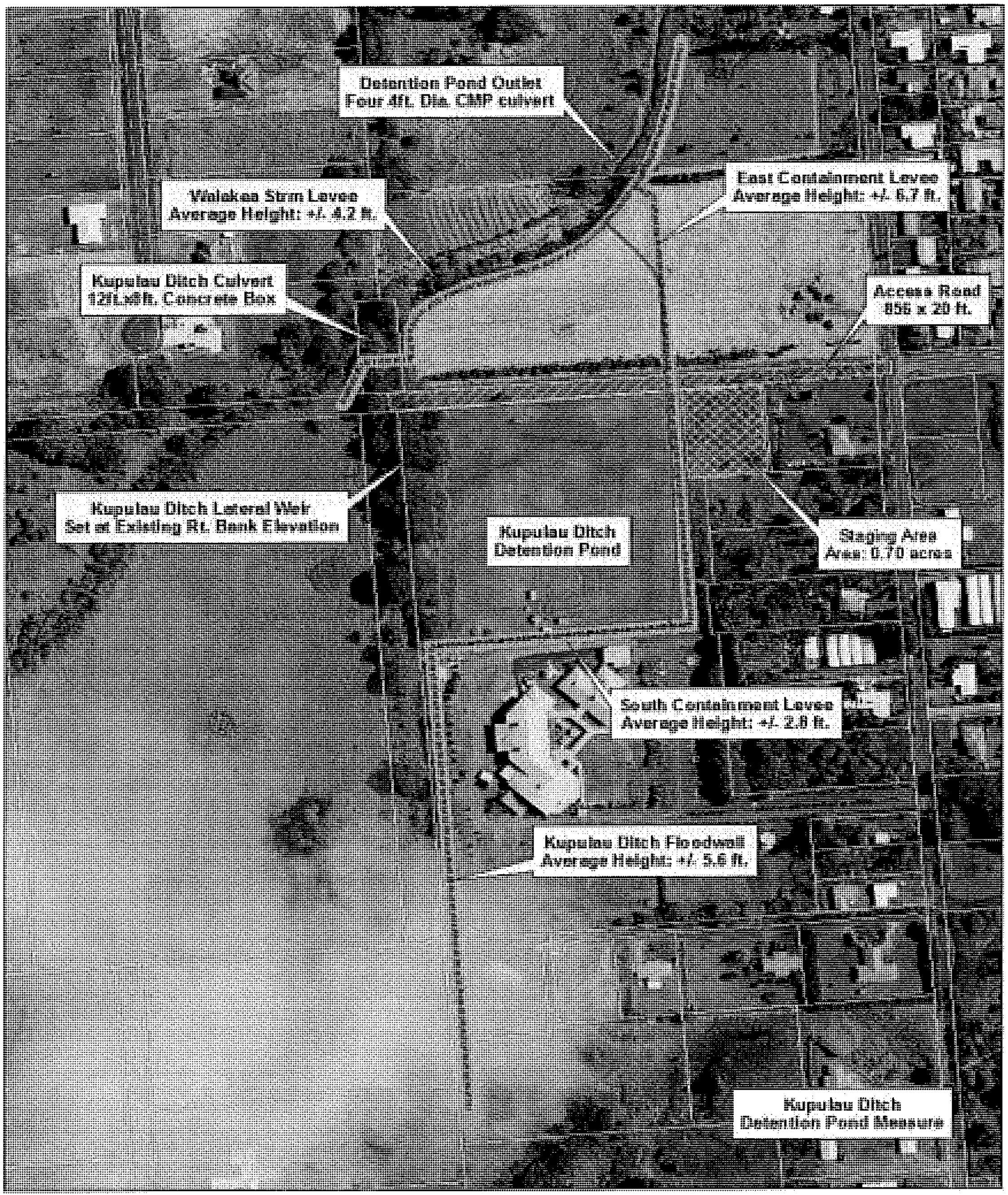
The non-Federal sponsor, County of Hawaii, are fully involved in the planning process. They are also experienced in working with US Army Corps of Engineers on similar projects.

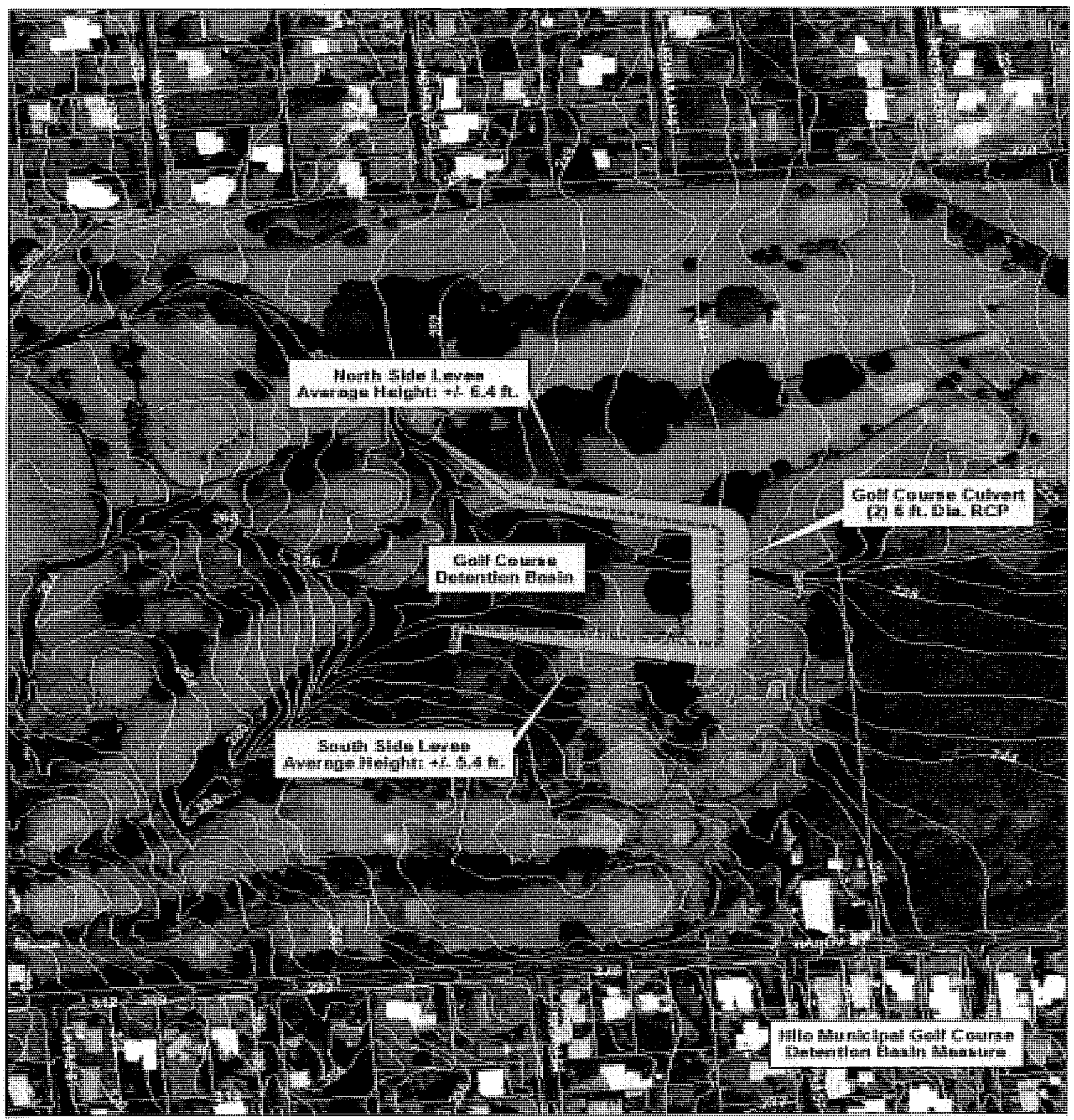
ADDENDUM

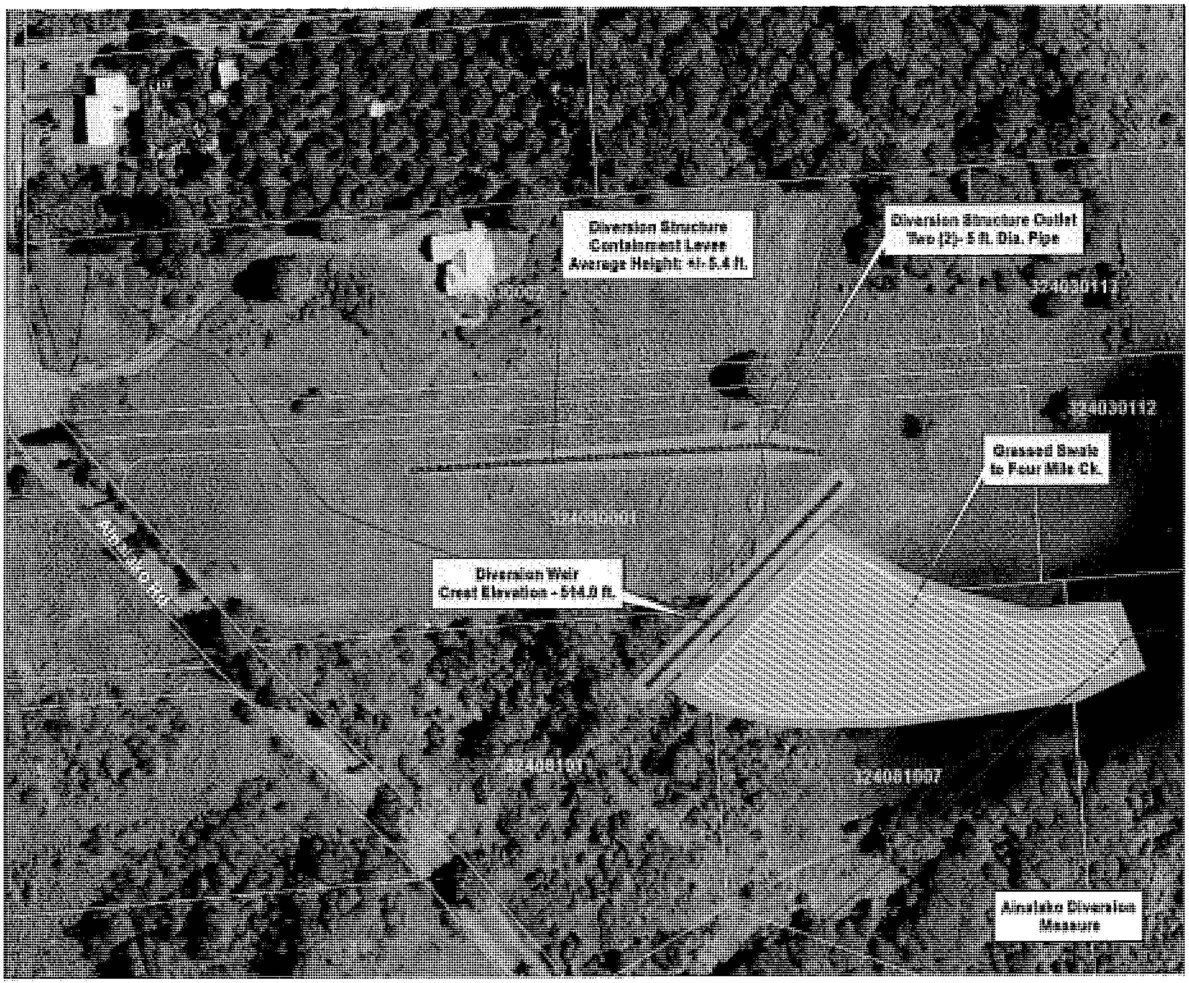
Island of Hawaii/ Project Location
Project Feature Map(s)



Project Location/ Project Features Map




North Side Levee
Average Height: +/- 6.4 ft.
Golf Course Culvert
(2) 6 ft. Dia. RCP
Golf Course
Detention Basin
South Side Levee
Average Height: +/- 5.4 ft.
Hilo Municipal Golf Course
Detention Basin Measure


Diversion Structure
Containment Levee
Average Height: +/- 5.4 ft.
Diversion Structure Outlet
Two (2)- 5 ft. Dia. Pipe
324030112
Grassed Swale
to Four Mile Ck.
Diversion Weir
Crest Elevation - 514.0 ft.
Diversion
Measure

WAIAKEA-PALAI STREAMS
Hilo, Island of Hawaii, Hawaii

CONTINUING AUTHORITIES PROGRAM SECTION 205
FLOOD RISK MANAGEMENT

Appendix E: Cost Estimate

MAY 2019

US Army Corps
of Engineers®
Honolulu District

Blank page to facilitate duplex printing

Cost Appendix

PN# 326040 Waiakea-Palai FRM, Hilo, Island of Hawaii, Hawaii

(7 May 19)

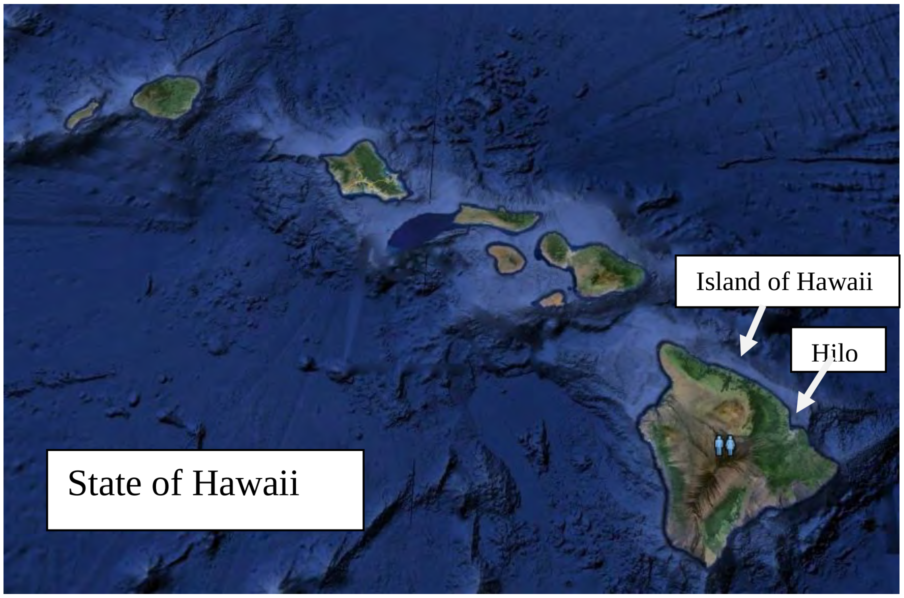
Contents

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 the Viable Alternatives.

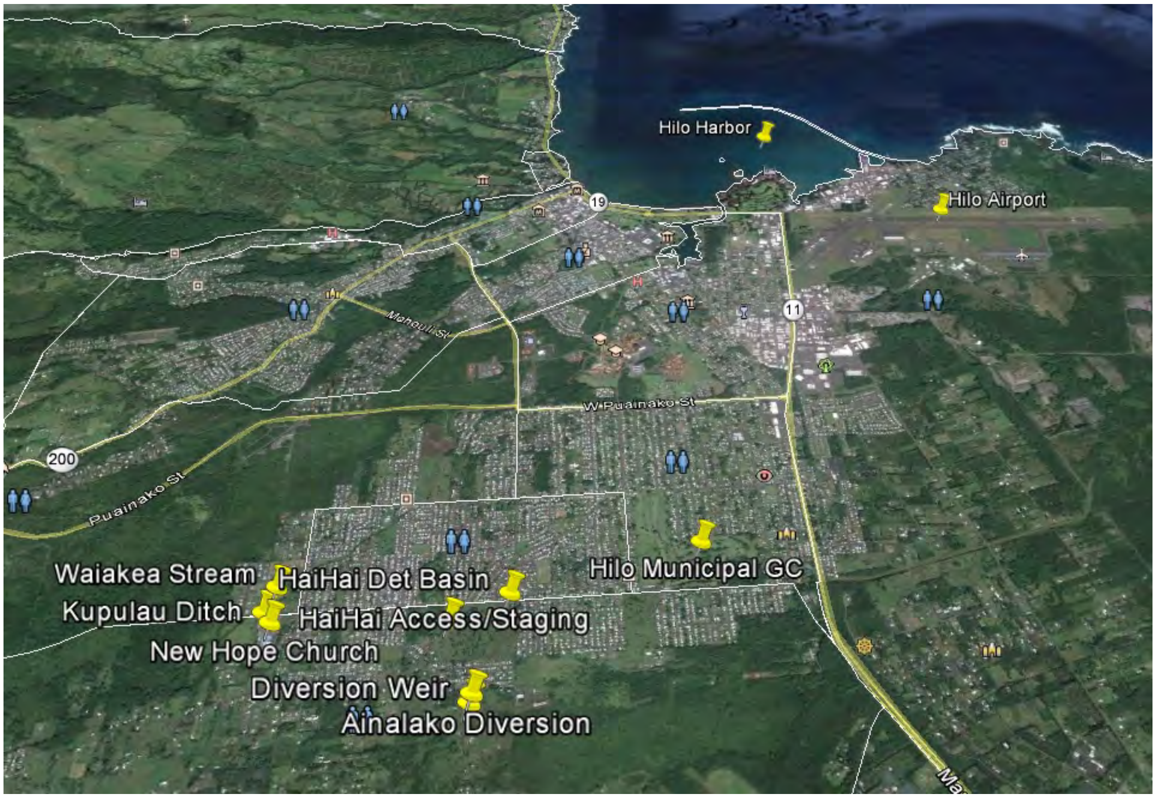


Table 1 Management Measures

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
	Stream Gage, 1EA	Upstream of Waiakea Stream and above the project.
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) * Ainaloko Diversion (Same as above)	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	Oct 2020	July 2020
Planning, Engrg & Design	Jan 2020	Dec 2020	June 2020
Solict/Award	Jan 2021	June 2021	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	Apr 2021
Construction End	Apr 2023
Midpoint of Construction	Apr 2022
Estimated Duration	24months

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 October 2014(1Q2015) 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, 15 Sep 2008; 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#482 16 Sep 2014 effective until September 2015 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) 19 – Buildings, Grounds and Utilities – This account covers the cost of a flood warning system.

4) 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.

5) 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.

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.

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.

8. 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, Ainalako Diversion 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) + Ainalako Diversion & Golf Course Detention (Avg. 10'H) (Class 4 Estimate)			
CWBS Acct	Est Cost @ EPL 1 Oct 14 (FY15) Including Contingency ($K)		Total Proj Cost @ Budget Year FY19 ($K)
01 Real Estate	$838		$939
Construction:			
11 Levees/ Floodwalls	$7,128		$8,277
19 Bldgs, Grounds & Utilities (Flood Warning System)	$37		$43
Total Construction Cost	$7,166		$8,321
30 Planning, Engrg & Design	$2,190		$2,482
31 Construction Mgt	$1,041		$1,258
Project cost Total (Shown on the TPCS)	$11,234		$13,000
Contingency	28.3%		

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. Total Project Cost Summary for the Initial Tentatively Selected Plan

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 Oct 2014, FY15)	Project First Cost (1 Oct 18)	Total Project Cost (Fully Funded)
$11,234,000	$11,860,000	$13,000,000

Based on 1 Oct 2014 price levels, the estimated project first cost is $11,234,000. 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 $8,450,000 which equates to 65% of the Total Project Cost (Fully Funded). The non-Federal share is estimated to be $4,550,000 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 $939,000.

---- End of Project Notes ---

Cost Appendix Attachments

**** 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: **4/16/2019**
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):				2019					
						Effective Price Level Date:				1-Oct- 18					
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	$5,538	$1,590	28.7%	$7,128	5.2%	$5,825	$1,673	$7,498		$7,498	10.4%	$6,430	$1,847	$8,277
19	BUILDINGS, GROUNDS & UTILITIES	$29	$9	30.0%	$37	4.7%	$30	$9	$39		$39	10.4%	$33	$10	$43
				-		-						-			
				-		-						-			
	CONSTRUCTION ESTIMATE TOTALS:	$5,567	$1,599		$7,166	5.2%	$5,855	$1,682	$7,537		$7,537	10.4%	$6,464	$1,857	$8,321
01	LANDS AND DAMAGES	$679	$159	23%	$838	6.9%	$726	$170	$896		$896	4.8%	$761	$178	$939
30	PLANNING, ENGINEERING & DESIGN	$1,701	$489	29%	$2,190	6.1%	$1,804	$518	$2,322		$2,322	6.9%	$1,928	$554	$2,482
31	CONSTRUCTION MANAGEMENT	$809	$232	29%	$1,041	6.1%	$858	$246	$1,105		$1,105	13.9%	$977	$281	$1,258
	PROJECT COST TOTALS:	$8,756	$2,479	28%	$11,234		$9,244	$2,616	$11,860		**$11,860**	9.6%	$10,131	$2,869	$13,000

__________ 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

ESTIMATED TOTAL PROJECT COST:		**$13,000**
ESTIMATED FEDERAL COST:	65%	$8,450
ESTIMATED NON-FEDERAL COST:	**35%**	$4,550
22 - FEASIBILITY STUDY (CAP studies):		**$400**
ESTIMATED FEDERAL COST:	50%	$200
ESTIMATED NON-FEDERAL COST:	50%	$200
ESTIMATED FEDERAL COST OF PROJECT		**$8,650**

**** 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: 4/16/2019

WBS Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
		Estimate Prepared: 8-Jul-15 Estimate Price Level: 1-Oct-14				Program Year (Budget EC): 2019 Effective Price Level Date: 1 -Oct-18								
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	RISK BASED 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	$2,970	$891	30.0%	$3,861	5.2%	$3,124	$937	$4,061	2022Q3	10.4%	$3,449	$1,035	$4,484
19	BUILDINGS, GROUNDS & UTILITIES	$29	$9	30.0%	$37	4.7%	$30	$9	$39	2022Q3	10.4%	$33	$10	$43
	CONSTRUCTION ESTIMATE TOTALS:	$2,999	$900	30.0%	$3,899		$3,154	$946	$4,101			$3,482	$1,045	$4,527
01	LANDS AND DAMAGES	$306	$70	22.8%	$376	6.9%	$327	$75	$402	2020Q4	4.8%	$343	$78	$421
30	PLANNING, ENGINEERING & DESIGN													
2.5%	Project Management	$75	$23	30.0%	$98	6.1%	$80	$24	$103	2020Q3	5.8%	$84	$25	$109
1.0%	Planning & Environmental Compliance	$30	$9	30.0%	$39	6.1%	$32	$10	$41	2020Q3	5.8%	$34	$10	$44
15.0%	Engineering & Design	$450	$135	30.0%	$585	6.1%	$477	$143	$620	2020Q3	5.8%	$505	$152	$657
1.0%	Reviews, ATRs, IEPRs, VE	$30	$9	30.0%	$39	6.1%	$32	$10	$41	2020Q3	5.8%	$34	$10	$44
1.0%	Life Cycle Updates (cost, schedule, risks)	$30	$9	30.0%	$39	6.1%	$32	$10	$41	2020Q3	5.8%	$34	$10	$44
1.0%	Contracting & Reprographics	$30	$9	30.0%	$39	6.1%	$32	$10	$41	2022Q3	13.9%	$36	$11	$47
3.0%	Engineering During Construction	$90	$27	30.0%	$117	6.1%	$95	$29	$124	2022Q3	13.9%	$109	$33	$141
2.0%	Planning During Construction	$60	$18	30.0%	$78	6.1%	$64	$19	$83	2020Q3	5.8%	$67	$20	$88
3.0%	Adaptive Management & Monitoring	$90	$27	30.0%	$117	6.1%	$95	$29	$124	2020Q3	5.8%	$101	$30	$131
1.0%	Project Operations	$30	$9	30.0%	$39	6.1%	$32	$10	$41	2020Q3	5.8%	$34	$10	$44
31	CONSTRUCTION MANAGEMENT													
10.0%	Construction Management	$300	$90	30.0%	$390	6.1%	$318	$95	$414	2022Q3	13.9%	$362	$109	$471
2.0%	Project Operation:	$60	$18	30.0%	$78	6.1%	$64	$19	$83	2022Q3	13.9%	$72	$22	$94
2.5%	Project Management	$75	$23	30.0%	$98	6.1%	$80	$24	$103	2022Q3	13.9%	$91	$27	$118
	CONTRACT COST TOTALS:	$4,655	$1,374		$6,029		$4,913	$1,450	**$6,364**			$5,388	$1,592	**$6,980**

**** 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: 4/16/2019

WBS Structure		ESTIMATED COST				PROJECT FIRST COST (Constant				TOTAL PROJECT COST (FULLY FUNDED)				
		Estimate Prepared:			8-Jul-15	Program Year (Budget EC):			2019					
		Estimate Price Level:			1-Oct-14	Effective Price Level Date:			1 -Oct-18					
				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*
	Ainalako Diversion													
11	LEVEES & FLOODWALLS	$1,380	$331	24.0%	$1,711	5.2%	$1,452	$348	$1,800	2022Q3	10.4%	$1,602	$385	$1,987
	CONSTRUCTION ESTIMATE TOTALS:	$1,380	$331	24.0%	$1,711		$1,452	$348	$1,800			$1,602	$385	$1,987
01	LANDS AND DAMAGES	$93	$28	30.0%	$121	6.9%	$99	$30	$129	2020Q4	4.8%	$104	$31	$135
30	PLANNING, ENGINEERING & DESIGN													
2.5%	Project Management	$35	$8	24.0%	$43	6.1%	$37	$9	$46	2020Q3	5.8%	$39	$9	$49
1.0%	Planning & Environmental Compliance	$14	$3	24.0%	$17	6.1%	$15	$4	$18	2020Q3	5.8%	$16	$4	$19
15.0%	Engineering & Design	$207	$50	24.0%	$257	6.1%	$220	$53	$272	2020Q3	5.8%	$232	$56	$288
1.0%	Reviews, ATRs, IEPRs, VE	$14	$3	24.0%	$17	6.1%	$15	$4	$18	2020Q3	5.8%	$16	$4	$19
1.0%	Life Cycle Updates (cost, schedule, risks)	$14	$3	24.0%	$17	6.1%	$15	$4	$18	2020Q3	5.8%	$16	$4	$19
1.0%	Contracting & Reprographics	$14	$3	24.0%	$17	6.1%	$15	$4	$18	2022Q3	13.9%	$17	$4	$21
3.0%	Engineering During Construction	$41	$10	24.0%	$51	6.1%	$43	$10	$54	2022Q3	13.9%	$50	$12	$61
2.0%	Planning During Construction	$28	$7	24.0%	$35	6.1%	$30	$7	$37	2020Q3	5.8%	$31	$8	$39
3.0%	Adaptive Management & Monitoring	$41	$10	24.0%	$51	6.1%	$43	$10	$54	2020Q3	5.8%	$46	$11	$57
1.0%	Project Operations	$14	$3	24.0%	$17	6.1%	$15	$4	$18	2020Q3	5.8%	$16	$4	$19
31	CONSTRUCTION MANAGEMENT													
10.0%	Construction Management	$138	$33	24.0%	$171	6.1%	$146	$35	$181	2022Q3	13.9%	$167	$40	$207
2.0%	Project Operation:	$28	$7	24.0%	$35	6.1%	$30	$7	$37	2022Q3	13.9%	$34	$8	$42
2.5%	Project Management	$35	$8	24.0%	$43	6.1%	$37	$9	$46	2022Q3	13.9%	$42	$10	$52
	CONTRACT COST TOTALS:	$2,096	$509		$2,605		$2,212	$537	**$2,749**			$2,428	$589	**$3,017**

****** 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: 4/16/2019

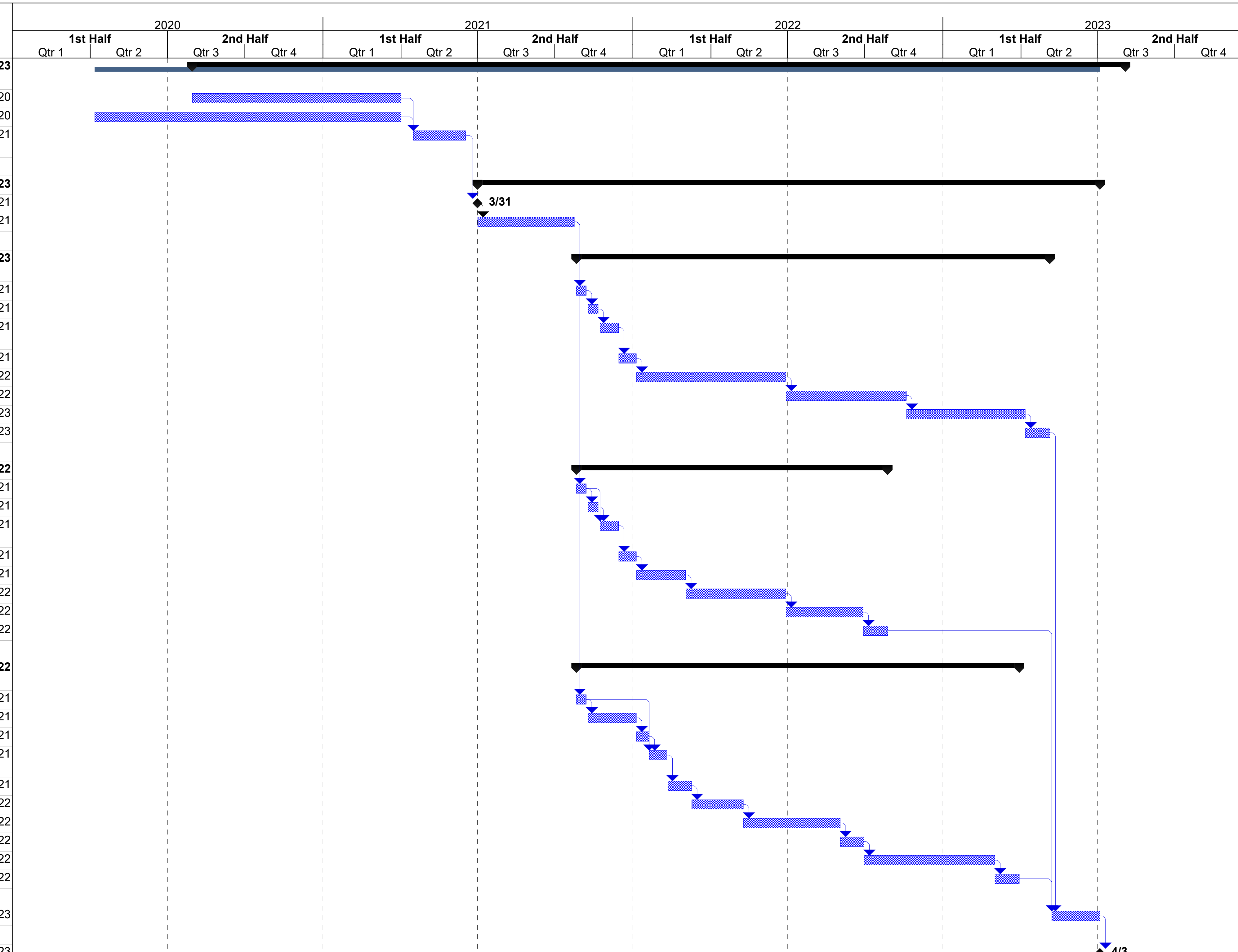
WBS Structure		ESTIMATED COST				PROJECT FIRST COST (Constant				TOTAL PROJECT COST (FULLY FUNDED)				
		Estimate Prepared: 8-Jul-15 Estimate Price Level: 1-Oct-14				Program Year (Budget EC): 2019 Effective Price Level Date: 1 -Oct-18								
				RISK BASED										
WBS NUMBER	Civil Works Feature & 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***
	Golf Course Detention													
11	LEVEES & FLOODWALLS	$1,188	$368	31.0%	$1,556	5.2%	$1,249	$387	$1,637	2022Q3	10.4%	$1,379	$428	$1,807
	CONSTRUCTION ESTIMATE TOTALS:	$1,188	$368	31.0%	$1,556		$1,249	$387	$1,637			$1,379	$428	$1,807
01	LANDS AND DAMAGES	$280	$61	21.8%	$341	6.9%	$299	$65	$365	2020Q4	4.8%	$314	$68	$382
30	PLANNING, ENGINEERING & DESIGN													
2.5%	Project Management	$30	$9	31.0%	$39	6.1%	$32	$10	$42	2020Q3	5.8%	$34	$10	$44
1.0%	Planning & Environmental Compliance	$12	$4	31.0%	$16	6.1%	$13	$4	$17	2020Q3	5.8%	$13	$4	$18
15.0%	Engineering & Design	$178	$55	31.0%	$233	6.1%	$189	$59	$247	2020Q3	5.8%	$200	$62	$262
1.0%	Reviews, ATRs, IEPRs, VE	$12	$4	31.0%	$16	6.1%	$13	$4	$17	2020Q3	5.8%	$13	$4	$18
1.0%	Life Cycle Updates (cost, schedule, risks)	$12	$4	31.0%	$16	6.1%	$13	$4	$17	2020Q3	5.8%	$13	$4	$18
1.0%	Contracting & Reprographics	$12	$4	31.0%	$16	6.1%	$13	$4	$17	2022Q3	13.9%	$14	$4	$19
3.0%	Engineering During Construction	$36	$11	31.0%	$47	6.1%	$38	$12	$50	2022Q3	13.9%	$43	$13	$57
2.0%	Planning During Construction	$24	$7	31.0%	$31	6.1%	$25	$8	$33	2020Q3	5.8%	$27	$8	$35
3.0%	Adaptive Management & Monitoring	$36	$11	31.0%	$47	6.1%	$38	$12	$50	2020Q3	5.8%	$40	$13	$53
1.0%	Project Operations	$12	$4	31.0%	$16	6.1%	$13	$4	$17	2020Q3	5.8%	$13	$4	$18
31	CONSTRUCTION MANAGEMENT													
10.0%	Construction Management	$119	$37	31.0%	$156	6.1%	$126	$39	$165	2022Q3	13.9%	$144	$45	$188
2.0%	Project Operation:	$24	$7	31.0%	$31	6.1%	$25	$8	$33	2022Q3	13.9%	$29	$9	$38
2.5%	Project Management	$30	$9	31.0%	$39	6.1%	$32	$10	$42	2022Q3	13.9%	$36	$11	$47
	CONTRACT COST TOTALS:	$2,005	$596		$2,600		$2,118	$629	**$2,747**			$2,315	$689	**$3,003**

Waiakea-Palai(revTSP)(FY19)

Estimated by	T. Kazunaga, POH-EC-S
Designed by	P. Murawski,
Prepared by	Tracy Kazunaga
Preparation Date	7/8/2015
Effective Date of Pricing	10/1/2014
Estimated Construction Time	1,497 Days

Description	ContractCost
Project Cost Summary Report	**5,566,569**
Kupulau Detention	**2,998,887**
11 Levees and Floodwalls	**2,970,065**
19 Buildings, Grounds, & Utilities	**28,822**
Ainalako Diversion	**1,380,023**
11 Levees	**1,380,023**
Golf Course Detention	**1,187,659**
11 Levees	**1,187,659**

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	**Ainalako Diversion**	**254 days**	**Mon 7/26/21**	**Wed 7/27/22**
21	Survey & layout	10 days	Mon 7/26/21	Fri 8/6/21
22	Mob	10 days	Mon 8/9/21	Fri 8/20/21
23	BMPs / Contractor's Storage Area/ Haul Road	15 days	Mon 8/23/21	Mon 9/13/21
24	Clear & Grub	3 wks	Tue 9/14/21	Mon 10/4/21
25	Overflow / Weir	2 mons	Tue 10/5/21	Wed 12/1/21
26	Levees	4 mons	Thu 12/2/21	Tue 3/29/22
27	Rain Delay	64 days	Wed 3/30/22	Tue 6/28/22
28	Cleanup & Demob	20 days	Wed 6/29/22	Wed 7/27/22
29				
30	**Golf Course Detention**	**360 days**	**Mon 7/26/21**	**Thu 12/29/22**
31	Survey & layout	10 days	Mon 7/26/21	Fri 8/6/21
32	Golf Course Coordination	2 mons	Mon 8/9/21	Mon 10/4/21
33	Mob	10 days	Tue 10/5/21	Tue 10/19/21
34	BMPs / Contractor's Storage Area/ Haul Road	15 days	Wed 10/20/21	Tue 11/9/21
35	Clear & Grub	4 wks	Thu 11/11/21	Wed 12/8/21
36	Culvert & Weir	2 mons	Thu 12/9/21	Mon 2/7/22
37	Levees	4 mons	Tue 2/8/22	Wed 6/1/22
38	Restore damaged areas	1 mon	Thu 6/2/22	Wed 6/29/22
39	Rain Delay	105 days	Thu 6/30/22	Wed 11/30/22
40	Cleanup & Demob	20 days	Thu 12/1/22	Thu 12/29/22
41				
42	Final Submittals/Closeout Contract	2 mons	Mon 2/6/23	Mon 4/3/23
43				
44	Project Construction Complete	0 days	Mon 4/3/23	Mon 4/3/23



P/N 326040: Waiakea-Palai Combo
Hilo, Island of Hawaii
Date: Thu 4/18/19

Legend: 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