Figure E1. Conceptual Rendering of the Waiakeakua Debris and Detention Basin

Figure E2. Conceptual Rendering of the Woodlawn Ditch Detention Basin

Figure E3. Conceptual Rendering of the Pukele Debris and Detention Basin

Figure E4. Conceptual Rendering of the Makiki Debris and Detention Basin

Figure E5. Conceptual Rendering of the Ala Wai Canal Floodwalls (near Ala Wai Boulevard)

Figure E6. Conceptual Rendering of the Ala Wai Canal Floodwalls (near Kalakaua Avenue)

Figure E7. Conceptual Rendering of the Hausten Ditch Detention Basin (with aesthetic improvements)

Figure E8. Conceptual Rendering of the Ala Wai Golf Course Detention Basin

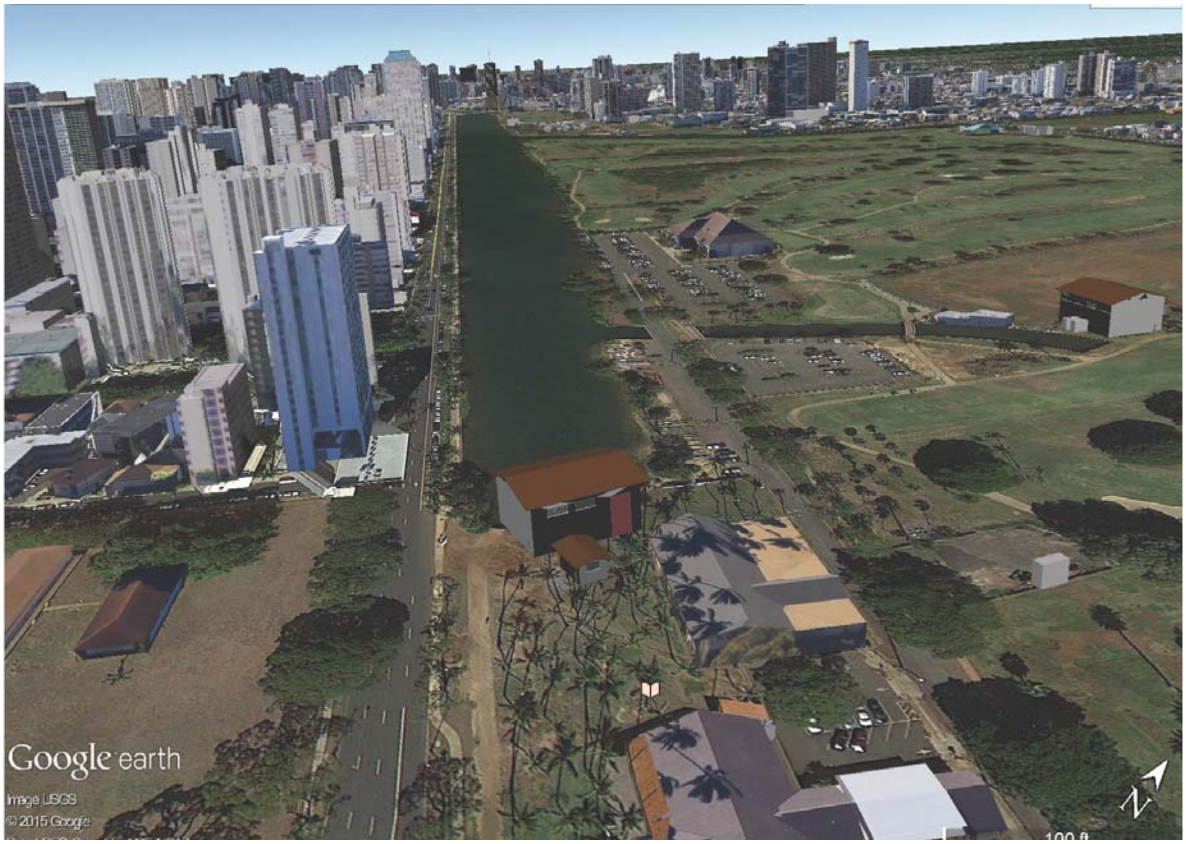


Figure E9. Conceptual Rendering of the Pump Stations at the East End of the Ala Wai Canal

This page is intentionally left blank.

Appendix E7
Fish and Wildlife Coordination Act Report

This page is intentionally left blank.

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:
2014-CPA-0062

OCT 3 1 2016

Anthony J. Paresa, P.E.
Deputy District Engineer
Programs and Project Management/Civil Works
U.S. Army Corps of Engineers
Building 230
Fort Shafter, Hawaii, 96858-5440

Dear Mr. Paresa:

In coordination with your staff, the U.S. Fish and Wildlife Service (Service) is providing this Final Coordination Act Report for the proposed Ala Wai Flood Risk Management Study. The Fish and Wildlife Coordination Act of 1934 [16 U.S.C. 661 et seq.; 48 Stat. 401], as amended (FWCA), was established to provide a basic procedural framework for the orderly consideration of fish and wildlife conservation measures to be incorporated into Federal water resources development projects. This report has been prepared under the authority of and in accordance with provisions of the FWCA, the Federal Clean Water Act of 1977 [33 U.S.C. 1251 et seq.; 62 stat. 1155], as amended (CWA), and the Endangered Species Act [16 U.S.C 1531 et seq.], as amended (ESA). These comments are also consistent with the National Environmental Policy Act of 1969 [42 U.S.C. 4321 et seq.; 83 Stat. 852], as amended, and other authorities mandating the Service's review of projects and provision of technical assistance to conserve trust resources.

This report was prepared by the Service in coordination with the State of Hawaii's Department of Land and Natural Resources. We have also solicited comments from the National Oceanic and Atmospheric Administration (NOAA), National Marine Fisheries Service (NMFS), and U.S. Environmental Protection Agency (EPA).

We appreciate the opportunity to provide input on the proposed project. If you have questions regarding the report, please contact Fish and Wildlife Biologist Kevin Foster (kevin_b_foster@fws.gov or 808-792-9420) or Aquatic Ecosystem Conservation Program Coordinator Dan Polhemus (Dan_Polhemus@fws.gov or 808-792-9400).

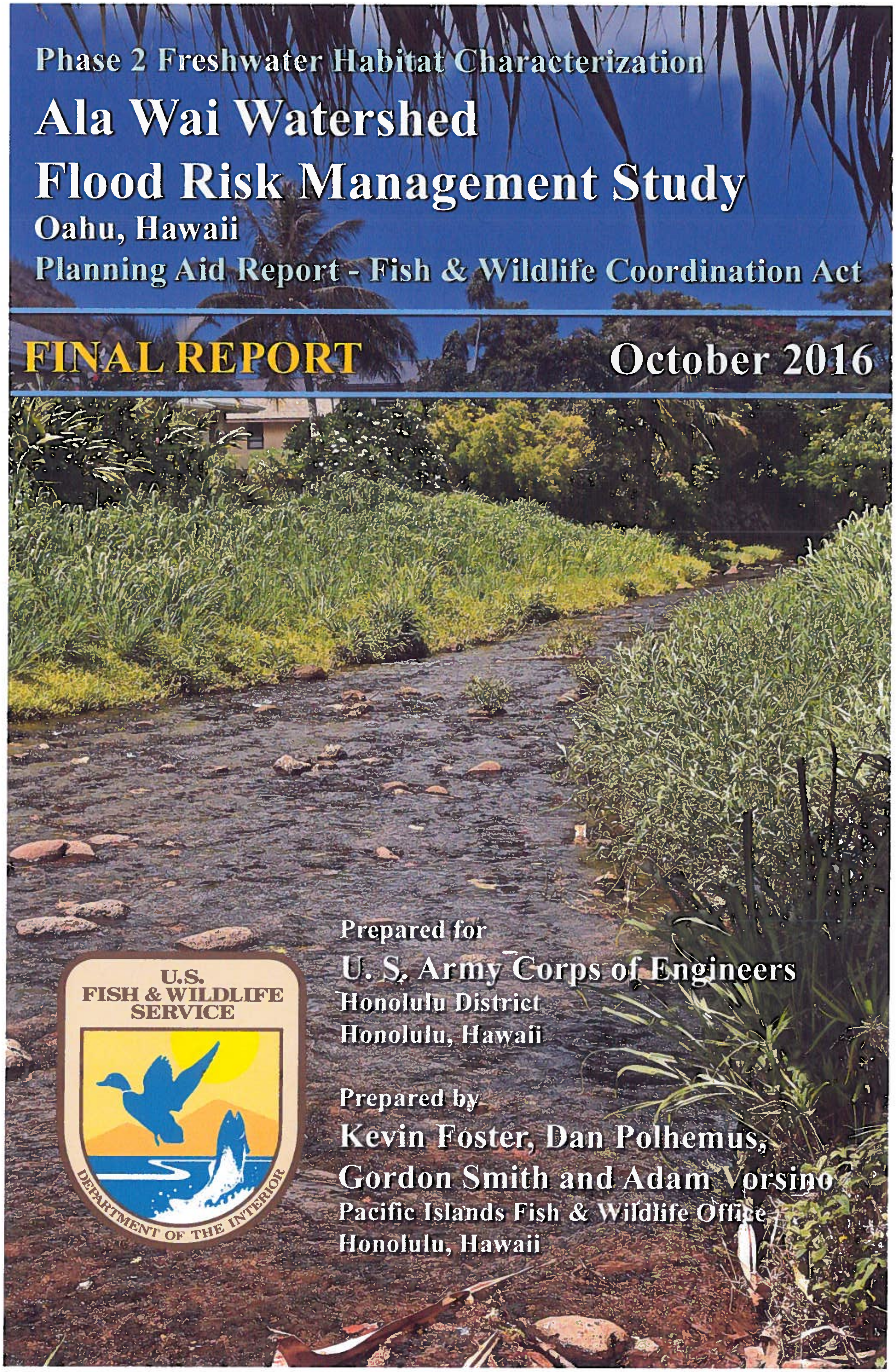
Sincerely,

Mary M. Abrams

Mary M. Abrams, Ph.D
Field Supervisor

Enclosures:
Final Coordination Act Report – Ala Wai
Flood Risk Management Study

cc:
NMFS-PIRO, Honolulu
HDAR-DLNR, Honolulu
USEPA-Region IX, Honolulu



Phase 2 Freshwater Habitat Characterization

Ala Wai Watershed Flood Risk Management Study

Oahu, Hawaii

Planning Aid Report - Fish & Wildlife Coordination Act

FINAL REPORT October 2016

U.S. FISH & WILDLIFE SERVICE
DEPARTMENT OF THE INTERIOR

Prepared for

U. S. Army Corps of Engineers
Honolulu District
Honolulu, Hawaii

Prepared by

Kevin Foster, Dan Polhemus, Gordon Smith and Adam Vorsino
Pacific Islands Fish & Wildlife Office
Honolulu, Hawaii

FINAL
FISH AND WILDLIFE COORDINATION ACT REPORT
ALA WAI WATERSHED FLOOD RISK MANAGEMENT STUDY
OAHU ISLAND, HAWAII

Prepared by:

Kevin B. Foster, Dan A. Polhemus, Gordon Smith, and Adam Vorsino
U.S. Department of the Interior
U.S. Fish and Wildlife Service
Pacific Islands Fish and Wildlife Office
Honolulu, Hawaii

Prepared for:

U.S. Army Corps of Engineers – Honolulu District
Honolulu, HI

October 2016

TABLE OF CONTENTS

INTRODUCTION

Authority, Purpose and Scope

The current document constitutes the U.S. Fish and Wildlife Service's (Service) final report on plans developed by the U.S. Army Corps of Engineers – Honolulu District (USACE) for flood risk management in the Ala Wai watershed, island of Oahu, State of Hawaii (Figures 1, 2 and 3). This report has been prepared under the authority of the Fish and Wildlife Coordination Act of 1934 (FWCA) [16 U.S.C. 661 *et seq.*; 48 Stat. 401], as amended, and other authorities mandating Department of the Interior (DOI) concern for environmental values. This report is also consistent with the National Environmental Policy Act of 1969 (NEPA) [42 U.S.C. 4321 *et seq.*; 83 Stat. 852], as amended and the Endangered Species Act of 1973 [16 U.S.C. 1531 *et. seq.*; 87 Stat. 884], as amended (ESA). The purpose of this report is to document existing fish and wildlife resources at the proposed project sites and to ensure that fish and wildlife conservation receives equal consideration with other proposed project objectives as required under the FWCA. The report includes an assessment of conspicuous diurnal fish and wildlife resources at the proposed project sites, an evaluation of potential impacts associated with the proposed alternative actions, and recommendations for fish and wildlife mitigation measures.

The proposed Ala Wai Watershed Flood Risk Management Study is authorized under the Rivers and Harbors Act of 1967 (Public Law 87-874). Section 209 is a general study authority that authorizes surveys in harbors and rivers in Hawaii "with a view to determining the advisability of improvements in the interest of navigation, flood control, hydroelectric power development, water supply and other beneficial water uses, and related land resources." This civil works project is being undertaken by the USACE as the Federal sponsor, in partnership with the State of Hawaii Department of Land and Natural Resources (DLNR), the non-Federal sponsor.

The overall purpose of the project is to reduce the risk of riverine flooding in the Ala Wai Watershed. Flooding has occurred within the watershed on multiple occasions, resulting in recorded property damages and health and safety risks. Analyses conducted in support of this project show that the 1-percent annual chance exceedance (ACE) floodplain extends over approximately 1,358 acres of the watershed. Modeling results indicate the 1-percent ACE flood would result in damages to more than 3,000 structures, with approximately $318 million in structural damages alone (2013 price levels), not accounting for loss in business income or other similar economic losses.

The USACE is conducting an integrated Feasibility Study/Environmental Assessment to assess the technical, environmental and economic feasibility of the implementation of flood control improvements within the Ala Wai Watershed. The study will include structural measures, including the following: (1) Waihi Debris and Detention Basin; (2) Waiakeakua Debris and Detention Basin; (3) Woodlawn Ditch Detention Basin; (4) Manoa In-Stream Debris Catchment;

(5) Kanewai Field Multi-purpose Detention Basin; (6) Waiomao Debris and Detention Basin; (7) Pukele Debris and Detention Basin; (8) Makiki Debris and Detention Basin; (9) Ala Wai Canal Floodwalls; (10) Hausten Ditch Detention Basin; and (11) Ala Wai Golf Course Multi-Purpose Detention Basin (for feature locations, see Fig. 3). Also, a non-structural measure includes a flood warning system. Finally, the USACE is proposing Aquatic Habitat Mitigation to offset project construction-related unavoidable impacts to fish and wildlife resources.

The preferred action will evaluate the construction of site specific in-stream debris and detention basins, access roads to support initial construction, vegetation removal, fill, and multi-purpose detention basin and floodwall construction activities for Manoa, Palolo, Makiki streams and the Ala Wai Canal. The preferred action will also evaluate a flood warning system for the entire Ala Wai watershed. Finally, operational and maintenance activities will be evaluated for debris and detention basins, multi-purpose detention basins, floodwalls and a flood warning system.

Construction of other structures, such as a single large dam or floodwater management pumping stations, has also been evaluated, but these are not anticipated to be feasible or effective. A large dam approximately 50-ft high and 350-ft long across Waihi and Waiakeakua Streams was considered. However, based on hydraulic modeling, it was determined that the most effective location of a dam of this size would be in the mid-watershed. Since this is a densely urban area, the large dam alternative was determined not to be feasible. Also, pumping during peak flows from the Ala Wai Canal or widening and deepening the canal or construction of another canal outlet have been considered, but determined not feasible or effective. Finally, other non-structural options were considered but determined insufficient to reduce overall flood risk. Therefore, these measures have been removed from further USACE consideration.

Service biologists have discussed the proposed project with staff of the National Marine Fisheries Service (NMFS) and the Hawaii Department of Land and Natural Resources, Division of Aquatic Resources (DAR). Concerns relative to the protection and conservation of important fish and wildlife resources in the Ala Wai Watershed expressed by DAR were incorporated into this FWCA report. Copies of this report are being provided to the NMFS, DAR, the Hawaii Office of State Planning, Coastal Zone Management Program (CZMP), the U.S. Environmental Protection Agency (EPA), and the Hawaii Department of Health Clean Water Branch (CWB).

Prior Fish and Wildlife Service Studies and Reports

In September 2015, the Service provided the USACE with a preliminary field data report concerning observations of federally listed damselflies within the footprint of the Ala Wai Watershed Flood Control Study. Service biologists were able to survey all proposed project footprints along Makiki Stream, Manoa Stream, and Palolo Stream. During these surveys, observations of stream habitat features, diadromous macrofauna and the insect order Odonata, which includes the federally listed species from the genus *Megalagrion*, were recorded. At

Waihi Stream, observations of the listed *Megalagrion nigrohamatum nigrolineatum* (Figs. 4 and 5) were documented throughout the survey area. This prior report presented data for the Service's qualitative survey of these federally listed damselflies within the project area.

In December 2015, the Service provided the USACE with a draft Coordination Act Report for the proposed Ala Wai Flood Risk Management Study. In this report, the Service evaluates the preferred action of specific in-stream debris and detention basins, access roads to support initial construction, vegetation removal, fill and multi-purpose detention basin and floodwall construction activities for Manoa, Palolo, Makiki streams and the Ala Wai Canal.

DESCRIPTION OF THE PROJECT AREA

The Ala Wai watershed is located on the leeward side of Oahu Island, Hawaii, on the southern slope of the extinct Koolau volcano between Punchbowl Crater and Diamond Head Crater (Figs. 1-3). The watershed is about 19 square miles (mi^2) (about, 12,064 acres), bounded to the north by the Koolau Mountains (with ridge crest elevations about 740 m or 2,400 feet), and by Mamala Bay, to the south. The Ala Wai watershed is comprised of three major drainages that include the Makiki drainage (1,687 acres), Manoa and Palolo drainage (6,247 acres) and storm water drainage from Kapahulu, Moiliili, Ala Moana and Waikiki areas (4,099 acres), all of which drain into the Ala Wai Canal. Makiki Stream, Manoa Stream and Palolo Stream are considered perennial streams, supporting surface flows in all or part of each stream throughout the year.

Makiki Stream

Makiki Stream is a relatively small stream originating near 655 meters (m) (1850 feet (ft)) on the southwestern flank of Mt. Tantalus in the Koolau Mountains, and flows southwestwards for approximately 5.6 kilometers (km) (3.5 miles (mi)) to its terminus in the Ala Wai canal (Fig. 3). The stream has three major branches, these being from west to east the Kanaha, Kanealole, and Moleka streams, the latter two of which join prior to their confluence with the Kanaha. The upper half of the Makiki catchment lies in steep, forested terrain on the slopes of Mt. Tantalus and Round Top, an area that receives up to 3,420 millimeters (~134 inches) of rain annually (Giambelluca, *et al.* 2013). The stream in this section flows in natural, unmodified channels, heavily shaded by a forest of introduced tree species, and is fed by two major springs, the Makiki Spring on the Kanealole branch, and the Herring Spring on the Moleka branch. At approximately 45 m (150 ft) elevation, just downstream from Makiki Street, the stream channel is artificially confined within a concrete box culvert, which runs under the streets and neighborhoods of Honolulu before re-emerging at sea level near the intersection of Philip Street and Kalakaua Avenue. From this point the stream runs in an open concrete channel for another 0.6 km (0.4 mi) to the Ala Wai Canal. There are no historic or active ditch diversions in the Makiki Stream catchment.

Makiki Stream has an active USGS gauge located at 21°17'48" N, 157°50'12" W, at an elevation of 3 m (10 ft), and has 69 years of record. Based on this time series, the stream at the gauge has a median discharge of 0.56 cubic feet per second (cfs).

Manoa Stream

Manoa Stream is a large stream in a bowl-like catchment, originating near 855 m (2,800 ft) on the southwestern flank of Konahuanui peak and adjacent ridgelines in the Koolau Mountains, and flows southwestwards for approximately 9.25 km (5.75 mi) to its terminus in the Ala Wai canal (Figure 3). The stream has two major branches, these being the Waihi on the west side of the basin, and the Waiakeakua on the east. The upper half of the Manoa catchment lies in steep, forested terrain on the slopes of the Koolau Mountains, in a very wet area that receives up to 3850 millimeters (~151 inches, or 12.6 ft) of rain annually at the headwaters of the Waihi branch, and 3550 millimeters (~140 inches, or 12 ft) annually at the headwaters of the Waiakeakua branch (Giambelluca, *et al.* 2013). The stream in its upper reaches flows in natural, unmodified channels for approximately 3.6 km (2.25 mi), being heavily shaded by a forest of introduced tree species, with some native vegetation on the upper slopes. Below Paradise Park, the stream passes through suburban neighborhoods in a partially modified channel for about 1.6 km (1.0 mi). At the Manoa District Park, near 50 m (160 ft) elevation the stream becomes confined within an artificial concrete channel, which continues downstream to the East Manoa Road bridge. Downstream from this bridge the stream flows in a re-aligned but partially natural channel, mostly following the base of the steep eastern wall of Manoa Valley. Downstream from Kanewai Park, at approximately 9 m (30 ft) elevation, the stream channel has been straightened, but not concrete-lined, and continues in this fashion for 2.25 km (1.4) miles, passing below the H-1 freeway and then continuing to its confluence with the Ala Wai Canal.

Both the Waihi and Waiakeakua branches of Manoa Stream also have active USGS stream gauges. The Waihi gauge is located at 21°19'42" N, 157°48'03" W, at an elevation of 88 m (290 ft), and has 69 years of record. Based on this time series, the stream at the gauge has a median discharge of 2.0 cfs. The Waiakeakua gauge is located at 21°19'41 N, 157°47'59" W, at an elevation of 89 m (294 ft), and has 97 years of record. Based on this time series, the stream at the gauge has a mean discharge of 3.6 cfs. The median of the combined flows of the two branches is therefore on the order of 5.6 cfs (approximately 10 times the discharge volume of Makiki Stream), which is reflective of the conditions prevailing during the current survey.

Palolo Stream

Palolo Stream is another large stream in a somewhat more tightly confined catchment than adjacent Manoa Stream, and originates near 810 m (2,665 ft.) on the southwestern flank of Mt. Olympus and adjacent ridgelines in the Koolau Mountains, and flows southwestwards for approximately 7.1 km (4.4 mi) before joining with Manoa Stream just upslope of the H-1 freeway (Figure 3). The stream has two major branches, these being the Pukele on the west side of the basin, and the Waiomao on the east. The upper third of the Palolo catchment lies in steep, forested terrain on the slopes of the Koolau Mountains, in a wet area that receives up to 3,050 millimeters (~120 inches, or 10 ft) of rain annually at the headwaters of the Pukele branch, and 2650 millimeters (~104 inches) annually at the headwaters of the Waiomao branch (Giambelluca *et al.* 2013). The stream headwaters in these upper reaches traverse unmodified channels for approximately 3.2 km. (2.0 mi.), being shaded by a forest of introduced tree species, with some native vegetation on the upper slopes. At approximately 160 m (530 ft) elevation both stream branches begin to traverse the suburban neighborhoods of Palolo Valley, with their channels becoming progressively more straightened and modified. Pukele Stream appears to be intermittent in its upper reaches, but receives significant spring inflow just upstream of the 10th Avenue bridge. Not far downstream of this bridge, at 75 m (250 ft) elevation, the stream becomes confined within a concrete channel, and retains this artificial character for the remaining 0.48 km (0.30 mi) of its length, until its confluence with Waiomao Stream at 68 m (225 ft) elevation. The Waiomao Stream exhibits higher volume in its headwaters, receiving perennial inflow from the outlet of a perched wetland in Kaau Crater. This branch also retains a more natural character to its channel until just before its confluence with the Pukele Stream, at which point it is confined within an artificial concrete channel, which then continues for the remaining 3.2 km (2.0 mi) length of the stream until its confluence with Manoa Stream just downslope of Kanewai Park.

The Pukele branch of Palolo Stream has an active USGS gauge located 21°18'24" N, 157°47'18" W, at an elevation of 105 m (345 ft), and has 65 years of record. Based on this time series, the stream at the gauge has a median discharge of 0.60 cfs. The Waiomao branch of Palolo Stream has an existing gauge structure located at 21°18'24" N, 157°46'50" W, at an elevation 120 m (400 ft), which formerly operated from 1911 to 2014; this gauge is no longer actively maintained. Based on historical records, it appears that the median discharge from the Waiomao branch is approximately 0.80 cfs, giving Palolo Stream below the confluence a combined median discharge volume of 1.40 cfs.

During the course of the current investigation continuous flow was present at all sites surveyed. Even so, a previous site visit to Pukele Stream in April 2015 had revealed the channel at this site to be dry, indicating that base flow in this reach becomes hyporheic at certain times of the year (generally the drier summer months), with water restricted to remnant pools forming at bedrock or saprolitic sills. The artificial channel at Woodlawn Ditch was consistently dry in both April 2014 and during the current sampling period. Following the definitions in Polhemus *et al.* (1992), Woodlawn Ditch is considered to be an intermittent, artificial ditch; the Pukele Stream sampling site is considered to represent a naturally interrupted stream midreach; and all other sampling sites surveyed are considered to represent continuously perennial stream midreach ecosystems possessing riffle and pool habitat.

Ala Wai Canal

The Ala Wai Canal is a man-made waterway, approximately 2 miles in length that was created for land reclamation purposes between 1920 and 1924. The depth of the canal ranges from about 3-8 m (10 to 25 ft) deep. The Ala Wai Harbor was originally constructed during the early 1900s by the United States military. The entire watershed drains through the Ala Wai Canal into Mamala Bay. Mamala Bay encompasses the ocean area offshore of southern Oahu from Diamond Head Crater to Barbers Point (Kalaeloa) Deep Draft Harbor. Complex coral reef communities have been described throughout Mamala Bay.

The State of Hawaii, Division of Aquatic Resources (DAR), in their Oahu volume of the *Atlas of Hawaiian Watersheds* series (Parham, *et al.* 2008) assigned the Ala Wai catchment an overall ranking of 8 on a scale of 1 to 10, with larger numbers equating to higher watershed quality based on land cover classes, size, wetness, reach diversity, and biological resources. This is a relatively high statewide ranking for a drainage system on Oahu, and is reflective of the relatively natural conditions prevailing in the upper catchment, despite the urbanization in the lower catchment. The DAR analysis did not break out metrics for the three individual streams within the Ala Wai catchment, because all flow into a single coterminous estuary.

FISH AND WILDLIFE RESOURCE CONCERNS AND PLANNING OBJECTIVES

The Service's primary concerns with the proposed project include potential impacts to endangered species and other fish and wildlife resources and their habitats from planned fill and debris removal activities in the stream and riparian habitat. Specific Service planning objectives are to maintain and enhance the existing significant habitat values at the proposed project site by (1) obtaining basic biological data for the proposed project site, (2) evaluating and analyzing the impacts of proposed-project alternatives on fish and wildlife resources and their habitats, (3) identifying the proposed-project alternative least damaging to fish and wildlife resources, and (4) recommending mitigation for unavoidable project-related habitat losses consistent with the FWCA and the Service's Mitigation Policy.

Under the authority of the ESA, the Department of the Interior and the Department of Commerce share responsibility for the conservation, protection, and recovery of federally listed endangered and threatened species. Authority to conduct consultations has been delegated by the Secretary of the Interior to the Director of the Service and by the Secretary of Commerce to the Assistant Administrator for Fisheries of the National Oceanic Atmospheric Administration (NOAA). Section 7(a)(2) of the ESA requires federal agencies, in consultation with and with the assistance of the Service or NMFS, to insure that any action authorized, funded, or carried out by such agency is not likely to jeopardize the continued existence of any listed species or result in the destruction or adverse modification of designated critical habitats. The Biological Opinion is the document that states the opinion of the Service or NMFS as to whether the federal action is likely to jeopardize the continued existence of listed species or result in the destruction or adverse modification of critical habitat.

The Service's Mitigation Policy (Service, 1981) outlines internal guidance for evaluating project impacts affecting fish and wildlife resources. The Mitigation Policy complements the Service's participation under NEPA and the FWCA. The Service's Mitigation Policy was formulated with the intent of protecting and conserving the most important fish and wildlife resources while facilitating balanced development of this nation's natural resources. The policy focuses primarily on habitat values and identifies four resource categories and mitigation guidelines. The resource categories are the following:

a. Resource Category 1: Habitat to be impacted is of high value for the evaluation species and is unique and irreplaceable on a national basis or in the ecoregion section.

b. Resource Category 2: Habitat to be impacted is of high value for the evaluation species and is relatively scarce or becoming scarce on a national basis or in the ecoregion section.

c. Resource Category 3: Habitat to be impacted is of high to medium value for the evaluation species and is relatively abundant on a national basis.

d. Resource Category 4: Habitat to be impacted is of medium to low value for the evaluation species.

The riffle and pool habitat is extensive at the planned Waihi Stream Detention Basin and Waiakeakua Stream Detention Basin project sites, and represents the major habitat of concern. The institutional significance of U.S. riffle and pool habitat has been established through its designation as a Special Aquatic Site under the Clean Water Act (40 CFR Part 230 §230.44/FR v.45n.249) (CWA). Such areas possess special ecological characteristics in regard to biological diversity, productivity, habitat, wildlife protection, and easily disrupted biological integrity, and contribute to the general overall environmental health or vitality of an entire ecosystem within a region. Furthermore, the riffle and pool habitat at this site supports a population of the federally listed blackline damselfly (*Megalagrion nigrohamatum nigrolineatum*).

For the purpose of this report and analysis, the federally listed blackline damselfly (*Megalagrion nigrohamatum nigrolineatum*) at the proposed project site was selected as the primary evaluation species for this section of the FWCA analysis. This species is endemic to the island of Oahu, and formerly occurred in both the windward and leeward drainages of the Koolau and Waianae mountain ranges (Polhemus & Asquith 1996). The species was extirpated in the Waianae Mountains sometime after 1980 (Polhemus 2007), but continues to persist as a series of discontinuous populations in the Koolau Mountains. The map and associated data in Polhemus (2007) indicated 22 known populations of this species still extant, although the population at

Waihi Stream was not reflected on this map, because it was unknown at that time. Although *M. nigrohamatum nigrolineatum* is the most widespread endemic damselfly remaining on Oahu, the loss of all remaining populations in the western half of the island in the past 35 years clearly indicates that its global population status is still declining.

EVALUATION METHODOLOGY

Damselfly Assessment

An initial qualitative survey conducted by Service biologists on July 27 and 28, 2015 revealed the presence of *M. nigrohamatum nigrolineatum* along Waihi Stream. Based on these results, a subsequent quantitative damselfly assessment was conducted on October 9 and 15, 2015, at the Waihi Stream location where the USACE has indicated it is planning to construct a Debris and Detention Basin. This assessment was designed to describe the damselfly population along this stream reach, and to gauge potential project impacts from the primary project alternative and the no action alternative. The distribution and relative abundance of damselflies were recorded along a transect that began upstream of the project footprint, passed through the footprint, and continued downstream (Figs. 4-6). Global Positioning System (GPS) data were also collected to identify the location of each survey transect.

The initial survey work at Waihi Stream was conducted by Service biologists Dr. Dan Polhemus, Mr. Gordon Smith and Ms. Jiny Kim, accompanied by Service volunteer Mr. Hunter Polhemus. All damselfly survey work was conducted between 9:00am and 5:00pm, and curtailed during periods of heavy rain.

Based on the presence of *M. nigrohamatum nigrolineatum* in the area downstream of the proposed project footprint at sites adjacent to water features on the grounds of the now-defunct Paradise Park, a second quantitative survey was undertaken on October 15, 2015 to determine to what extent native damselflies were utilizing habitats in this area. This supplemental Waihi corridor survey work was conducted by Service biologists Dr. Dan Polhemus, Mr. Gordon Smith and Ms. Jiny Kim, accompanied by Service volunteer Mr. Hunter Polhemus between 9:00 AM and 12:00 noon. Because this survey was cut short by the onset of rainy weather, another supplemental survey was conducted at the same sites by service biologist Dr. Dan Polhemus and Service volunteer Mr. Hunter Polhemus on October 23, 2015, during sunny weather from 9:00 AM to 12:00 noon. For these three Waihi Stream surveys as a whole, Dr. Polhemus and Ms. Kim provided all photographs and collected the GPS waypoints that appear in this report.

The Waiakeakua branch of Manoa Stream was initially surveyed qualitatively by Service biologists Dr. Dan A. Polhemus and Mr. Gordon Smith on 27 July 2015. At the time, no definitive native damselfly sightings were recorded, but one fleeting observation indicated that such species might be potentially be present. Following the positive detections at nearby Waihi Stream, the Waiakeakua site was revisited on February 11, 2016 by a survey team consisting of

Dr. Dan Polhemus and Service volunteer Mr. Hunter Polhemus, accompanied by Ms. Becca Frager and Mr. Kevin Nishimura from the U. S. Army Corps of Engineers, and Mr. Glenn Higashi and an assistant from the State of Hawaii Division of Aquatic Resources. As with the Waihi survey described above, this assessment was designed to determine the presence or absence of *M. nigrohamatum nigrolineatum* at this site, describe and quantify any native damselfly population that might be present along this stream reach, and to gauge potential project impacts from the primary project alternative and the no action alternative. This second survey revealed that *M. nigrohamatum nigrolineatum* was in fact present within the proposed project area on Waiakeakua Stream. For surveys on this tributary, Dr. Polhemus and Mr. Higashi provided all photographs and GPS waypoints that appear in this report.

Methodology

During each of the surveys outlined above, a team of 2-4 experienced observers moved downstream at a slow pace, beginning at a point on the stream reach above the proposed project foot print and continuing downstream through the footprint itself, and then along the stream reach below the footprint. For the first survey, the point of entry for the initial quantitative survey along Waihi Stream was at the point where that stream crosses the Manoa Falls trail. The point of exit was at the Waaloa Way bridge (Figs. 4-6). The total distance covered was approximately 0.5 mile. Any small tributaries entering the main stream channel were also reconnoitered for the presence or absence of damselflies. For the second set of quantitative surveys the points of entry and exit were adjacent to the Treetops restaurant building, with access to water features obtained by walking along disused roads and walkways, with the total distance spanned adjacent to the stream being approximately 0.10 mile. At Waiakeakua stream, the survey proceeded from the USGS gauging station at the second bridge on Waakaua Street to the first stream fork, then up the right fork to the point where it passes under the third bridge on Waakaua Street, and up the left fork to the site of an abandoned residence. The total distance covered from the gauging station to the forks was approximately 0.10 mile, the distance traversed up the right fork above the confluence was also approximately 0.10 mile, and the distance traversed up the left fork above the confluence was approximately 0.15 mile, for a total of 0.35 mile of total stream corridors sampled at this site.

The observers continuously scanned for adult damselflies as they moved down the stream channel. When a damselfly was spotted, the team halted, and one observer kept the initially sighted damselfly in view. The other 3 observers scanned in all other directions for 2 minutes, to determine if other damselflies were also present in the area. If observations of additional individuals were made, these were called out verbally, and the newly sighted individuals also continuously tracked, in order to prevent double counting. At the end of 2 minutes the team huddled, discussed their mutual observations, and attained consensus as to the total number of individuals sighted. These data were then recorded, noting also any tandem pairs or oviposition behavior observed. The team then continued moving downstream until the next adult damselfly was spotted, at which point the above procedure was repeated. The above process was carried out down the entire length of Waihi Stream and along the reaches of Waiakeakua Stream described above. In total, sightings were made at 10 individual points along Waihi Stream, and at 5 individual points along Waiakeakua Stream; these observations were recorded by GPS and illustrated (Figs. 4-6). A preliminary estimate of population size and density was developed using transect data collected on two separate dates from the Waihi Stream area, and on one date from the Waiakeakua Stream area. All analyses were conducted in the R statistical environment (Team 2013) using the R package 'unmarked' (Fiske et al. 2015).

To derive this estimate it was assumed that observers were able to collect information on the species and status of the organism approximately 25 meters from an observation point along the Waihi stream transect. Counts were summarized for both survey days, and all points were assessed for possible direct (area modification) or indirect (downstream of modified area) impact. Of the 31 presence point localities collected on 10/9/2015, and 20 collected on 10/15/2015, between 56 and 75% of the damselfly presence localities were located in, or downstream of, the area to be modified.

To estimate population size and abundance in unmarked populations, the methodology of Chandler et al. (2011) was used. This likelihood estimate has been shown to effectively estimate population size, density, and survey detection probability, and is especially powerful at accounting for the spatial dynamics of motile organisms. For this assessment two models that assumed either a Negative Binomial distribution, or a Poisson distribution, were compiled to form an ensemble estimate using a weighted mean approach.

The Likelihood estimate from Chandler et al (2011) is briefly described below:

$$L(\lambda, \Phi, p|y_{it}) = \prod_{i=1}^{R} \left\{ \sum_{M_i=\max(y_{it})}^{\infty} \left(\prod_{T=1}^{T} \frac{M_i}{y_{i1}!\, y_{i2}!\, y_{i3}!\, y_{it0}!} \times (\Phi\pi_1)^{y_{it1}} (\Phi\pi_2)^{y_{it2}} (\Phi\pi_3)^{y_{it3}} (\Phi\pi_0)^{M_i - y_{it}} \right) f(M_i|\lambda) \right\}$$

Eq. 3 from Chandler et al (2011)

- M_i is the superpopulation size, or the assumed maximum number of individuals that could possibly be collected at plot i for occasion to t over all occasions (T) and plots (R).
- y_{it} is a vector of counts made at plot i on occasion t that are conditional on the subset of the superpopulation present N_{it} at that plot and occasion
- π_{it} represents a vector of multinomial cell probabilities computed from detection probabilities (p)
- λ is the discrete mean of the Poisson of negative binomial probability distribution as a function of M_i.
- Φ is the probability that a member of the superpopulation is present within the survey plot.

Fish Biomass Assessment

A complementary assessment of fish and wildlife resources was conducted by the Bishop Museum and State of Hawaii Division of Aquatic Resources in October, 2014 to help determine fish species composition and biomass within the affected Makiki, Palolo and Manoa Streams. Fish and other stream animal surveys were accomplished using two methods. The first method involved visual surveys completed in tandem with High Definition Fish Survey (HDFS) and High Definition Stream Surveys (HDSS) (see below). The visual surveys were further confirmed with net samples conducted by DAR biologists and technicians. While the visual surveys were widespread and covered all the habitat areas, these surveys likely missed some small or cryptic animals.

The second and more extensive fish and aquatic animal survey involved the use of the HDFS approach. The HDFS method utilized pole-mounted, high- definition, underwater video cameras to capture images of fish or other aquatic animals at a specific location. The underwater cameras were also geo-referenced so that specific time and place information was recorded for all video observations. By logging GPS data with underwater video, the HDFS results can easily be integrated with the HDSS habitat information gathered at the same location.

An estimate fish biomass for the more common and native species was prepared in September 23, 2016 by Dr. James Parham, Bishop Museum and submitted to the Service (Appendix C). The original and new survey videos were analyzed and the results presented to estimate an aggregate species' biomass within the Ala Wai Watershed Streams.

Methodology

To develop biomass estimates for fishes in Manoa, Palolo and Makiki Streams, a series of steps were completed.

1. The underwater video was watched, each sample site was given a unique Site ID and the sites date, time, GPS location, video file, and stream name were recorded.
2. From the underwater video footage, an estimate of the viewing area (m^2) was determined. This was used in the estimate of fish biomass (g/ m^2). Area was estimated by determining the forward visibility, the distance traveled if the camera moved, and the proportion of the site obscured.
3. The underwater video footage was watched and scored for the species type, their size, and number present at each sample location. With any timed observation of live animals (visual or video), it is possible that the same fish may swim in and out of the viewing area. As a result, the maximum number of fish (Max N) in the screen during the sample viewing time

is used to control for this possibility. Once the video frame with the maximum number of an individual species was determined, the individuals were then counted within predetermined size classes. The result of this step was a size class count for each species within each underwater video sample site.

- For this analysis of fish biomass, the native goby, o'opu nakea (*Awaous stamineus*), and the introduced fishes, longfin armored catfish (*Hypostomus watwata*), bristlenose catfish (*Ancistrus temmincki*), and convict cichlid (*Archocentrus nigrofasciatus*) were selected by USFWS and DAR. The native goby, o'opu nakea, is the most widespread native stream fish in the Ala Wai Watershed streams and the two catfish species occupy similar habitat to the native gobies. Convict cichlid are representative of a non-demersal species.

4. The biomass for each fish within a size class was determined from length/weight measurements collected from specimens in Oahu streams provided by DAR. The standard length/weight relationship, Weight = a $(\text{Length})^{b}$ was fit to the data using Table Curve 2D v 5.01 (Systat Software Inc., 2002) to find the species specific coefficient values for a and b. The median length of the observed species within each size class was used to estimate the weight of the species observed by applying the length/weight relationship. This step provided the total weight of a species within each sample site.

5. The results of the biomass estimate at individual sample sites was averaged within stream and stream reach areas. The streams (Manoa, Palolo, and Makiki) and reaches (lower, middle, and upper) provided a way to generalize the results into more appropriate areas associated with the flood mitigation actions.

DESCRIPTION OF FISH AND WILDLIFE RESOURCES

In contrast to diadromous macrofauna, Odonata and other Hawaiian stream insects are strictly associated with freshwaters, and do not make periodic transits to the ocean, although they can disperse along the stream corridor by flight. As such, the occurrences of individual species can be more localized, and there are a number of endemic species restricted to individual islands. Within the Odonata, the group of greatest concern to the Service is a set of native damselflies in the endemic Hawaiian genus *Megalagrion*, five of which have now been listed under the Endangered Species Act. Three of these listed species – *Megalagrion leptodemas*, *Megalagrion oceanicum*, and *Megalagrion nigrohamatum nigrolineatum* – are endemic to Oahu, and all of these taxa, as well as several other non-ESA-listed species in the genus, had been previously recorded from the Ala Wai watershed (Appendix A1-A10).

Given previous records of ESA-listed Odonata in the Ala Wai watershed, it was necessary to ascertain that these species did not occupy the stream reaches that will be impacted by the proposed project. In other cases, native damselflies have been found on Oahu at unexpectedly low elevations and in relatively developed settings, the salient example being a remnant population of *Megalagrion xanthomelas* on a tributary to Moanalua Stream at Tripler Army Medical Center (Polhemus 1996). Therefore, the Service's biological survey team made a visual census for *Megalagrion* and other Odonata species at all proposed project sites. Service biologists evaluated these project sites and found evidence of *M. nigrohamatum nigrolineatum* at the Waihi and Waiakeakua Project Construction Sites, but found no evidence of damselflies within any of the other proposed project sites.

Waihi Stream at Paradise Park – Debris and Detention Basin

Habitat throughout the reach surveyed consisted of rocky riffles and shallow pools, with small tributaries entering from along the banks and forming small, shallow, standing pools lateral to the main stream channel. The channel at the upper end of the reach surveyed was open and unshaded, abruptly transitioning downstream to heavy shading from large figs and other introduced trees. Such heavy shading continued the rest of the way to the Waaloa Way Bridge.

Megalagrion nigrohamatum nigrolineatum was found throughout the shaded section of the channel, particularly in the lateral pools formed by small tributaries, with both mating pairs and ovipositing females observed. On October 9, 2015, approximately 31 damselflies were observed in the area of the stream where planned construction activities may occur. On October 15, approximately 20 damselflies were observed outside of the planned construction site, but in areas that may be vulnerable to indirect effects related to project construction, personnel and vehicles. On October 23, 2015 approximately 10 damselflies were again observed adjacent to water features in the former Paradise Park, in areas lying outside of the planned construction site, but that may be vulnerable to indirect effects related to project construction, personnel and vehicles. These damselflies were not observed near any of the deep ponds in the area, which harbored introduced fishes, but were instead found in the vicinity of shallow, laminar flows formed by pond overflows, and lying parallel to or crossing disused asphalt roads. These small overflows also created muddy areas with small isolated pools, around which adult damselflies were also observed.

Waiakeakua Stream above USGS gauge at Waakaua Street bridge – Debris and Detention Basin

The habitat throughout this reach consists entirely of riffle and shallow pool habitat, heavily shaded downstream by a thick overstory of hau (*Hibiscus tiliaceus*) and upstream by various tall, introduced trees. The stream banks are steep in many sections, and have a heavy growth of bamboo. The USGS gauge at the lower terminus of the reach surveyed has a vertical, overhanging drop at the exit to the Parshall flume that represents a barrier to faunal passage of diadromous biota in this system. Weather at the time of the survey as partly cloudy, transitioning to fully sunny as the day progressed.

Megalagrion nigrohamatum nigrolineatum was sporadically encountered along the stream reaches surveyed. Individuals were particularly concentrated at three spots:

1) The riffle at the first right hand bend upstream of the bridge and gauging site, beyond the hau patch that overtops the stream just above the bridge.

2) At the confluence of the two stream forks, on both branches, for approximately 50 feet upstream of the confluence on the right hand fork and 100 feet above the confluence on the left hand fork.

3) At the upper limit of the survey on the left fork, where the stream begins to become confined between bedrock walls.

On February 11, 2016, a total of 2 male damselflies were observed in the area of the stream where planned construction activities for the Waiakeakua detention basin may occur, and an additional 9 damselflies were observed outside of the planned construction site, but in areas that may be vulnerable to indirect effects related to project construction, personnel and vehicles. A subsequent change in scope regarding the size of this detention basin has resulted in these latter sightings points now also falling within the project footprint.

Makiki Debris and Detention Basin

Makiki Stream – midreach above Board of Water Supply pump station, 60 m. (200 ft.), 21°19'02'N, 157°48'06"W, water temperature 26 °C, 27 July 2015. Macrofauna observed: *Macrobrachium lar.* Odonata observed: *Ischnura posita* (I).

Habitat throughout the reach surveyed consisted of riffles and small pools, with the stream entering a concrete channel below. The stream channel was heavily shaded by tall, introduced trees, and contained a significant amount of debris, particularly discarded automobile tires. The water was clear, probably originating from the Herring Spring further up Makiki Valley. Weather was sunny at the time of the survey.

Woodlawn Ditch and Detention Basin

Manoa Stream – Woodlawn Ditch below East Manoa Road, 71 m. (235 ft.), 21°18'58'N, 157°48'07"W, 27 July 2015. Macrofauna observed: None. Odonata observed: None.

The Woodlawn Ditch at this location consists of an entirely dry, heavily shaded channel with steep banks and a bed of rocks and gravel. No aquatic biota was present. Weather was sunny at the time of the survey.

Manoa Stream – midreach at Woodlawn Street bridge, 44 m. (145 ft.), 21°18'29'N, 157°48'33"W, water temperature 27 °C, 27 July 2015. Macrofauna observed: Armored catfish. Odonata observed: None.

Habitat in this reach consisted entirely of riffles, with no deep pools. The channel was ~50% shaded upstream of the bridge, and ~90% shaded below the bridge. The stream banks were covered with grasses and yellow-flowering *Wedelia trilobata*. Weather was sunny at the time of the survey.

Manoa Park Instream Debris Catchment

Manoa Stream – midreach at Kahaloa Street Bridge, Manoa District Park, 50 m. (165 ft.), 21°18'49'N, 157°48'23"W, water temperature 25 °C, 27 July 2015. Macrofauna observed: Armored catfish, Poeciliidae. Odonata observed: *Pantala flavescens* (native).

Habitat in this reach consisted entirely of riffles below the Kahaloa Street bridge, and a long, deep pool upstream of the bridge. The channel was mostly unshaded throughout the reach surveyed. The stream banks were covered with grasses, and the stream entered a concrete channel at the downstream terminus of the reach surveyed. Weather was sunny at the time of the survey.

Kanewai Field Multi-Purpose Detention Basin

This site is land-side managed vegetation. No Fish and Wildlife Resources exist at this location.

Waiomao Debris and Detention Basin

Palolo Stream – Waiomao Stream upstream of Lamaku Place to former USGS gauging station, 114 m. (375 ft.), 21°18'22'N, 157°47'02"W, water temperature 25.5 °C, 28 July 2015. Macrofauna observed: Armored catfish, Poeciliidae, *Awaous.* Odonata observed: None.

This stream was surveyed from the end of Lamaku Place upstream to the former USGS gauging station. The habitat along the reach surveyed consisted of riffles and pools, with the waters of the stream tea-colored due the the presence of tannins from its headwater wetland in the Kaau Crater. The stream bed contained numerous exposures of bedrock, which often formed small cascades. The stream channel was heavily shaded by introduced trees. Weather was sunny at the time of the survey.

Pukele Debris and Detention Basin

Palolo Stream – Pukele Stream at Ipulei Place, 128 m. (420 ft.), 21°18'34'N, 157°47'11"W, water temperature 24 °C, 28 July 2015. Macrofauna observed: None. Odonata observed: None.

Habitat throughout the reach surveyed consisted of riffles and deep pools with very clear water, moderately shaded by tall introduced trees. The stream banks were steep, and covered with grasses, bare dirt, or in some sections rock revetment. No water was observed at this site during a previous visit on 14 April 2015. Although flow was present at the time of the current surveys, no aquatic biota was observed, indicating that this reach may be intermittent. Weather was sunny at the time of the survey.

Hausten Ditch Detention Basin

This site is land-side managed vegetation. No Fish and Wildlife Resources exist at this location.

Ala Wai Golf Course Detention Basin.

This site is land-side managed vegetation. No Fish and Wildlife Resources exist at this location.

Fish Biomass Results for Manoa, Palolo and Makiki Streams

A total of 745 sites throughout Manoa, Palolo and Makiki streams were surveyed using the HDFS methodology (Table 1). The area in upper Manoa Stream containing 230 sites was the most recently survey by DAR. A total of 310 sites was surveyed in the upper end of the streams and are the most useful comparison for the upper detention basins proposed in the flood mitigation plan.

Table 1: Location of survey sites

Stream	Reach Code	Sample Sites
Palolo	Lower	45
Makiki	Lower	94
Manoa	Middle	63
Palolo	Middle	133
Manoa	Upper	230
Palolo	Upper	103
Makiki	Upper	77
Total		745

Species Observations:

All 745 survey sites were reviewed for the presence of native gobies or the three introduced species. O'opu nakea and o'opu naniha were the most common native gobies (Table 2). Only one o'opu nopili (*Sicyopterus stimpsoni*) and three o'opu akupa (*Eleotris sandwicensis*) were observed in all of the samples. Nearly 300 each of the longfin armored catfish, bristlenose catfish, and convict cichlid were observed throughout the streams. The bristlenose catfish was the most common species counted in the upper stream reaches, although liberty mollies and guppies were likely observed in greater numbers.

Table 2: Size distribution of selected fishes in Ala Wai Watershed streams.

O'opu nakea

Category	Length Range (in)	Number Observed
small	< 3	6
medium	3 to 5	10
large	> 5	5
Total		21

O'opu naniha

Category	Length Range (in)	Number Observed
small	< 3	0
medium	3 to 5	5
large	> 5	13
Total		18

Longfin Armored Catfish

Category	Length Range (in)	Number Observed
small	< 2.5	11
medium	2.5 to 4	81
large	4 to 6	138
ex. Large	> 6	57
Total		287

Bristlenose catfish

Category	Length Range (in)	Number Observed
small	< 2	41
medium	2 to 3.5	133
large	> 3.5	120
Total		294

Convict Cichlid

Category	Length Range (in)	Number Observed
small	> 2	70
medium	2 to 4	162
large	> 4	62
Total		294

Biomass estimates for the various species varied both among streams and among reaches (Table 3). This is partially due to the sampling locations, because habitat availability was not consistent among locations, and also partially due to the presence of other species. In Manoa stream, for example, smallmouth bass were common throughout the deeper areas of the middle reach and tilapia were very common in the lower reaches.

Several patterns were apparent. First, native fishes are not common in the Ala Wai Watershed streams. It is likely that habitat modification and the introduction of numerous other species has decreased their abundance.

Second, O'opu nakea can be found throughout the streams with at slightly higher abundances in the middle and upper reaches.

Third, longfin armored catfish were very common in the lower and middle reaches of the streams and sometimes found in extremely high density. This species could be found in very shallow, swift water and in deeper, slower pools. Longfin armored catfish do not appear to occur in the upper reaches of the streams.

Fourth, Bristlenose catfish however are more common in the upper reaches of the streams although they exist throughout all stream reaches. Bristlenose catfish occupy similar habitat to the native gobies in the upper reaches of the streams and were observed co-occurring with o'opu nakea in a few locations.

Table 3: Biomass estimates for the various species for lower, middle and upper reaches of Palolo Stream, Makiki Stream and Manoa Stream.

				Observed weight (g)				Biomass (g/m2)			
Area code	Stream	Reach Code	Total Area Surveyed (m2)	Longfin Armored Catfish	Bristlenose Catfish	Convict Cichlid	O'opu Nakea	Longfin Armored Catfish	Bristlenose Catfish	Convict Cichlid	O'opu Nakea
2	Palolo	Lower	42.4	977.6	63.5	399.9	8.9	23.0	1.5	9.4	0.2
3	Makiki	Lower	94.4	255.4	101.0	326.1	34.7	2.7	1.1	3.5	0.4
4	Manoa	Middle	112.6	4,333.6	127.0	419.2	0.0	38.5	1.1	3.7	0.0
5	Palolo	Middle	77.2	981.6	127.9	2,396.0	86.3	12.7	1.7	31.0	1.1
7	Manoa	Upper	97.6	0.0	463.1	0.0	0.0	0.0	4.7	0.0	0.0
8	Palolo	Upper	68.2	0.0	1,019.2	0.0	72.0	0.0	14.9	0.0	1.1
9	Makiki	Upper	111.6	0.0	315.4	0.0	71.2	0.0	2.8	0.0	0.6

Climate Change

Future impacts from climate change are likely to affect ecosystems in the Ala Wai watershed during the remainder of this century and beyond. In particular, more episodic, but severe rainfall events may lead to flash floods of higher amplitutde and intensity. Rising sea levels will also influence the Ala Wai Canal estuarine system, and will impact coastal infrastructure, resulting in flooding, increased coastal erosion, drinking water contamination, sewage overflow and increased decreased coastal water quality (PIRC 2012). Sea level rise may also result in increased development in upland areas as residents are compelled to move inland from low-lying coastal sites, a dynamic that would place added stress on natural resources in the midreaches and headwaters of the watershed.

DESCRIPTION OF ALTERNATIVES EVALUATED

In September, 2015, the USACE provided the Service with initial project design information. In September, 2016, the USACE provided the Service with supplemental project design information that expanded the scope of the planned project construction at most detention basin sites (Table 4). The project calls for the construction of dams crossing the Waihi tributary, the Waiakeakua tributary, Manoa Stream, Makiki Stream and Palolo Stream. Culverts would be constructed to allow natural base flow to pass beneath these structures and the bottoms of the streams would not be hardened at these sites. Detention Basins would be designed where debris would accumulate upstream of each dam/culvert. Permanent access roads would need to be constructed to support planned project construction and future maintenance. Also, temporary staging areas would be necessary to prepare support equipment (Figure 4). The detention basins would be designed to catch debris, and such debris would need to be removed after every big storm, or at minimum once a year by the City and County during regular maintenance cycles. City and County maintenance debris removal typically involves tracked vehicles, such as bulldozers or backhoes, entering streams and removing accumulated sediment and other debris.

Alternative 1: Detention Basin Construction

Table 4 represents the approximate areal extent of each the preferred project Alternative construction activities (Figures 8-17).

Table 4a. Waihi Debris and Detention Basin Planned Construction Limits

Construction Activity	Area (in square feet) / Impact Duration
Detention Basin (100 year Pool)	58,870 Permanent
Dam/Culvert	35,200 Permanent
Staging Area	2,480 Temporary
Access Road	17,000 Permanent

Table 4b. Waiakeakua Debris and Detention Basin Planned Construction Limits

Construction Activity	Area (in square feet) / Impact Duration
Detention Basin (100 year Pool)	139,740 Permanent
Dam/Culvert	41,620 Permanent
Staging Area	2,320 Temporary
Access Road	21,600 Permanent

Table 4c. Makiki Debris and Detention Basin Planned Construction Limits

Construction Activity	Area (in square feet) / Impact Duration
Detention Basin (100 year Pool)	21,245 Permanent
Dam/Culvert	17,165 Permanent
Staging Area	2,500 Temporary
Access Road	14,400 Permanent
Storage Excavation	14,040 Permanent

Table 4d. Woodlawn Ditch Debris and Detention Basin Planned Construction Limits

Construction Activity	Area (in square feet) / Impact Duration
Detention Basin (100 year Pool)	75,830 Permanent
Dam/Culvert	37,520 Permanent
Staging Area	2,500 Temporary
Access Road	11,000 Permanent

Table 4e. Manoa Park In-Stream Debris Catchment Planned Construction Limits

Construction Activity	Area (in square feet) / Impact Duration
Detention Basin (100 year Pool)	0
Dam/Culvert	540 Permanent
Staging Area	2,500 Temporary
Access Road	0

Table 4f. Kanewai Debris and Detention Basin Planned Construction Limits

Construction Activity	Area (in square feet) / Impact Duration
Detention Basin (100 year Pool)	212,810 Permanent
Dam/Culvert	39,425 Permanent
Staging Area	2,480 Temporary
Access Road	6,500 Permanent

Table 4g. Waiomao Debris and Detention Basin Planned Construction Limits

Construction Activity	Area (in square feet) / Impact Duration
Detention Basin (100 year Pool)	44,950 Permanent
Dam/Culvert	19,890 Permanent
Staging Area	2,500 Temporary
Access Road	9,600 Permanent
Storage Excavation	12,465 Permanent

Table 4h. Pukele Debris and Detention Basin Planned Construction Limits

Construction Activity	Area (in square feet) / Impact Duration
Detention Basin (100 year Pool)	34,660 Permanent
Dam/Culvert	16,660 Permanent
Staging Area	2,500 Temporary
Access Road	3,000 Permanent
Storage Excavation	15,620 Permanent

Table 4i. Hausten Ditch Debris and Detention Basin Planned Construction Limits

Construction Activity	Area (in square feet) / Impact Duration
Detention Basin (100 year Pool)	150,600 Permanent
Dam/Culvert	10,505 Permanent
Staging Area	5,950 Temporary
Access Road	0

Table 4j. Ala Wai Multi-Purpose Basin Planned Construction Limits

Construction Activity	Area (in square feet) / Impact Duration
Detention Basin (100 year Pool)	5,851,950 Permanent
Dam/Culvert	172,795 Permanent
Staging Area	25,727 Temporary
Access Road	0

Alternative 2: No Action

No action would be taken to modify stream located within the Ala Wai Watershed, resulting in no change to current habitats.

PROJECT IMPACTS

Riffle and pool habitat and riparian habitat contribute to supporting the extant population of federally listed damselflies. We would anticipate some permanent loss of habitat due to the construction of the dam and culvert in the stream (Table 5). We would also anticipate additional permanent loss of habitat due to maintenance removal of debris in the detention catchment area, due to the use of City and County of Honolulu heavy equipment, such as bulldozers, front end loaders, and backhoes. The use of heavy equipment to remove debris from the basin catchment area will result in the removal of not only debris, but also native vegetation and topsoil, and will destroy both the riffle and pool and adjacent riparian habitat. The project access road would also have further negative impact on native damselflies, due to alteration and permanent loss of riparian habitat. Finally, the staging area would have temporary impacts on native damselflies, but we would anticipate these impacts to be constrained to the duration of the construction period.

Table 5a. Waihi Debris and Detention Basin Planned Construction Limits

Affected Habitat	Area (in square feet) / Impact Duration
Stream and Riparian	111,070 Permanent
Stream and Riparian	2,480 Temporary

Table 5b. Waiakeakua Debris and Detention Basin Planned Construction Limits

Affected Habitat	Area (in square feet) / Impact Duration
Stream and Riparian	202,960 Permanent
Stream and Riparian	2,320 Temporary

Table 5c. Makiki Debris and Detention Basin Planned Construction Limits

Affected Habitat	Area (in square feet) / Impact Duration
Stream and Riparian	66,850 Permanent
Stream and Riparian	2,500 Temporary

Table 5d. Woodlawn Ditch Debris and Detention Basin Planned Construction Limits

Affected Habitat	Area (in square feet) / Impact Duration
Stream and Riparian	124,350 Permanent
Stream and Riparian	2,500 Temporary

Table 5e. Manoa Park In-Stream Debris Catchment Planned Construction Limits

Affected Habitat	Area (in square feet) / Impact Duration
Stream and Riparian	540 Permanent
Stream and Riparian	2,500 Temporary

Table 5f. Kanewai Debris and Detention Basin Planned Construction Limits

Affected Habitat	Area (in square feet) / Impact Duration
Managed Vegetation	258,735 Permanent
Managed Vegetation	2,480 Temporary

Table 5g. Waiomao Debris and Detention Basin Planned Construction Limits

Affected Habitat	Area (in square feet) / Impact Duration
Stream and Riparian	86,905 Permanent
Stream and Riparian	2,500 Temporary

Table 5h. Pukele Debris and Detention Basin Planned Construction Limits

Affected Habitat	Area (in square feet) / Impact Duration
Stream and Riparian	69,940 Permanent
Stream and Riparian	2,500 Temporary

Table 5i. Hausten Ditch Debris and Detention Basin Planned Construction Limits

Affected Habitat	Area (in square feet) / Impact Duration
Managed Vegetation	161,105 Permanent
Managed Vegetation	5,950 Temporary

Table 5j. Ala Wai Multi-Purpose Basin Planned Construction Limits

Affected Habitat	Area (in square feet) / Impact Duration
Managed Vegetation	6,024,745 Permanent
Managed Vegetation	25,727 Temporary

Table 6. Total Combined Project Permanent and Temporary Impacts By Habitat Type

Habitat Type	*Area (in square feet) / Impact Duration*
Stream and Riparian	662,615 Permanent Loss
Stream and Riparian	17,300 Temporary Loss
Managed Vegetation	6,444,585 Permanent Loss
Managed Vegetation	34,157 Temporary Loss

In summary, the Service would anticipate that the permanent loss of about 662,615 square feet (15.21 acres) of stream and riparian habitat would result from planned project construction activities. A subset of this area, approximately 314,030 square feet (7.2 acres), would result in the permanent loss of damselfly habitat. We would also anticipate approximately 17,300 square feet (0.39 acres) of stream and riparian habitat would be temporarily lost due. Likewise, a subset of this area, approximately 4,800 square feet (0.11 acres), would result in the temporary loss of damselfly habitat.

For managed vegetation habitat, we would expect that about 6,444,585 square feet (147.94 acres) would be permanently lost and 34,157 square feet (0.78 acres) would be temporarily lost.

Based on the Service's survey data and using this likelihood estimate, the size of the *M. nigrohamatum nigrolineatum* population along the survey transect was estimated at approximately 64 individuals, as derived from the ensemble model using the repeated count data described above. A density estimate of 37 individuals per hectare (±SE = 20.89) was projected. Assuming that between 50 to 55% of the damselfly population in the area would be affected by the Waihi Debris and Detention Basin; this construction project may negatively impact approximately 28 to 31 adult damselflies at this specific time point. For Waiakeakua stream, approximately 58% of the population would be affected by the construction area, as such the construction would likely affect about 20 damselflies.

Information regarding the population size of nymphs (immatures) was not obtained, but impacts to this life stage would also occur, which could potentially double the total number of individuals affected. In addition, most of the individuals observed during this survey (90%) were males. Although the primary sex ratio for *M. nigrohamatum nigrolineatum* is not known, and some damselfly species are known to have skewed sex ratios, there is no current data to indicate that the primary sex ratio in this species deviates from 1:1. As such, females may be residing in more cryptic sites along the stream corridor prior to mating. This is a further indication that negative impacts are likely to affect up to 3 times more individuals than conservatively estimated above.

Given that for this assessment no information regarding demographic characteristics of the population was used, any future incorporation of life stage based counts (*i.e.*, nymph and adult), basic demographic information, and increasing the number of data collection dates to include seasonal variance will likely increase the accuracy of the population size/density assessment. Also, the methodology used here assumes some level of sensitivity variance due to emigration between localities (Chandler, Royle, and King 2011). It may be useful in future assessments to account for this sensitivity variance using a multi-observer/double observer sampling methodology (Royle and Dorazio 2006).

FISH AND WILDLIFE SERVICE RECOMMENDATIONS

Avoidance and Minimization

Based on observations from the Service survey, the federally listed damselfly *Megalagrion nigrohamatum nigrolineatum* was commonly observed in the upper portion of the project area in the Manoa Stream catchment. Furthermore, biologists observed several breeding sites within the project footprint. The Service is therefore concerned that up to 46 individuals and three breeding sites at Waihi Stream, and up to 20 individuals at Waiakeakua Stream may be negatively impacted by planned project construction-related dredging activities, and considers this to be a conservative estimate for reasons discussed above.

Therefore, to avoid planned project construction-related impacts to federally listed damselflies, the Service recommends that both the Waihi Stream Debris and Detention Basin and

Waiakeakua Stream Debris and Detention Basin be consolidated into one debris and detention basin that will be relocated downstream and south of the following position (Fig. 7):

Latitude = 1708314.06637
Longitude = 57831.148998
(Note: Coordinate system: NAD_1983_PA11_StatePlane_Hawaii_3_FIPS_5103_Feet).

Compensatory Mitigation

The Service supports removal of migration barriers at Falls 7 and 8 to facilitate migration of native gobies, *O'opu nakea* and *O'opu naniha* through the various reaches of Manoa stream and the ocean for the purposes of offsetting planned project impacts to affected fish resources. Please refer to the USACE's Mitigation, Monitoring and Adaptive Manage Plan and performance criteria (Appendix D). Calculations for habitat replacement were drawn from Dr. Jim Parham's report, "Report on updating the spreadsheet results for the Hawaiian Stream Habitat Evaluation Procedure (HSHEP) Associated with the Streams in the Ala Wai Canal Flood Risk Management Study," July 12, 2016 (Appendix E). An addendum to the Adaptive Management Plan – Ala Wai Canal Project was prepared by the USACE-Honolulu District on July 14, 2016 (Appendix F). The HSHEP model was certified by the U.S. Army Corps of Engineers in May 28, 2015 (Appendix G).

In addition, the Service considers the aquatic resources and riparian habitat at Waihi Stream and Waiakeakua stream to be unique in that these areas provide specialized ecological functions that support the evaluation species, the federally listed *Megalagrion nigrohamatum nigrolineatum*, including breeding areas. At no other location within the project area have similar riffle/pool and riparian habitat conditions, such as those that support the evaluation species, been observed; this is primarily due to the close proximity of the other sites to human development. The Service considers the riffle/pool and riparian habitat at Waihi Stream and Waiakeakua Stream to meet the definition of Resource Category 2 (Habitat to be impacted is of high value for evaluation species and is relatively scarce or becoming scarce on a national basis or in the ecoregion section). The Service does not believe the HSHEP sufficiently considered the importance and unique riffle/pool and riparian ecological qualities of Waihi Stream and Waiakeakua Stream. Although we support the proposed mitigation for purposes of offsetting impacts to native fish, the USACE's proposed mitigation will not offset expected project impacts to Resource Category 2 riffle/pool and riparian habitat, also support federally listed damselflies. The Service recommends that unavoidable impacts at Waihi Stream and Waiakeakua stream should be mitigated in a manner that is consistent with national mitigation goals of "no net loss of in-kind habitat value for resource category 2", which also benefits evaluation species, such as the listed *Megalagrion nigrohamatum nigrolineatum*. We are willing to work with the USACE to develop appropriate mitigation that benefits the survival of this species.

Recommended Compensatory Mitigation:

The Service recommends that the USACE restore riffle/pool and riparian habitat to adequately offset planned project construction-related impacts at Waihi Stream and Waiakeakua Stream. We recommend a 3:1 ratio be used as a scale for compensatory mitigation to ensure adequate riffle/pool and riparian habitat is restored to offset anticipated losses. Based on information recently provided by the USACE, we expect that about 314,030 square feet (7.2 acres) of riffle/pool and riparian habitat will be permanently lost at Waihi and Waiakeakua streams. Therefore, we recommend that the USACE restore 942,090 square feet (21.6 acres) of degraded riffle/pool and riparian habitat to similar quality currently at Waihi Stream and Waiakeakua stream (Table 4). Also, we recommend the USACE restore 14,400 square feet (0.3 acres) of riffle/pool and riparian habitat be restored for a period equivalent to the time that of temporary construction-related loss.

Table 4. Compensatory Mitigation Ratio 3:1 Offset

Habitat Type	*Area (in square feet) / Impact Duration*	*3:1 Ratio (square feet)*
Stream and Riparian	314,030 Permanent Loss	942,090 in perpetuity
Stream and Riparian	4,800 Temporary Loss	14,400 equivalent to the duration of impact

We are willing to work with the USACE to develop a mitigation plan to ensure that restoration of riffle/pool and riparian habitat is successfully implemented. We recommend that a mitigation plan include Scientific Monitoring and this could be undertaken jointly by the Service and the State of Hawaii Department of Land and Natural Resources (DLRN). We also recommend that Performance Standards be designed in concert with the USACE, Service and State of Hawaii DLNR to ensure the quality and effectiveness of the recommended restoration is achieved.

Contaminated Sediments

At Manoa Stream, the U. S. Geological Survey has described a variety of contaminants found within stream sediments. Elevated levels of nutrients (*e.g.*, nitrates, phosphates), organochlorine insecticides (*e.g.*, dieldrin, chlordane, and DDT) and semivolatile organic compounds, herbicides, and polyaromatic hydrocarbons (PAHs) have all been detected in the stream sediments of the Manoa watershed (USGS, 2001). Stream sediments at the proposed catchment basins will be subject to repeated exposure and re-entrainment due to continuous debris maintenance removal conducted with heavy equipment by the City and County of Honolulu. Therefore, we recommend that planned construction and maintenance-related activities be conducted in accordance with State of Hawaii Department of Health regulations concerning contaminated stream sediments.

Post-construction Monitoring

The Service recommends that post-construction monitoring field work be conducted to evaluate anticipated impacts to federally listed damselflies and stream habitat. Some of these areas have already been identified and documented through the FWCA surveys. Post-construction surveys are important because they provide information on whether actual project-related impacts are greater or less than anticipated project-related impacts. If there are any appreciable differences, the compensatory mitigation can be recalculated so that it is appropriately scaled to the actual project-related impacts.

Post-construction surveys should be conducted immediately (*e.g*, ideally 1 week to 1 month) after final construction activities have ceased. Follow up monitoring surveys should be conducted at intervals of six months and one year from final construction to determine if any secondary or indirect impacts have occurred to resources adjacent to the project construction site.

The Service also recommends that performance standards for compensatory mitigation be developed in cooperation with other state and federal resource agencies. The effectiveness of the implemented compensatory mitigation should be evaluated, and including long-term monitoring, plans for adaptive management, and financial assurances should be obtained to ensure the compensatory mitigation projects for both the removal of Falls 7 and 8 and also for the restoration of riffle/pool and riparian habitat are implemented.

Best Management Practices

The following special conditions apply to all activities pertaining to project construction and maintenance activities for this project:

(1) The permittee should make every effort to develop and implement a plan spanning the length of this general permit which schedules conducting anticipated work at streams and storm-drains during the dry season, and anticipated work at beach areas during nonswell season. Work should be ceased and re-scheduled in the event of an out-of-season heavy rainfall or swell;

(2) Use of bulldozers to remove sediments may be allowed when the permittee provides documentation that the sediment is unvegetated, or otherwise void of vegetal root systems and that equipment-specific best management practices (BMPs) shall be in place to avoid more than *de minimis* discharges to waters of the United States;

(3) Avoid conducting maintenance activities that will lead to mid- and long-term destabilization and exposure of bare sediment/sand along stream banks, stream bed and beaches;

(4) Prior to starting any authorized activity, determine via surveys or available literature whether coral reef and/or seagrass beds are present near, or downstream of, areas where the activities will be conducted. Where coral reef or seagrass could be indirectly impacted by the authorized work, the permittee must minimize any potential impacts by limiting the extent of inwater work by conducting the work from land, limiting the footprint of the work/dredge area, and implementing appropriate BMPs;

(5) No debris, petroleum projects, or deleterious materials or wastes shall be allowed to fall, flow, leach, or otherwise enter any waters of the United States;

(6) All authorized activities shall be done in a manner so as to confine and isolate the construction activity and to control and minimize turbidity. Silt curtains or other appropriate and effective silt containment devices approved by the Corps shall be used to minimize turbidity and shall be properly maintained throughout the entire period of in-water work to prevent the discharge of any material to the downstream aquatic habitat. All sediment control devices installed as BMPs (i.e., fabric sandbags, silt curtains/screens, etc.) downstream or makai of the authorized work shall remain in place until the in-water work is completed and will be removed in their entirety and disposed of at an appropriate upland location once the water quality of the affected area has returned to its pre-construction condition;

(7) Return flow or runoff from upland dewatering site(s)/disposal site(s) shall be contained on land and shall not be allowed to discharge and/or re-enter any waters of the United States;

(8) No sidecasting or stockpiling of excavated materials in the aquatic environment is authorized. All excavated materials shall be placed above the high tide line (in coastal areas), above the ordinary high water mark at all other waters of the United States, or disposed of in an upland location. The permittee shall demonstrate that there is no reasonable expectation that disposal locations adjacent to high tide lines on the ocean, or in floodplains adjacent to other rivers or streams, would result in the material being eroded into the nearby waterbody by high tides and/or flood events;

(9) Warning signs shall be properly deployed and maintained until the portion of the in-water work is completed and the affected area water quality has returned to its preconstruction condition and turbidity control devices have been removed from the waterway;

(10) Fueling, repair, and other activities with any potential to release pollutants will occur in a location where there is no potential for spills to have an effect on waters of the United States;

(11) If a visible plume and/or floating petroleum products are observed outside of the containment area, the following measures shall be taken:

(a) All in-water work shall stop;

(b) The permittee or contractor shall inform the Corps immediately and the Corps will consult with appropriate agencies;

(c) The site shall be inspected by the permittee to ascertain the source of the plume;

(d) Control measures shall be refurbished, modified, and/or improved,
e.g., additional silt containment devices will be installed, as necessary to ensure the integrity of the containment area;

(e) Work shall not continue until after the plume or oil sheen is no longer visible.

(12) An individual, designated responsible for environmental monitoring, will be on-site during clearing operations. This individual will conduct visual inspections, perform water quality sampling and other environmental monitoring, as appropriate, and report all results to the Corps on a regular basis during clearing operations;

(13) When the Corps is notified that an authorized activity is detrimental to fish and wildlife resources, the Corps will issue a suspension order until all pertinent issues have been satisfactorily resolved. The permittee shall comply with any Corps-directed remedial measures deemed necessary to mitigate or eliminate the adverse effect;

(14) Unless terminated earlier, the expiration date of this general permit will be five years from the date of issuance. At that time, there will be a re-evaluation and review of the environmental effects of the activities authorized under the general permit. The re-evaluation will incorporate the views of federal, state, and local agencies and the public following issuance of a new public notice. This general permit may be reissued, revised, or revoked, as appropriate. Individual projects authorized under this permit, but not completed prior to the expiration date of the general permit, may proceed in accordance with the terms and conditions of this permit, regardless of the outcome of the re-evaluation and review.

The USACE shall designate an individual to oversee compliance of each BMP during clearing operations. This individual will complete a daily on-site inspection and report all results to the USACE on a regular basis during clearing operations.

SUMMARY AND FISH AND WILDLIFE SERVICE POSITION

Federally listed damselflies, and riffle and pool habitat, have been identified as the species of major concern and habitat of major concern respectively in regard to the proposed project. The blackline damselfly, *Megalagrion nigrohamatum nigrolineatum*, which is restricted to the island of Oahu, occurs at the Waihi Stream and Waiakeakua Stream Debris and Detention Basins, and was selected as the evaluation species for this study. The institutional significance of riffle and pool habitat, and federally listed species, have been established through their designation under the Clean Water Act [40 CFR Part 230 §230.44/FR v. 45n.249] and the Endangered Species Act [16 U.S.C. 1531 *et seq.;* 87 Stat. 884] respectively. To various degrees, the riffle and pool habitat within and adjacent to the planned construction sites at Waihi Stream and Waiakeakua Stream promotes specialized ecological functions important to *M. nigrohamatum nigrolineatum*, including species recruitment, foraging, and sheltering from predators. Based on recent field surveys at Waihi Stream and Waiakeakua Stream, the Service estimates that at least 66 blacklined damselflies would be negatively impacted as a consequence of project implementation. We recommend that the Debris and Detention Basins at Waihi Stream and Waiakeakua Stream be moved to a site lower in the Manoa Stream catchment to avoid project construction-related impacts to *M. nigrhamatum nigrolineatum* and habitat at Waihi Stream and Waiakeakua streams (Fig. 7). If moving the debris and detention basins at Waihi and Waiakeakua Streams is not feasible, then we recommend the Service, USACE and State of Hawaii Department of Land and Natural Resources work together to develop appropriate mitigation to offset unavoidable project impacts to Resource Category 2 riffle/pool habitat and riparian habitat.

To offset unavoidable project impacts to fish resources, we recommend the removal of migration barriers at Falls 7 and 8 to facilitate migration of native gobies, *O'opu nakea* and *O' opu nopili* through the various reaches of Manoa stream and the ocean.

To offset unavoidable impacts to Resource Category 2 riffle/pool and riparian habitat, we recommend that a mitigation plan be developed to restore degraded riffle/pool and riparian habitat in the amount of 942,090 square feet in perpetuity and 14,400 square feet equivalent to the temporary duration project construction impacts.

The Service further recommends that a risk assessment be conducted to evaluate the potential hazards that may arise from mobilization of contaminated stream sediments. We also recommend that post-construction monitoring be conducted to confirm anticipated project-related impacts did not exceed expectations. Finally, the USACE shall designate an individual to oversee compliance of each BMP during clearing operations on a daily basis and report all results to the USACE on a regular basis during clearing operations.

Any changes to the proposed project plan or to the recommendations in this report will also require additional coordination with the Pacific Islands Fish and Wildlife Office in Honolulu, Hawaii.

REFERENCES CITED

Chandler, Richard B., J. Andrew Royle, and David I. King. 2011. "Inference about Density and Temporary Emigration in Unmarked Populations." *Ecology* 92 (7): 1429–35. doi:10.1890/10-2433.1.

Fiske, Ian, Richard Chandler, David Miller, Andy Royle, Marc Kery, Jeff Hostetler, and Rebecca Hutchinson. 2015. *Unmarked: Models for Data from Unmarked Animals* (version 0.11-0). https://cran.r-project.org/web/packages/unmarked/index.html.

Giambelluca, T.W., Q. Chen, A.G. Frazier, J.P. Price, Y.-L. Chen, P.-S. Chu, J.K. Eischeid, and D.M. Delparte. 2013. Online Rainfall Atlas of Hawai'i. Bull. Amer. Meteor. Soc. 94, 313-316. doi: 10.1175/BAMS-D-11-00228.1.

Iserbyt, Arne, Jessica Bots, Hans Van Gossum, and Thomas N. Sherratt. 2013. "Negative Frequency-Dependent Selection or Alternative Reproductive Tactics: Maintenance of Female Polymorphism in Natural Populations." *BMC Evolutionary Biology* 13 (1): 139.

McPeek, Mark A. 2008. "Ecological Factors Limiting the Distributions and Abundances of Odonata." *Dragonflies and Damselflies: Model Organisms for Ecological and Evolutionary Research*, 51.

Polhemus, D. A. and A. Asquith. 1996. Hawaiian Damselflies: a field identification guide. Hawaii Biological Survey Handbook No. 1. Bishop Museum Press, Honolulu. x + 122 pp.

Polhemus, D. A. 2007. Biology recapitulates geology: the distribution of *Megalagrion* damselflies on the Koolau Volcano of Oahu, Hawaii. Bishop Museum Bulletins in Cultural and Environmental Studies, 3: 233-246.

Royle, J.A., and R.M. Dorazio. 2006. "Hierarchical Models of Animal Abundance and Occurrence." *Journal of Agricultural, Biological, and Environmental Statistics* 11 (3): 15.

Team, R. Core. 2013. *R: A Language and Environment for Statistical Computing*. Vienna, Austria. http://www.R-project.org.

FIGURES

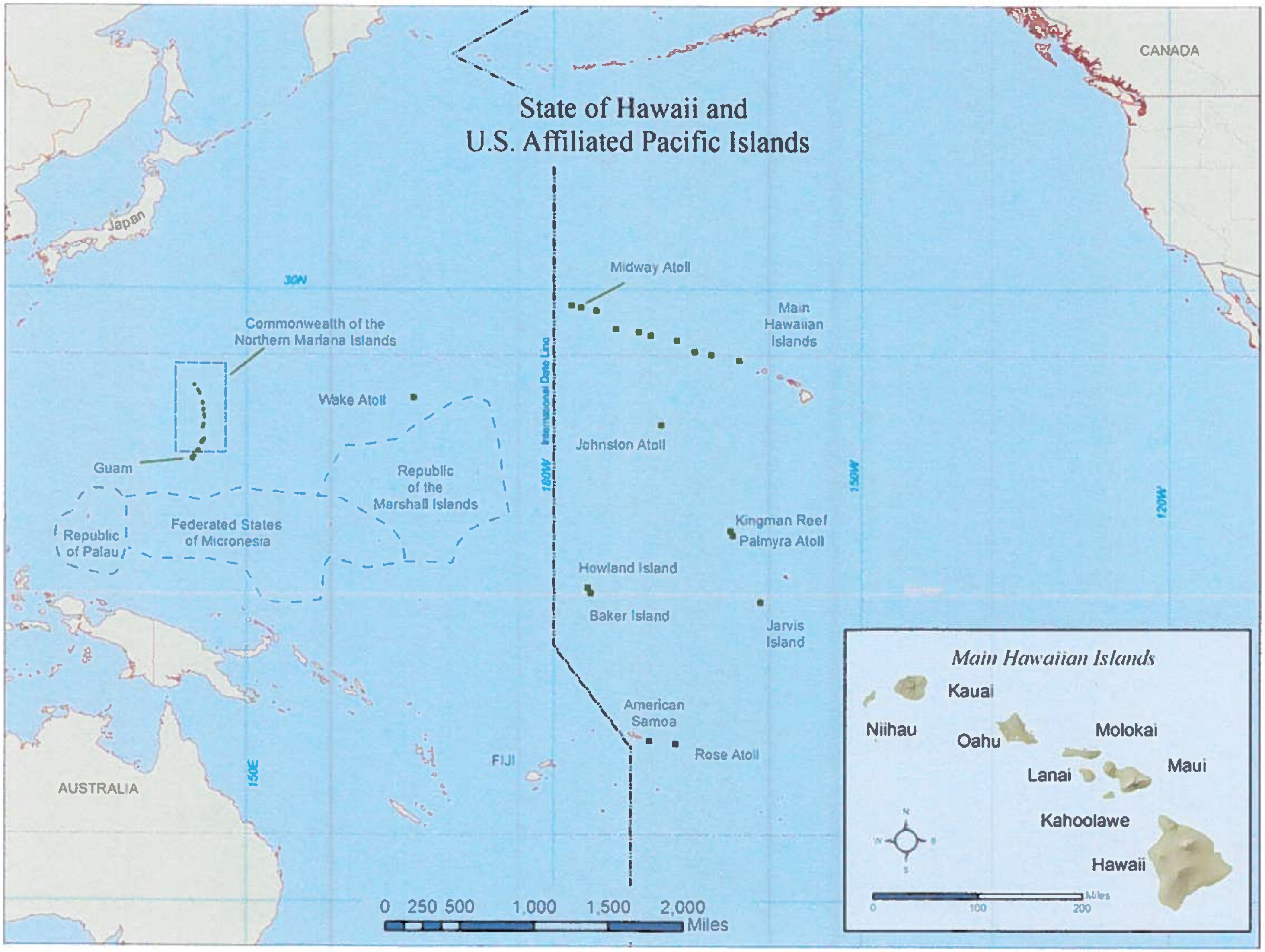


Figure 1. Map of the Pacific Ocean showing location of the Hawaiian Islands

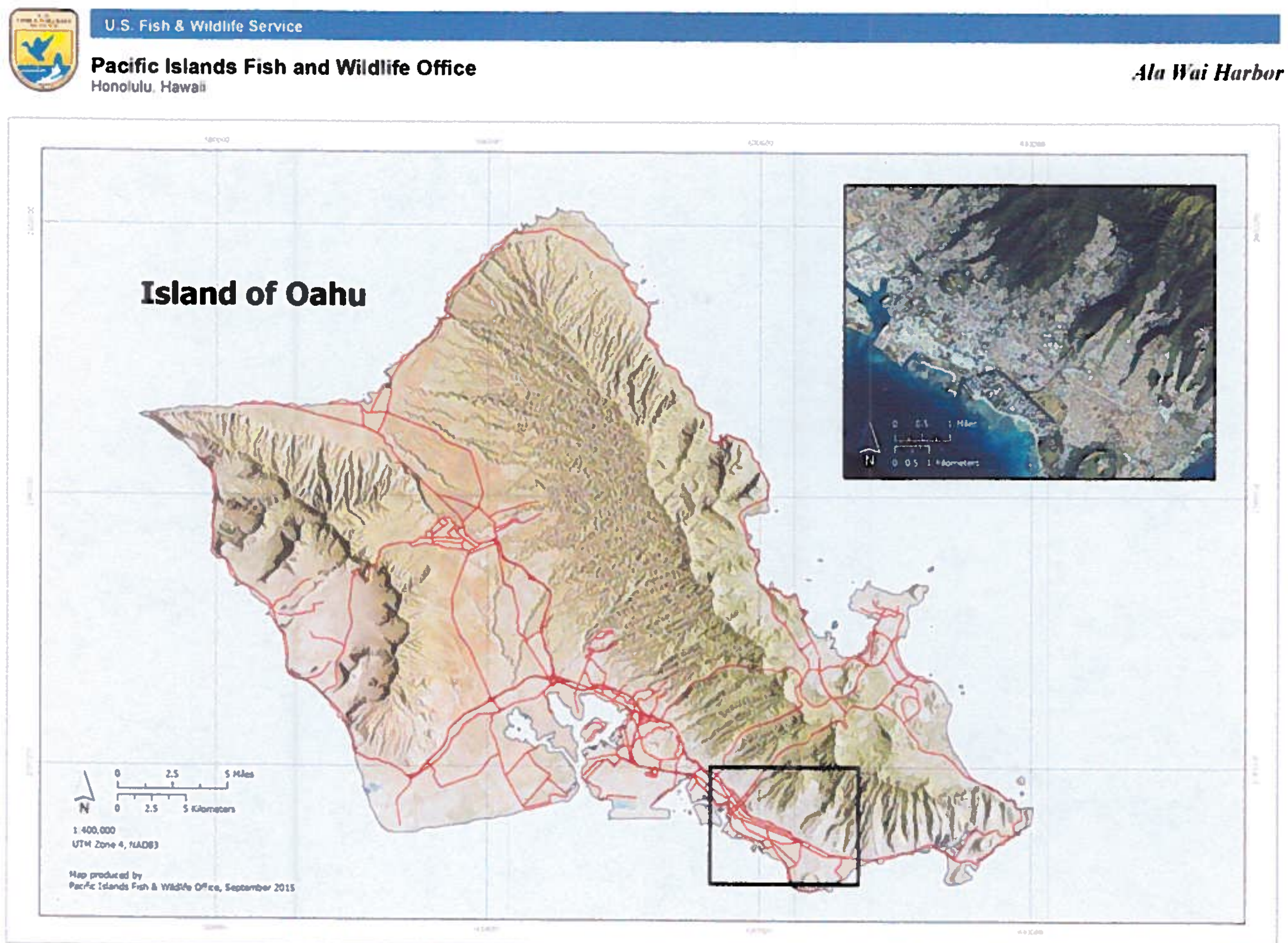


Figure 2. Map of Hawaii Island with Ala Wai Watershed inset.

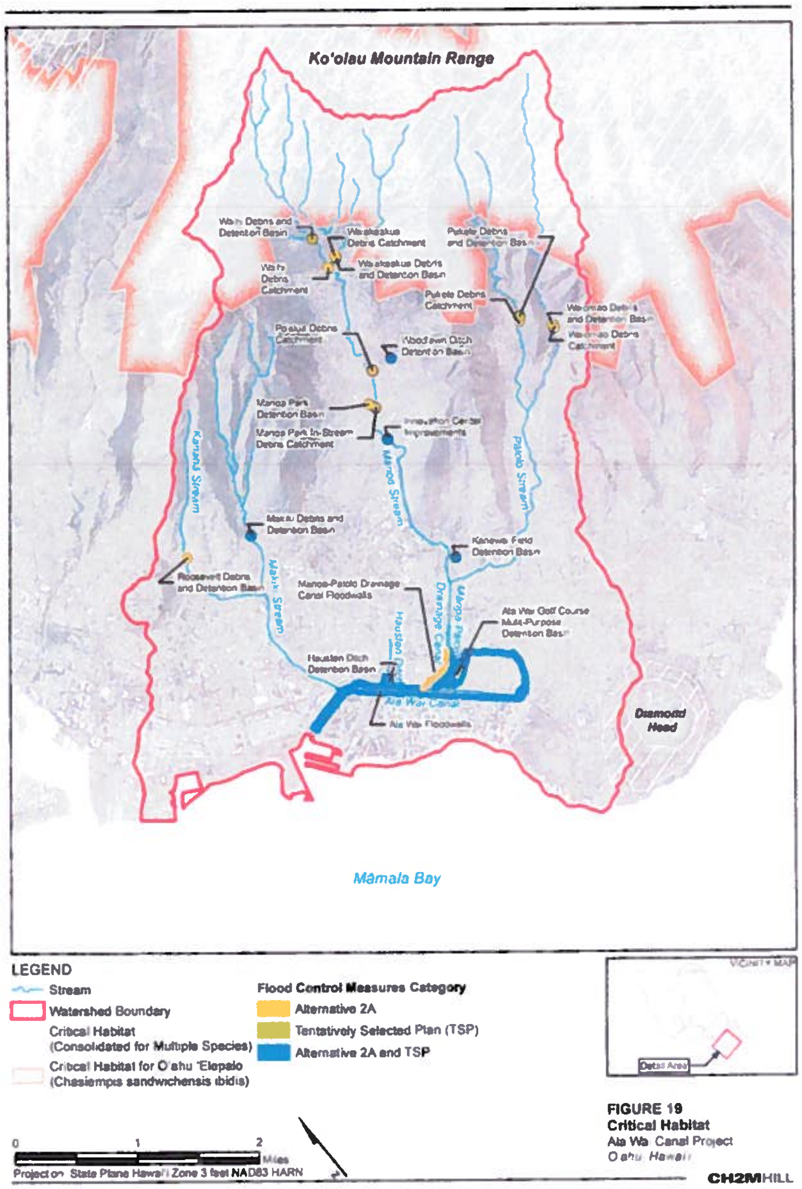


Figure 3. Map of Ala Wai Watershed Flood Control Project Area.

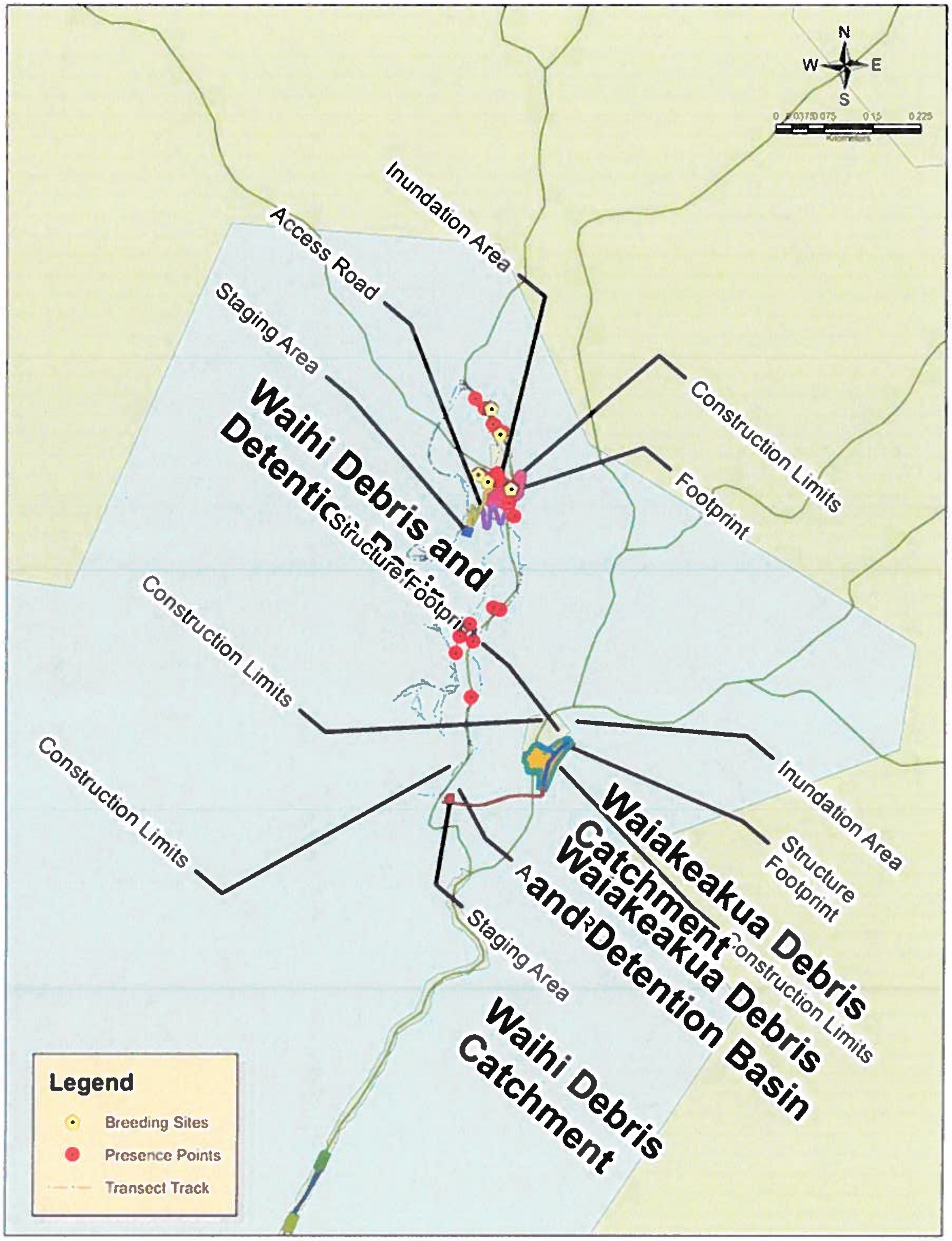


Figure 4. Map of Damselfly observations at Waihi Stream Debris and Detention Basin (DDB).

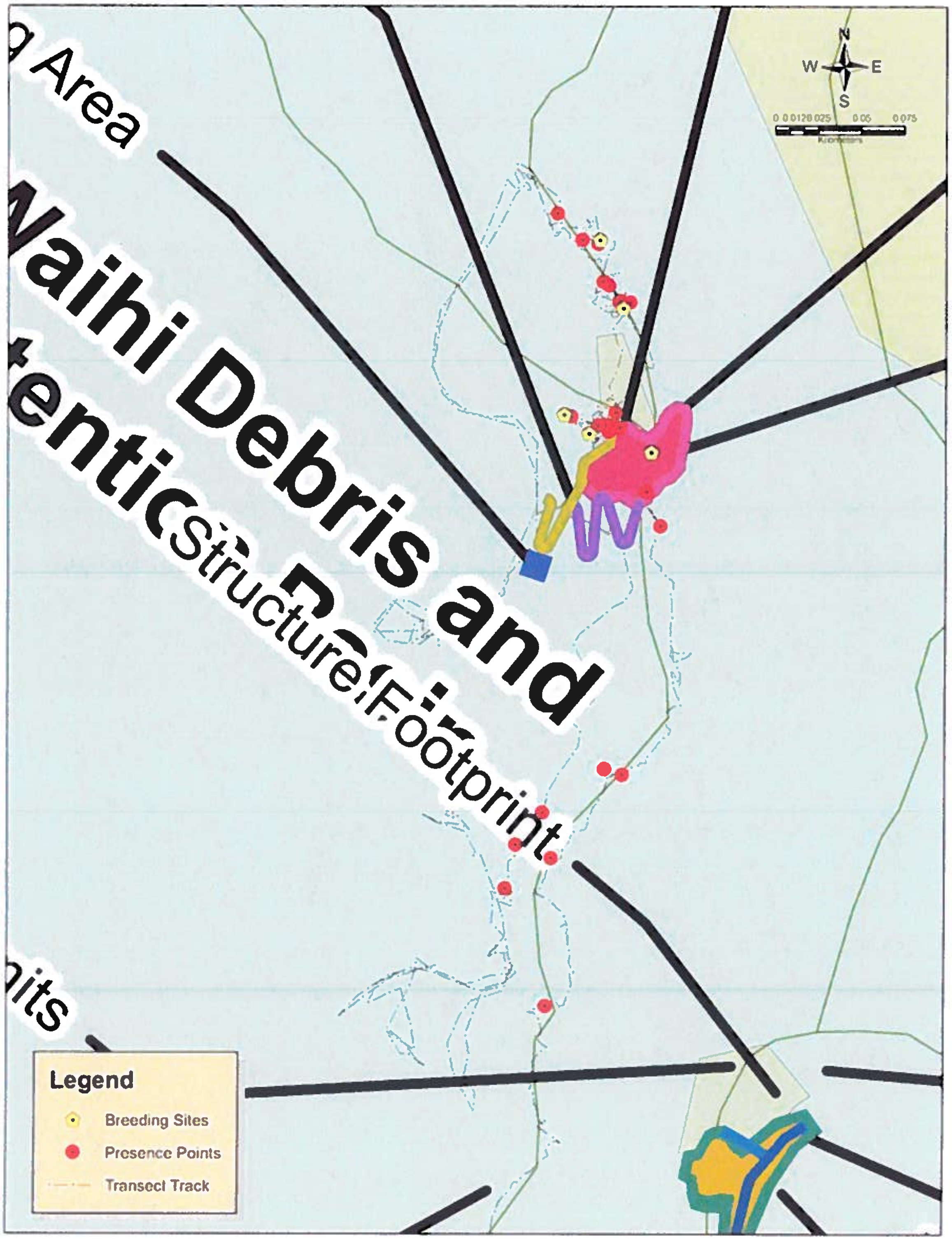


Figure 5. Closeup Map of Damselfly observations at Waihi Stream DDB.

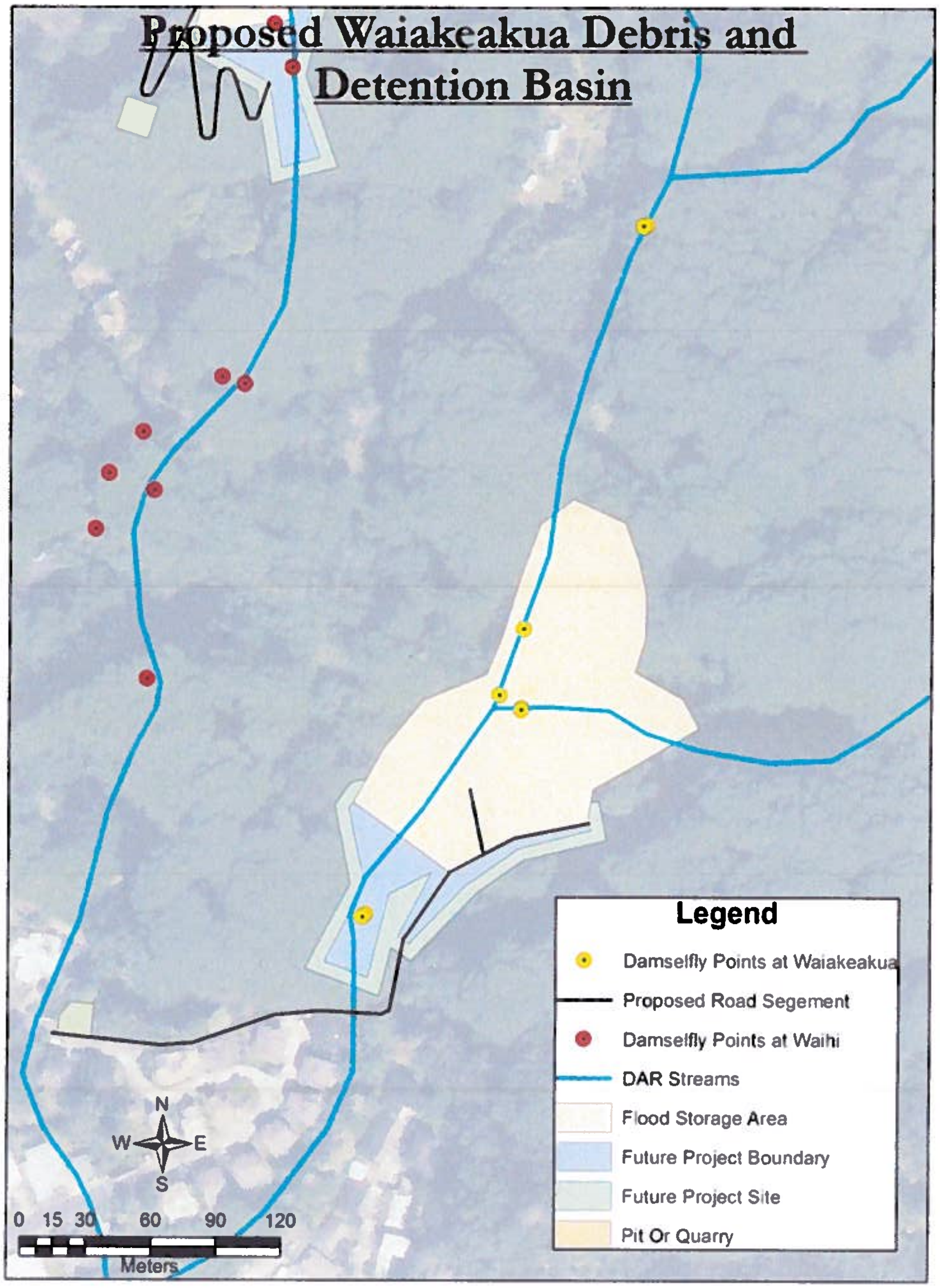


Figure 6. Map of Damselfly observations at Waiakeakua Stream DDB.

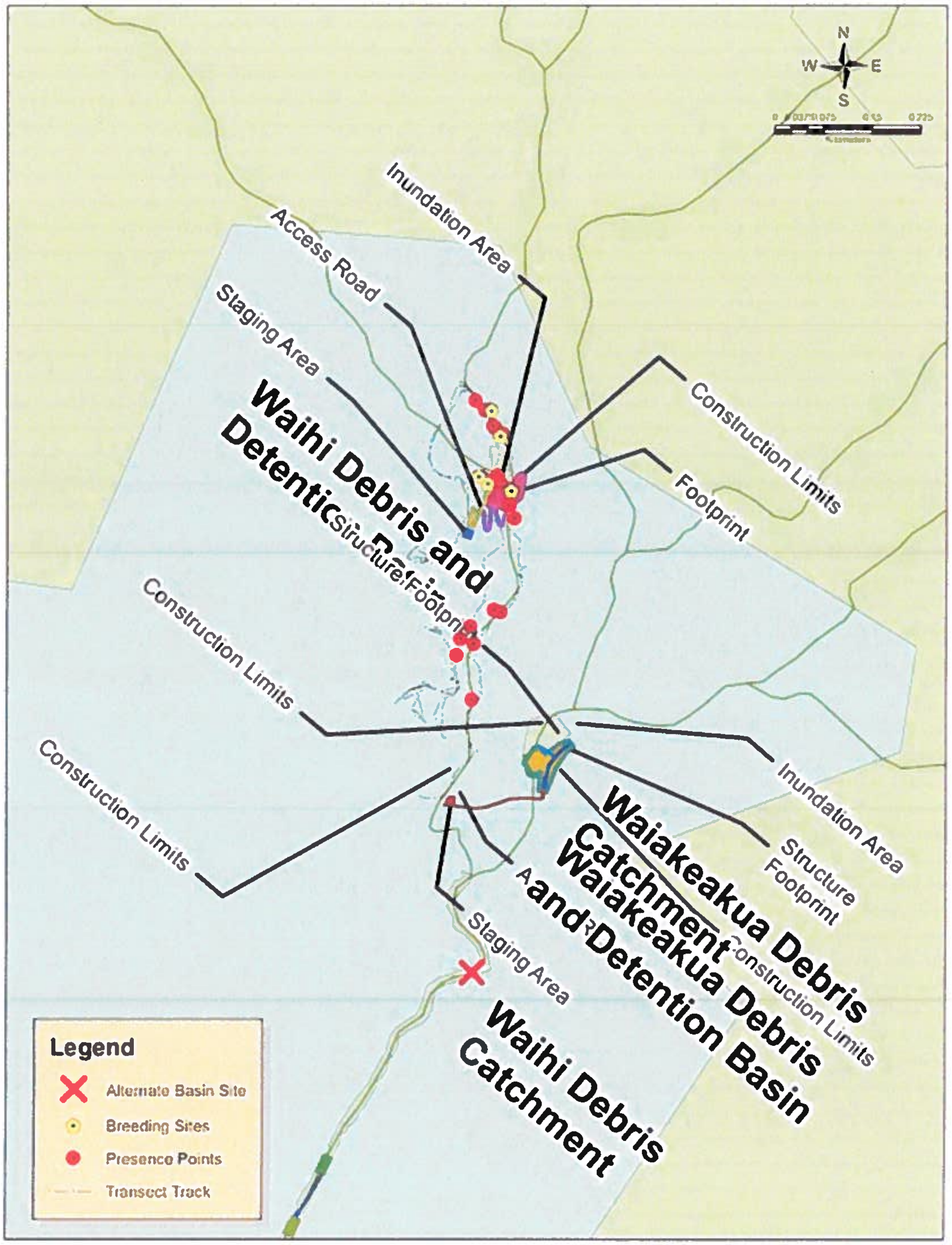


Figure 7. Alternative Basin Site (Debris and Detention): Red X = Latitude = 1708314.06637 and Longitude = 57831.148998
(Note: Coordinate system: NAD_1983_PA11_StatePlane_Hawaii_3_FIPS_5103_Feet)

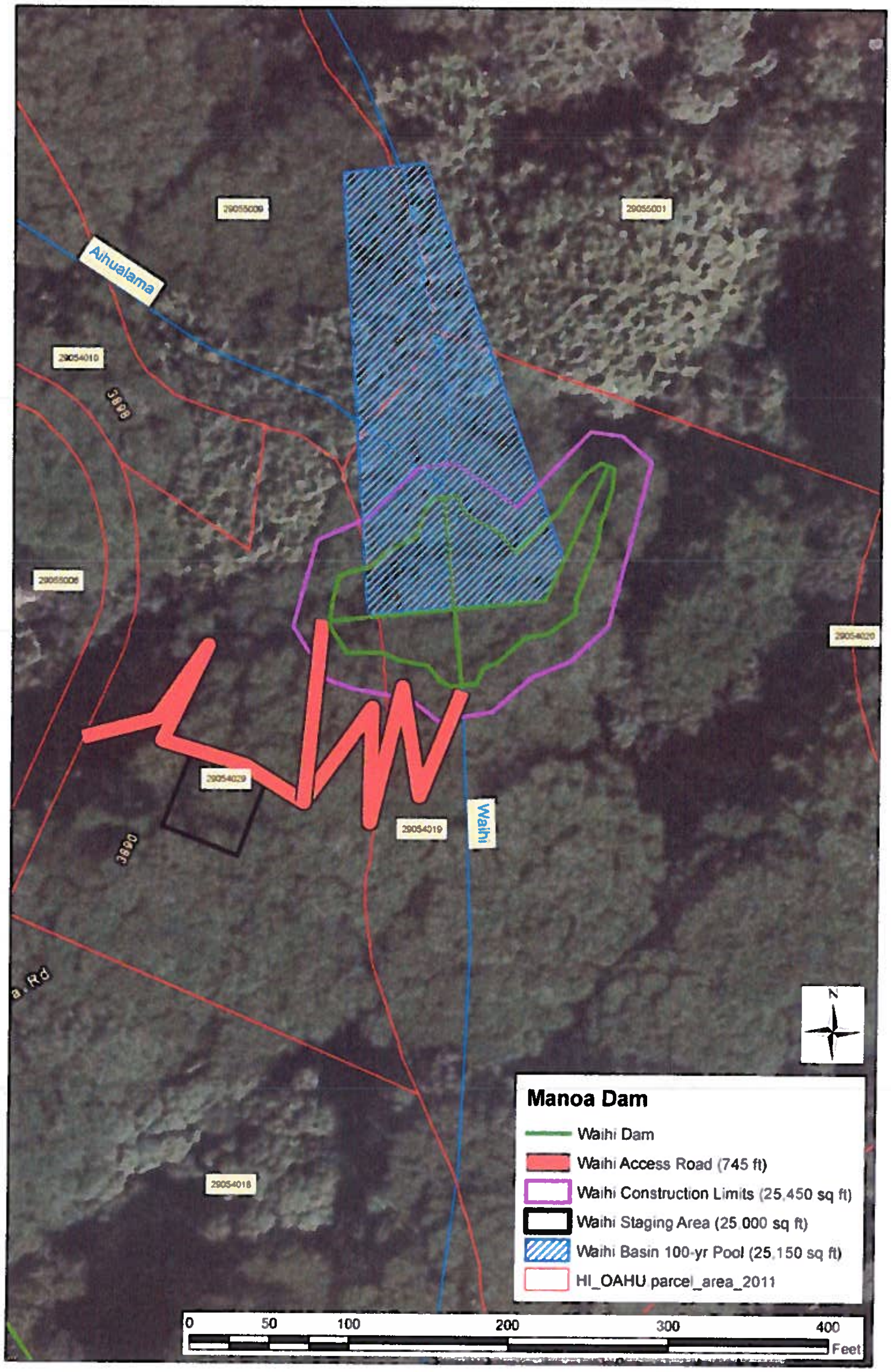


Figure 8. Map of Waihi Stream Debris and Detention Basin, Manoa Stream.

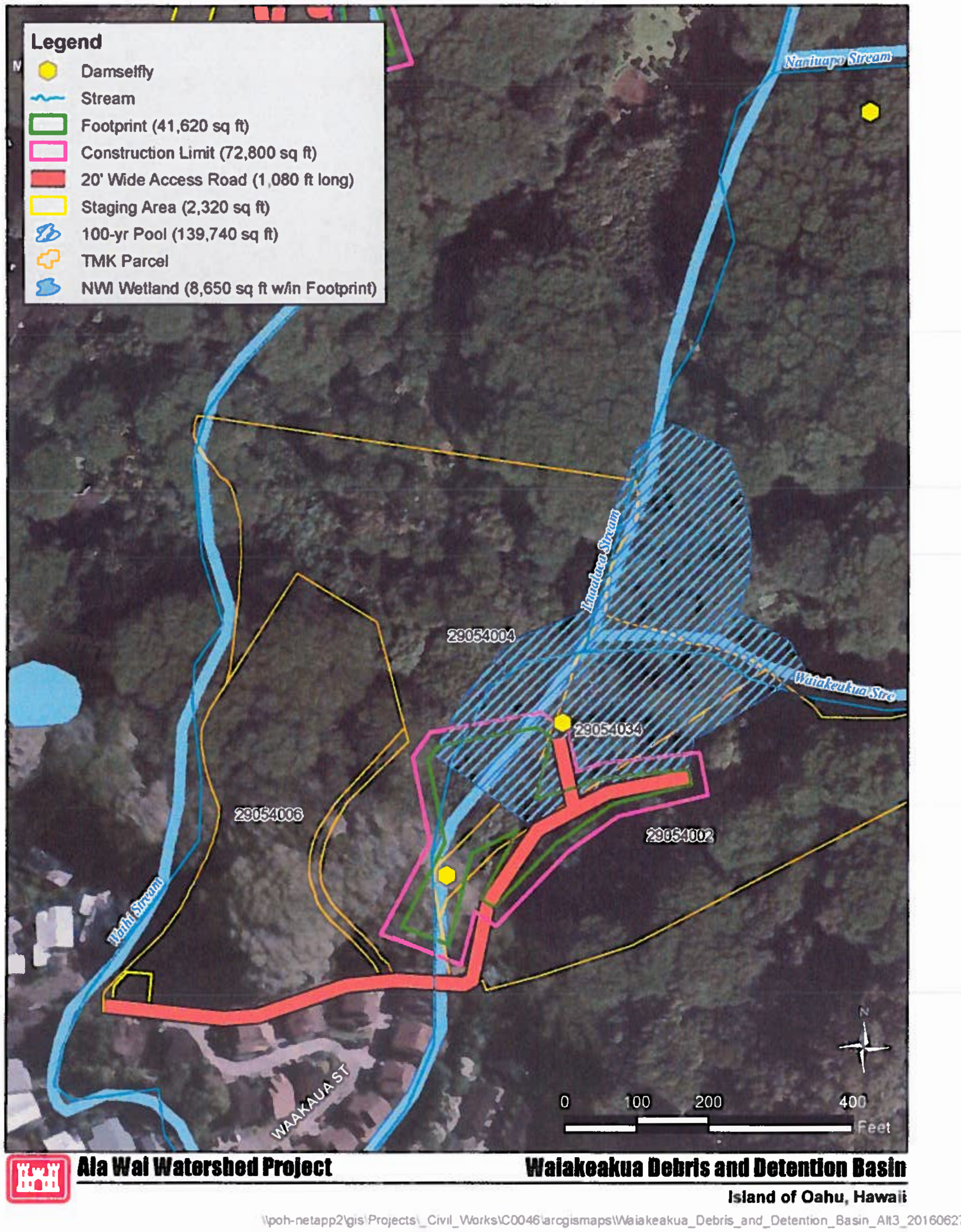


Figure 9. Map of Waiakeakua Stream Debris and Detention Basin, Manoa Stream.

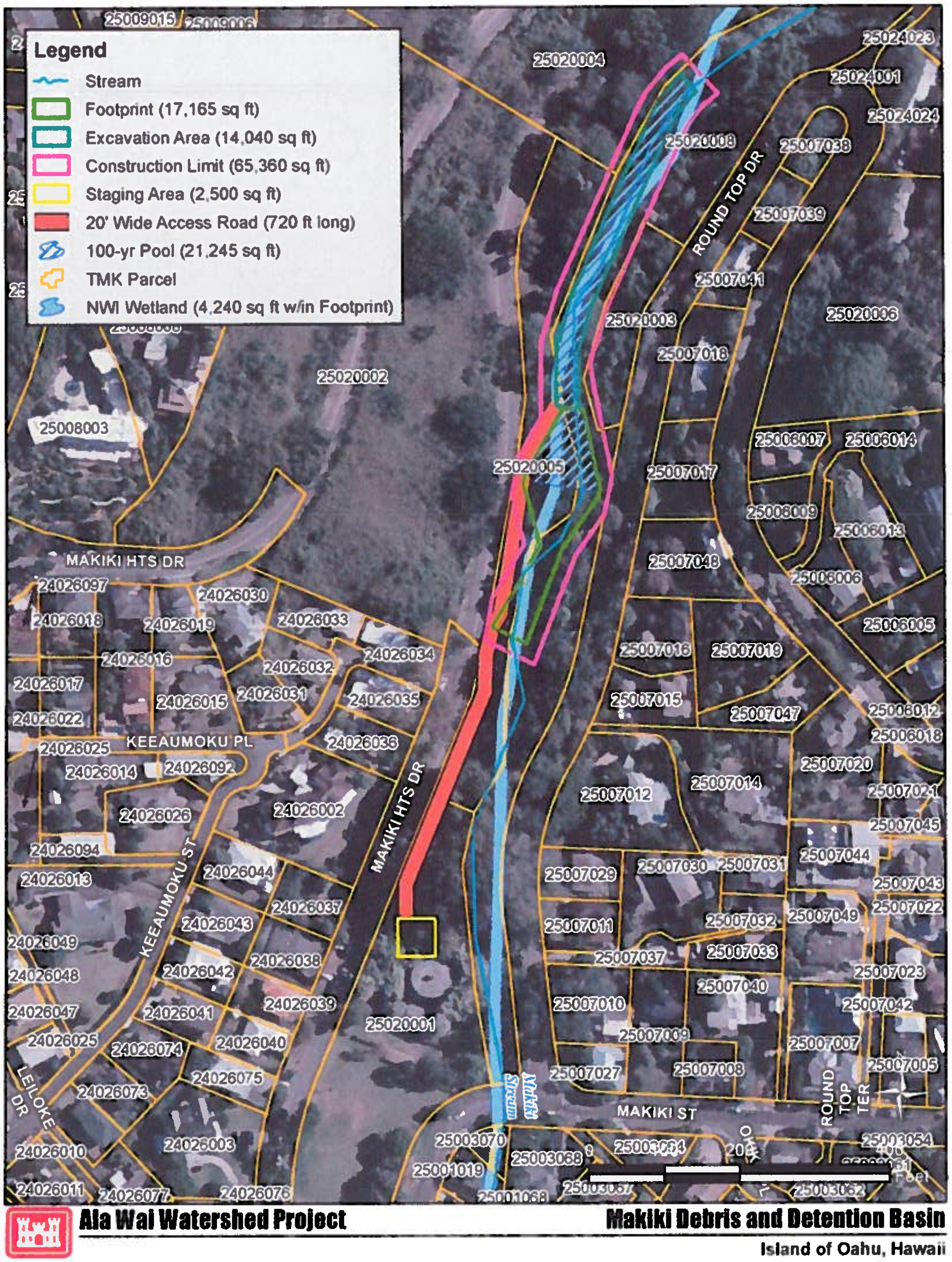


Figure 10. Map of Makiki Stream Debris and Detention Basin, Makiki Stream.

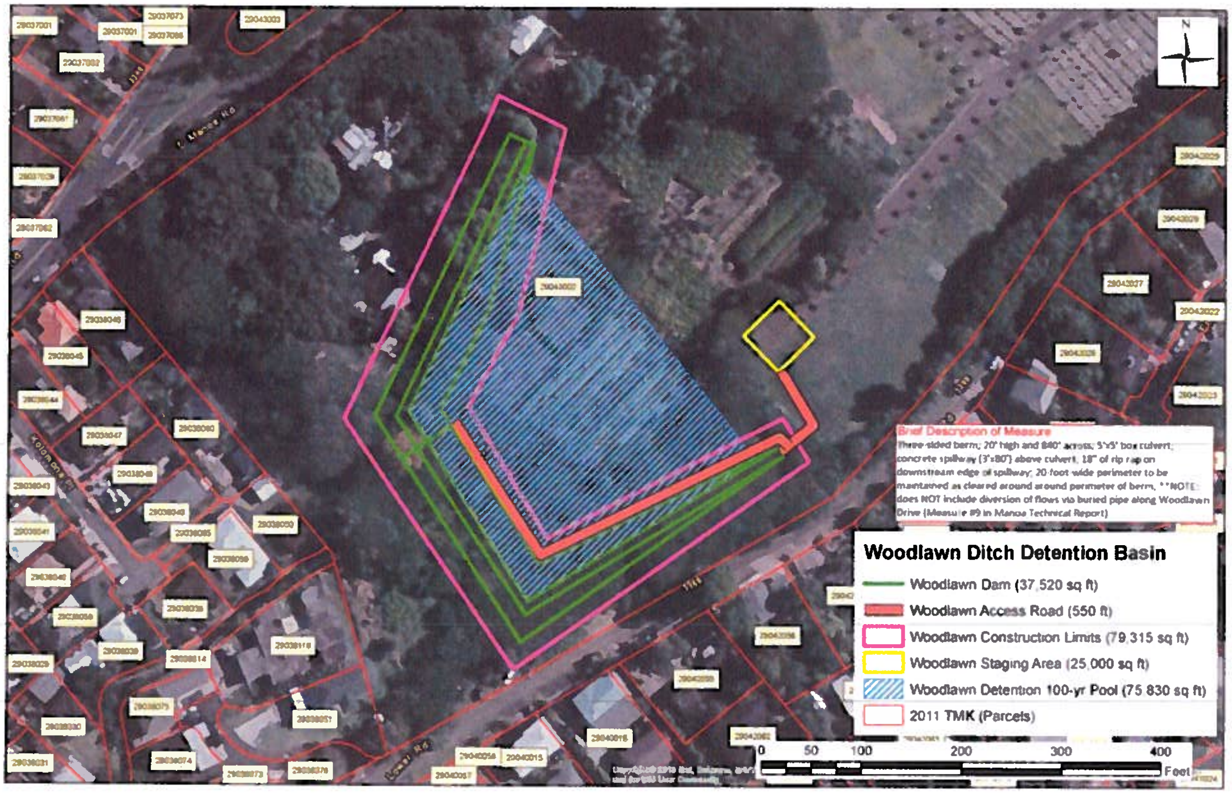


Figure 11. Map of Woodlawn Ditch Detention Basin, Manoa Stream.

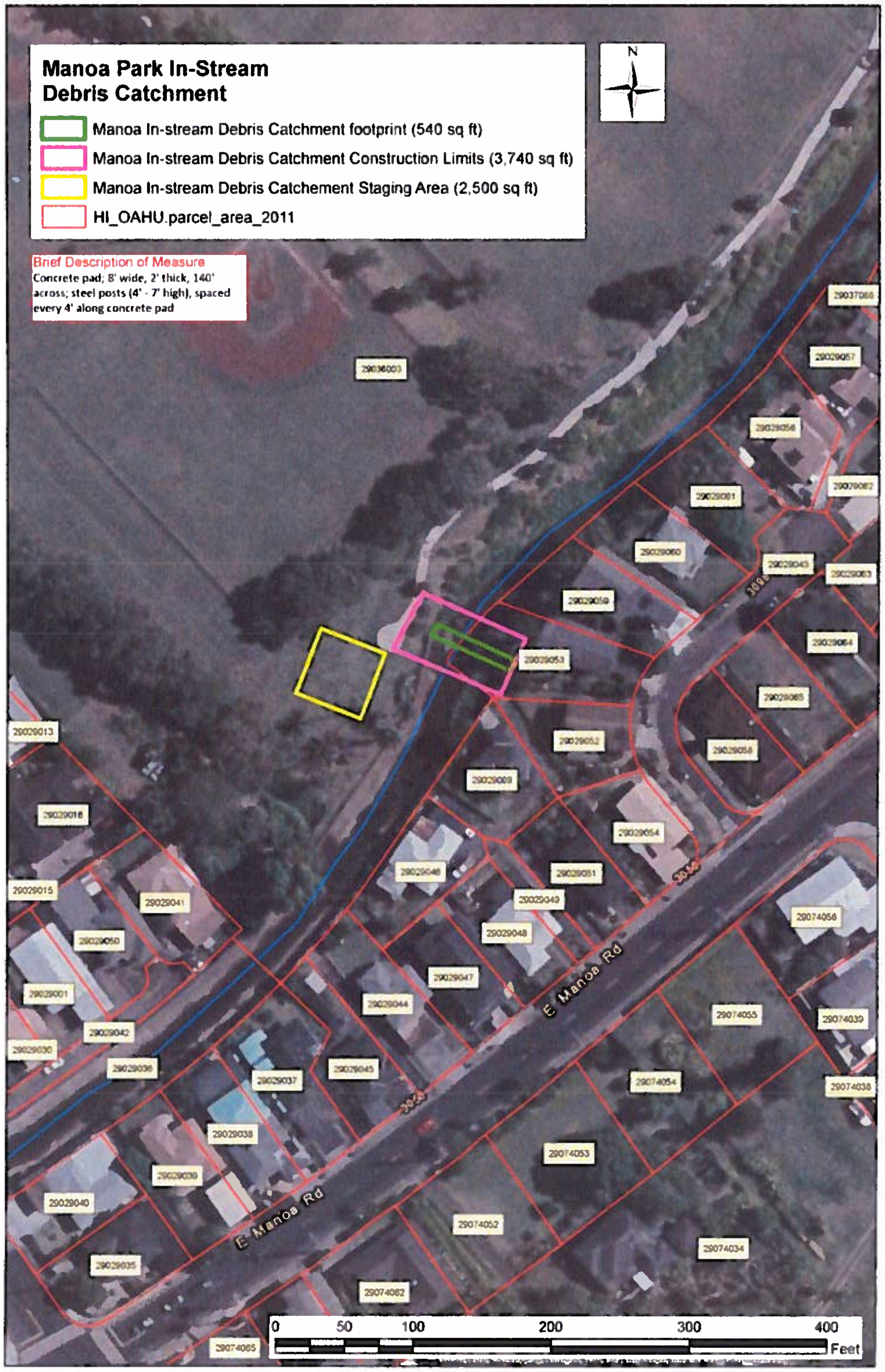


Figure 12. Map of Manoa In-stream Debris Catchment, Manoa Stream.

Figure 13. Map of Kanewai Field Multi-Purpose Detention Basin, Manoa Stream.

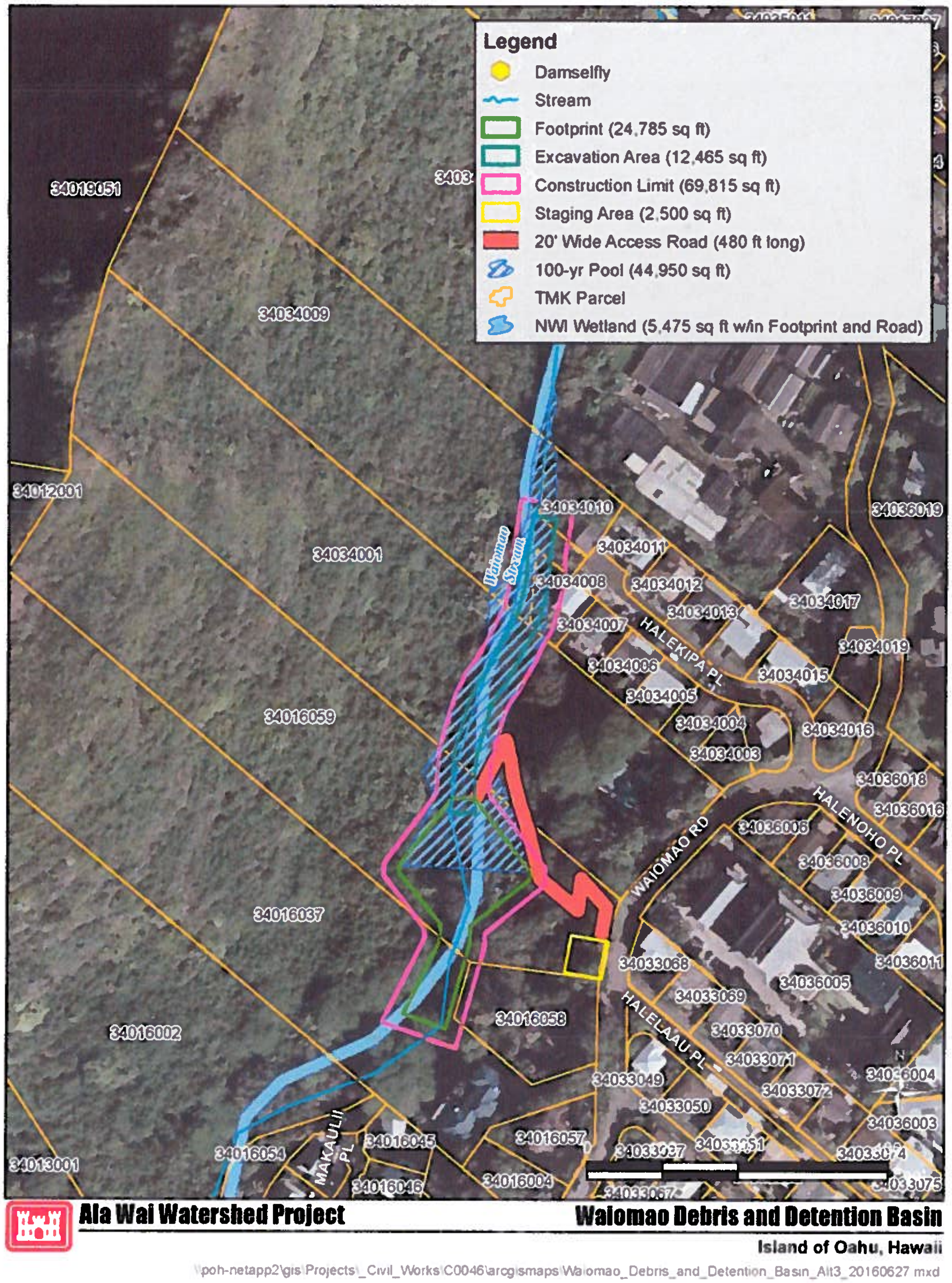


Figure 14. Map of Waiomao Debris and Detention Basin, Manoa Stream.

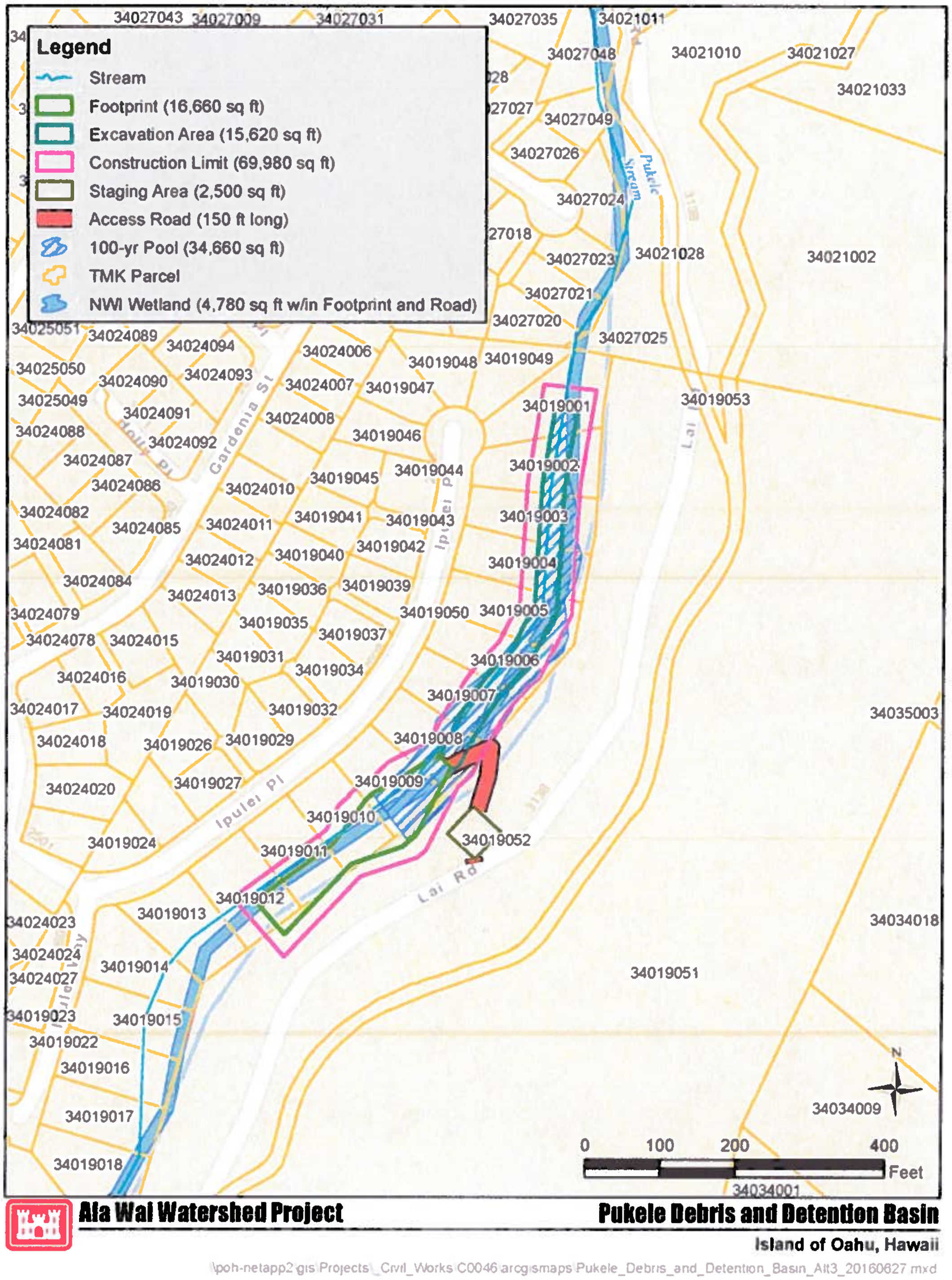


Figure15. Map of Pukele Debris and Detention Basin, Manoa Stream.

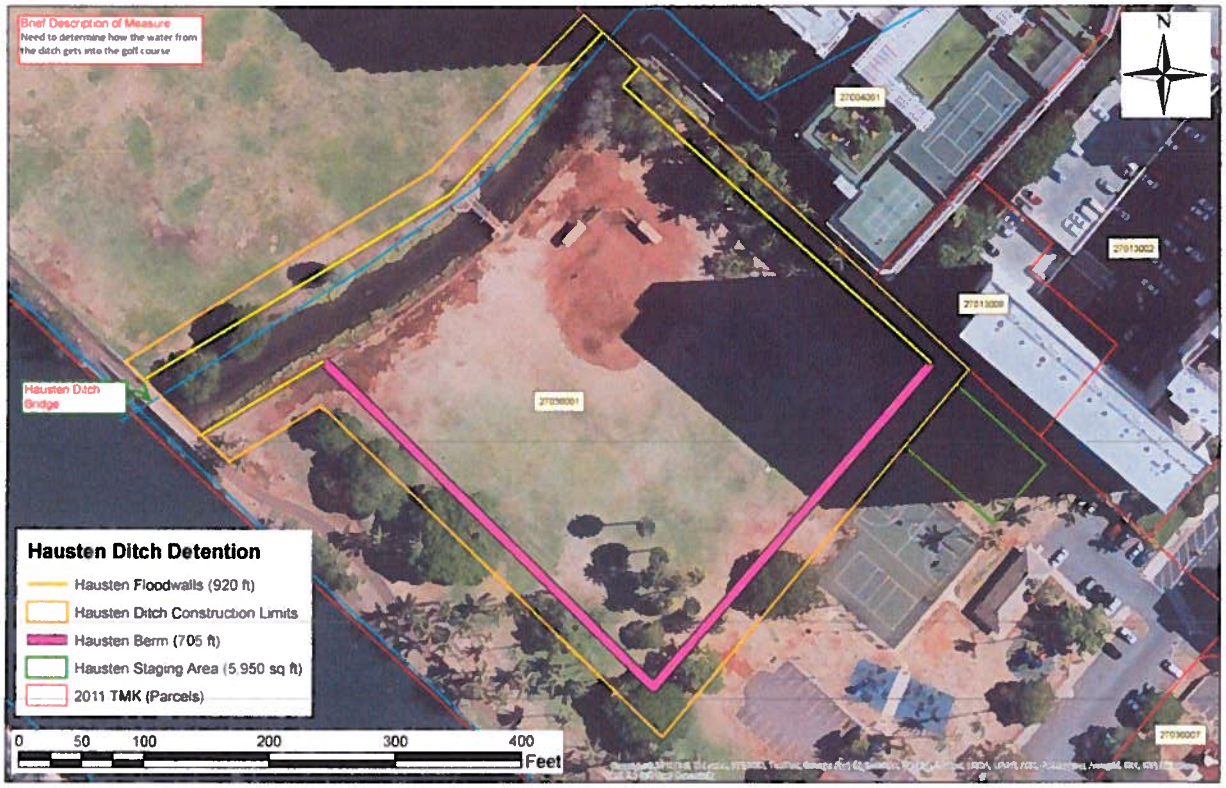


Figure 16. Map of Hausten Ditch Detention Basin, Manoa Stream.

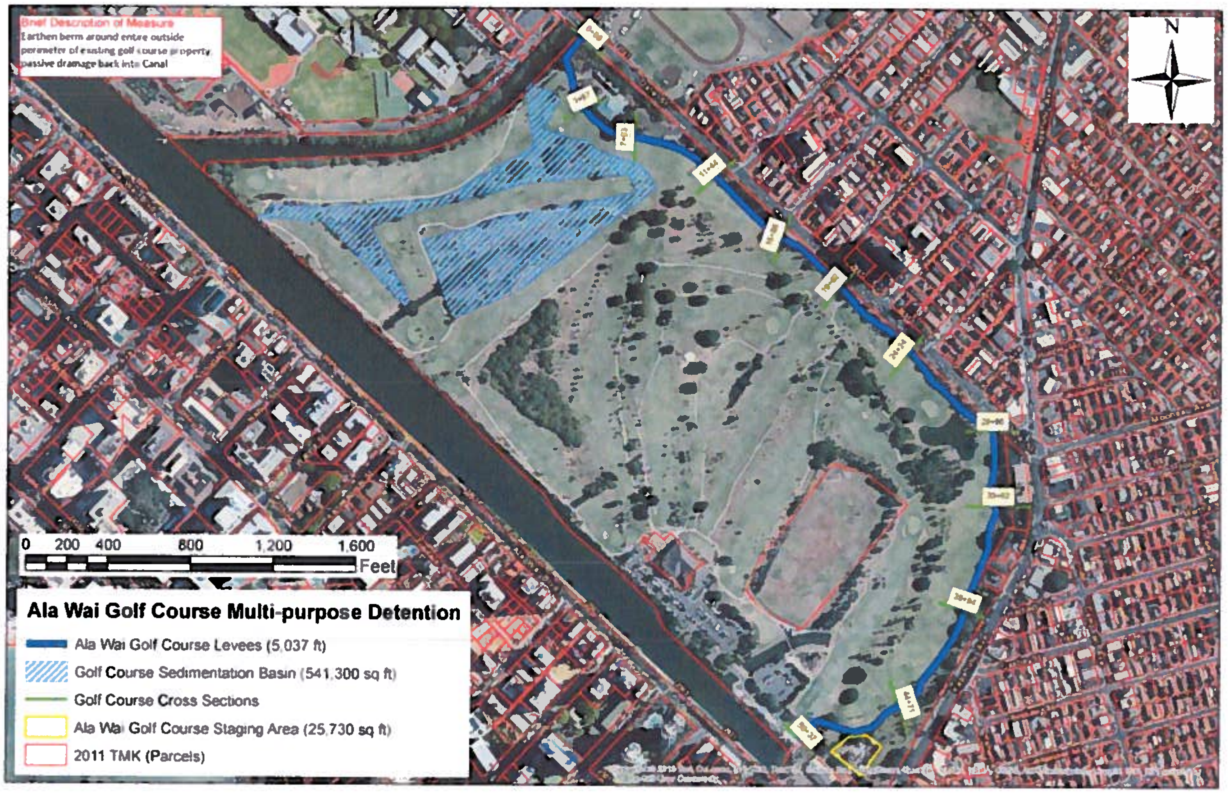


Figure 17. Map of Ala Wai Golf Course Multi-Purpose Detention Basin.

APPENDIX A – PHOTOGRAPHS OF FISH AND WILDLIFE RESOURCES

Figure A-1. Blackline damselfly, *Megalagrion nigrohamatum nigrolineatum*, male.

Figure A-2. Blackline damselfly, *Megalagrion nigrohamatum nigrolineatum*, male

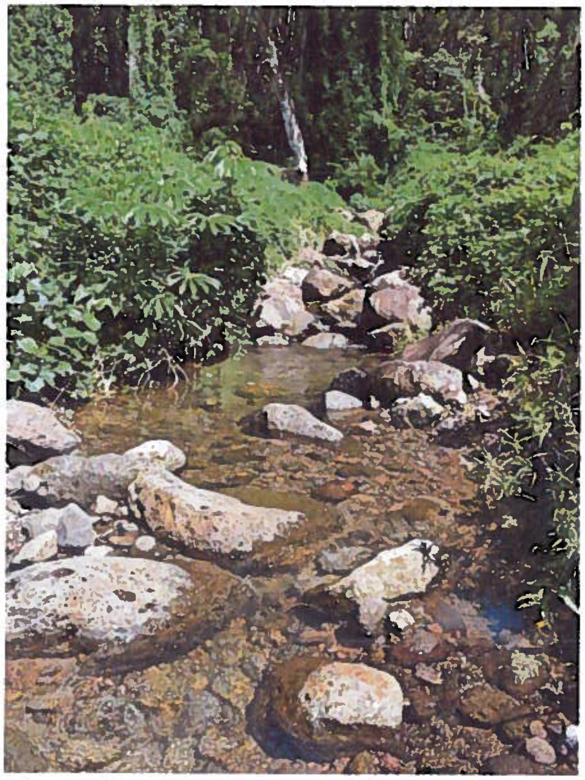


Figure A-3a.Manoa Stream, Waihi DDB Site (Basin).

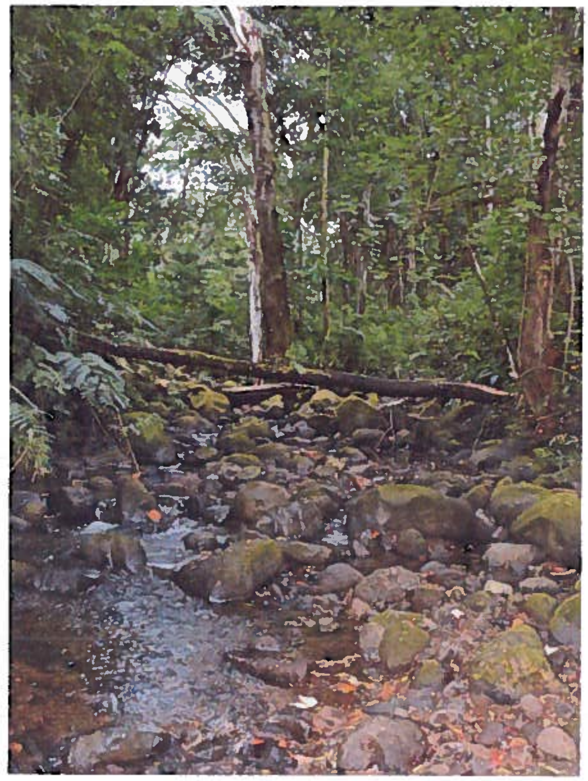


Figure A-3b.Manoa Stream, within project footprint.

Figure A-4a. Manoa Stream Waihi DDB
Breeding Habitat: *M. nigrohamatum nigrolineatum*

Figure A-4b. Manoa Stream,Waihi DDB,
Riparian seepage.

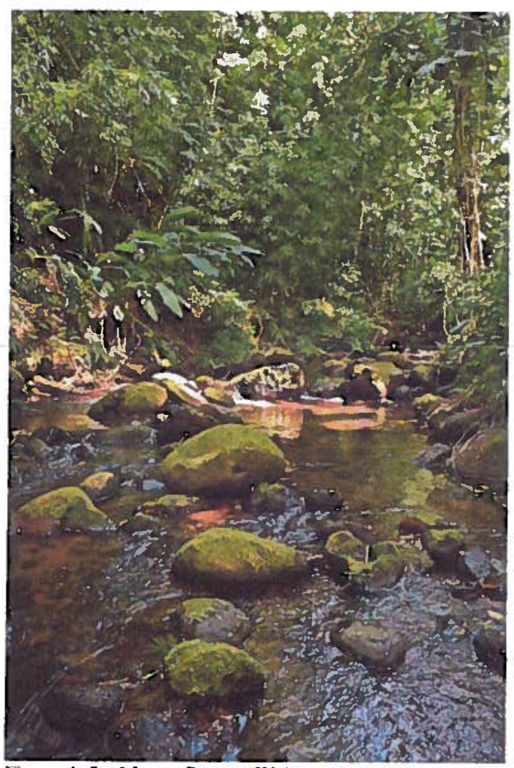


Figure A-5a. Manoa Stream, Waiakeakua stream, DDB Site.
Fork going upstream above confluence, near the upper
Bound of the project footprint.

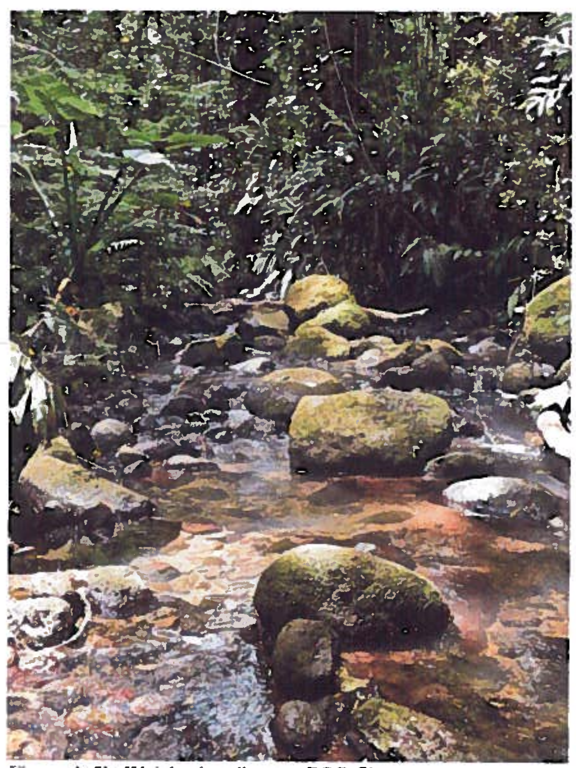


Figure A-5b. Waiakeakua Stream, DDB Site.
Main stream between gauge forks. Both areas represent M.
nigrohamatum nigrolineatum habitat.


Figure A-6. Makiki Stream, DDB Site.

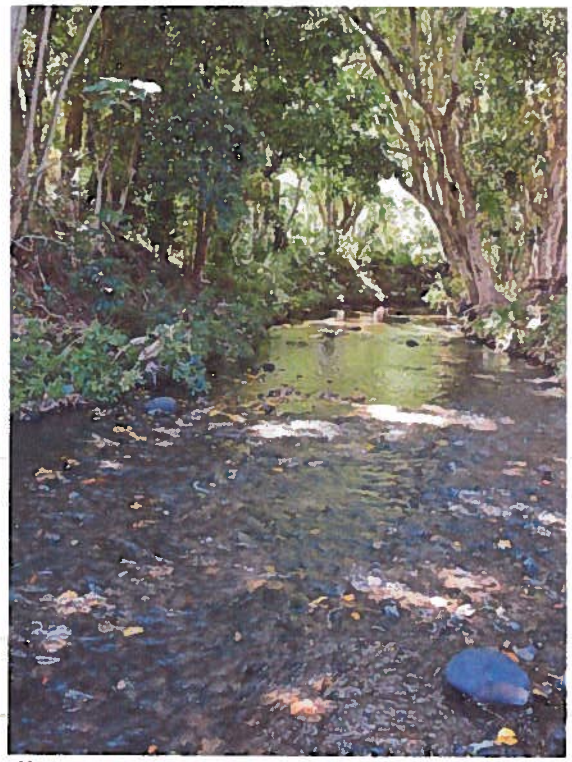


Figure A-7. Manoa Stream, Woodlawn DDB Site.

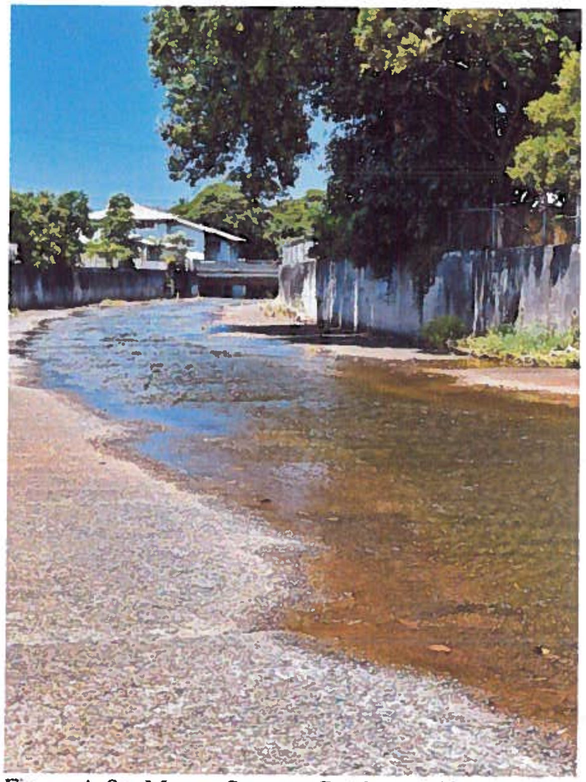


Figure A-8a. Manoa Stream, Catchment Site.

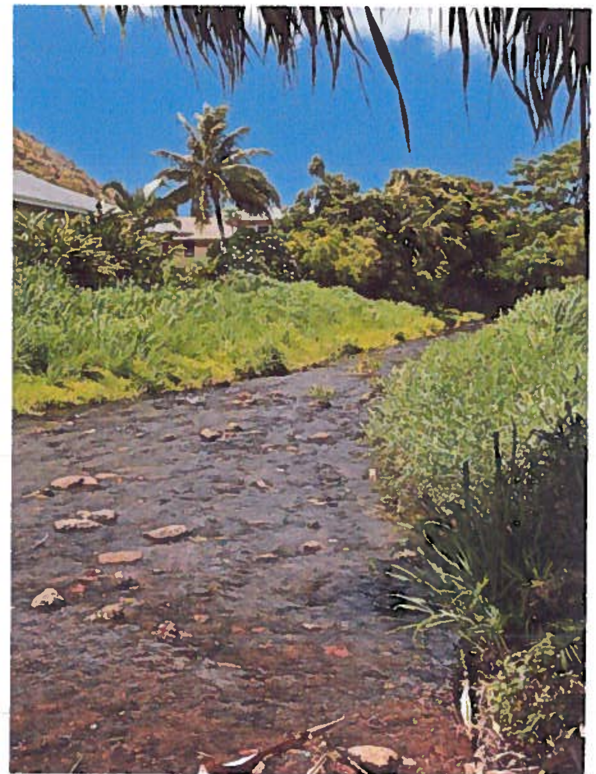


Figure A-8b. Manoa Stream, Catchment Site.

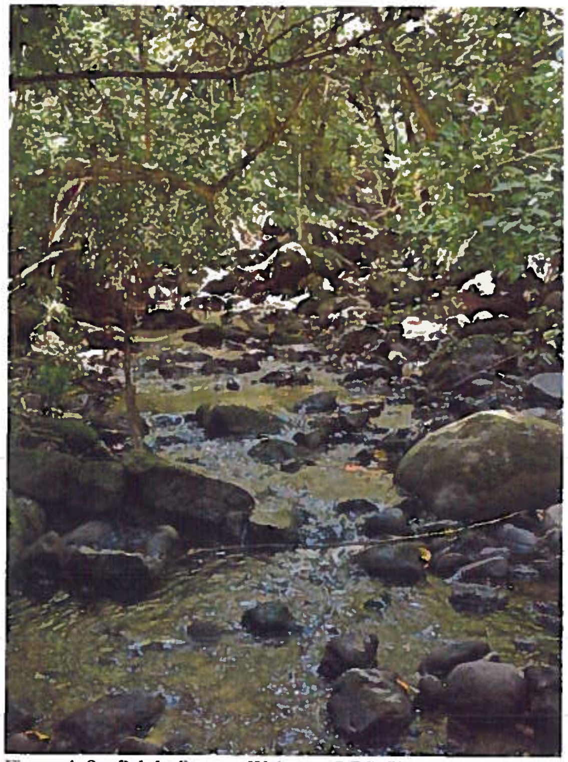


Figure A-9a. Palolo Stream, Waiomao DDB Site.

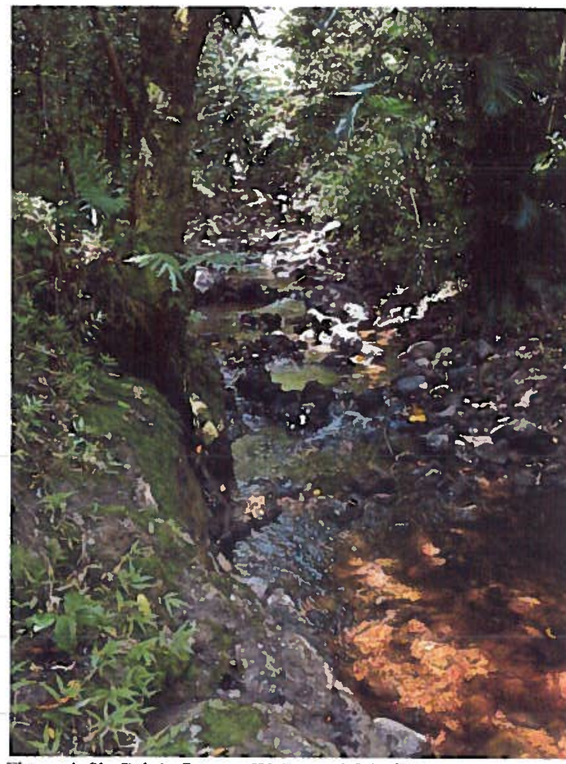


Figure A-9b. Palolo Stream, Waiomao DDB Site.

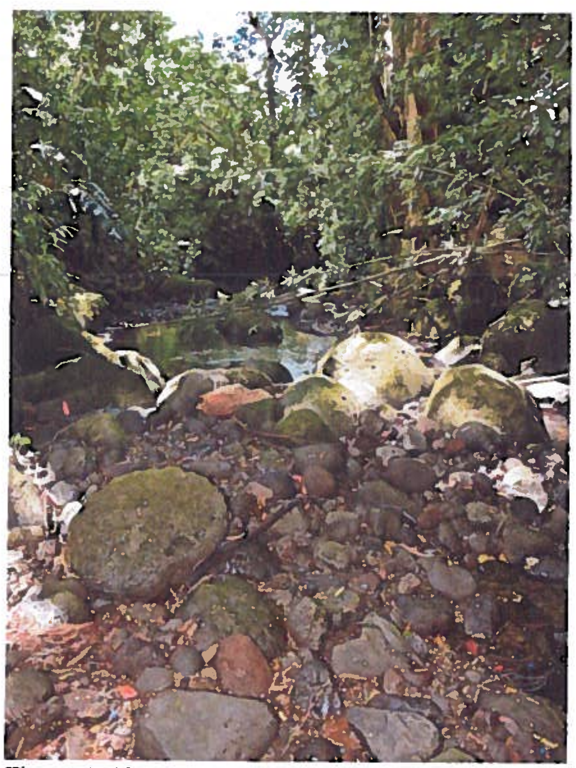


Figure A-10a. Palolo Stream, Pukele DDB Site.

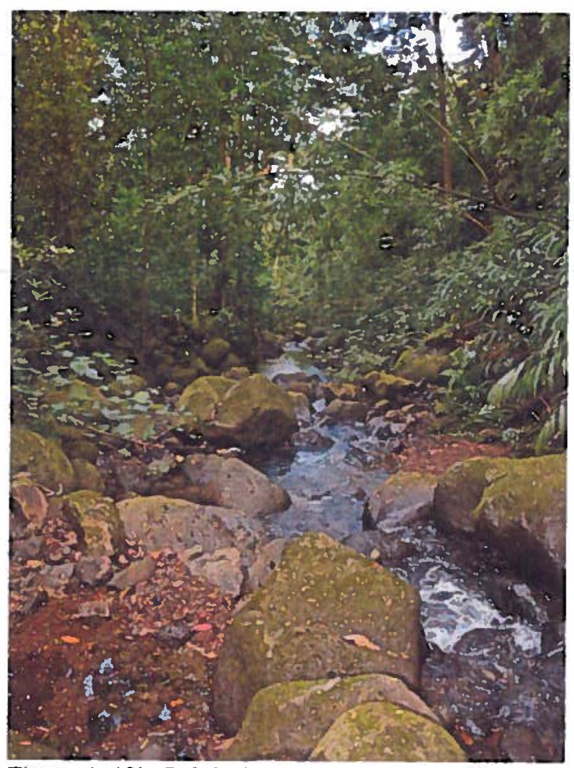


Figure A-10b. Palolo Stream, Pukele DDB Site.

APPENDIX B – PHOTOGRAPHS OF POST-DEBRIS REMOVAL MAINTENANCE AT WAILUPE DEBRIS AND DETENTION BASIN

Figure B-1. Examples of Maintenance Dredging in Detention Basin Pool Area – Vegetation and debris removed and soil exposed by bulldozer.

Figure B-2. Examples of Maintenance Dredging in Detention Basin Pool Area – Exposed soil and altered stream.

Figure B-3. Examples of Maintenance Dredging in Detention Basin Pool Area - Large boulders and debris accumulate in the stream.

Figure B-4. Examples of Maintenance Dredging in Detention Basin Pool Area – Backhoe removing debris from stream.

Figure B-5. Examples of Maintenance Dredging in Detention Basin Pool Area – Culvert.

APPENDIX C – Fish Biomass Estimates from High Definition Fish Survey Video in Ala Wai Watershed Streams, Oahu September 23, 2016 Dr. James Parham, Certified Fisheries Professional

Fish Biomass Estimates from High Definition Fish Survey Video in Ala Wai Watershed Streams, Oahu

September 23, 2016

Submitted to:

Glenn R. Higashi, Aquatic Biologist
Stream Surveys & Aquatic Resources Database Manager
Division of Aquatic Resources, DLNR
1151 Punchbowl Street, Room 330
Honolulu, HI 96813

&

Kevin B. Foster
Fish and Wildlife Biologist
Department of the Interior
300 Ala Moana Blvd, Rm 3-122
Honolulu, HI 96850-0001

Submitted by:

Dr. James Parham, Certified Fisheries Professional
President, Parham & Associates Environmental Consulting, LLC
149 Hedgelawn Drive
Hendersonville, TN 37075
www.ParhamEnvironmental.com

Table of Contents

List of Figures

List of Tables

Introduction:

The USACE along with its state partners has proposed the Ala Wai Canal Flood Mitigation Project to reduce the risk of flooding and associated property damage within the Ala Wai watershed. In general, the flood risk management project is focused on holding back or diverting peak flood flows to lessen the impact of a flooding event. The infrastructure needed to do this is expected to have an impact on aquatic habitat and native Hawaiian stream animals.

As part of the assessment of habitat and instream conditions, the Hawaii Division of Aquatic Resources (DAR) collected geo-referenced underwater video footage using the High Definition Fish Survey (HDFS) methodology from the Ala Wai Watershed streams (Manoa, Palolo, and Makiki). The results of the surveys were summarized by Parham and Higashi 2015 in a report documenting the species observed and their distribution throughout the streams. Subsequent to that report, DAR has collected additional underwater video footage from Manoa Stream.

To support a review of the USACE Flood Mitigation Project, the USFWS needs an estimate fish biomass for the more common species. To estimate a species' biomass within the Ala Wai Watershed Streams, the original and new survey videos were analyzed with this specific output as a goal. This report describes the methods used and results for fish biomass estimate from the HDFS surveys in the Ala Wai Streams.

Methods:

To develop biomass estimates for fishes in Manoa, Palolo and Makiki Streams, a series of steps were completed.

1. The underwater video was watched, each sample site was given a unique Site ID and the sites date, time, GPS location, video file, and stream name were recorded.

2. From the underwater video footage, an estimate of the viewing area (m^2) was determined. This was used in the estimate of fish biomass (g/m^2). Area was estimated by determining the forward visibility, the distance traveled if the camera moved, and the proportion of the site obscured.

3. The underwater video footage was watched and scored for the species type, their size, and number present at each sample location. With any timed observation of live animals (visual or video), it is possible that the same fish may swim in and out of the viewing area. As a result, the maximum number of fish (Max N) in the screen during the sample viewing time is used to control for this possibility. Once video frame with the maximum number of an individual species was determined, the individuals were then counted within predetermined size classes. The result of this step was a size class count for each species within each underwater video sample site.

- For this analysis of fish biomass, the native goby, o'opu nakea (*Awaous stamineus*), and the introduced fishes, longfin armored catfish (*Hypostomus watwata*), bristlenose catfish (*Ancistrus temmincki*), and convict cichlid (*Archocentrus nigrofasciatus*) were selected by USFWS and

DAR. The native goby, o'opu nakea, is the most widespread native stream fish in the Ala Wai Watershed streams and the two catfish species occupy similar habitat to the native gobies. Convict cichlid are representative of a non-demersal species.

4. The biomass for each fish within a size class was determined from length/weight measurements collected from specimens in Oahu streams provided by DAR. The standard length/weight relationship, Weight = a(Length)^{b} was fit to the data using Table Curve 2D v 5.01 (Systat Software Inc., 2002) to find the species specific coefficient values for a and b. The median length of the observed species within each size class was used to estimate the weight of the species observed by applying the length/weight relationship. This step provided the total weight of a species within each sample site.

5. The results of the biomass estimate at individual sample sites was averaged within stream and stream reach areas. The streams (Manoa, Palolo, and Makiki) and reaches (lower, middle, and upper) provided a way to generalize the results into more appropriate areas associated with the flood mitigation actions.

Results

All the data used in this report are provided in an associated spreadsheet.

Sampling effort:

A total of 745 sites throughout Manoa, Palolo and Makiki streams were surveyed using the HDFS methodology (Table 1). The area in upper Manoa Stream containing 230 sites was the most recent survey by DAR. A total of 310 sites was surveyed in the upper end of the streams and are the most useful comparison for the upper detention basins proposed in the flood mitigation plan.

Table 1: Location of survey sites

Stream	Reach Code	Sample Sites
Palolo	Lower	45
Makiki	Lower	94
Manoa	Middle	63
Palolo	Middle	133
Manoa	Upper	230
Palolo	Upper	103
Makiki	Upper	77
Total		745

Species Observations:

All 745 survey sites were reviewed for the presence of native gobies or the three introduced species. O'opu nakea and o'opu naniha were the most common native gobies (Table 2). Only one o'opu nopili (*Sicyopterus stimpsoni*) and three o'opu akupa (*Eleotris sandwicensis*) were observed in all of the samples. Nearly 300 each of the longfin armored catfish, bristlenose catfish, and convict cichlid were observed throughout the streams. The bristlenose catfish was the most common species counted in the upper stream reaches, although liberty mollies and guppies were likely observed in greater numbers.

Table 2: Size distribution of selected fishes in Ala Wai Watershed streams.

O'opu nakea

Category	Length Range (in)	Number Observed
small	< 3	6
medium	3 to 5	10
large	> 5	5
Total		21

O'opu naniha

Category	Length Range (in)	Number Observed
small	< 3	0
medium	3 to 5	5
large	> 5	13
Total		18

Longfin Armored Catfish

Category	Length Range (in)	Number Observed
small	< 2.5	11
medium	2.5 to 4	81
large	4 to 6	138
ex. Large	> 6	57
Total		287

Bristlenose catfish

Category	Length Range (in)	Number Observed
small	< 2	41
medium	2 to 3.5	133
large	> 3.5	120
Total		294

Convict Cichlid

Category	Length Range (in)	Number Observed
small	> 2	70
medium	2 to 4	162
large	> 4	62
Total		294

Length / Weight relationships:

DAR provided length and weight information from recent field surveys in Oahu streams. Michael Blum from Tulane University collected the information on longfin armored catfish, bristlenose catfish, and convict cichlids. Kauaoa Fraiola collected the information on o'opu nakea. The length and weight data for each species was plotted on a graph and the standard length weight relationship was fitted to the data. The following graphs and tables show the results for the length/weight relationships for these four species.

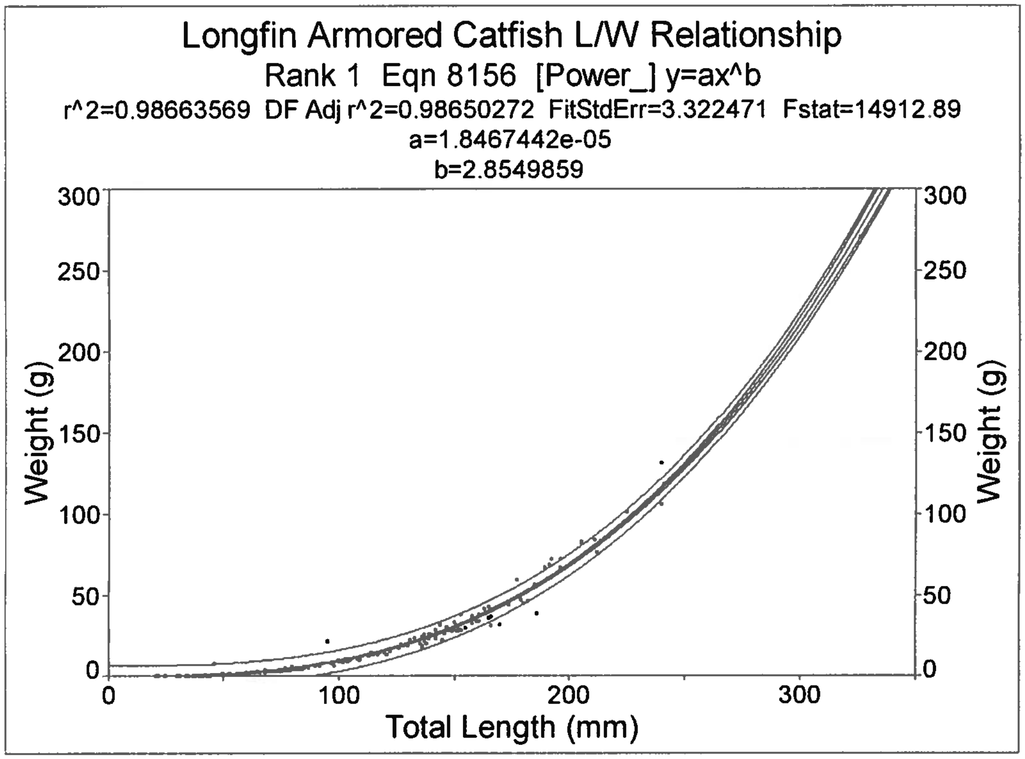


Figure 1: Length to Weight relationship for longfin armored catfish (*Hypostomus watwata*) based on 204 individuals collected from Oahu streams.

Table 3: Size categories, estimated median length within the size category, and related weights for longfin armored catfish (*Hypostomus watwata*).

Category	Length Range (in)	Length Median (in)	Length Median (mm)	Weight (g)
small	< 2.5	2	51	1.37
medium	2.5 to 4	3.5	89	6.77
large	4 to 6	5	127	18.74
ex. Large	> 6	7.5	191	59.63

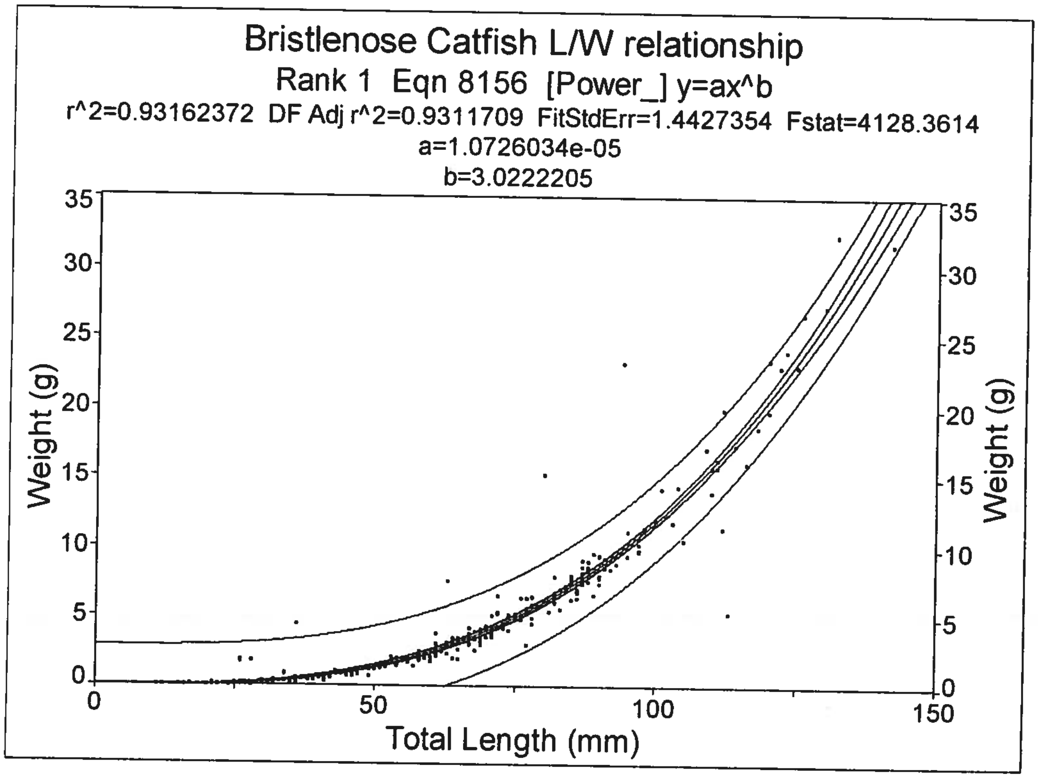


Figure 2: Length to Weight relationship for bristlenose catfish (*Ancistrus temmincki*) based on 305 individuals collected from Oahu streams.

Table 4: Size categories, estimated median length within the size category, and related weights for bristlenose catfish (*Ancistrus temmincki*).

Category	Length Range (in)	Length Median (in)	Length Median (mm)	Weight (g)
small	< 2	1.5	38	0.64
medium	2 to 3.5	3	76	5.23
large	> 3.5	4	102	12.47

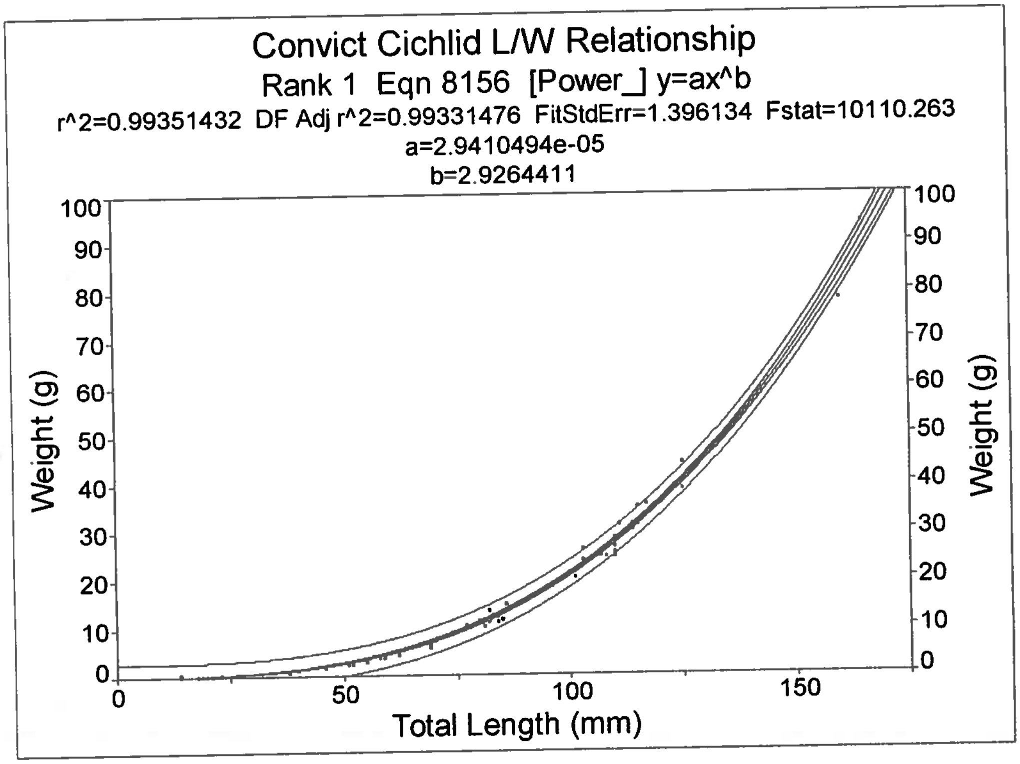


Figure 3:Length to Weight relationship for convict cichlid (*Archocentrus nigrofasciatus*) based on 68 individuals collected from Oahu streams.

Table 5: Size categories, estimated median length within the size category, and related weights for convict cichlid (*Archocentrus nigrofasciatus*).

Category	Length Range (in)	Length Median (in)	Length Median (mm)	Weight (g)
small	< 2	1.5	38	1.24
medium	2 to 4	3	76	9.46
large	> 4	4.5	114	30.99

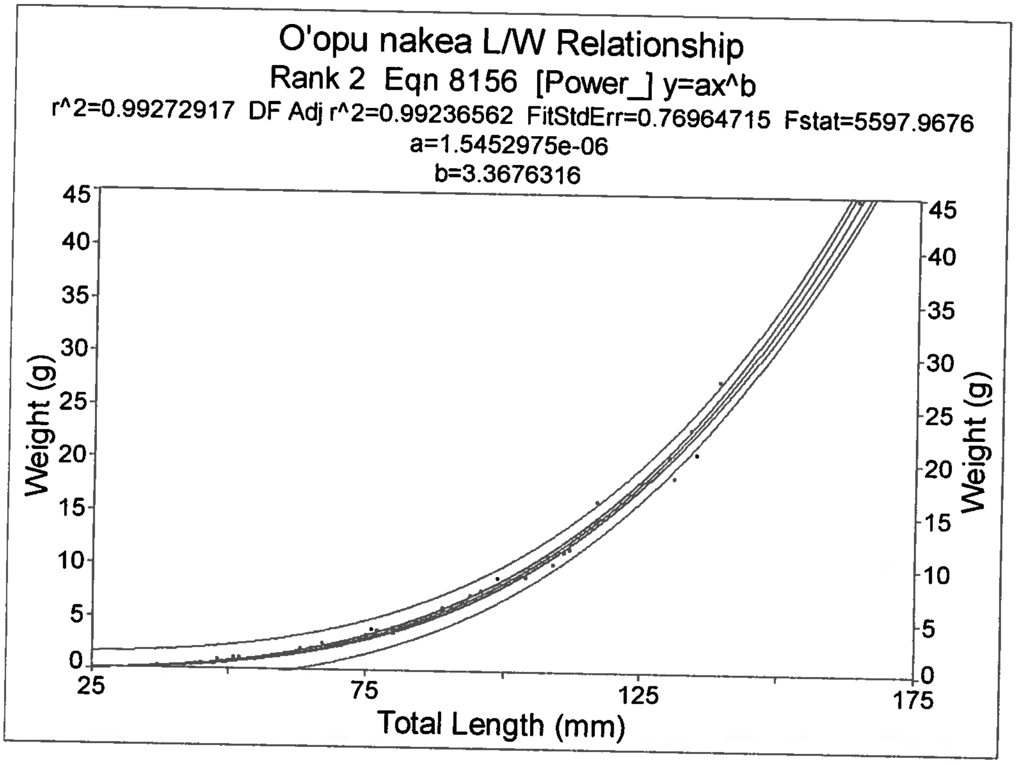


Figure 4: Length to Weight relationship for o'opu nakea (*Awaous stamineus*) based on 44 individuals collected from Oahu streams.

Table 6: Size categories, estimated median length within the size category, and related weights for o'opu nakea (*Awaous stamineus*).

Category	Length Range (in)	Length Median (in)	Length Median (mm)	Weight (g)
small	< 3	2.5	64	1.82
medium	3 to 5	4	102	8.86
large	> 5	6	152	34.71

Biomass Estimates:

Biomass estimates for the various species varied both among streams and among reaches (Table 7 and Table 8). This is partially due to sampling locations as habitat availability was not consistent among locations and partially due to the presence of other species. In Manoa stream, for example, smallmouth bass were common throughout deeper areas of the middle reach and tiliapia were very common in the lower reaches. For a better understanding of the variability of habitat, please see the report "Ala Wai Flood Risk Management Project Impact to Native Stream Animal Habitat and Possible Habitat Mitigation Options" by Parham, 2015.

Several patterns were apparent. Native fishes are not common in the Ala Wai Watershed streams. It is likely that habitat modification and the introduction of numerous other species has decreased their abundance. O'opu nakea can be found throughout the streams with at slightly higher abundances in the middle and upper reaches. Longfin armored catfish were very common in the lower and middle reaches of the streams and sometimes found in extremely high density. This species could be found in very shallow, swift water and in deeper, slower pools. Longfin armored catfish do not appear to occur in the upper reaches of the streams. Bristlenose catfish however are more common in the upper reaches of the streams although they exist throughout all of the stream reaches. Bristlenose catfish occupy similar habitat to the native gobies in the upper reaches of the streams and were observed co-occurring with o'opu nakea in a few locations.

Table 7: Biomass estimates grouped by stream and reach.

				Observed weight (g)				Biomass (g/m^2)			
Area code	Stream	Reach Code	Total Area Surveyed (m^2)	Longfin Armored Catfish	Bristlenose Catfish	Convict Cichlid	O'opu Nakea	Longfin Armored Catfish	Bristlenose Catfish	Convict Cichlid	O'opu Nakea
2	Palolo	Lower	42.4	977.6	63.5	399.9	8.9	23.0	1.5	9.4	0.2
3	Makiki	Lower	94.4	255.4	101.0	326.1	34.7	2.7	1.1	3.5	0.4
4	Manoa	Middle	112.6	4,333.6	127.0	419.2	0.0	38.5	1.1	3.7	0.0
5	Palolo	Middle	77.2	981.6	127.9	2,396.0	86.3	12.7	1.7	31.0	1.1
7	Manoa	Upper	97.6	0.0	463.1	0.0	0.0	0.0	4.7	0.0	0.0
8	Palolo	Upper	68.2	0.0	1,019.2	0.0	72.0	0.0	14.9	0.0	1.1
9	Makiki	Upper	111.6	0.0	315.4	0.0	71.2	0.0	2.8	0.0	0.6

Table 8: Biomass estimates grouped by reach.

		Observed weight (g)				Biomass (g/m^2)			
Reach Code	Total Area Surveyed (m^2)	Longfin Armored Catfish	Bristlenose Catfish	Convict Cichlid	O'opu Nakea	Longfin Armored Catfish	Bristlenose Catfish	Convict Cichlid	O'opu Nakea
Lower	136.8	1,233.0	164.5	726.1	43.6	9.0	1.2	5.3	0.3
Middle	189.8	5,315.2	254.9	2,815.2	86.3	28.0	1.3	14.8	0.5
Upper	277.4	0.0	1,797.8	0.0	143.2	0.0	6.5	0.0	0.5

Conclusions:

The use of HDFS in the Ala Wai watershed streams was the first time it had been applied in Hawaii. The HDFS approach had both strengths and weaknesses for estimating fish biomass in Hawaiian streams.

Strengths:

- the use of geo-referenced underwater video is much faster and applicable to a wider range of instream conditions than visual assessments using snorkeling gear. We were able to sample in shallow water and in poor quality water where snorkelers may not want to swim. Preliminary estimates on the improvement in speed comparing HDFS to snorkel surveys has shown approximately a 10-fold improvement in speed. If this holds true for this survey, we would have collected approximately 75 observations of fish using the snorkeling approach as compared to nearly 750 observations using HDFS.
- The video is reviewable and can be used for multiple different uses. The original purpose was to document the occurrence and distribution of species within the streams. The video collected for that purpose was combined with additional video and used to estimate fish biomass. This eliminated the need to go out and collect additional surveys for this new purpose.
- The geo-referenced video can be analyzed in conjunction with High Definition Stream Survey video allowing a much better understanding of the distribution and occurrence of species with respect to instream habitat.

Weaknesses:

- Standardization of the sampling approach should be improved to increase reliability of the results. Using a fixed time in each location would make it easier to have comparable samples. This recommendation has already been instituted in the HDFS approach and made the newer upper Manoa surveys easier to review.
- In other standardization that should be implemented is the inclusion of standard measurement devices (i.e. rulers) that would be placed in some portion of the samples. This would provide a very helpful reference when estimating the area or the size of individual fish. DAR is in the process of testing various measuring devices for use in this method.

The Ala Wai watershed streams are highly modified in both habitat and contain of numerous introduced species. Native species are still present at low densities throughout the streams. The bristlenose catfish may be a good analog to understanding native goby biomass in these highly modified systems. This catfish species lives on the bottom and scrapes algae for food. From personal observations of native gobies throughout Hawaiian streams, they appear to be of similar size and use similar habitats to the bristlenose catfish. It may be that bristlenose catfish outcompete native gobies or it may be that native gobies can no longer easily access habitat in the Ala Wai watershed streams and that the bristlenose catfish are filling the void left by the native gobies. Either way the biomass of the native species is far lower than I have observed in other island streams.

It should also be noted that these biomass estimates are not inclusive of all species observed during the surveys and therefore should not be used to estimate total biomass in any stream section. Other fish species like tilapia, smallmouth bass or liberty mollies as well as crustaceans like grass shrimp, crayfish and Tahitian prawns were observed during the surveys and may be locally abundant.

APPENDIX D – MITIGATION, MONITORING AND ADAPTIVE MANAGE PLANALA WAI CANAL PROJECT, OAHU, HAWAII, U.S. ARMY CORPS OF ENGINEERS,HONOLULU DISTRICT, AUGUST 2015

Draft

Mitigation, Monitoring and Adaptive Management Plan

Ala Wai Canal Project; Oahu, Hawaii

U.S. Army Corps of Engineers, Honolulu District

August 2015

This page is intentionally left blank.

Contents

Tables

Figures

Attachments

1.1 Introduction

At the request of the State of Hawaii Department of Land and Natural Resources (DLNR) and as authorized under Section 209 of the Flood Control Act of 1962, the U.S. Army Corps of Engineers, Honolulu District (USACE) is conducting a feasibility study for the Ala Wai Canal Project, Oahu, Hawaii (hereafter referred to as "the project"). The purpose of the project is to reduce the threat to life and reduce property damage from riverine flooding within the Ala Wai Watershed.

The Ala Wai Watershed is located on the southeastern side of the island of Oahu, Hawaii. The watershed encompasses 19square miles (mi^2) (12,064 acres) and extends from the ridge of the Ko'olau Mountains to the nearshore waters of Mamala Bay. It includes Maikiki, Manca, and Palolo Streams, which drain to the Ala Wai Canal, a 2-mile-long, man-made waterway constructed during the 1920s to drain extensive coastal wetlands. This construction and subsequent draining allowed the development of the Waikiki district.

The project is currently a feasibility study, considering a variety of non-structural and structural flood risk management measures. Plan formulation and evaluation resulted in tentative selection of an alternative plan for implementation (referred to as the tentatively selected plan). A detailed discussion of the plan formulation process and the components of the tentatively selected plan are provided in the Draft Feasibility Study Report with Integrated Environmental Impact Statement (EIS), hereafter referred to as "Feasibility Report/EIS ."

As detailed in the Implementation Guidance for Section 2036(a) of the Water Resources Development Act (WRDA) of 2007- Mitigation for Fish and Wildlife and Wetland Losses, it is the policy of the USACE Civil Works program to demonstrate that damages to all significant ecological resources have been avoided and minimized to the extent practicable, and that any remaining unavoidable damages have been compensated to the extent possible. The mitigation planning process should seek to compensate for non-negligible impacts to the extent incrementally justified and ensure that the recommended project will not have more than negligible adverse impacts on ecological resources. Engineering Regulation (ER) 1105-2-100 ("Planning Guidance Notebook") requires the use of a habitat-based methodology, supplemented with other appropriate information to describe and evaluate the impacts of the alternatives plans, and to identify the mitigation need of the with-project condition as measured against the future without-project condition. Once a mitigation need has been identified, mitigation objectives must be developed to address the identified losses. Mitigation objectives are used to guide formulation of appropriate mitigation management features and to establish benchmarks for evaluating the performance of the mitigation plans.

The regulations require assessment of environmental impacts and associated mitigation actions in a manner that addresses changes in ecological resource quality. Changes to habitat must be assessed as a function of improvement or degradation in habitat quality and/or quantity, as expressed quantitatively in physical units or indexes (but not monetary units). In the case of mitigation for significant environmental impacts, ecosystem restoration actions must be formulated and evaluated in terms of their net contributions to increases in ecosystem value, expressed in non-monetary units. Mitigation actions also need to go through a Cost Effectiveness and Incremental Cost Analysis (CE/ICA) to ensure benefits are optimized relative to cost.

Preparation of a mitigation plan is required, and should present the objectives, plan design, determination of success criteria and monitoring needs, all of which should be developed in coordination with Federal and State resource agencies to the extent practicable. The mitigation plan should include the following:

The project has also previously been referred to as the "Ala Wai Watershed Project"; for consistency with the Congressional documentation, the project will continue to be referred to as the "Ala Wai Canal Project."

(1) a description of the physical action to be undertaken to achieve the mitigation objectives within the watershed in which such losses occur;

(2) the type, amount, and characteristics of the habitat being restored;

(3) ecological success criteria for mitigation based on replacement of lost functions and values of the habitat, including hydrologic and vegetative characteristics;

(4) a plan for monitoring to determine the success of the mitigation, including the cost and duration of any monitoring and the entities responsible for any monitoring;

(5) a contingency plan (i.e. adaptive management) for taking corrective actions in cases where monitoring demonstrates that mitigation measures are not achieving ecological success; and

(6) should land acquisition be proposed as part of the mitigation plan, a description of the lands or interests in lands to be acquired for mitigation and the basis for a determination that such lands are available for acquisition.

This mitigation and monitoring plan has been developed in compliance with these requirements. It includes a discussion of the quantification of habitat impacts, identification of mitigation objectives and proposed mitigation actions, and development of the proposed monitoring and adaptive management approach.

2.1 Assessment of Impacts to Aquatic Habitat

As described above, USACE regulations require the use of a habitat-based methodology to describe and evaluate the impacts of alternative plans, as well as to identify the need for mitigation to offset unavoidable ecological impacts of the with-project conditions as measured against the future without-project condition. As the outputs of ecosystem restoration are not readily convertible to actual monetary units (as is required for traditional benefit-cost analyses), ecosystem outputs must be clearly identified and quantified in appropriate units, preferably ones that measure change in ecosystem value and productivity. Measurable changes in ecosystem values are typically described in terms of suitability indices or habitat units, with an ecosystem output model used to quantify the changes over a SO-year period of analysis. Following is a description of the ecosystem output model selected for use on the project, and a summary of the modeling results for the existing (without-project) condition and with implementation of the tentatively selected plan.

2.2 Description of Ecosystem Model

Analogous with Habitat Evaluation Procedure (HEP) method and Habitat Suitability Index models developed by natural resource biologists elsewhere, the Hawaiian Stream Habitat Evaluation Procedure (HSHEP) is a habitat-based model that was developed as a tool to support management of Hawaii's streams and associated habitat for freshwater flora and fauna. Specifically, the model is intended to provide managers with the ability to quantify changes in habitat for native Hawaiian stream animals in response to actions such as channel alterations, flow modifications, land use change and watershed development, or construction of in-channel structures. It captures the major aspects of native stream animal ecology, the typical geomorphology of Hawaiian streams, and common modifications to the environment.

The HSHEP model is an outgrowth of a history of collaboration among biologists at the State of Hawaii Division of Aquatic Resources (DAR) and researchers at various universities, agencies, museums, and private companies. The collaborative effort focused on understanding the different aspects of the ecology and management of amphidromous stream animals, which have a life history involving downstream and upstream migration (Fitzsimons and Nishimoto, 2007). In recent years, efforts have focused on combining the information gained from the wide range of studies into an integrated model of Hawaiian streams that include the life history characteristics of amphidromous animals, island hydrology and geomorphology, and critical management issues.

The HSHEP model follows the overall Habitat Evaluation Procedure (HEP) model concepts developed by the U.S. Fish and Wildlife Service (USFWS) to evaluate the quantity and quality of habitat available for a species of concern (USFWS, 1980a,b, USFWS, 1981). In general, a Habitat Evaluation Procedure (HEP) model uses measurable attributes of habitat quality and quantity to create relationships between habitat suitability and animal occurrence and density. The suitability relationships are converted into standardized Habitat Suitability Indices (HSI) that encompass the range of observed habitat conditions. Habitat quality is assessed based on the HSI values and habitat quantity is defined based on area, which when multiplied, provide overall habitat units (HUs) for a given area. This process may be used to assess changes associated with different management scenarios for a specific area, or to allow comparison across multiple sites. The HSHEP merges this traditional HEP approach with multi-spatial modeling capabilities for Hawaiian streams (Parham, 2002; Kuamo'o et al., 2006; Parham, 2008). The multi-spatial component addresses issues of scale in understanding differences in habitat availability and species distribution.

A detailed description of the HSHEP model development and design is provided in Attachment 1. The USACE Ecosystem Center of Expertise (ECO-PCX) reviewed this information, and granted approval for its use on the Ala Wai Canal Project on May 19, 2015 (Attachment 2).

2.2 Methodology

Detailed stream and fish surveys to support the HSHEP modeling effort were conducted by aquatic biologists, Dr. James Parham (Bishop Museum) and Glenn Higashi (DAR). As part of this effort, the streams in the Ala Wai Watershed were surveyed, including approximately 8.7 kilometers of Manoa Stream, 1.6 kilometers of Makiki Stream, and 3.7 kilometers of Palolo Stream. The stream surveys were recorded using high-definition video, and the survey data were subsequently processed according to the variables in the HSHEP model. Using the HSHEP model, the habitat suitability was then determined for each of the native aquatic species along approximately each meter of stream; the average suitability was then calculated for defined stream segments. A combination of the habitat suitability and the area of each segment were then used to calculate HUs for each individual species, as well as for the combination of all native species within each segment.

Despite the robust dataset available for native species in Hawaii's streams, there is still some degree of inherent uncertainty in the underlying assumptions used to model habitat quality. In particular, the extent to which in-stream structures restrict upstream migration (e.g., in response to varying flow regimes over time) has not previously been quantified, but has an important bearing on the modeling of upstream habitat quality. As such, the resource agencies requested consideration of different assumptions of species passage, in order to better understand the possible range of resulting habitat quality values. In response to this request, both the "expected scenario" and a "worst-case scenario" were modeled, as described below.

- The "expected scenario" reflects the project team's best professional judgement; it assumes that existing in-stream structures with an overhanging lip create a passage barrier for native species 50% of the time, and channelized reaches reduce passage by 10% for every 100 meters. These assumptions were used as the basis for calculation of the baseline impact and evaluation of mitigation requirements.
- The "worst-case scenario" reflects a more conservative set of assumptions that overhanging structures only allow for passage of native species approximately 35% of the time, and channelized reaches reduce passage by 15%for every 100 meters. This scenario is intended to bound the range of possible conditions, thus providing a basic sensitivity analysis of the model

results. It was used as a means to validate the outcomes of the mitigation development process (that is, to confirm that the mitigation would still adequately compensate for the habitat impacts even with a more conservative set of assumptions).

The model results for the existing and future-without project condition, as well as the conditions based on implementation of the tentatively selected plan are presented below. Application of the model for the mitigation measures is discussed in Section 3.3. Additional detail regarding model application is provided in Attachment 3.

2.3 Model Results

2.3.1 Existing and Future Without-Project Condition

Based on the methodology described above, the HSHEP model was used to determine existing quality of the streams and associated aquatic habitat within the Ala Wai Watershed. The analysis also considered the future without-project condition (i.e., the most likely condition expected to exist in the future in the absence of the proposed project), as this defines the benchmark against which alternative plans are evaluated.

Future changes in watershed and stream conditions have the potential to influence the amount and/or quality of freshwater stream habitat. For example, future watershed improvements could positively influence stream health, thus increasing habitat quality over time. Conversely, continued degradation could reduce the amount and/or quality of stream habitat. Based on the extent of existing urbanization and development within the Ala Wai Watershed, and more specifically along the streams, it is expected that further development will be minimal. Some degree of redevelopment may occur in the neighborhoods throughout the watershed, however this is not expected to substantially affect the physical or biological characteristics of the streams. While there may be some slight changes in localized conditions, the overall species composition and habitat structure is not expected to change dramatically over the period of analysis. Therefore, for the purposes of this analysis, it is assumed that habitat conditions will remain relatively constant over time, such that the HUs associated with the existing and future without-project conditions will be commensurate.

The HUs associated with the existing and future without-project conditions are summarized in Table I; a detailed discussion of the results is provided in Attachment 3.

TABLE 1
Habitat Units Associated with the Existing and Future Without-Project Condition

Location	Habitat Units (HUs)	
	Expected Scenario	Worst-Case Scenario
Manoa Stream	36,713	35,391
Palolo Stream	1,377	834
Makiki Stream	7,800	7,495
Hausten Ditch	8,681	8,681
Total	**54,572**	**52,401**

2.3.2 Tentatively Selected Plan

The tentatively selected plan for the Ala Wai Canal Project is comprised of a series of flood risk management measures, including debris and detention basins, debris catchment structures, flood walls, and improvements to the flood warning system. A description of each measure and the estimated area of impact is provided in Table 2. A detailed discussion of the tentatively selected plan (and the plan formulation process) is provided in the Draft Feasibility Report/EIS.

The characteristics of the proposed measures were used to define changes in habitat quality using the HSHEP model, as needed to calculate HUs based on implementation of the tentatively selected plan. Changes in habitat quality associated with implementation of the tentatively selected plan include potential loss of aquatic habitat (e.g., due to placement of structures within the stream) and decreased passage for native aquatic species. As described in Section 3.6 of the Draft Feasibility Report/EIS, design features have been incorporated to avoid and minimize these impacts to the extent practicable (e.g., use of natural bottom arch culverts to maintain species passage); however, some degree of impact is unavoidable. The anticipated changes in habitat conditions were based on professional judgment of the project team, including input from the resource agencies.

Key assumptions that were made as part of the HSHEP modeling of the with-project condition are listed below. The assumptions were discussed and agreed upon with the resource agencies (as part of a meeting with USFWS and DAR on January 23, 2015), and were subsequently refined as part of the model application process.

- The area to be impacted by each measure was defined as the length of stream within the permanent structure footprint plus the area needed for O&M (generally the entire length of stream within the construction limits).
  - The aquatic habitat to be impacted by the Kanewai Detention Basin and the Ala Wai Golf Course Detention Basin is limited to the streambank within the notched spillway footprint.
  - The Ala Wai Canal floodwalls will not result in any impacts to the aquatic environment.
  - Improvements to the flood warning system will involve negligible work in the streams; as such, it is assumed there would be no impact to the aquatic environment.
- To be conservative, it has been assumed that habitat for aquatic species would be entirely eliminated within the permanent footprint of the debris catchment and detention structures (and stand-alone debris catchment structures), but that species passage would be maintained via a natural bottom arch culvert.
  - Within the area to be excavated behind the Waiomao Debris and Detention Basin, a low-flow channel will be reformed and the existing substrate will be replaced following construction. Recognizing that there could be some degree of long-term habitat degradation associated with the excavation (and ongoing vegetation management), it is assumed that there would be an approximately 50% decrease in habitat quality within this area. The "worst-case scenario" assumes 100% loss of habitat within the area to be excavated.
  - An in-stream structure associated with an abandoned USGS gaging station is located within the area to be excavated for the Waiomao Debris and Detention Basin, and will be removed as part of project construction. This in-stream structure is a barrier to upstream passage of native species, and its removal will provide habitat benefits by increasing accessibility to upstream habitat (thereby offsetting some of the habitat losses). This benefit is reflected in the with-project condition.
  - It is assumed that there would be an approximately 20% loss of habitat quality within the reach directly affected by the notched spillways for the Kanewai and Ala Wai Golf Course detention basins. The "worst-case scenario" assumes 100% loss of habitat within these reaches.

- The debris and detention structures are not designed to trap sediment (except for the sediment basin at the Ala Wai golf course). Therefore, it has been assumed that there would be no substantial changes in substrate/embeddedness in downstream habitat.
- The inundation area behind each detention structures is not included as part of the impact area. Inundation of the_se areas would be infrequent and short in duration; for example, inundation resulting from the 1%annual chance exceedance (ACE) flood would last less than 12 hours. As such, there are expected to be little to no potential effects to stream habitat and aquatic species.

The results of the HSHEP modeling for the with-project condition are summarized in Table 3; a detailed discussion of the results is provided in Attachment 3 . Based on a comparison of these results to those for the future without-project condition, implementation of the project is expected to result in a loss of 192 HUs as shown in Table 3.

As it is expected that the impacts would be immediately realized following construction of the project features (i.e., there would not be a delay or "compounding" effect on habitat quality over time), it is therefore assumed that habitat conditions would remain constant.over the life of the project.

TABLE 3

Loss of Habitat Units Associated with Implementation of the Tentatively Selected Plan (As Compared to the Future Without-Project Condition)

Location	Habitat Units (HUs)				
	Existing Conditions	With-Project Conditions			Net Loss
		Lost	Gained"	Total	
EXPECTED SCENARIO					
Manoa Stream	36,713	191	0	36,522	191
Palolo Stream	1,377	11	118	1,484	-107
Makiki Stream	7,800	24	0	7,777	24
Hausten Ditch	8,681	84	0	8,597	84
Total	54,572	310	118	54,380	192
WORST-CASE SCENARIO					
Manoa Stream	35,391	808	0	34,584	808
Palolo Stream	834	3	32	863	-29
Makiki Stream	7,495	11	0	7,484	11
Hausten Ditch	8,681	420	0	8,261	420
Total	52,401	1,242	32	51,192	1,210

Note:

• The "expected scenario" reflects the project team's best professional judgement, and serves as the basis for calculation of the baseline impact and evaluation of mitigation requirements. The "worst-case scenario" reflects a more conservative set of assumptions and is intended to provide a basic sensitivity analysis of the model results (to help validate the outcomes of the mitigation development process).

• The anticipated gain of HUs for the with-project condition is associated with removal of an abandoned USGS gaging station within the area to be excavated for the Waiomao Debris and Detention Basin. This in-stream structure is a barrier to upstream passage of native species, and its removal will provide habitat benefits by increasing accessibility to upstream habitat.

3.1 Description of Proposed Mitigation

3.2 Mitigation Objectives

Based on the type of habitat to be impacted, and within the context of the habitat requirements for native Hawaiian aquatic species (as defined in the HSHEP model), the following objectives were developed to guide the mitigation development effort:

- Restore and/or enhance physical conditions to improve in-stream habitat for native Hawaiian aquatic species
- Improve passage for native Hawaiian aquatic species to increase access to upstream areas of high-quality habitat

In consultation with the resource agencies, it was determined that application of these mitigation objectives should not be limited to the specific habitat parameters or areas impacted by the project, but rather should be considered within the context of the overall watershed. In other words, the mitigation development process should entail a watershed approach, wherein the conditions throughout the watershed are assessed to identify those habitat parameters and locations where mitigation might provide the greatest benefit for native aquatic species as a whole.

3.2 Mitigation Development Approach

To support the mitigation development effort, a framework was developed based on a series of iterative tasks informed by the stream surveys and HSHEP modeling results. Each task was conducted within the context of the SMART planning approach employed for the overall flood risk management project, as described in the Draft Feasibility Report/EIS. First, as shown in Figure 1, the key stressors and primary factors limiting habitat quality for native aquatic species in the Ala Wai Watershed were broadly defined based on best professional judgment and the results of the stream surveys. This information was used as the basis for identifying potential mitigation concepts, or actions that could be implemented to address the various stressors. Using the HSHEP model results for the existing conditions, these concepts were further refined and applied to site-specific locations. A site visit was conducted for each of the potential mitigation locations to validate and refine the mitigation concept. In addition, other relevant information was gathered, including land ownership and existing channel maintenance activities. This information was then considered as part of a detailed screening process, which involved a comprehensive set of criteria (based on those used for the overall flood risk management project, and tailored to the mitigation effort). Those measures carried forward from the screening process were then combined into various mitigation alternatives that could be implemented to compensate for the habitat impacts associated with the overall flood risk management project. Conceptual design drawings were prepared for the range of mitigation measures/alternatives (to an approximately 10 percent level of design), based upon which cost estimates were developed. In addition, the habitat benefits associated with each alternative were quantified using the HSHEP model. The costs and benefits were then used as inputs to a CE/ICA, which provided the basis for selection of the mitigation alternative for implementation. The resource agencies were consulted throughout this process, and their input was incorporated as appropriate. The results of this process are described in the subsequent sections.

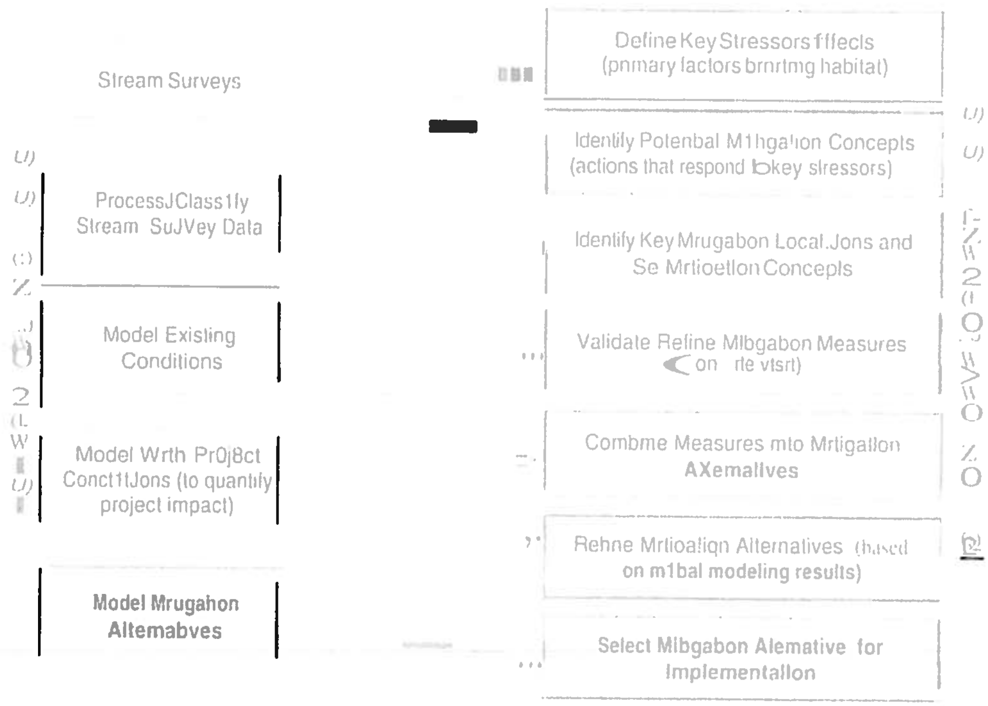


FIGURE 1
Overview of the HSHEP Modeling and Mitigation Development Process

3.3 Development of Mitigation Measures/Alternatives

3.3.1 Mitigation Concepts

As described above, the initial list of mitigation concepts was developed in response to the primary factors believed to be limiting habitat quality for native aquatic species in the Ala Wai Watershed; this effort was primarily based on best professional judgment and the results of the stream surveys. The list of initial mitigation concepts is provided in Table 4.

It is important to note that there are some stressors that are generally understood to be contributing to degradation of Hawaii's stream habitat and faunal assemblage, but were determined to either be outside the scope of mitigation efforts for this project or are not considered key limiting factors in the Ala Wai Watershed (given other overriding conditions). These include prevalence of invasive aquatic species and inputs of stormwater runoff. Although both of these stressors are common throughout the Ala Wai Watershed, it was determined that the project could result in a limited response to these conditions, and as such, mitigation efforts should focus on key stressors related to physical habitat conditions.

TABLE 4
Initial Mitigation Concepts

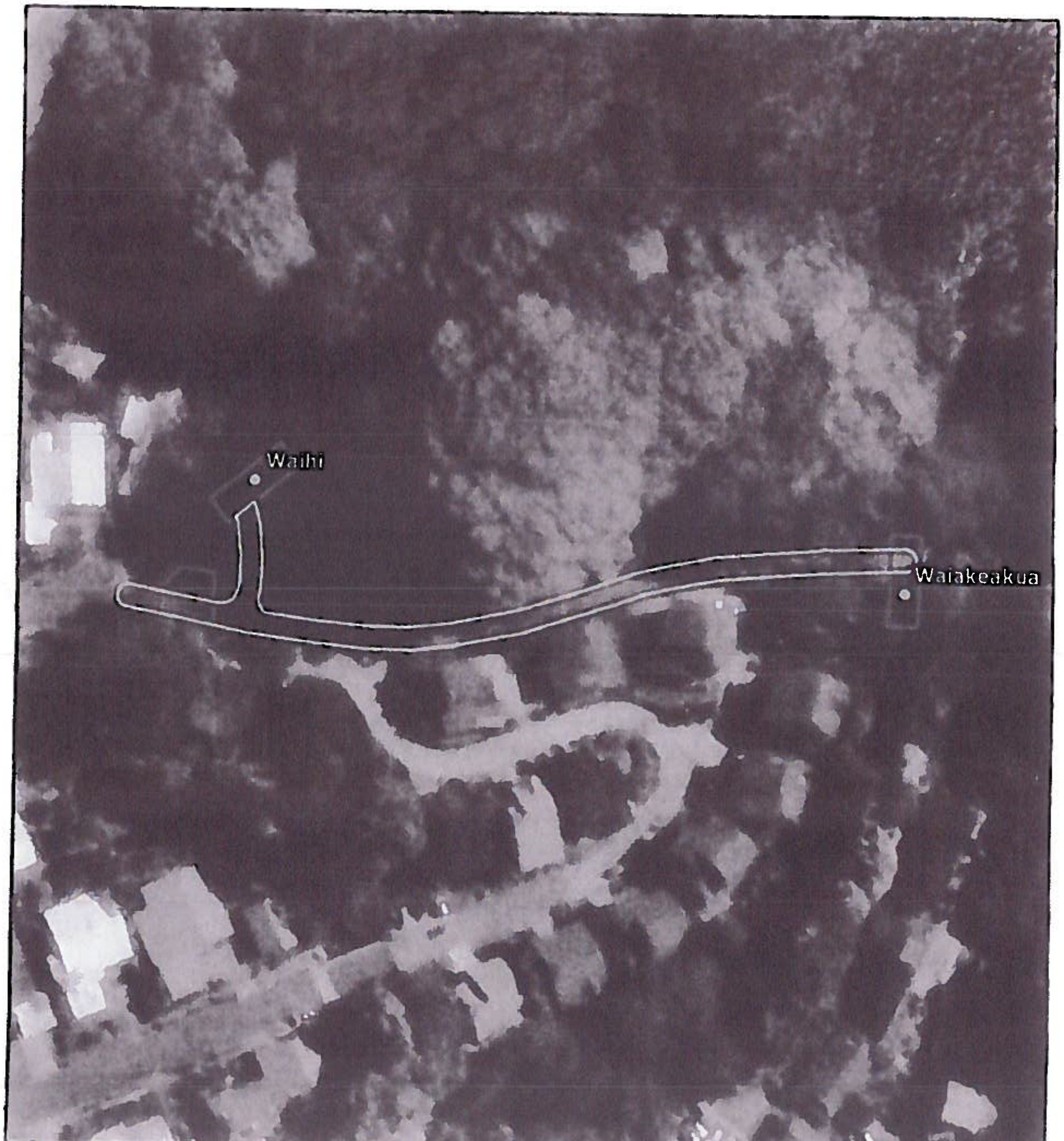
Response to Key Stressors	Mitigation Concept
Improve migratory pathway	Remove passage barrier (e.g., overhung structures)
	Install low-flow channel along channelized reach
	Install resting riffles along channelized reach
Improve in-stream habitat	Add new habitat pools in channelized reach
	Enhance existing in-stream habitat in unchannelized reach
Provide bank stabilization	Stabilize exposed/eroding banks
	Stabilize failing walls
Improve riparian habitat	Restore/enhance riparian habitat

The initial concepts were further reviewed and validated within the context of the HSHEP model source data and preliminary results for the existing habitat conditions. Through this effort, several of the concepts were eliminated from further consideration, as follows:

- **Enhance existing in-stream habitat in unchannelized reach:** Although there are reaches of unchannelized habitat with less than ideal conditions (e.g., degraded channel form, presence of trash, etc.), the results of the stream surveys indicate that these reaches still provide adequate habitat for native aquatic species, especially when compared to channelized reaches. As such, it was determined that enhancement of habitat in unchannelized reaches would not address a key stressor for native aquatic species in the Ala Wai Watershed.
- **Stabilize failing walls:** Although a wall failure could certainly affect in-stream habitat, should one occur, it was determined that stabilization of existing channel infrastructure is more of a channel maintenance issue than a habitat management issue. Therefore, this measure was eliminated from further consideration.
- **Restore/enhance riparian habitat:** Given the heavy urbanization and encroachment of development in the areas directly adjacent to the streams, there is very little opportunity for restoration of the riparian corridor in the Ala Wai Watershed without extensive land acquisition (which is beyond the scope of mitigation for this project). Although dominated by non-native species, the extant riparian habitat is not believed to be key limiting factor relative to in-stream habitat quality for native aquatic species (especially when considered in context with other factors, such as channelization). As such, this measure was also eliminated from further consideration.

3.3.2 Preliminary Mitigation Measures

The remaining mitigation concepts were carried forward for further consideration, and based on the review of the HSHEP model source data and preliminary results, key areas for habitat improvement were identified based on those concepts . This information was used as the basis for siting each of the mitigation concepts in locations where habitat benefits could be maximized. A site visit was conducted for each of the potential mitigation locations to validate and refine the various mitigation concepts. The resulting measures are summarized in Table S, and the locations are shown in Figure 2 .



LEGEND
Impact Area Description
Construction Limits
Access
Staging

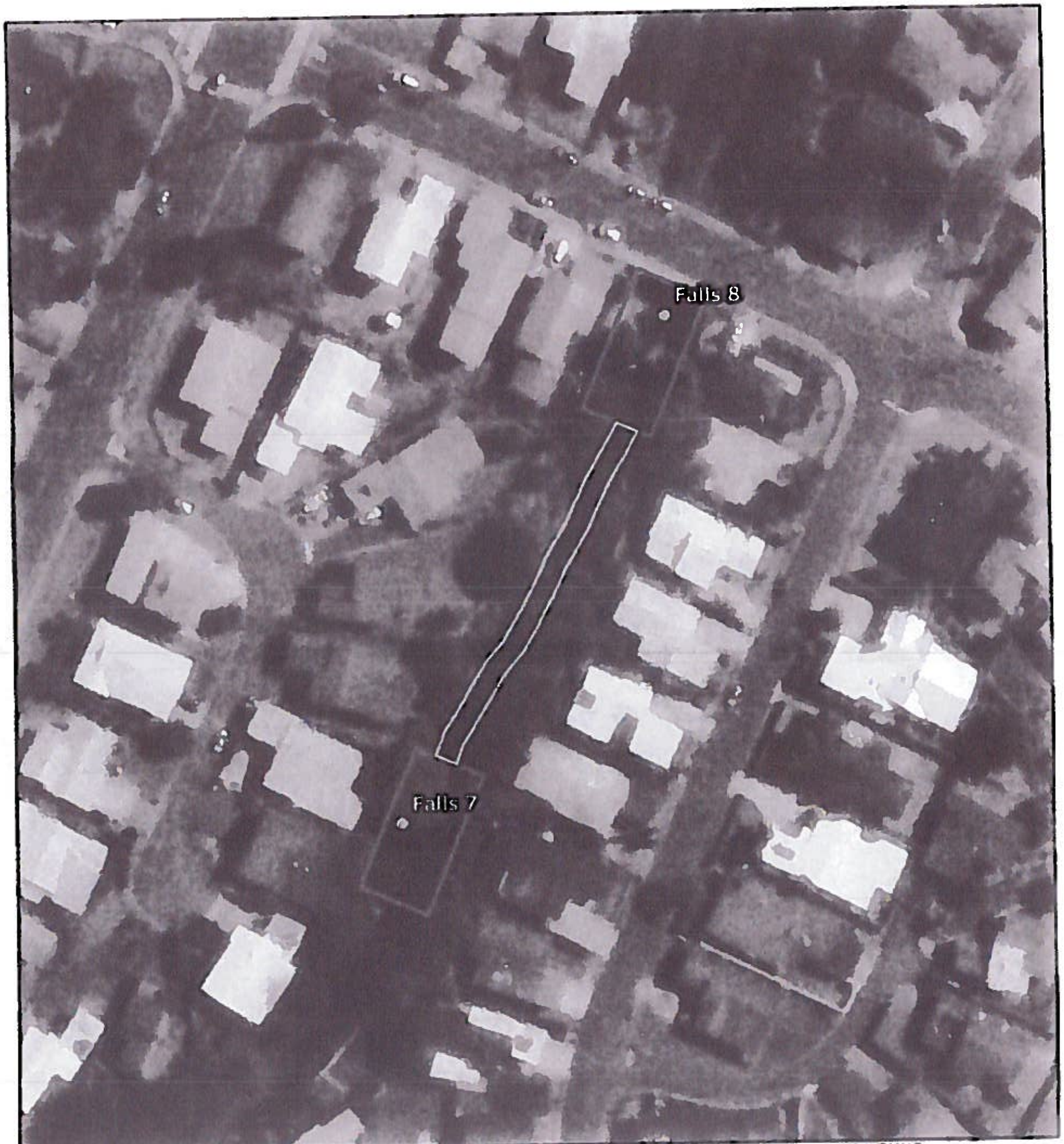
Notes
1 Area of interest subject to change

J

VICINITY MAP


FIGURE 2a
Falls 11 and 12
Mitigation Measure Impact Areas
Ala Wai Watershed

CH2MHILL.



LEGEND
Impact Area Description
Construction Limits
Access
Staging

Notes
1 Area of interest subject to change

VICINITY MAP

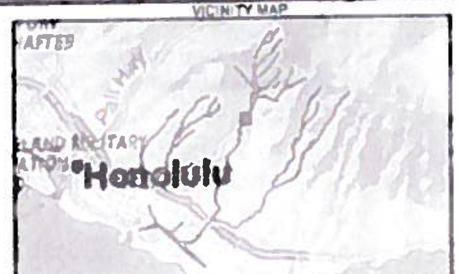


FIGURE 2b
Falls 7 and 8
Mitigation Measure Impact Areas
Ala Wai Watershed

CH2MHILL.

LEGEND
Impact Area Description
[ ]construction Limits
Access
Staging

Notes
1 Area of interest subject to change

VICINITY MAP

FIGURE 2c
Manoa Concrete Channel
Mitigation Measure Impact Areas
Ala Wai Watershed

CH2MHILL

TABLE 5
Preliminary Mitigation Measures

Mitigation Measure	Location	Description
Remove Passage Barner		
Falls 6	Manca Stream, approximately 0.3 mile upstream of Manca District Park	Remove overhanging lip associated with undercutting at existing utility line crossing
Falls 7	Manca Stream, approximately 0.6 mile upstream of Manca District Park	Remove overhanging lip associated with undercutting at existing in-stream structure
Falls 8	Manoa Stream, approximately 0.7 mile upstream of Manca District Park	Remove overhanging lip associated with undercutting at existing in-stream structure
Falls 11	Waihi Stream, at USGS gaging station	Remove overhanging lip associated with undercutting at existing USGS gaging station
Falls 12	Waiakeakua Stream, at USGS gaging station	Remove overhanging lip associated with undercutting at existing USGS gaging station
Falls PS	Waiomao Stream, at USGS gaging station	Remove overhanging lip associated with undercutting at existing USGS gaging station
Install Low-flow Channel and/or Habitat Pools Along Channelized Reach•		
Manoa Stream	Approx. 1100 feet of concrete channel downstream of Manoa District Park	Notch low-flow channel and/or habitat pools into concrete and add natural substrate
Palolo Stream	Approx. 1.5 miles of concrete channel through Palaia Valley	Notch low-flow channel and/or habitat pools into concrete and add natural substrate
Install Resting Riffles Along Channelized Reach•		
Manoa Stream	Approx. 1100 feet of concrete channel downstream of Manoa District Park	Mount low-profile curbs onto surface of concrete to create pockets of resting habitat
Palolo Stream	Approx. 1.5 miles of concrete channel through Palolo Valley	Mount low-profile curbs onto surface of concrete to create pockets of resting habitat
Bank Stabilization		
Manoa Stream	Above Kahaloa Bridge near Manca District Park	Reduce slope and install geotextile fabric and vegetation to stabilize ~300 feet of eroding bank

NOTE:
• Installation of a low-flow channel, habitat pools and/or resting riffles was initially considered for the channelized reach of Makiki Stream. However, it was determined that the extensive section of underground channel that is upstream of the channelized reach would severely limit the benefits gained by these measures. As such, these measures were eliminated from further consideration.

3.3.3 Screening and Refinement of Mitigation Measures

In order to ensure that the mitigation measures carried forward for further consideration meet a set of minimum standards, a detailed screening process was conducted. This process utilized a comprehensive set of criteria based on those used for the overall flood risk management project (which were defined within the context of he federal criteria specified in the Engineer Regulation [ER] 1105-2-100; "USACE Planning Guidance Notebook") and tailored to the mitigation effort. The screening criteria that were applied to the mitigation measures are summarized in Table 6.

TABLE 6
Criteria Used to Screen Mitigation Measures

Criteria	Description
Technical feasibility	Is it feasible/viable to construct measure?
Application in Hawaii	Has the measure been successfully applied in Hawaii?
Compatibility/Dependency	Is the measure dependent on another action to be functional?
Flood reduction	Does measure substantially increase potential for flooding?
Implementation cost*	What is the ROM cost to construct the measure?
Cost effectiveness*	Is the habitat gain worth the cost?
Land availability and ownership	Is there enough space to implement measure (including staging/access?)
	Is the land owned by State/C&C or a few private landowner?
	Can real estate rights be reasonably obtained?
O&M requirements	What is the estimated level of effort (need for new practice/equipment)?
	Would the measure conflict with existing O&M practices?
Acceptability	Will the measure displace people/activities? It is legally acceptable?
Biological resources	Would the measure adversely affect any known sensitive biological resources?
	Would the measure increase the potential for passage of non-native (invasive) species?
Historic/archaeological resources	Would the measure adversely affect any known historic/archaeological resources?
Sediment contamination	Would the measure be located in an area with known (or high potential for) sediment contamination?

NOTE:
* Recognizing that the purpose of the CE/ICA is to provide a quantifiable basis for evaluation of cost-effectiveness, the criteria related to implementation cost and cost- effectiveness were used to screen out measures that were considered to be excessively expensive or ineffective, so as to focus the mitigation development effort on reasonable and practicable mitigation solutions, consistent with the SMART planning approach.

The information required to complete the screening process was subsequently compiled, including consultation and coordination with State and County agencies, and other entities as needed. This effort resulted in the elimination of the measures listed below; the detailed screening results are contained in Attachment 4. In addition, based on additional information obtained through consultation, it was determined that two of the measures were no longer warranted, such that they were also eliminated from further consideration, as listed below.

- **Remove Passage Barrier at Falls 6:** Based on coordination with the City & County of Honolulu, it was determined that the Department of Facilities Maintenance (DFM) is in the process of resolving the erosion and undercutting associated with this structure . The design effort has been completed and the proposed design is expected to adequately address fish passage requirements; therefore, this measure was eliminated from further consideration (and instead is reflected in the future without-project conditions) .
- **Remove Passage Barrier at Falls PS:** The specific location of this structure was verified based on the stream survey data, and was determined to be within the footprint of the excavation area for the Waiomao Debris and Detention Basin. It was confirmed that the

structure would be removed as part of construction of the debris and detention basin such that the mitigation measure was eliminated from further consideration (and instead is reflected in the with-project condition).

- **Install Low-Flow Channel, Habitat Pools and/or Resting Riffles Along Channelized Portion of Palolo Stream:** Based on initial review of the real estate requirements, it was determined that this measure involved a multitude of property owners, and obtaining the real estate rights would require extensive coordination and would be cost-prohibitive. Therefore these measures were eliminated from further consideration.

The remaining measures were carried forward for further consideration as part of the identification of mitigation alternatives

3.3.4 Conceptual Design of Mitigation Measures

For the measures carried forward from the screening process, conceptual design drawings were developed to a 10 percent level of design. This effort incorporated the best available information and collective knowledge of the habitat requirements for native aquatic species; it also considered lessons learned from other past projects and input from the resource agencies. Key design considerations are discussed below.

The passage barrier removal design was based on previous passage barrier removal efforts completed by DAR (and others) on Waihe'e Stream (see Figure 3). Based on information gained from this successful effort, the measure would restore a near vertical surface to the face of the existing in stream structure, which is expected to allow for native aquatic species passage, while deterring upstream passage of non-native species. It would be comprised of non-systematic placement of grouted stones that would mimic natural stream features and allow multiple pathways for water flow.

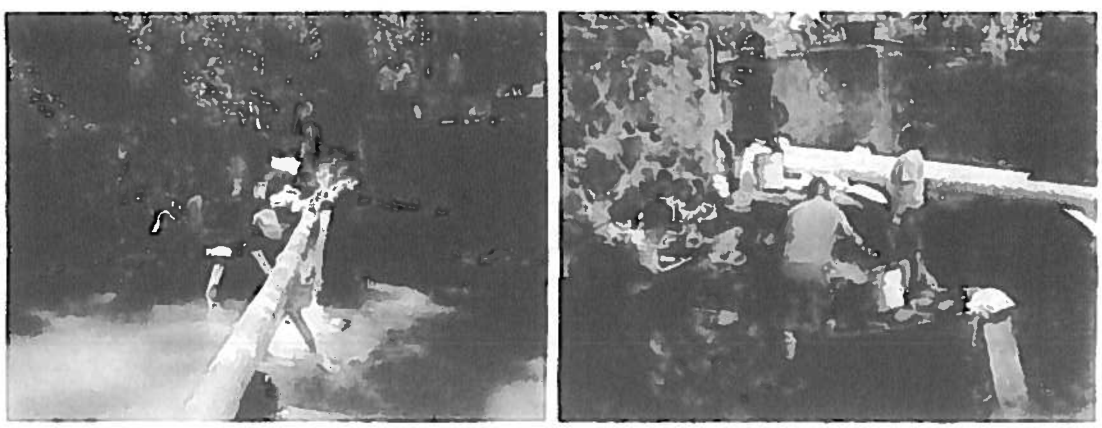


FIGURE 3
Previous Passage Barrier Removal Efforts on Waihe'e Stream (photos provided by Glenn Higashi [DAR])

The design for installation of in-stream habitat and passage within the channelized reach of Manoa Stream incorporates design features and dimensions based on best professional judgment regarding native species habitat requirements. Specifically, the conceptual designs assume that up to 6 inches of water is required to maintain passage (e.g., for the resting riffles), and at least 18 inches of water is needed to provide in-stream habitat (e.g., for the habitat pools and low flow channel); the dimensions and spacing of these features reflects characteristics of natural stream habitat. Passage and/or habitat would be installed over the full 1,100 feet of the channelized reach in Manoa Stream given the mitigation objectives, shorter increments were not considered

The 10-percent design drawings for each of the mitigation measures carried forward from the screening process are contained in Attachment 5.

3.3.5 Identification of Mitigation Alternatives

Based upon the 10-percent design concepts, the mitigation measures were then combined into alternatives that could be implemented to adequately compensate for the habitat impacts associated with the overall flood risk management project. Specifically, this effort sought to identify alternatives comprised of measures that either alone or in combination would provide a gain of HUs equal to or greater than the loss of HUs anticipated from implementation of the tentatively selected plan, thus compensating for the loss of habitat quality associated with project implementation. Recognizing that there are many possible measure combinations, consistent with SMART planning principles, a focused number of alternatives were defined based on estimated habitat benefits and functionality, as discussed below.[2]

Given the limited passage allowed by existing in-stream barriers, removal of a barrier is expected to provide little to no benefit to native aquatic species if downstream barriers are still in place. Therefore, the alternatives were formulated to only include combinations of barrier removal starting at the furthest downstream barrier (i.e. Falls 7) and moving upstream. Possible alternatives involving removal of upstream barriers with downstream barriers still in place were not considered (e.g., Falls 8, 11and/or 12). As Falls 11and 12are located on separate tributaries to Manoa Stream, they were combined with Falls 7 and 8, both in parallel and together. As preliminary analyses indicated that the concrete channel improvements were not cost effective, they were not considered in combination with any other measures. Based on these concepts, the following alternatives were identified:

- Remove passage barrier at Falls 7
- Remove passage barriers at Falls 7 and 8
- Remove passage barriers at Falls 7,8 and 11
- Remove passage barriers at Falls 7, 8, and 12
- Remove passage barriers at Falls 7, 8, 11and 12
- Install low-flow channel in concrete portion of Manoa Stream
- Install habitat pools in concrete portion of Manoa Stream
- Install resting riffles in concrete portion of Manoa Stream

Cost estimates were prepared for each alternative based on the conceptual design drawings. In addition, the habitat benefits were determined for each alternative, based on the HSHEP model outputs. The results of these efforts were then used to support the CE/ICA, which provided the basis for selection of the mitigation alternative for implementation. The results of this process are described in the subsequent sections.

3.4 Evaluation of Mitigation Alternatives

3.4.1 Habitat Benefits

Using the same methodology as described in Section 2, the HSHEP model was used to quantify the HUs associated with the various mitigation alternatives; the results are summarized in Table 7. As shown in Table 7, the mitigation alternatives involving removal of passage barriers provide a

[2] Although the CE/ICA software allows for all possible measure combinations to be automatically generated based on the cost and benefit of each measure, the benefits for the passage barrier removal measures are not additive, thus requiring the HSHEP model to be run for each individual measure combination.

significant increase in HUs relative to the concrete channel improvements. Despite the relatively small footprint of the barrier removal measures, the large gain of HUs reflects the overall extent of upstream habitat that would be made available to migrating native species. In contrast, the improvements along the channelized reach of Manoa Stream would only affect a relatively small, localized area.

However, in all cases, the mitigation alternatives would provide substantially more HUs than needed to offset the impacts of the flood risk management project. Because the flood risk management measures would only affect in-stream habitat within the footprint of the proposed flood risk management structures (with no anticipated impacts to species passage), a relatively small number of HUs are expected to be lost. Although the mitigation benefit would far exceed the impact of the proposed project, the mitigation alternatives reflect a reasonable range of options to improve instream habitat for native species, based on the best professional judgment of the project team. Despite the large number of HUs provided relative to the anticipated project impact, the estimated costs and level of effort of the mitigation alternatives is within the range that is appropriate for the scale and level of detail available for the proposed flood risk management project. Although different mitigation options or smaller-scale efforts that would result in fewer HUs (i.e. an increase in HUs more commensurate with the number of HUs lost) could certainly be identified, these would not address the key habitat needs identified for native aquatic species in the Ala Wai Watershed.

TABLE 7
Gain of Habitat Units Associated with Implementation of Mitigation Alternatives (As Compared to the With-Project Condition

Location	With-Project (HUs Lost)	Mitigation Alternatives (HUs Gained)							
		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
EXPECTED SCENARIO									
Manoa Stream	191	1,353	3,870	5,456	6,082	7,668	1,292	1,214	1,207
Palolo Stream	-107	0	0	0	0	0	0	0	0
Makiki Stream	24	0	0	0	0	0	0	0	0
Hausten Ditch	84	0	0	0	0	0	0	0	0
Total	**192**	**1,353**	**3,870**	**5,456**	**6,082**	**7,668**	**1,292**	**1,214**	**1,207**
WORST-CASE SCENARIO									
Manoa Stream	808	803	2,817	4,457	5,105	6,745	1,299	1,225	1,219
Palaia Stream	-29	0	0	0	0	0	0	0	0
Makiki Stream	11	0	0	0	0	0	0	0	0
Hausten Ditch	420	0	0	0	0	0	0	0	0
Total	**1,210**	**803**	**2,817**	**4,457**	**5,105**	**6,745**	**1,299**	**1,225**	**1,219**

3.4.2 Cost Estimates

An estimate of the implementation costs was developed as a bottom rolled-up type estimate at the conceptual (10 percent) design level, using FY2014 unit prices. In addition to the estimated costs, the CE/ICA also considers the O&M costs, as these are considered necessary to achieve the habitat benefits over the lifetime of the project. The estimated costs for each mitigation alternative is summarized in Table 8. Annualization of these costs, as needed to support the economic analysis is included in Attachment 6.

TABLE 8

Summary of Estimated Costs for MitiQation Alternatives (FY2014 Price Level)

Cost Component [1]	Falls 7	Falls 7 and 8	Falls 7, 8 and 11	Falls 7, 8 and 12	Falls 7, 8, 11and 12	Low-Flow Channel	Habitat Pools	Resting Riffles
Construction	$67,869	$132,848	$169,801	$170,544	$207,498	$798,018	$172,393	$178,294
Real Estate	$15,900	$27,100	$32,700	$29,300	$34,900	$4,500	$4,500	$4,500
Pre construction Monitoring	$9,2.50	$9,250	$9,250	$9,2.50	$9,2.50	$9 250	$9,250	$9,2.50
Post-construction Monitoring	$76,2.50	$76,250	$76,2.50	$76,2.50	$76,2.50	$76,2.50	$76,2.50	$76,2.50
O&M	$2.9,467	$45,712	$67,450	$67,636	$76,874	$92,301	$55,599	$57,074
Interest During Construction	$1,491	$2..918	$3.729	$3.746	$4,557	$17,52.6	$3,786	$3,916
Contingency	$40,300	$60,118	$73,889	$74,116	$85,387	$239,055	$72,180	$73,980
Total Estimated Cost	$2.40,52.6	$354,197	$433,070	$430,841	$494,715	$1,236,900	$393,958	$403,2.64

NOTES:

[1] Based on FY2014 (October 2013) price levels) and 3.5% discount rate; to be updated prior to Final Feasibility Report/EIS.

'Assume contingency equal to 25.5% of the construction cost plus 20% of the pre-construction monitoring, post-construction monitoring, and OMRR&R costs

3.4.3 Cost Effectiveness and Incremental Cost Analysis (CE/ICA)

As specified in the USACE regulations, the outputs of ecosystem restoration are not monetized, as is required for traditional benefit-cost analyses. Rather, evaluation of alternative restoration plans considers the relationship of habitat benefits to project costs to identify the most cost-effective plans for various levels of restoration output and provide a basis for determining whether increasing levels of restoration output are worth the added cost.

The evaluation process includes two distinct analyses to identify cost-effective and incrementally justified plans. First, the cost effectiveness analysis is conducted to identify which alternative plans have output levels that cannot be produced more cost effectively by another plan. "Cost effective" means that, for a given level of output, no other plan costs less, and no other plan yields more output for less money. Subsequently, through the incremental cost analysis, the range of plans is evaluated to arrive at a "best" level of output. The subset of cost effective plans are examined sequentially (by increasing scale and increment of output) to ascertain which plans are most efficient in the production of restoration benefits; these are referred to as "best buy plans." They provide the greatest increase in output for the least increase in cost. That is, they have the lowest incremental cost per unit of output. The incremental analysis will not necessarily identify an optimal plan; rather, there may be a series of best buy plans. In this case, the results must be synthesized with other decision-making criteria (for example, acceptability, completeness, effectiveness, reasonableness of costs, risk and uncertainty) to provide the basis for selection of a particular plan.

The IWR Planning Suite software (IWR Plan, version 1.0.11.0) was used to conduct the CE/ICA for this project. Inputs to the CE/ICA included average annual habitat units (AAHUs) and estimated average annual cost (AAC), which are calculated based on the benefits and costs (as presented in

Tables 7 and 8, respectively) averaged over the SO-year period of analysis. As previously noted, the analysis was based on the "expected scenario."

As listed in Table 9, the results of the CE/ICA indicate that the following mitigation alternatives are cost-effective: No Action; Falls 7; Falls 7 and 8; Falls 7, 8 and 12; and Falls 7, 8, 11 and 12. Only Falls 7, 8, 11 and 12 and the No Action Alternative are considered best buy plans. A detailed discussion of the CE/ICA and the results are provided in Attachment 6.

TABLE 9
CE/ICA Results

Alternative	Estimated Cost for CE/ICA [1,2]	AAC	AAHUs	Cost-Effective	AAC/ AAHU	Best Buy?	Incremental Cost of BB Plan over Last BB Plan	Incremental Output of BB Plan over Last BB Plan	Incremental Cost/Output of Best Buy Plan
No Action	$0	$0	0	Yes	-	Yes	-	-	-
Resting Riffles	$403,264	$15,105	1,195	No	$12.64	No	N/A	N/A	N/A
Habitat Pools	$393,958	$14,753	1,202	No	$12.27	No	N/A	N/A	N/A
Low-Flow Channel	$1,236,900	$49,564	1,279	No	$38.75	No	N/A	N/A	N/A
Falls 7	$240,526	$9,014	1,340	Yes	$6.73	No	N/A	N/A	N/A
Falls 7 and 8	$354,197	$13,362	3,831	Yes	$3.49	No	N/A	N/A	N/A
Falls 7, 8 and 11	$433,070	$16,101	5,401	No	$2.98	No	N/A	N/A	N/A
Falls 7, 8 and 12	$430,841	$16,000	6,021	Yes	$2.66	No	N/A	N/A	N/A
Falls 7, 8, 11 and 12	$494,715	$18,440	7,591	Yes	$2.43	Yes	$19,102	7,783	$2.45

NOTES:
[1] The estimated costs utilized for CE/ICA are equal to the investment costs plus future costs, in present value terms. For each alternative, the investment costs include construction, real estate, PED, and construction management; future costs include post-construction monitoring and O&M.
The costs for the mitigation alternatives all fall within the estimated cost that is currently assumed for the tentatively selected plan, as described in the Cost Engineering Appendix.

3.5 Selection of Mitigation Plan

While the selected alternative need not be a best buy plan for the purposes of mitigation, it must be cost-effective; other decision-making criteria may include acceptability, completeness, effectiveness, reasonableness of costs, and risk and uncertainty. As summarized in Table 9, four of the passage barrier removal alternatives are cost-effective; only Falls 7, 8, 11 and 12 is a best buy plan (along with the No Action alternative).

Although Falls 7 alone is cost-effective, there is some degree of risk and uncertainty that this alternative would not adequately meet the required mitigation burden. Although there is assumed to be some degree of existing passage through Falls 8 (such that the habitat model indicates an adequate gain of HUs for removal of Falls 7 under the "expected scenario"), there is inherent risk in this assumption, such that it is possible that there is little to no existing passage through Falls 8. Based on this assumption, removal of Falls 7 alone would only measurably increase access to the approximately 100 meters of in-stream habitat between Falls 7 and Falls 8, and would not adequately meet the mitigation burden (as indicated by the "worst-case scenario").

Furthermore, the incremental cost per habitat unit (AAC/AAHU) drops significantly with the addition of Falls 8, such that substantially more benefits would be realized for a relatively small increase in cost. As shown in Table 9, the incremental cost of implementing Falls 7 is $6.73 per unit output, but is only $3.49 for Falls 7 and 8. Given the proximity of these features and the nature of the required work, the added cost of addressing Falls 8 is minimal, but the added benefit would be substantial (as a much greater extent of upstream habitat would be made available). Although the incremental cost of adding Falls 12and/or Falls 11and 12is even lower ($2.66 and $2.43, respectively), these alternatives provide an excessive amount of habitat benefit relative to the project impacts, that the project team determined these were not worth the added cost.

These considerations, which are consistent with the USACE's Environmental Operating Principles [3] (USACE, 2012), were used the project team as the basis for selection of Falls 7 and 8 as the selected mitigation alternative for the project.

4.1 Monitoring and Adaptive Management

As specified in the guidance, monitoring includes the systematic collection and analysis of data that provides information needed to assess project performance, determine whether ecological success has been achieved, or whether adaptive management may be needed to attain project benefits. The monitoring plan should include a description of the monitoring activities, the criteria for success, and the estimated cost and duration of the monitoring (recognizing that monitoring should continue until such time as the Secretary determines that the success criteria have been met).

A preliminary description of these items is provided below. It is expected that this information would continue to be refined as the detailed designs are further refined, and the monitoring plan would be finalized during the next phase of the project.

4.2 Monitoring Approach and Activities

In order to capitalize on the detailed baseline data and comprehensive approach to quantifying aquatic habitat quality, monitoring of the mitigation efforts would involve repeated stream and fish surveys, with analysis as part of the HSHEP model. The information gathered as part of these efforts directly relate to the mitigation objectives, which focus on the physical in-stream habitat conditions and passage for native species. Specifically, the stream surveys would record the physical in-stream conditions, with the HSHEP model outputs translating those conditions into habitat quality for native aquatic species. The fish surveys would directly measure the presence and abundance of native species along the stream gradient, particularly in reaches where passage has been restored. Consideration of these data relative to the HSHEP model results would help to correlate species presence/abundance with habitat quality and passage. Direct comparison with the baseline conditions data (and each subsequent year of monitoring data) would also allow for a clear understanding of the change in conditions over time.

4.3 Performance Criteria

Performance criteria represent the desired conditions to be achieved by the end of the performance monitoring period, as needed to determine project success. To the extent possible, performance criteria should be SMART (specific, measurable, achievable, relevant, and time-bound), and include target values and ranges, as appropriate, accounting for natural variability and management actions.

---

[3] In particular, the USACE's Environmental Operating Principles direct the USACE to "create mutually supporting economic and environmentally sustainable solutions," as well as to consider the environment in employing a risk management and systems approach throughout the life cycles of projects and programs."

The proposed criteria are summarized in Table 10; specific quantities for these criteria would be developed as part of the final design phase.

TABLE 10
Performance Standards and Monitoring Requirements

Mitigation Objective	Performance Criteria	Monitoring Approach
Restore and/or enhance physical in-stream conditions to improve habitat for native Hawaiian aquatic species	Increased habitat units (HSHEP) ; specific quantification to be determined in final design phase	Stream surveys with HSHEP model
Improve passage for native Hawaiian aquatic species to upstream areas of high-quality habitat	Increased presence (either in total, or as a percentage) of native species in upper reaches, specific quantification to be determined in final design phase	Fish surveys with species counts

4.4 Analysis and Reporting

To provide the basis for evaluating project performance, the data collected as part of the above-described monitoring efforts would be compiled and analyzed. The analysis would use the performance criteria to evaluate whether the mitigation measures are achieving restoration success The results of the analysis would be presented in a report; a report would be produced annually for each year that monitoring is conducted (see Section 4.5 for a discussion of the monitoring schedule). After the final year of monitoring, assuming the performance criteria have been met, the project sponsors would be responsible for preparing a close-out report.

In the event that the evaluation indicates that the project has not met the performance criteria, the project sponsors would consider implementation of adaptive management actions as needed to attain the ecosystem objectives for the project. Considerations for the adaptive management approach are discussed below.

4.4 Adaptive Management

Adaptive management is a structured process of learning and using newly-acquired knowledge to adjust and improve project implementation. The adaptive management process promotes flexible decision-making as outcomes from management actions are better understood. This approach helps to reduce the risk of not achieving ecosystem restoration goals. Implementation guidance for WRDA 2007 specifies that an adaptive management plan should be developed for all ecosystem restoration projects. Specifically, the information generated by the performance monitoring, as described above should be used by the project sponsors to guide decisions relative to operational or structural changes that may be needed to ensure that the ecosystem restoration project meets the success criteria. This decision-making process may depend on a number of variables, including the timing and/or spatial scale of the performance issue, the urgency with which the issue must be addressed, and/or the type of adjustment that is needed to respond to the issue. The guidance specifies that if an adjustment is anticipated due to high uncertainty in achieving the desired outputs/results, the nature and cost of such actions should be explicitly described as part of the decision document and expressed in each of the monitoring reports as they are performed.

To evaluate the adaptive management measures that may be required for the proposed project, the potential risk and uncertainty relative to achieving the performance standards was assessed and potential adaptive management measures were identified. Specific measures that were considered included changes to project-related conditions, as well as external factors. As part of the assessment, the extent to which these adaptive management measures could address the potential deficiencies was considered.

In general, this assessment concluded that there is little risk that the structural components of the mitigation actions would require modification, such that the adaptive management does not need to account for physical changes to the in-stream structures. Similar efforts to eliminate passage barriers have been conducted on Oahu with high levels of success, and the proposed mitigation design would build upon these efforts. Structural repairs to address erosion and/or settlement that might occur over time would be covered as part of standard O&M. In terms of achieving the performance standards, the primary risk that was identified is associated with increased abundance and predation by non-native aquatic species. As previously described, prevalence of non-native species is not currently believed to be a key limiting factor for native aquatic species in the Ala Wai Watershed (given the overall habitat conditions); however, to the extent that the monitoring results indicate that this may be the case in the future, the adaptive management approach for the project incorporates non-native species removal. It is assumed that this effort would be similar to those previously conducted by the State of Hawaii DAR staff (assumed to cost approximately $30,000); any adaptive management costs incurred during the monitoring period would be cost-shared with the non-federal sponsor.

4.5 Monitoring Schedule

The implementation guidance for Section 2039 of WRDA 2007 specifies that monitoring would be initiated upon completion of construction, and should continue until ecological success has been documented; the law allows for but does not require a 10-year cost-shared monitoring plan. If monitoring is required beyond the 10-year period, it would be the responsibility of the non-federal sponsor. Based on the nature of the proposed mitigation measures, it is assumed that monitoring would be conducted annually over a 5-year period, which would start upon completion of construction.[4] The exact timing of monitoring would be determined in the final design phase.

4.6 Responsibilities and Cost

Consistent with the requirements of WRDA 2007, the cost of monitoring would be included as part of the total project costs and be cost-shared, with 65 percent of the costs paid by USACE and the other 35 percent paid by the State of Hawaii, as the non-federal sponsor. The estimated cost for the proposed monitoring activiies is summarized in Table 11. Any additional post-construction monitoring past the designated monitoring period would be entirely the responsibility of the non-federal sponsor. As the non-federal sponsor, the State of Hawaii would also be responsible for O&M activities for the mitigation measures implemented as part of the tentatively selected plan.

TABLE 11
Estimated Monitoring Costs

Parameter	Estimated Level of Effort (Per Monitoring Event)	Approximate Cost
Stream and fish surveys	Assumes a total of 20 person-days per monitoring event	$5,000
Data processing	Assumes a total of 5 person-days per monitoring event	$1,250

[4] In many cases, pre project monitoring is conducted as needed to establish the basis for measuring restoration success. It is assumed that a single pre monitoring event would be conducted prior to construction.

TABLE 11
Estimated Monitoring Costs

Parameter	Estimated Level of Effort (Per Monitoring Event)	Approximate Cost
Analysis and reporting	Assumes a total of 10 person-days per monitoring event; assumes $500 in expenses per monitoring event	$3,000
Total (per monitoring event)		$9,250
Project Total (assuming 5 monitoring events)		$46,250

NOTE: Assumes $250 in labor charges per person-day.

References

USACE (U.S. Army Corps of Engineers). 2000. "Planning Guidance Notebook." Engineer Regulation 1105-2-100. April 22.

USACE (U.S. Army Corps of Engineers). 2009. *Implementation Guidance for Section 2039 of the Water Resources Development Act of* 2007 *(WRDA 2007) - Monitoring Ecosystem Restoration.* August.

Fitzsimons, J. M. and R. T. Nishimoto. 2007. Introduction. In: Biology of Hawaiian Streams and Estuaries, N. L. Evenhuis and J. M. Fitzsimons, eds. Bishop Museum Bulletin in Cultural and Environmental Studies 3:1-10.

Parham, J.E. 2002. Spatial models of Hawaiian streams and stream fish habitats. Ph.D. Dissertation, Louisiana State University, Museum of Natural Science, Baton Rouge, LA. 155 p.

Kuamo'o, D. G. K., G. R. Higashi & J. E. Parham. 2007. Structure of the Division of Aquatic Resources Survey Database and use with a Geographic Information System. In: Biology of Hawaiian Streams and Estuaries, N. L. Evenhuis & J. M. Fitzsimons, eds. Bishop Museum Bulletin in Cultural and Environmental Studies 3: 315-322.

Parham, J.E. 2008. Development of a Database Modeling Tool to Predict Aquatic Species Distributions within Hawaiian Streams. Division of Aquatic Resources, DLNR, State of Hawaii. 56 p.

USACE (U.S. Army Corps of Engineers). 2012. Environmental Operating Principles. Available online at: http://www.usace.army.mil/Missions/Environmental/EnvironmentalOperatingPrinciples.aspx

USACE (U.S. Army Corps of Engineers). 2000. "Planning Guidance Notebook." Engineer Regulation 1105-2-100. April 22.

USFWS (U.S. Fish and Wildlife Service). 1980a. Habitat as the Basis for Environmental Assessment (101 ESM). U.S. Fish and Wildlife Service, Washington, DC.

USFWS (U.S. Fish and Wildlife Service). 1980b. Habitat evaluation procedure (HEP) Manual (102 ESM). U.S. Fish and Wildlife Service, Washington, DC.

USFWS (U.S. Fish and Wildlife Service). 1981. Standards for the development of habitat suitability index models (103 ESM). U.S. Fish and Wildlife Service, Washington, DC.

APPENDIX E – REPORT ON UPDATING THE SPREADSHEET RESULTS FOR THE HAWAIIAN STREAM HABITAT EVALUATION PROCEDURE (HSHEP) ASSOCIATED WITH THE STREAMS IN THE ALA WAI CANAL FLOOD RISK MANAGEMENT STUDY, JULY 12, 2016, JAMES E. PARHAM.

Report on updating the spreadsheet results for the Hawaiian Stream Habitat Evaluation Procedure (HSHEP) associated with the streams in the Ala Wai Canal Flood Risk Management Study.

7/12/2016

Submitted to:

Michael D. Wyatt, POH

US Army Corps of Engineers

Honolulu, Hawaii

Submitted by:

James E. Parham. Ph.D.

President, Parham & Associates Environmental Consulting. LLC.

149 Hedgelawn Dr., Hendersonville, TN 37075

Jim.Parham@ParhamEnvironmental.com

Introduction:

The Hawaiian Stream Habitat Evaluation Procedure (HSHEP) was used to estimate current conditions and project impacts for proposed actions in Manoa, Makiki, and Palolo Streams associated with the Ala Wai Canal Flood Mitigation Project. The application of the model was based on extensive field surveys within the streams as well as stream surveys statewide. To estimate project impacts, the designs of the flood mitigation projects were used as defined at the time. As the project has advanced, changes to the design specification occurred in response to overall project review. This report documents changes to the original HSHEP model which reflect the new project design specifications.

In addition to this report, an updated spreadsheet of the results and GIS shapefiles of the newly defined segments has been provided to the US Army Corps of Engineers (USACE).

Methods:

Several steps needed to be completed to update the spreadsheet to allow the new changes to be reflected in the results:

1. New stream segments associated with the updated plans were created in ArcGIS 10.2.
2. The new segments had their instream habitat conditions associated with them from the prior model.
3. The new segments had the habitat suitability for the native instream biota associated with them from the prior model.
4. The impacts of the new design specification changes were reviewed and criteria were determined for them.
5. All of these changes were updated into the HSHEP spreadsheet and new impacts were determined for the current conditions and eight different mitigation scenarios.

The following further describes the steps:

<u>Development of New Stream Segments:</u>

The USACE provided PDF copies of the new flood mitigation projects sites (Appendix 1) and associated GIS shapefiles. In addition to the drawings, a spreadsheet of the changes was also provided (Appendix 2). Some additional guidance to understanding the changes was also provided by USACE in an email discussion.

Primarily, there were three changes associated with the new plans:

1. The addition or expansion of an upstream excavation area,
2. the replacement of the open bottom arch culverts with box culverts, and
3. the addition of downstream riprap scour protection areas.

These changes were not found at all sites and impacted different amounts of the stream channel. To create the new stream segments, the old stream segments were split and redefined based on the GIS shapefiles to reflect the new designs. At all five sites, all three types of plan changes were included within the model (Figure 1). When the project did not call for one of the changed types, a segment with zero length was included in the model. This was done for consistency of approach and for flexibility in modeling possible future changes to the plans. Stream segment code numbers were modified to clearly identify the site changes.

30	28	Manoa	Manoa	
31	29	Manoa	Manoa	
32	30	Manoa	Manoa	
33	31	Manoa	Manoa	
34	32	Manoa	Manoa	
35	50	Manoa	Waiahi	
36	51	Manoa	Waiahi	
37	52	Manoa	Waiahi	
38	53	Manoa	Waiahi	Waiahi Detention Basin
39	54	Manoa	Waiahi	
40	55	Manoa	Waiahi	
41	56	Manoa	Waiahi	
42	61	Manoa	Unnamed off Waiahi	
43	80	Manoa	Luaalaea	
44	81	Manoa	Luaalaea	
45	82	Manoa	Luaalaea	Waiakeakua Detention Basin
46	83	Manoa	Luaalaea	
47	90	Manoa	Waiakeakua	
48	100	Manoa	Luaalaea	
49	110	Manoa	Luaalaea	
50	120	Manoa	Nanhuapo	

1	29	Manoa	Manoa		Barrier: Falls 7
	30	Manoa	Manoa		Barrier: Falls 8
	31	Manoa	Manoa		
	32	Manoa	Manoa		
	50	Manoa	Waiahi		
36	51	Manoa	Waiahi		Barrier: Falls 11
3	52	Manoa	Waiahi		
38	5301	Manoa	Waiahi	Waiahi Detention Basin Scour	yes
3	5302	Manoa	Waiahi	Waiahi Detention Basin	box
40	5303	Manoa	Waiahi	Waiahi Detention Basin Excavation	no
41	54	Manoa	Waiahi		
42	55	Manoa	Waiahi		
4	56	Manoa	Waiahi		
44	61	Manoa	Unnamed off Waiahi		
4	80	Manoa	Luaalaea		
46	81	Manoa	Luaalaea		Barrier: Falls 12
47	8201	Manoa	Luaalaea	Waiakeakua Detention Basin Scour	yes
48	8202	Manoa	Luaalaea	Waiakeakua Detention Basin	arch
49	8203	Manoa	Luaalaea	Waiakeakua Detention Basin Excavati	no
50	83	Manoa	Luaalaea		
51	90	Manoa	Waiakeakua		

Overall | Summary&Impacts | SegmentInfo | HSI | Current

Figure 1. Screen capture of Segment Info pages in old (left) and updated (right) HSHEP model result spreadsheets showing the creation of the new segment identification numbers.

<u>Associating Habitat Availability and Habitat Suitability to the New Segments from Prior Model Information</u>:

A similar process was used to associate the information from the HSHEP model with the newly defined stream segments. Given the short turnaround time allowed for this update, a complete redo of all stream segments within the model was not done. The new stream segments were reviewed against the model data for each segment and the appropriate data was included in the spreadsheet defining the results. As a result of this approach, there are small differences in some of the nearby segments that result in small changes to the overall habitat units within the model (54,572 HU in original model vs 54,458 HU in the new model). These changes are minuscule (0.209 % difference between models) and are unlikely to affect the overall conclusions for appropriate mitigation actions.

When reviewing the data for the new stream segment information, the original detention basin and upstream area were associated with the new detention basin footprint and upstream excavation area and the downstream riprap scour protection area was associated with the immediate downstream segment. In some cases, the new project site footprints included more than one downstream or upstream segment and in these cases the appropriate information was applied from all affected stream segments. The exact linear measurements for each area were determined from the associated spreadsheet information provided by USACE and included within the model spreadsheet (Figure 2). This allowed for some discrepancies between GIS data sources while capturing the specifics of the new project designs.

	A	B	C	D	E	S	T	U	V	W
43	56	Manoa	Waiahi			567	15	90%	4	2333
44	61	Manoa	Unnamed off Waiahi			531	15	90%	4	2184
45	80	Manoa	Luaalaea			191	34	90%	9	1768
46	81	Manoa	Luaalaea		Barrier: Falls 12	12	24	90%	7	80
47	8201	Manoa	Luaalaea	Waiakeakua Detention Basin Scour	yes	46	24	90%	7	306
48	8202	Manoa	Luaalaea	Waiakeakua Detention Basin	arch	61	27	90%	8	458
49	8203	Manoa	Luaalaea	Waiakeakua Detention Basin Excavati	no	0	25	90%	7	0
50	83	Manoa	Luaalaea			38	25	90%	7	261
51	90	Manoa	Waiakeakua			864	15	90%	4	3557
52	100	Manoa	Luaalaea			257	20	90%	5	1413
53	110	Manoa	Luaalaea			960	15	90%	4	3949
54	120	Manoa	Naniuapo			815	15	90%	4	3354
55	200	Palolo	Palolo			44	30	85%	8	344
56	201	Palolo	Palolo	Channelized	Chan Barrier	528	40	33%	4	2086
57	202	Palolo	Palolo			570	30	86%	8	4522
58	203	Palolo	Palolo	Channelized	Chan Barrier	2003	38	45%	5	10451
59	210	Palolo	Waiomao	Channelized	Chan Barrier	154	35	45%	5	739
60	211	Palolo	Waiomao			789	35	45%	5	3788
61	212	Palolo	Waiomao			269	22	83%	6	1489
62	213	Palolo	Waiomao			0	25	90%	7	0
63	2141	Palolo	Waiomao	Waiomao Detention Basin Scour	yes	46	25	90%	7	318
64	2142	Palolo	Waiomao	Waiomao Detention Basin	box	52	20	90%	5	285
65	2143	Palolo	Waiomao	Waiomao Detention Basin Excavation	Barrier: P_Falls 5 (yes)	122	35	89%	9	1150
66	216	Palolo	Waiomao			1768	15	90%	4	7275
67	220	Palolo	Pukele	Channelized	Chan Barrier	566	40	50%	6	3447
68	221	Palolo	Pukele			459	30	90%	8	3777
69	222	Palolo	Pukele			262	30	90%	8	2156
70	2231	Palolo	Pukele	Pukele Detention Basin Scour	yes	46	30	90%	8	379
71	2232	Palolo	Pukele	Pukele Detention Basin	box	49	30	90%	8	483

Figure 2. Screen capture of the updated HSHEP model spreadsheet showing the newly determined stream lengths (column S) for the site changes. For row 49, the Waiakeakua Upstream excavation area the stream length is 0 reflecting no upstream excavation area although the stream segment coding is in place for future site modifications. Row 65 shows the Waiomao Excavation area and its appropriate length of 122m (400 ft).

Determining Impacts of New Design Changes:

Determining the impacts of the new design changes was done in consultation with Glenn Higashi at the Hawaii Division of Aquatic Resources. We attempted to follow similar impact criteria as had been developed for the first model. For the upstream excavation areas, we applied the expected and maximum impact criteria values as had been previously determined for the first model. For the downstream riprap scour protection areas, we applied similar criteria values (Figure 3). In both of these cases, it is likely that there will be some habitat in the stream in these areas although it is not considered a natural stream bottom. The maximum impact would remove 100% of habitat in these areas. No changes in criteria scoring were made for the actual detention dam footprint as that had already been determined for the first model. For the change from the natural bottom arch culvert to the box culvert, we applied the same values as the channelized barriers determined for the first model. In this case, we had assumed some decrease in passage for each 100 m of channelized stream (Figure 4). Although the box culverts were not 100 m in length, we considered them to have passage barrier values as if they were 100 m in length. This estimate avoided underestimating the impact of the fish passing under these dams through the box culverts.

	A	B	C	D
1	Habitat Impact Variables			
2		Habitat Remaining		
3	Type	Current Impact (live Values)	Expected Impact	Max Impact
4	Off-channel Detention Intakes	0.8	0.8	0
5	In-channel Sites	0	0	0
6	Upstream Detention Excavation	0.5	0.5	0
7	Channel Maintenance	0.5	0.5	0.5
8	Downstream Scour Area	0.5	0.5	0

Figure 3. Screen capture of the habitat impact weighting criteria used for the updated HSHEP model.

G	H	I	J	K
Barrier Impact Variables				
	Habitat Remaining			
Type	Current Impact (live Values)	Expected	Max Barrier	
Channelized Barriers (per 100m)	0.9	0.9	0.85	
Undercut Barriers	0.5	0.5	0.35	
Box Culverts	0.9	0.9	0.85	

Figure 4. Screen capture of the barrier impact weighting criteria used for the updated HSHEP model.

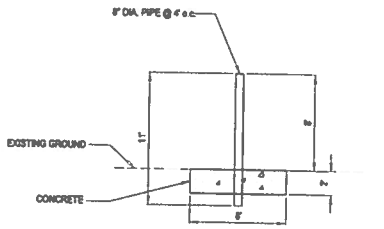
Updating the HSHEP Model Result Spreadsheet:

Results from the new model were added to the HSHEP model result spreadsheet. All formulas and dependencies were updated and double checked. The mitigation values for each of the eight different scenarios were recalculated and added to the overall results page.

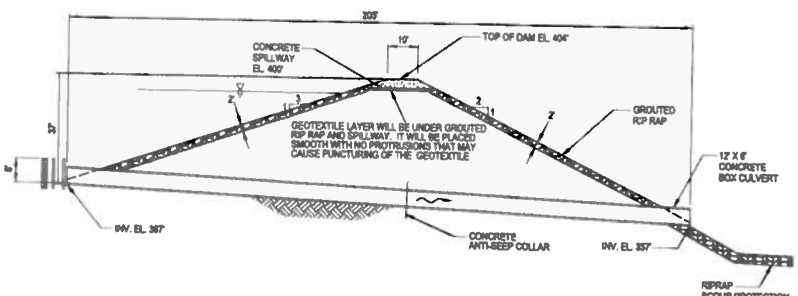
Results and Conclusion:

An updated spreadsheet and associated GIS file were provided to the USACE with this report. The intent of this report is not to discuss the findings but to document the process in which the spreadsheet was updated with the new site information.

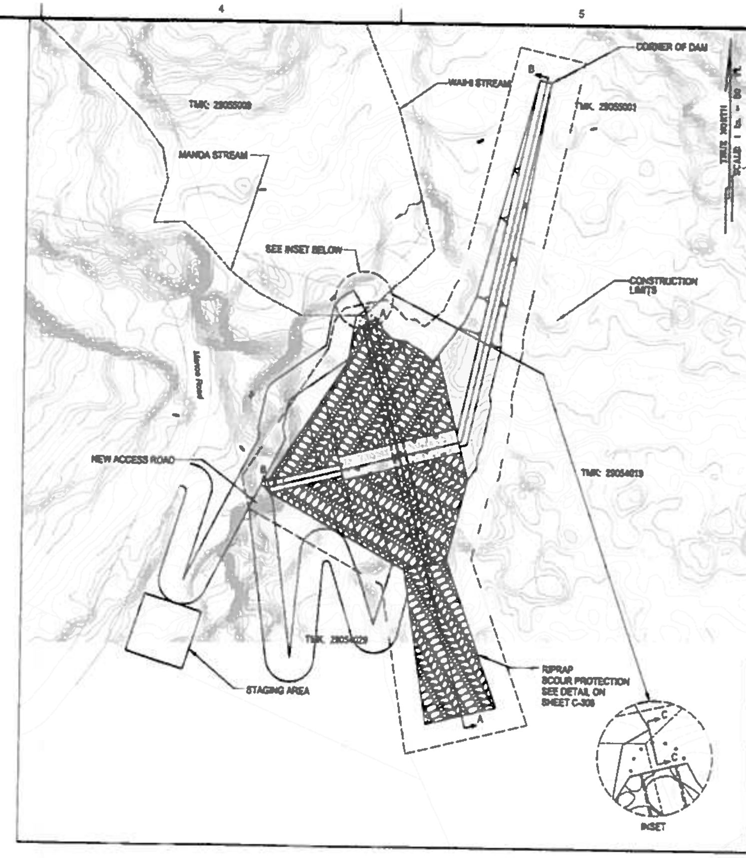
In a general sense, the conclusions of this updated model are unchanged from the first model run. The biggest difference is the loss of habitat associated with the increased footprint of the projects and a decrease in upstream passage where box culverts are used. The removal of the falls 7 and 8 as a mitigation scenario remains the most promising scenario in terms of habitat units gained for effort expended.



WAIHI DEBRIS AND DETENTION BASIN
SECTION C-C
SCALE: 1"=5'

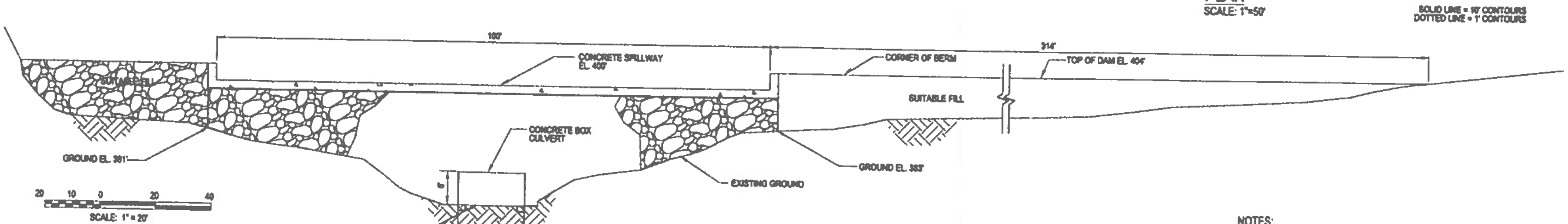


WAIHI DEBRIS AND DETENTION BASIN
SECTION A-A
SCALE: 1"=20'



PLAN
SCALE: 1"=50'

SCALE: 1" = 50'
SOLID LINE = 10' CONTOURS
DOTTED LINE = 1' CONTOURS



WAIHI DEBRIS AND DETENTION BASIN
SECTION B-B
SCALE: 1"=10'

NOTES:

1. THE ACCESS ROAD WILL ALSO BE USED FOR MAINTENANCE.

US Army Corps of Engineers® Honolulu District

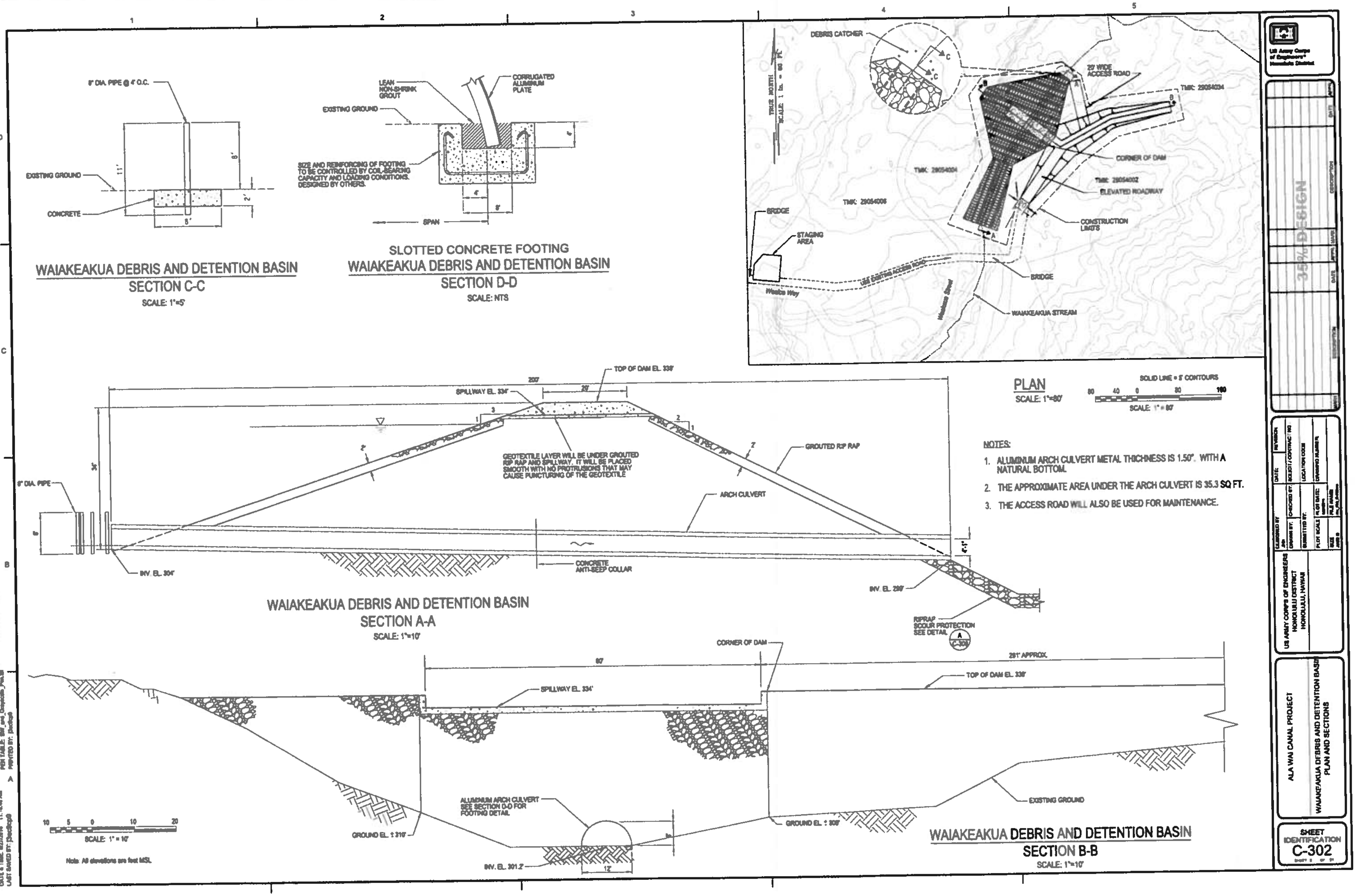
35% DESIGN

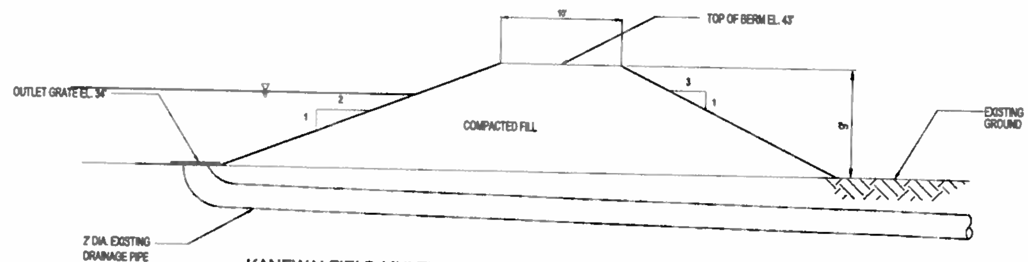
US ARMY CORPS OF ENGINEERS
HONOLULU DISTRICT
HONOLULU, HAWAII

ALA WAI CANAL PROJECT

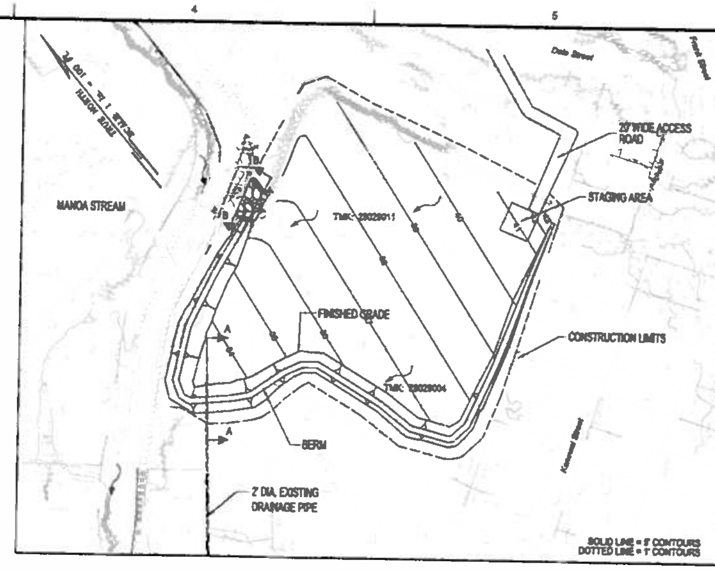
WAIHI DEBRIS AND DETENTION BASIN
PLAN AND SECTIONS

SHEET IDENTIFICATION
C-301

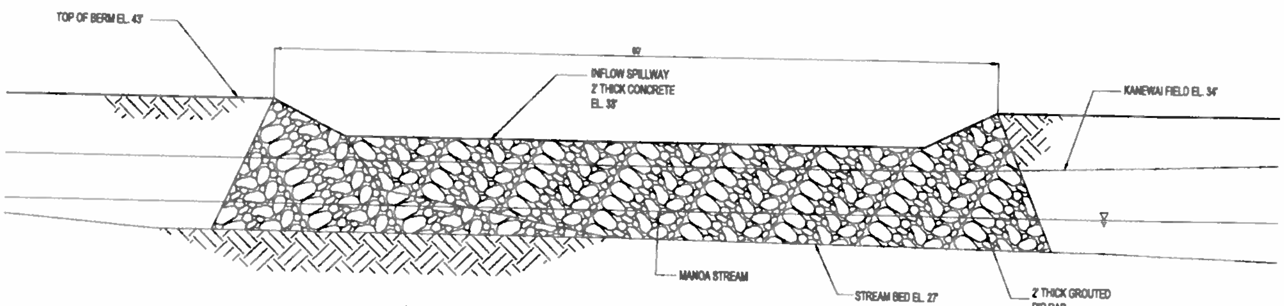

WAIAKEAKUA DEBRIS AND DETENTION BASIN
SECTION C-C
SCALE: 1"=5'
8" DIA. PIPE @ 4' O.C.
EXISTING GROUND
CONCRETE
SLOTTED CONCRETE FOOTING
WAIAKEAKUA DEBRIS AND DETENTION BASIN
SECTION D-D
SCALE: NTS
LEAN NON-SHRINK GROUT
CORRUGATED ALUMINUM PLATE
SIZE AND REINFORCING OF FOOTING TO BE CONTROLLED BY COIL-BEARING CAPACITY AND LOADING CONDITIONS. DESIGNED BY OTHERS.
SPAN
DEBRIS CATCHER
27' WIDE ACCESS ROAD
CORNER OF DAM
ELEVATED ROADWAY
CONSTRUCTION LIMITS
BRIDGE
STAGING AREA
WAIAKEAKUA STREAM
PLAN
SCALE: 1"=80'
SOLID LINE = 5' CONTOURS
NOTES:
1. ALUMINUM ARCH CULVERT METAL THICHNESS IS 1.50". WITH A NATURAL BOTTOM.
2. THE APPROXIMATE AREA UNDER THE ARCH CULVERT IS 35.3 SQ FT.
3. THE ACCESS ROAD WILL ALSO BE USED FOR MAINTENANCE.
TOP OF DAM EL. 338'
SPILLWAY EL. 334'
GEOTEXTILE LAYER WILL BE UNDER GROUTED RIP RAP AND SPILLWAY. IT WILL BE PLACED SMOOTH WITH NO PROTRUSIONS THAT MAY CAUSE PUNCTURING OF THE GEOTEXTILE
GROUTED RIP RAP
ARCH CULVERT
8" DIA. PIPE
INV. EL. 304'
CONCRETE ANTI-SEEP COLLAR
INV. EL. 298'
RIPRAP SCOUR PROTECTION SEE DETAIL
WAIAKEAKUA DEBRIS AND DETENTION BASIN
SECTION A-A
SCALE: 1"=10'
CORNER OF DAM
261' APPROX.
SPILLWAY EL. 334'
ALUMINUM ARCH CULVERT SEE SECTION D-D FOR FOOTING DETAIL
GROUND EL. ± 310'
INV. EL. 301.2'
GROUND EL. ± 308'
EXISTING GROUND
WAIAKEAKUA DEBRIS AND DETENTION BASIN
SECTION B-B
SCALE: 1"=10'
SCALE: 1" = 10'
Note: All elevations are feet MSL
US Army Corps of Engineers Honolulu District
35% DESIGN
US ARMY CORPS OF ENGINEERS
HONOLULU DISTRICT
HONOLULU, HAWAII
ALA WAI CANAL PROJECT
WAIAKEAKUA DEBRIS AND DETENTION BASIN
PLAN AND SECTIONS
SHEET IDENTIFICATION
C-302



KANEWAI FIELD MULTI-PURPOSE DETENTION BASIN
SECTION A-A
SCALE: 1" = 5'



PLAN
SCALE: 1" = 100'



KANEWAI FIELD MULTI-PURPOSE DETENTION BASIN
SECTION B-B
SCALE: 1" = 5'

SCALE: 1" = 5'
Note: All elevations are feet MSL

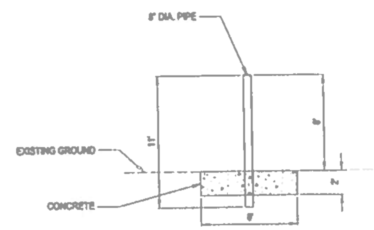
US Army Corps of Engineers® Honolulu District

35% DESIGN

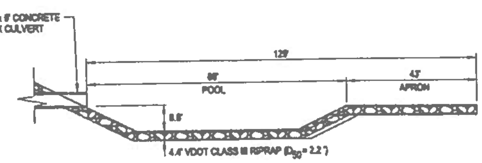
US ARMY CORPS OF ENGINEERS
HONOLULU DISTRICT
HONOLULU, HAWAII

ALA WAI CANAL PROJECT
KANEWAI FIELD MULTI-PURPOSE DETENTION BASIN
PLAN AND SECTIONS

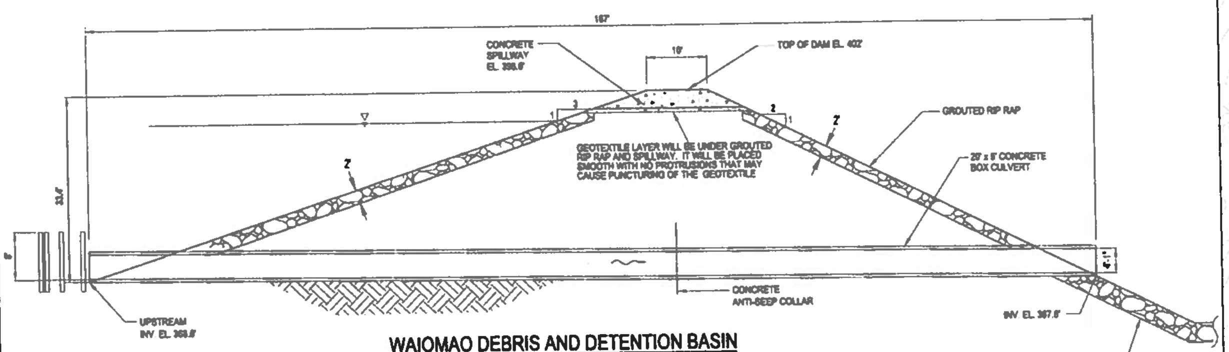
SHEET IDENTIFICATION
C-306



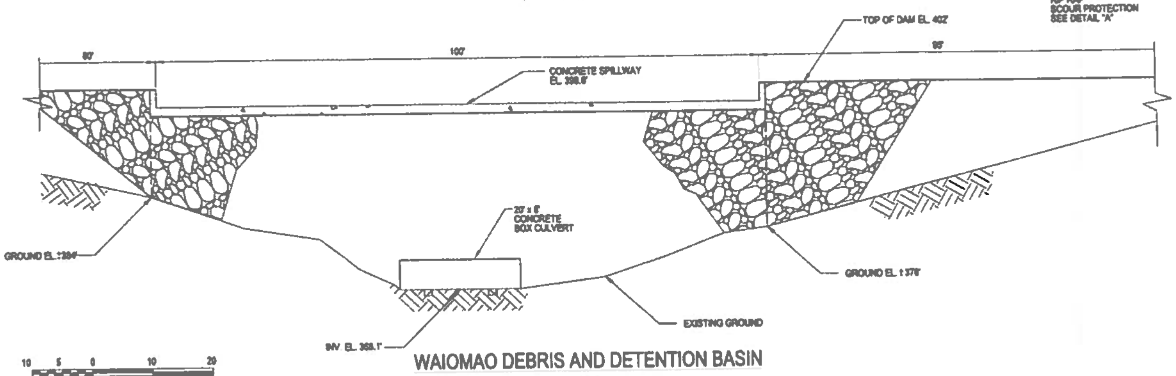
WAIOMAO DEBRIS AND DETENTION BASIN
SECTION C-C
SCALE: 1"=5'



A
C-308
RIPRAP DISSIPATION & SCOUR PROTECTION DETAIL
SCALE 1"=20'

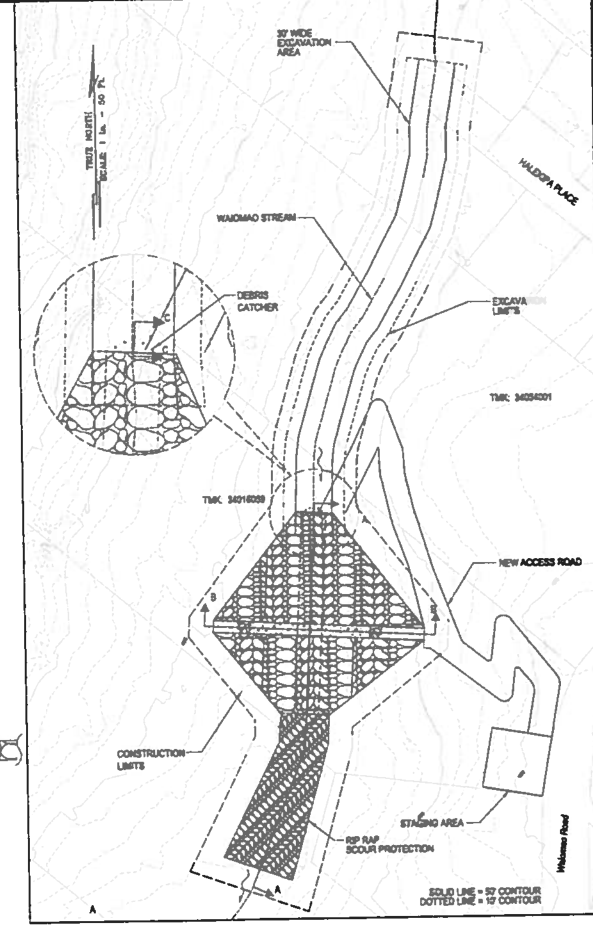


WAIOMAO DEBRIS AND DETENTION BASIN
SECTION A-A
SCALE: 1"=10'



Note: All elevations are feet MSL

WAIOMAO DEBRIS AND DETENTION BASIN
SECTION B-B
SCALE: 1"=10'



PLAN
SCALE: 1"=50'

50 25 0 50
SCALE 1" = 50'

NOTES:

1. THE ACCESS ROAD WILL ALSO BE USED FOR MAINTENANCE.

35% DESIGN

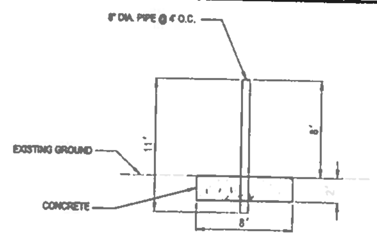
US Army Corps of Engineers
Honolulu District

US ARMY CORPS OF ENGINEERS
HONOLULU DISTRICT
HONOLULU, HAWAII

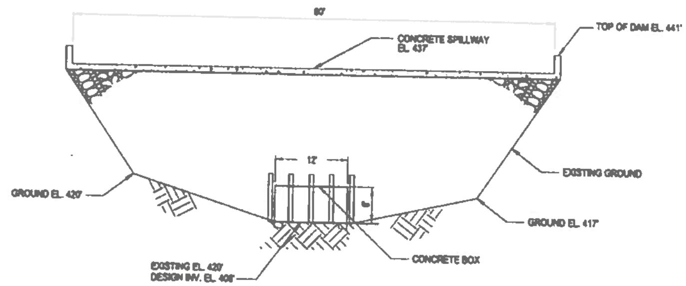
ALA WAI CANAL PROJECT

WAIOMAO DEBRIS AND DETENTION BASIN
PLAN AND SECTIONS

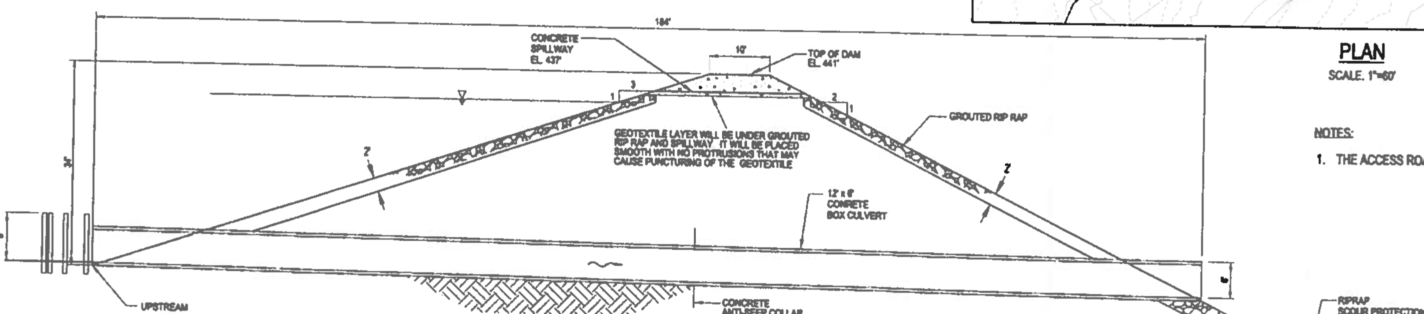
SHEET IDENTIFICATION
C-308



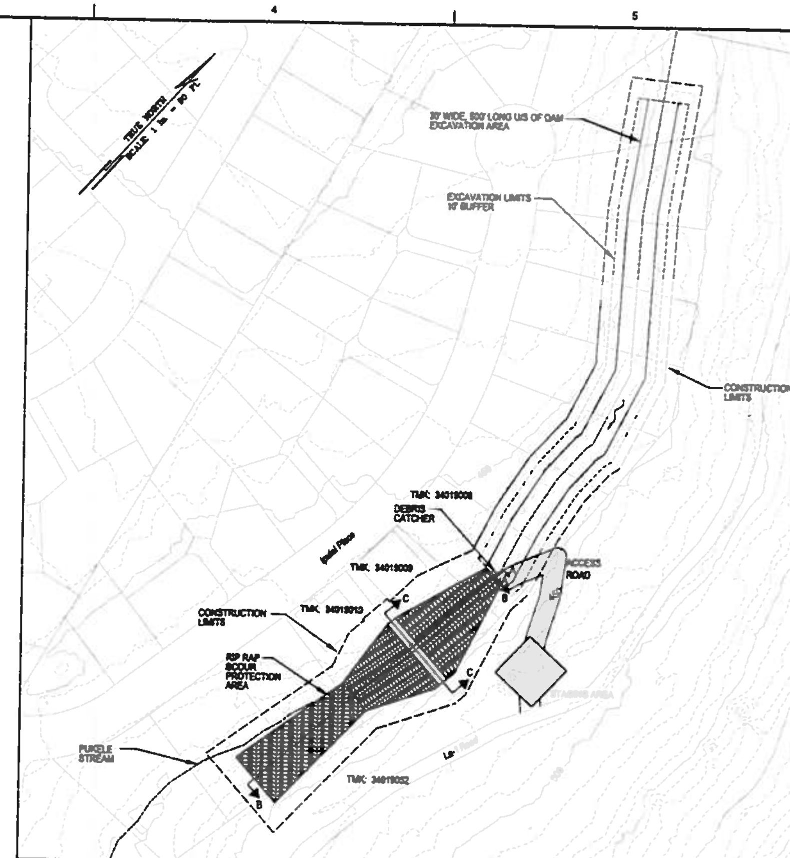
PUKELE DEBRIS AND DETENTION BASIN
SECTION A-A
SCALE 1"=5'



PUKELE DEBRIS AND DETENTION BASIN
SECTION C-C
SCALE: 1"=5'



PUKELE DEBRIS AND DETENTION BASIN
SECTION B-B
SCALE: 1"=5'



PLAN
SCALE: 1"=60'

SOLID LINE = 50' CONTOURS
DOTTED LINE = 10' CONTOURS

NOTES:

1. THE ACCESS ROAD WILL ALSO BE USED FOR MAINTENANCE.

SCALE: 1" = 5'
Note: All elevations are feet MSL.

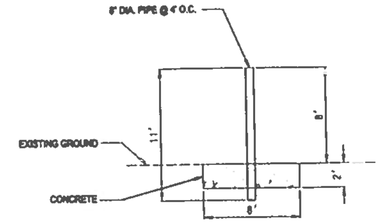
US Army Corps of Engineers® Honolulu District

35% DESIGN

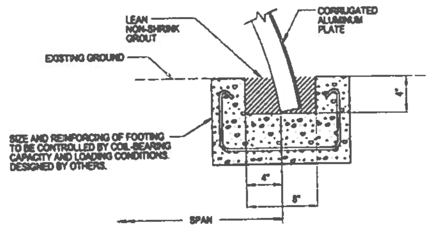
US ARMY CORPS OF ENGINEERS
HONOLULU DISTRICT
HONOLULU, HAWAII

ALA WAI CANAL PROJECT
PUKELE DEBRIS AND DETENTION BASIN
PLAN AND SECTIONS

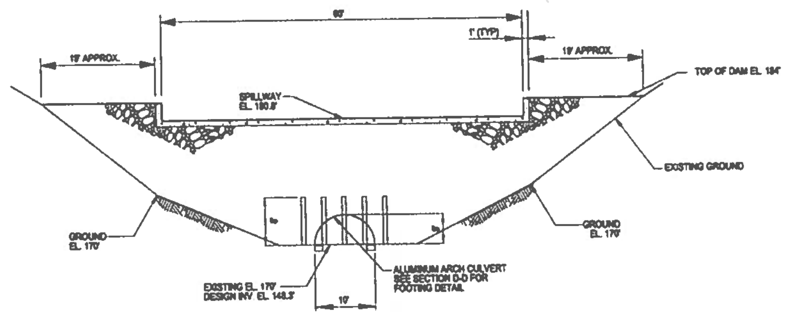
SHEET IDENTIFICATION
C-313



MAKIKI DEBRIS AND DETENTION BASIN
SECTION A-A
SCALE: 1"=5'



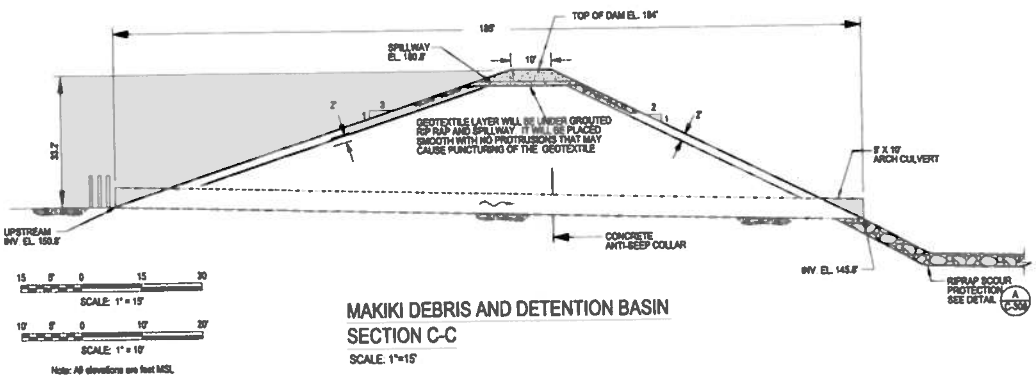
SLOTTED CONCRETE FOOTING
MAKIKI DEBRIS AND DETENTION
SECTION D-D
SCALE: NTS



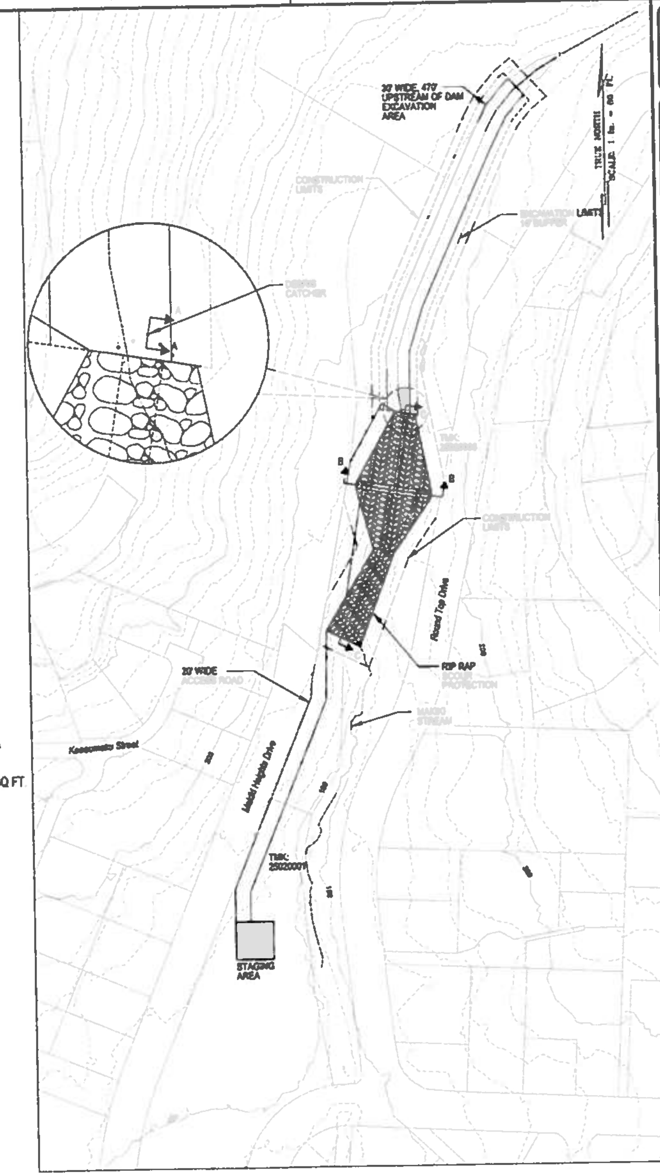
MAKIKI DEBRIS AND DETENTION BASIN
SECTION B-B
SCALE: 1"=1

NOTES:

1. ALUMINUM ARCH CULVERT METAL THICHNESS IS 1.50" WITH A NATURAL BOTTOM.
2. THE APPROXIMATE AREA UNDER THE ARCH CULVERT IS 35.3 SQ FT
3. THE ACCESS ROAD WILL ALSO BE USED FOR MAINTENANCE.



MAKIKI DEBRIS AND DETENTION BASIN
SECTION C-C
SCALE: 1"=15'



PLAN
SCALE: 1"=60'

SOLID LINE = 50' CONTOURS
DOTTED LINE = 10' CONTOURS

US Army Corps of Engineers® Honolulu District

35% DESIGN

US ARMY CORPS OF ENGINEERS
HONOLULU DISTRICT
HONOLULU, HAWAII

ALA WAI CANAL PROJECT

MAKIKI DEBRIS AND DETENTION BASIN
PLAN AND SECTIONS

SHEET IDENTIFICATION
C-315

Ala Wai Canal FRM Detention Basin Areas

	Footprint (ft^2)				Storage	
Basin	2015	2016	Difference	Difference (ac)	2015	2016
Makiki	7,250	17,165	**9,915**	**0.228**	-	14,040
Waihi	12,714	35,200	**22,486**	**0.516**	-	-
Waiakeakua	29,180	41,620	**12,440**	**0.286**	-	-
Woodlawn	37,520	37,520	-	-	-	-
Manoa Debris	540	540	-	-	-	-
Kanewai	39,425	39,425	-	-	-	-
Waiomao	6,985	19,890	**12,905**	**0.296**	21,235	12,465
Pukele	2,920	16,660	**13,740**	**0.315**	-	15,620
Hausten Ditch	-	-	-	-	-	-
Ala Wai Golf	531,300	531,300	-	-	-	-
Total Acreage	15.33	16.97	1.64	1.64	0.49	0.97

	No data
	Questionab
	Cross-checl

Design Changes	Berm Height	Top Width	Elevation	Storage excavation	Bottom Widt	Distance
Makiki	30	10	184	Yes	30	470
Waihi	37	10	404	No	0	0
Waiakeakua	34	20	338	No	0	0
Woodlawn				No		
Manoa Debris				No		
Kanewai	9	1	43	No	0	0
Waiomao	33.5	10	402	Yes	30	400
Pukele	30	10	441	Yes	30	500
Hausten Ditch	7.02			No		
Ala Wai Golf	7.49			Yes		

Excavation (ft^2)		Construction Limits (ft^2)				
Difference	Difference (ac)	2015	2016	Difference	Difference (ac)	2015
14,040	**0.322**	11,800	65,360	**53,560**	**1.230**	2,500
-	-	25,450	64,225	**38,775**	**0.890**	2,500
-	-	51,820	72,800	**20,980**	**0.482**	2,500
-	-	79,315	79,315	-	-	2,500
-	-	3,740	3,740	-	-	2,500
-	-	275,729	267,610	**(8,119)**	**(0.186)**	2,500
(8,770)	**(0.201)**	47,690	69,815	**22,125**	**0.508**	2,500
15,620	**0.359**	9,770	69,980	**60,210**	**1.382**	2,500
-	-	-	-	-		5,950
-	-	-	-	-		-
0.48	0.48	11.60	15.91	4.31	4.31	0.60

le result
ced

Volume (Y^3)	Outlet	Length	Scour protection?	
3035	Arch culvert	160	Yes	
0	Box culvert	205	Yes	
0	Arch culvert	200	Yes	
		60	No	No change
		8	No	No change
0	Existing pipe	0	No	Change in berm height
3060	Box culvert	170	Yes	
14330	Box culvert	160	Yes	
			No	One-foot increase in WSE for 100-year
			No	Half-foot increase in WSE for 100-year, no chang

Staging Area (ft²)			100-Year Pool (ft²)			
2016	Difference	Difference (ac)	2015	2016	Difference	Difference (ac)
2,500	-	-	23,140	21,245	**(1,895)**	**(0.04)**
2,480	**(20)**	**(0)**	25,150	58,870	**33,720**	**0.77**
2,320	**(180)**	**(0)**	37,647	139,740	**102,093**	**2.34**
2,500	-	-	75,830	75,830	**-**	**-**
2,500	-	-	-	-	**-**	**-**
2,480	**(20)**	**(0)**	222,468	212,810	**(9,658)**	**(0.22)**
2,500	-	-	2,525	44,950	**42,425**	**0.97**
2,500	-	-	-	34,660	**34,660**	**0.80**
5,950	-	-	-	-	**-**	**-**
-	-		-	-	**-**	**-**
0.59	(0.01)		8.88	13.50	4.62	4.62

	2015 Culvert Length	Difference
	130	30
	130	75
	110	90
	60	0
	8	0
	0	0
	130	40
	130	30
		0
ge in excavated area		0

NWI Impact	
Ft^2	
4,240	OK
3,485	OK
8,650	OK
-	Need NWI Impact for 2016 design
-	Need NWI Impact for 2016 design
-	Need footprint calc for 2015 design
5,475	OK
4,780	Need 100-year pool calc for 2015 design
-	Need footprint calc for 2015 design
-	Need footprint calc for 2015 design
0.611	

APPENDIX F – ADDENDUM TO MITIGATION, MONITORING AND ADAPTIVE MANAGEMENT PLAN, ALA WAI CANAL PROJECT, U.S. ARMY CORPS OF ENGINEERS – HONOLULU DISTRICT, JULY 14, 2016.

Addendum to
Mitigation, Monitoring and Adaptive Management Plan
Ala Wai Canal Project
U.S. Army Corps of Engineers, Honolulu District
14 July 2016

1. The draft Mitigation, Monitoring, and Adaptive Management Plan (MMAMP; USACE 2015) and its attachments describe the use of the Hawaiian Stream Habitat Evaluation Procedure (HSHEP) to evaluate the impacts of the Ala Wai Canal project on aquatic habitat, and summarize the results of the HSHEP modeling effort. As with other Habitat Evaluation Procedure (HEP) models, the HSHEP uses measurable attributes of habitat quality and quantity to create relationships between habitat suitability and animal occurrence and density. The suitability relationships are converted into standardized Habitat Suitability Indices (HSI) that encompass the range of observed habitat conditions. Habitat quality is assessed based on the HSI values and habitat quantity is defined based on area, which when multiplied, provide overall habitat units (HUs) for a given area. Adverse impacts to stream habitat can then be expressed as HUs lost, while mitigation efforts that improve stream habitat can be quantified as HUs gained.

2. When the HSHEP was applied to the Ala Wai Canal project, following the methodology and assumptions detailed in the MMAMP, the resulting total HUs lost within the Ala Wai watershed due to project impacts was calculated as 192 under the "expected scenario" (described in Section 2.2 of the MMAMP) and 1,210 under the "worst-case scenario". When these HU losses were compared against the HU gains calculated for an array of mitigation alternatives developed for the project, it was apparent that the mitigation alternative involving the removal of migration barriers at "Falls 7" and "Falls 8" would provide a sufficient gain in HUs to offset the HU losses from project impacts (Table 7 of the MMAMP).

3. In May 2016, the Corps' internal review of the project revealed that several of the project elements would need to be redesigned to provide sufficient stormwater retention and management capacity. Some of the design changes, such as additional excavation within the detention basins and riprap scour protection downstream of the detention structures, represented additional impacts to stream habitat beyond what had been modeled by the HSHEP.

4. The Corps contracted James Parham of Parham and Associates Environmental Consulting, LLC, to update and rerun the HSHEP model to reflect the changes to project design (Parham 2016a). Dr. Parham's update of the HSHEP spreadsheet included creating new model stream segments to reflect the updated plans, reviewing the impacts of the project changes and determining criteria for them. The most relevant design changes included in the updated model included:

- The addition or expansion of an upstream excavation area at three sites;
- The replacement of the open bottom arch culverts with box culverts at three sites; and
- The addition of downstream riprap scour protection areas at five sites.

Dr. Parham consulted with Glenn Higashi at the Hawaiian Division of Aquatic Resources in determining the impacts of the design changes. They followed a similar impact criteria methodology as had been developed for the first model, as much as possible. For the upstream excavation areas, they applied the expected and maximum impact criteria values as had been previously determined for the first model; similar criteria values were applied to the new downstream riprap scour protection areas. In both of these cases, it is likely that there will be some habitat in the stream in these areas although it is not considered a natural stream bottom. The maximum impact would remove 100% of habitat in these areas. No changes in criteria scoring were made for the actual detention dam footprint as that had already been determined for the first model. For the change from the natural bottom arch culvert to the box culvert, they applied the same values as the determined for channelized stream segments in the first model. Each box culvert was assigned the barrier impact value of 100 meters of channelized stream, although the box culverts will range in length from roughly 49 to 62 meters, providing some conservatism to the assessment of impact of the box culverts (Parham 2016b).

5. Table 1 below updates Table 7 from the MMAMP, comparing the calculated HUs lost with the redesigned project ("2016 Scope") with those calculated for the original scope, and with the net HU gained from an abbreviated set of mitigation alternatives. Despite the additional impacts to stream habitat inherent in the project design changes, the benefit from the "Falls 7 and 8" mitigation alternative remains sufficient to offset the total project impacts.

Table 1. Comparison of HUs Lost/Gained between Original and Expanded Project Scope

Location	*2015 Scope With-Project HUs Lost*	2016 Scope With-Project HUs Lost	Mitigation Alternatives – Net HUs Gained		
			"Falls 7"	"Falls 7, 8"	"Falls 7, 8, 11"
EXPECTED SCENARIO					
Manoa Stream	*191*	233	1,308	3,736	5,147
Palolo Stream	*-107*	-59	0	0	0
Makiki Stream	*24*	38	0	0	0
Hausten Ditch	*84*	84	0	0	0
Total	***192***	**295**	**1,308**	**3,736**	**5,147**
WORST CASE SCENARIO					
Manoa Stream	*808*	825	796	2,688	4,065
Palolo Stream	*-29*	-15	0	0	0
Makiki Stream	*11*	29	0	0	0
Hausten Ditch	*420*	420	0	0	0
Total	***1,210***	**1,259**	**796**	**2,688**	**4,065**

References:

U.S. Army Corps of Engineers, Honolulu District (USACE). 2015. Mitigation, Monitoring, and Adaptive Management Plan (draft), Ala Wai Canal Project, Oahu, Hawaii. August 2015.

Parham, James E. 2016a. Ala Wai HSHEP Impact Worksheet Final 07/07/2016 with updated plans. 7 July 2016.

Parham. 2016b. Report on updating the spreadsheet results for the Hawaiian Stream Habitat Evaluation Procedure (HSHEP) associated with the streams in the Ala Wai Canal Flood Risk Management Study. 12 July 2016.

APPENDIX G - SINGLE-USE APPROVAL OF THE HAWAIIAN EVALUATION PROCEDURE FOR THE ALA WAI CANAL FLOOD RISK MANAGEMENT PROJECT, HAWAII, MAY 28, 2015.

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS
441 G STREET, NW
WASHINGTON, DC 20314-1000

REPLY TO
ATTENTION OF

CECW-P

28 May 2015

MEMORANDUM FOR Director, National Ecosystem Restoration Planning Center of Expertise (ECO-PCX)

SUBJECT: Single-Use Approval of the Hawaiian Stream Habitat Evaluation Procedure for the Ala Wai Canal Flood Risk Management Project, Hawaii

1. The HQUSACE Model Certification Panel has reviewed the Hawaiian Stream Habitat Evaluation Procedure (HSHEP) in accordance with EC 1105-2-412 and has determined that the model and its accompanying documentation are sufficient to approve its use for the Ala Wai Canal flood risk managament study, Oahu, Hawaii. Adequate technical reviews have been accomplished and the Panel considered the assessments of the ECO-PCX and the Agency Technical Review in making this determination.

2. The HSHEP model was developed through collaboration between the Hawaii Division of Aquatic Resources and researchers at universities, state agencies, museums, and private entities. The model follows the Habitat Evaluation Procedure concepts and methodology to capture the major aspects of native stream animal ecology, geomorphology of Hawaiian streams, and common modifications to the environment. The intent of the model is to be useful in assessing the potential impacts of stream channel modification, flow alteration, land use change, climate change, stream restoration, and barrier modifications on native stream animal habitat quality and quantity. The HSHEP is designed to be used at site, stream segment, and stream and watershed scales depending on the scenario and level of detail required. Variables at the watershed scale include stream and watershed size, watershed wetness, watershed stewardship, the amount of estuary and shallow water marine habitats associated with the watershed, and the watershed land cover quality. Variables in the model describe instream habitat and animal distributions include factors such as elevation, distance from the ocean, and the presence of instream barriers. Finally, at the site level, more specific characteristics are included as suitability indices for six instream flow assessment (e.g., depth, velocity, and substrate) or habitat assessment (e.g., habitat type, depth, substrate, and temperature for habitat assessment) depending on the project objectives. Habitat suitability for eight species of native stream animals (i.e., five fish, two crustaceans, and one mollusk) was determined using presence/absence data as the basis for habitat utilization. Habitat utilization is the frequency of occurrence for an individual species in each habitat category. Suitability is developed by dividing the percent utilization for each habitat category with the percent available. The resulting suitability curve ranges from 0 (unsuitable) to 1.0 (highly suitable). By combining HSHEP results from multiple scales, the overall model provides an assessment of habitat suitability with respect to its location in a stream and is comparable.

3. The HSHEP model has been reviewed by the Hawaii Division of Aquatic Resources, the USFWS and private consultants utilizing the model for hydroelectric licensing applications. Additionally, the ECO-PCX managed a review of the HSHEP model. The review was conducted by an ecologist with expertise in tropical island flora and fauna, associated habitat requirements, and extensive ecological modeling expertise, Dr. Kyle McKay, ERDC Environmental Laboratory. Comments received pursuant to this review recommended actions to clarify and improve model documentation and improve the overall usability of the model. The model documentation and inherent user's guide was

updated to more explicitly describe the intended use and appropriate documentation for variables, use of scales, and addition of variables. Documentation was improved to further detail application methodology, assumptions and limitations of the model, and address statistical model development issues.

4. The HSHEP has sufficient technical quality, is computationally correct, meets usability criteria and is policy compliant.

APPLICABILITY: The HSHEP is approved for single use on the Ala Wai Canal flood risk management study, Oahu, Hawaii.

Bruce D Carlson

BRUCE D. CARLSON
Deputy Chief, Planning and Policy Division
Directorate of Civil Works

APPENDIX H – STATE OF HAWAII, DIVISION OF AQUATIC RESOURCES, DEPARTMENT OF LAND AND NATURAL RESOURCES.

DAVID Y. IGE
GOVERNOR OF HAWAII

SUZANNE D. CASE
CHAIRPERSON
BOARD OF LAND AND NATURAL RESOU
COMMISSION ON WATER RESOURCE MANA

KEKOA KALUHIWA
FIRST DEPUTY

JEFFREY T. PEARSON P.E.
DEPUTY DIRECTOR - WATER

AQUATIC RESOURCES
BOATING AND OCEAN RECREATION
BUREAU OF CONVEYANCES
COMMISSION ON WATER RESOURCE MANA
CONSERVATION AND COASTAL LAN
CONSERVATION AND RESOURCES ENFORC
ENGINEERING
FORESTRY AND WILDLIFE
HISTORIC PRESERVATION
KAHOOLAWE ISLAND RESERVE COMMIS
LAND
STATE PARKS

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES
DIVISION OF AQUATIC RESOURCES
1151 PUNCHBOWL STREET, ROOM 330
HONOLULU, HAWAII 96813

October 27, 2016

Mary Abrams, Project Leader
U.S. Fish and Wildlife Service
Pacific Islands Fish and Wildlife Office
300 Ala Moana Boulevard
Honolulu, Hawaii 96850

Dear Ms. Abrams:

The Division of Aquatic Resources (DAR), Department of Land and Natural Resources (DLNR) has been collaborating and conducting stream habitat and fish surveys along with U.S. Fish and Wildlife damselfly surveys on the Ala Wai Canal Flood Risk Management Study streams- Makiki, Manoa and Palolo. The data and results of this study were incorporated into the Fish and Wildlife Coordination Act (FWCA) report.

Project impacts include habitat loss from the footprint of the debris/detention basins and dam culverts to slow flood flows and fish migration barrier issues. In stream habitat loss can be mitigated by removal of migration barriers at Falls 7 and 8 to facilitate migration of native gobies, *'O'opu nakea,* and *'O'opu nopili,* through the various reaches of Manoa stream from the ocean which DAR fully supports. The distribution of *'O'opu naniha* is not usually found above these falls. These barriers are undercut preventing the native gobies from migrating upstream. Based on previous experience in the restoration of an undercut barriers in Waihee Stream on Oahu, DAR recommends that the modification to the barrier provide a surface of contact that has slope angle of near vertical to prevent invasive species migrating upstream.

USFWS staff conducted damselfly surveys on Ala Wai streams and discovered the federally listed blackline damselfly, *Megalagrion nigrohamatum nigrolineatum*, which is restricted to the island of Oahu, occurring at two sites: the Waihi Stream and Waiakeakua Stream Debris and Detention Basins on Manoa Stream. This was selected as the evaluation species for this study.

The Stream Habitat Evaluation Procedure (HSHEP) for the Ala Wai Canal Flood Risk Management Study was modeled for in stream native fish habitat and therefore didn't capture the importance and unique riffle/pool and riparian ecological qualities of Waihi Stream and Waiakeakua Stream for Hawaiian damselflies. The Service considers the riffle/pool and riparian habitat at Waihi Stream and Waiakeakua Stream to meet the definition of Resource Category 2 (Habitat to be impacted is of high value for evaluation species and is relatively scarce or becoming scarce on a national basis or in the ecoregion section).

DAR agrees on the Service's recommendation that the Debris and Detention Basins at Waihi Stream and Waiakeakua Stream be moved to a site lower in the Manoa Stream catchment to avoid project construction-related impacts to *M. nigrhamatum nigrolineatum* and habitat at Waihi Stream and Waiakeakua streams. If moving the debris and detention basins at Waihi and Waiakeakua Streams is not feasible, then we recommend the Service, USACE and State of Hawaii Department of Land and Natural Resources work together to develop appropriate mitigation to offset unavoidable project impacts to Resource Category 2 riffle/pool habitat and riparian habitat.

DAR agrees on the Service's construction and maintenance BMPS and further recommendations that a risk assessment be conducted to evaluate the potential hazards that may arise from mobilization of contaminated stream sediments and that post-construction monitoring be conducted to confirm anticipated project-related impacts did not exceed expectations. Finally, the USACE shall designate an individual to oversee compliance of each BMP during clearing operations on a daily basis and report all results to the USACE on a regular basis during clearing operations.

Thank you for providing DAR the opportunity to review and comment on the FWCA report.

Sincerely,

Bruce S. Anderson, Ph.D.
Administrator

DEPARTMENT OF THE ARMY
HONOLULU DISTRICT, U.S. ARMY CORPS OF ENGINEERS
FORT SHAFTER, HAWAII 96858-5440

November 1, 2016

Civil and Public Works Branch
Programs and Project Management Division

Kevin Foster
Pacific Islands Fish and Wildlife Office
U.S. Fish and Wildlife Service
300 Ala Moana Boulevard, Room 3-122
Box 50088
Honolulu, Hawaii 96850

Dear Mr. Foster:

Thank you for taking the time to provide the U.S. Army Corps of Engineers (USACE) with a final Fish and Wildlife Coordination Act report (CAR) for the Ala Wai Canal Flood Risk Management study. We have fully considered the comments included in the CAR and provide the following response to you in the interests of open communication and coordination between our agencies.

USACE Engineering Regulations (ER) 1105-2-100 Appendix C provides a prescriptive process for the development of compensatory mitigation for aquatic resource impacts of civil works projects. Included below is information related to how the mitigation plan has evolved to provide you with additional context for the selection of the current mitigation plan and the USACE investment recommendation to Congress. The process utilized is outlined below for your information and future use:

1. Inventory and categorize ecological resources

A series of resource inventories conducted by USACE and others have been utilized in this study. In addition to a species list for the study area provided by USFWS in 2008, natural resource inventories were completed by AECOS under contract to USACE in 2010 and 2014 which have been shared with your agency. At a 14 OCT 2014 meeting to discuss Fish and Wildlife Coordination Act compliance, USFWS encouraged USACE to utilize the best available information from the State of Hawaii. In response to this request, specific stream surveys were conducted by the State of Hawaii, along with James Parham of the Bishop Museum, as in-kind and contract services for the study to parameterize the habitat modeling utilized to assess the current, future without-project condition, and future with-project condition.

2. Determine significant net losses

Assessment of impacts resulting from the alternative plans was conducted through use of the Hawaii Stream Habitat Evaluation Procedure (HSHEP). A 23 JAN 2015 meeting was convened to provide USFWS a presentation on the HSHEP model and discuss its use in the study. At that time, 10% conceptual designs were presented and initial impacts and potential mitigation measures were assessed and discussed. HSHEP utilizes multiple scales of analysis ranging from a watershed scale to site-specific scale assessment to evaluate impacts. The model assesses both the amount of habitat available as well as the quality of habitat through the habitat suitability index. This includes stream habitat types and geomorphic characteristics including cascades, riffles, runs, various types of pools and substrate types. Ground cover and watershed condition are also included to characterize the riparian environment. Survey data is utilized to verify the frequency of selected species within each habitat. The model then applies those physical parameters to the ecological habitat needs of fourteen different species. Loss of habitat can occur from physical displacement of habitat as a result of project feature and/or elimination of access to upstream habitat for migratory species as a result of an ecological barrier (dam, vertical impoundment, velocity barrier, etc.). It was the understanding of USACE from the 23 JAN 2015 meeting that both the State of Hawaii and USFWS were generally supportive of the use of HSHEP in evaluating impacts under the National Environmental Policy Act. Use of the HSHEP model was approved by USACE on 28 MAY 2015 and the technical sufficiency of the model was affirmed through an internal review.

3. Define mitigation planning objectives

The 23 JAN 2015 meeting further explored the mitigation planning objectives, screening criteria for mitigation plans, and plan selection constraints with USFWS. In general, USACE was encouraged by USFWS and the State of Hawaii to adopt a watershed context to mitigation as opposed to mitigating individual impacts at specific project sites. Criteria utilized in screening mitigation plans included technical feasibility, the likelihood of success in Hawaii, dependency on other features, potential for reducing flood risk, implementation cost, cost effectiveness, land availability and ownership, operations and maintenance requirements, acceptability, avoidance of adverse effects to biological resources, avoidance of adverse effects to cultural resources and avoidance of adverse effects on mobilization of contaminated sediments. USACE consequently evaluated a number of mitigation plans that focused on a holistic substitute of fish and wildlife resources as opposed to direct replacement mitigation approach (per 40 CFR 1508.20). The fundamental assumption with this approach is that at a minimum, no net loss in the cumulative habitat value within the watershed will occur as a result of the mitigation.

4. Define a common unit of measurement

Mitigation for adverse impacts proposed by USACE must be quantified in a common unit of measurement. The common unit of measurement utilized in the HSHEP model is habitat units (HUs). HUs are the expected average annual quantity of a specific quality of habitat expected to be found in a given areas. HUs are spatially explicit and are evaluated throughout the watershed in a number of temporal conditions including existing conditions as well as future without-project and future with-project conditions. USACE assumes that the HSHEP model assessment of HUs integrates all of the critical considerations of adverse and beneficial project impacts including assessment of habitat type, quality of habitat and position of specific habitat within important ecological regions of the watershed. Habitat impacts at locations such as Waihi Basin and Waiakeakua Basin, for example, include specific physical parameters such as quality of riffle and pool habitat in the with- and without-project condition.

5. Identify and assess mitigation strategies

The initial concepts for mitigation measures were presented at the 23 JAN 2015 and received tentative support from both USFWS and the State of Hawaii. These concepts were further refined and included in the draft Feasibility Report and integrated Environmental Impact Statement which was released for public review on 20 AUG 2015.

6. Define and estimate costs of mitigation plan increments

Under USACE ER 1105-2-100 Appendix C, USACE is required to perform an incremental cost analysis in order to justify the least cost mitigation plan that provides full mitigation of losses. This analysis utilizes estimated costs for mitigation features and compares the relative benefit defined under the common metric of HUs. As noted in the mitigation plan included in Appendix E of the Feasibility Report and Environmental Impact Statement, increments required to achieve replacement of HUs includes promotion of fish passage at Falls 7 and Falls 8 of Manoa Stream. Implementation of the mitigation plan at Falls 7 did not fully replace the HUs lost as a result of the flood risk management project, however, with the addition of Falls 8, the number of HUs dramatically exceeds the losses estimated. As a result, the combined flood risk management features and mitigation features are estimated to provide a net benefit in HUs to the watershed.

The FWCA report provided by USFWS includes a number of recommendations for consideration in the selection of a recommended plan. As noted above, USACE has fully considered those comments and provides its response below.

<u>Avoidance and minimization of impacts</u>. USFWS has encouraged USACE to relocate the Waihi Detention Basin further downstream to avoid impacts to Endangered Species Act (ESA) protected damselflies that have been found in the area. It is worth noting that a biological opinion (bi-op) received from separate ESA Section 7 consultation with USFWS and the bi-op proposes relocation of the basin as well as other actions to minimize a take of ESA species. USACE has agreed to perform several actions to minimize impacts to ESA species under the bi-op, however, the location of the detention basins is seen as an unavoidable impact. USACE has concluded that moving the basins further downstream would induce additional risk to surrounding homes while moving the basins upstream would potentially increase environmental impacts. For this reason, the basins were not moved to avoid the assessed impacts. In addition, many of the upstream detention basins on other tributaries include excavation to meet flood storage targets whereas in the Manoa basins (Waihi and Waiakeakua) given the environmental sensitivity, excavation for flood storage was eliminated altogether in order to avoid adverse impacts.

Compensatory mitigation. The CAR notes the use of HSHEP to evaluate impacts resulting from flood risk management features throughout the watershed. While the CAR identifies two of the fish species utilized in HSHEP, it is worth noting that the model also includes habitat evaluations of additional fish species, as well as crustaceans and mollusks. The governing assumption is that the diversity of the species selected accounts for the habitat quality over a range of ecological habitat requisites. Further, it should be acknowledged that the HSHEP model specifically accounts for various types of riffle and pool habitat. While the CAR posits that the habitat lost in the area of Waihi and Waiakeakua is of unique value, USFWS fails to demonstrate how those losses are unaccounted for in the HSHEP model other than through conjecture. In fact, the impacts assessed for the Manoa valley features constitute 78% of the overall permanent adverse impacts from the flood risk management features even though the features in Manoa compose only 46% of the total area permanently impacted by the project: 233 HUs lost in Manoa valley of the 295 HUs lost for the entire project. The root of the disparity in acreage impacted versus HUs lost is due to the quality of habitat lost, as calculated by the HSHEP model; i.e. quality of habitat is a key consideration in the impact assessment. As such, the USACE position is that the HSHEP analysis uses appropriate resource categorization to account for both the quality and quantity of habitat lost as a result of the Waihi and Waiakeakua features. It is also worth noting that the mitigation features proposed at Falls 7 and Falls 8 are both located on Manoa stream which will receive an estimated net gain of 3736 HUs as a result of the mitigation plan. The amount of mitigation provided on a HU basis will far overcompensate for the losses. This is a result of the dual estimates (estimated and worst case scenario) provided by the analysis, but also is a function of the magnitude of benefits provided by restoring fish passage above Falls 8, which will open a significant aquatic corridor within the Manoa stream.

It is noted that the CAR calls for an additional 3:1 replacement of habitat for compensatory mitigation for the Waihi and Waiakeakua stream impacts. Given the information in the preceding paragraph, USACE is unable to justify further compensatory mitigation for adverse impacts beyond what is proposed in the mitigation plan. However, it is unclear how USFWS calculated permanent losses within these areas to arrive at its compensatory mitigation recommendation. Based on information provided to USFWS, accounting for the construction limits and access roads as permanent impacts from the detention basins, the estimated impacts from the Waihi and Waiakeakua detention basins are respectively 81,225 ft^2 and 94,400 ft^2, totaling 175,625 ft^2 or approximately four acres. This is a significant difference from the 314,030 ft^2 calculated by USFWS in the CAR, however the CAR estimates unfortunately are not further supported with any maps or analysis which could be used verify how USFWS arrived at its determination.

Contaminated Sediments. At the 23 JAN 2015 meeting between USFWS and USACE, USACE identified several contaminated sites within the watershed which provided a planning constraint on the mitigation plan. This criteria was further applied as selection criteria for the recommended mitigation plan. Consequently, known contaminated sites have been avoided throughout the development of the recommended plan. USACE is aware of the concerns related to remobilization of sediment, in general, throughout the duration of the project. Sediment mobilization will primarily be addressed through best management practices identified in Section 5 of the Feasibility Study and Environmental Impact Statement. Erosion and sediment control will be revisited during the Design Phase in order to ensure that adequate measures are in place to minimize sediment mobilization during construction. An operations and maintenance plan will also be developed which will dictate erosion and sediment control criteria during post-construction activities conducted by the non-Federal sponsor. On balance, it is assumed that construction of the debris and detention basins will have a minor positive impact on sediment mobilization in the watershed due to the flow attenuating characteristics of the basins.

Post-Construction Monitoring. Through Section 7 ESA consultation, USACE has agreed to provide monitoring of damselflies for ESA compliance in the vicinity of the Waihi and Waiakeakua detention basins at three specific periods: a preconstruction site survey, a post-construction site survey and an additional survey within one-year of construction completion. This appears to be consistent with the recommendations of the CAR. Additional monitoring of the mitigation sites will occur annually for no more than five years following the completion of the construction, as specified in Appendix E of the Feasibility Report and Environmental Impact Statement.

Best Management Practices. The guidelines provided in the CAR for implementation of best management practices to reduce sediment erosion during construction appear to be reproduced from the USACE Clean Water Act (CWA) Section 404 regulatory guidelines. USACE has no objection to these guidelines in principle, however, be advised that USACE does not seek permits from its own agency for the construction of Civil Works projects. Methods to control site erosion are outlined in Section 5 of the Feasibility Report and Environmental Impact Statement and will be further refined during the Design Phase of the project.

Thank you again for your participation in the development of this study. If you have any questions or require additional information, please contact USACE at (808) 835-4031 or email michael.d.wyatt@usace.army.mil.

Sincerely,

Michael D. Wyatt
Senior Planner/Project Manager

Appendix E~~7~~8

~~Draft~~EIS Record of Decision

This page is intentionally left blank.

RECORD OF DECISION

ALA WAI CANAL FLOOD RISK MANAGEMENT STUDY
OAHU, HAWAII

The Final Integrated Feasibility Report and Environmental Impact Statement (IFR/EIS) dated 7 April 2017, for the Ala Wai Canal Flood Risk Management Study addresses flood risk management opportunities and feasibility in the Ala Wai watershed in the City of Honolulu, Island of Oahu, Hawaii. The final recommendation is contained in the report of the Chief of Engineers, dated 21 December 2017. Based on these reports, the reviews by other Federal, State, and local agencies, Tribes, input of the public, and the review by my staff, I find the plan recommended by the Chief of Engineers to be technically feasible, economically justified, in accordance with environmental statutes, and the public interest.

The Final IFR/EIS, 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:

- Six in-stream debris and detention basins of varying height in the upper reaches of the watershed, one standalone debris catchment structure, three multi-purpose detention basins, floodwalls along the Ala Wai Canal averaging four feet in height and an earthen levee at the perimeter of an adjacent golf course averaging seven feet in height, two pump stations to reduce the threat of interior flooding, and a flood warning system

- Implementation of the environmental compensatory mitigation and associated monitoring and adaptive management plan. Monitoring will continue until the mitigation is determined to be successful based on the identified criteria within the Final Mitigation and Monitoring Plan included in Appendix E2. Monitoring is expected to last no more than 5 years.

In addition to a "no action" plan, a range of structural and non-structural alternatives were evaluated. The alternatives included an initial screening on a wide variety of management measures at a qualitative level. Management measures to reduce peak flows, increase channel capacities, improve debris management and channel maintenance, as well as non-structural measures to reduce flooding consequences were considered. Management measures carried forward past the initial screening were grouped into combinations of management measures consisting of five alternative plans in addition to the No Action plan. Alternatives considered included a Manoa Dam, multiple debris and detention basins in the developed portion of the watershed, multiple debris and detention basins in the upper watershed, a focus on line of protection along the Ala Wai Canal, and a non-structural alternative that included land purchases and relocations in flood-prone areas. Alternative Plans were screened at a qualitative level and two alternatives, in addition to the No Action Alternative, were carried forward into the final array of alternative plans. The final array of plans were developed at a 10% level of design, and quantitative technical analysis was applied. Based on an evaluation and comparison of environmental effects and criteria established under USACE guidance, the recommended plan was selected. Alternative 3A-2.2, which is the National Economic Development (NED) plan and the environmentally preferable alternative, would reduce the risks associated with a flood event with a 1-percent annual chance of exceedance with 95-percent conditional non-exceedance probability.

For all alternatives, the potential effects to the following resources were evaluated:

	In-depth evaluation conducted	Brief evaluation due to minor effects	Resource unaffected by action
Air quality and climate change	☐	☒	☐
Biological resources	☒	☐	☐
Threatened/Endangered species	☒	☐	☐
Cultural resources	☐	☒	☐
Hazardous, toxic & radioactive waste	☐	☐	☒
Hydrology and hydraulics	☒	☐	☐
Land use	☐	☒	☐
Noise	☐	☒	☐
Public health and safety	☐	☒	☐
Public services and utilities	☐	☒	☐
Socio-economics and environmental justice	☐	☒	☐
Geology, seismicity and soils	☐	☒	☐
Water quality	☐	☒	☐
Groundwater resources	☐	☒	☐
Surface water resources	☐	☒	☐
Recreation	☐	☒	☐
Visual resources	☐	☒	☐
Transportation and traffic	☐	☒	☐

All practical 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/EIS will be implemented to minimize impacts. Consistent with reducing flood risk in an environmentally sustainable manner, the project will be designed, constructed and operated to avoid impacts to native aquatic species by incorporating natural bottom arch culverts to maintain species passage where appropriate and by limiting work in the streams to low-flow conditions. All practicable means to avoid or minimize adverse environmental effects have been incorporated into the recommended plan.

The recommended plan will result in unavoidable adverse impacts to stream and aquatic habitat. To mitigate for these unavoidable adverse impacts, the U.S. Army Corps of Engineers will construct improvements in conjunction with the construction of the recommended plan, consisting of to two in-stream structures to eliminate a migratory passage barrier for aquatic species on the Manoa stream. The compensatory mitigation will be monitored for 10 years to ensure the project is successful and sustainable.

Pursuant to section 7 of the Endangered Species Act of 1973, as amended, the U.S. Fish and Wildlife Service (FWS) issued a biological opinion, dated 1 August 2016, that determined that the recommended plan will not jeopardize the continued existence of the following federally listed species or adversely modify designated critical habitat: blackline Hawaiian damselfly (*Megalagrion nigrohamatum nigrolineatum*). All terms and conditions, conservation measures, and reasonable and prudent alternatives and measures resulting from these consultations shall be implemented in order to minimize take of endangered species and avoid jeopardizing the species.

Pursuant to section 106 of the National Historic Preservation Act of 1966, as amended, the U.S. Army Corps of Engineers determined that historic properties may be adversely affected by the recommended plan. The Corps and the Hawaii State Historic Preservation Officer entered into a Programmatic Agreement (PA), dated 9 November 2016. All terms and conditions resulting from the agreement shall be implemented in order to minimize adverse impacts to 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 E3 of the IFR/EIS.

A water quality certification pursuant to section 401 of the Clean Water Act will obtained from the State of Hawaii, Department of Health prior to construction. In a letter dated 1 January 2017, the State of Hawaii, Department of Health provided a letter which requested construction-specific information in order to meet the requirements of the water quality certification. Approvals are 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.

A determination of consistency with the State of Hawaii Coastal Zone Management program pursuant to the Coastal Zone Management Act of 1972 was obtained from the State of Hawaii, Office of Planning. All conditions of the consistency determination shall be implemented in order to minimize adverse impacts to the coastal zone.

Public review of the draft IFR/EIS was completed on 9 November 2015. All comments submitted during the public comment period were responded to in the Final IFR/EIS. A 30-day waiting period and state and agency review of the Final IFR/EIS was completed on 25 June 2017. As a result of state and agency review, an errata was added to the final IFR/EIS to add clarifications and correct errors within the report; no significant changes to the report resulted from the review.

Technical, environmental, and economic 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 the review of these evaluations, I find that benefits of the recommended plan outweigh the costs and any adverse effects. This Record of Decision completes the National Environmental Policy Act process.

SEP 13 2018

Date

R.D. James
Assistant Secretary of the Army
(Civil Works)

Appendix E9
Essential Fish Habitat (EFH) Assessment

This page is intentionally left blank.

ESSENTIAL FISH HABITAT ASSESSMENT

ALA WAI CANAL PROJECT
OAHU, HAWAII

Prepared by:
U.S. ARMY ENGINEER DISTRICT, ALASKA
ENVIRONMENTAL RESOURCES SECTION

For:
HONOLULU DISTRICT, U.S. ARMY CORPS OF ENGINEERS
CIVIL AND PUBLIC WORKS BRANCH
PROGRAMS AND PROJECT MANAGEMENT DIVISION
FORT SHAFTER, HAWAII

March 2016

updated July 2016

ESSENTIAL FISH HABITAT ASSESSMENT

Ala Wai Canal Project
Oahu, Hawaii

1. Introduction

1.1 Preface
The 1996 amendments to the Magnuson-Stevens Fishery Conservation and Management Act set forth the essential fish habitat (EFH) provision to identify and protect important habitats of federally managed marine and anadromous fish species. Federal agencies that fund, permit, or undertake activities that may adversely affect EFH are required to consult with the National Marine Fisheries Service (NMFS) regarding the potential effects of their actions on EFH and respond in writing to NMFS recommendations.

EFH is defined as those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity. “Waters” include aquatic areas and their associated physical, chemical, and biological properties that are used by fish, and may include aquatic areas historically used by fish where appropriate. ”Substrate” includes sediment, hard bottom, structures underlying the waters, and associated biological communities.

1.2 Project Purpose
The purpose of the project is to reduce flood risk within the Ala Wai Watershed, which includes lands within and upgradient of central Honolulu, Hawaii. Flooding has occurred within the watershed on multiple occasions, resulting in recorded property damages and health and safety risks. Flooding can result from typical rainfall events, and is exacerbated by the flashy nature of the streams, and by debris generated by the surrounding watershed. Historic alterations to the stream channels do not adequately manage flood risk. Analyses conducted in support of this project show that the 1-percent annual chance exceedance (ACE) floodplain extends over approximately 1,358 acres of the watershed. Modeling results indicate the 1-percent ACE flood would result in damages to more than 3,000 structures, with approximately $318 million in structural damages alone (USACE 2015).

1.3 Project Authority
The Ala Wai Canal Project feasibility study is authorized under Section 209 of the Flood Control Act of 1962 (Public Law 87-874). Section 209 is a general study authority that authorizes surveys of harbors and rivers in Hawaii “with a view to determining the advisability of improvements in the interest of navigation, flood control, hydroelectric power development, water supply, and other beneficial water uses, and related land resources.”

The Corps is the Federal sponsor of the project; the non-Federal sponsor is the State of Hawaii Department of Land and Natural Resources (DLNR), represented by the Engineering Division. A Feasibility Cost Sharing Agreement (FCSA) was originally executed with DLNR in March 2001; the agreement was amended in December 2006 and November 2012.

1.4 Project Area Description

The Ala Wai watershed is located on the southeastern side of the island of Oahu. The watershed encompasses 19 square miles (12,064 acres) and extends roughly 5 miles from the ridge of the Koʻolau Mountains to the near-shore waters of Mamala Bay. It includes the drainages of Makiki, Manoa, and Palolo streams, which flow to the Ala Wai Canal, a 2-mile-long, man-made waterway constructed during the 1920s to drain extensive coastal wetlands. This construction and subsequent draining allowed the development of the Waikiki District. The study area is shown in Figure 1.

The Ala Wai watershed contains approximately 200,000 residents, and is the most densely populated watershed in Hawaii. The upper portion (approximately 7.5 square miles, or 40 percent of the watershed) is zoned as Conservation District, which is intended to protect natural and cultural resources, including the island's aquifer. The remaining approximately 11 square miles of the middle and lower watershed is heavily urbanized, supporting a high density of single-family residences, condominiums, hotels, businesses, and schools.

1.5 Project Description

The Ala Wai Project "tentatively selected plan" consists of multiple structures intended to slow and temporarily detain high flows of water within the watershed and reduce the risk of flooding, particularly in the Waikiki area and the lower portions of the watershed, and to also create locations where debris swept into the streams will preferentially accumulate for more effective removal from the stream system. These structures include floodwalls along the Ala Wai Canal, 3 large multi-purpose detention basins in the lower watershed, 6 in-stream debris and detention basins in the upper watershed, and 1 standalone debris catchment structure. In addition, the plan includes improvements to the flood warning system, and compensatory mitigation in the form of in-stream improvements to eliminate migratory passage barriers for native species at two locations.

These plan components are described in detail in the draft feasibility report/environmental impact statement (FR/EIS; USACE 2015); the structural components are summarized in Table 1 below, and their locations shown on Figure 1. The existing project design drawings (35% stage for the flood risk management structures, 10% stage for the mitigation features) were provided to the NMFS previously.

Table 1 – Summary of Ala Wai Project Structural Components

1	Ala Wai Canal floodwalls	Concrete floodwalls along Ala Wai Canal, approx. 1.7 miles along the left bank and 0.9 mile along the right bank, ranging up to approximately 5 feet high; three pump stations and gates to address potential flooding on land-side of floodwalls
2	Hausten Ditch detention basin	Concrete floodwalls and earthen berm (4.3 feet high) to provide detention for local drainage; install slide gates at existing bridge to control flow of floodwaters between Hausten Ditch and Ala Wai Canal
3	Ala Wai Golf Course multi-purpose detention basin	Earthen berm, up to approximately 7 feet high around outside perimeter of golf course property, with floodgate across main entrance road; passive drainage back into Ala Wai Canal
4	Kanewai Field multi-purpose detention basin	Earthen berm, approximately 9 feet high, around 3 sides of the field; grouted rip-rap inflow spillway along bank of Mānoa Stream to allow high flows to enter the basin; existing drainage pipe at south end of basin to allow water to re-enter stream.
5	Manoa in-stream debris catchment	Concrete pad, approximately 8 feet wide and 60 feet across, within concrete-lined portion of stream channel; steel posts (up to approx.7 feet high) evenly spaced 4 feet apart along concrete pad.
6	Makiki debris and detention basin	Earthen dam surfaced with concrete spillway above culvert and rip-rap on upstream and downstream sides, approximately 24 feet high and 100 feet across; arch culvert to allow small storm flows to pass. Debris catchment feature located on upstream end of culvert. New access road to be constructed for construction and O&M.
7	Woodlawn Ditch detention basin	Three-sided berm, approximately 15 feet high and 840 feet across; arch culvert to allow small storm flows to pass; concrete spillway above culvert with rip-rap on upstream and downstream side
8	Pukele debris and detention basin	Earthen dam, approximately 30 feet high and 120 feet across; box culvert to allow small storm flows to pass; concrete spillway above culvert with grouted rip-rap on upstream and downstream side; debris catchment feature located on upstream end of culvert; approx. 150 feet of riprap scour protection downstream of culvert. Excavation of 14,330 yd3 to provide required detention volume upstream of berm. New access road to be constructed for construction and O&M.
9	Wai'oma'o debris and detention basin	Earthen dam, approximately 33.5 feet high and 120 feet across; box culvert to allow small storm flows to pass; concrete spillway above culvert, with grouted rip-rap on upstream and downstream side; debris catchment feature located on upstream end of culvert; approx. 150 feet of riprap scour protection downstream of culvert. Excavation of approx. 3,060 yd3 to provide required detention volume upstream of berm; low-flow channel with existing substrate to be restored following excavation. New access road to be constructed for construction and O&M.
10	Waiakeakua debris and detention basin	Earthen dam, approximately 34 feet high and 185 feet across; arch culvert to allow small storm flows to pass; concrete spillway above culvert with grouted rip-rap on upstream and downstream side; debris catchment feature located on upstream end of culvert; approx. 150 feet of riprap scour protection downstream of culvert .New access road to be constructed for construction and O&M.
11	Waihi debris and detention basin	Earthen dam, approximately 37 feet high and 225 feet across; box culvert to allow small storm flows to pass; concrete spillway above culvert with grouted rip-rap on upstream and downstream side; debris catchment feature located on upstream end of culvert; approx. 150 feet of riprap scour protection downstream of culvert . New access road to be constructed for construction and O&M.

12	Mitigation Measure Falls 7	Remove overhanging lip associated with undercutting at existing in–stream structure within Manoa Stream, approximately 0.6 mile upstream of Manoa District Park
13	Mitigation Measure Falls 8	Remove overhanging lip associated with undercutting at existing in–stream structure within Manoa Stream, approximately 0.7 mile upstream of Manoa District Park

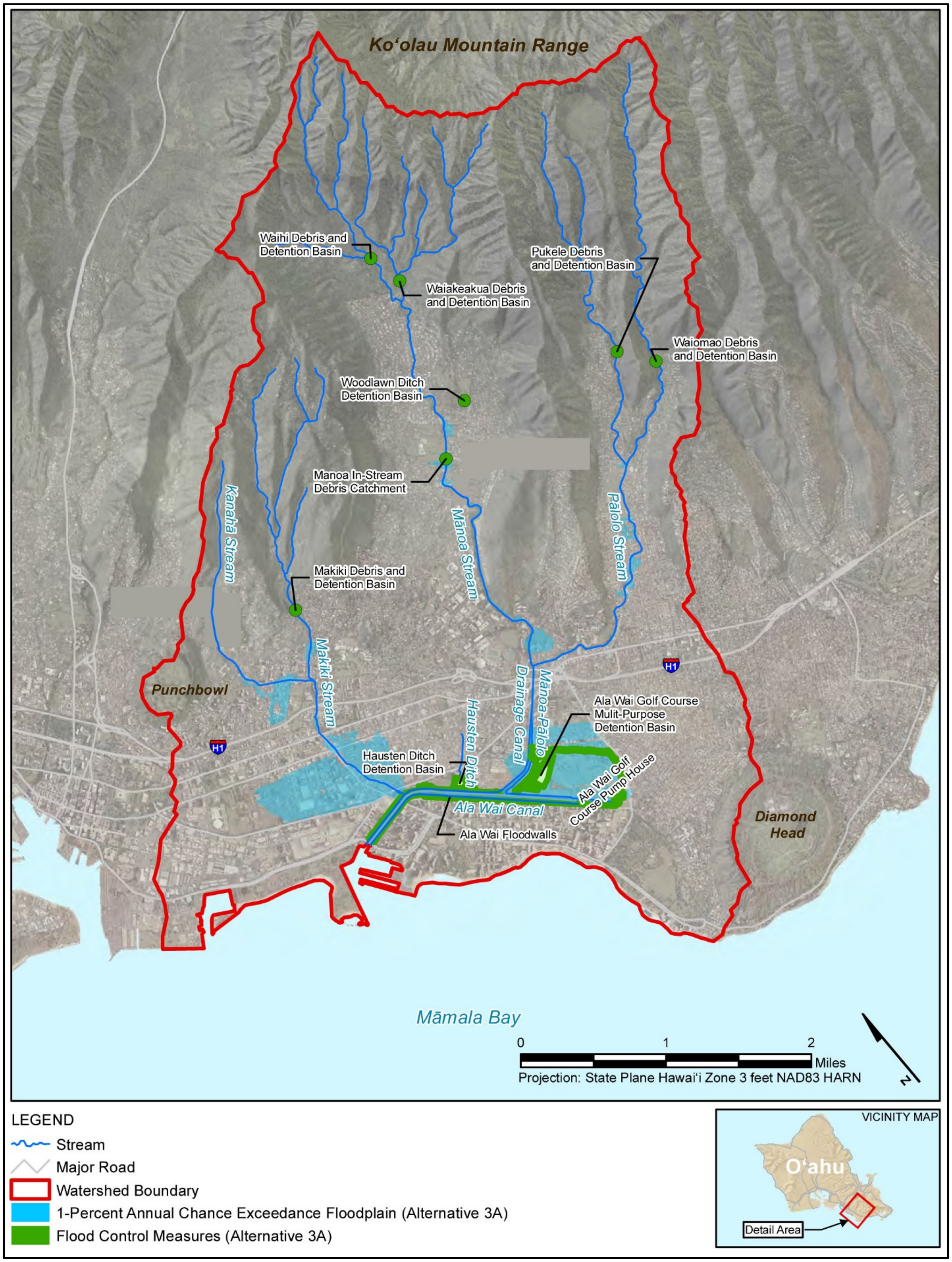


Figure 1. Location of Ala Wai Watershed and Project Features (adapted from USACE 2015).

Post-construction operations and maintenance (O&M) at each of the structures will include periodic inspections, controlling vegetation within the project limits (allowing no woody vegetation to grow, and trimming other vegetation to 6 inches or less) twice per year, and clearing accumulated debris (i.e., organic detritus and trash) annually and after flood events. In general the project limit for each feature will extend no further than 20 from the dam or berm. An exception is the Wai'oma'o debris and detention basin, the construction of which will include excavation of an expanded detention basin upstream of the dam; the roughly 250-foot-by-100-foot area cleared for the excavation will be included in the project limit and maintained as described above.

2. Essential Fish Habitat

Essential fish habitat (EFH) in the marine waters surrounding the Hawaiian Islands is described in two fishery ecosystem plans (FEPs) prepared by the Western Pacific Regional Fishery Management Council (WPRFMC). The FEP for the Hawaiian Archipelago (WPRFMC 2009a) specifically manages demersal resources and habitats associated with the extended Hawaiian Islands, while pelagic resources are managed under a separate Pacific Pelagic FEP (WPRFMC 2009b).

No EFH exists in the project areas. The Ala Wai Canal, which receives surface waters from the Ala Wai watershed, is contiguous with Mamala Bay (figure 1), which fronts much of the southeast Oahu coastline. The draft FR/EIS identified the following EFH as being present in Mamala Bay:

- Bottomfish: water column down to 400 meters from shoreline out to the 200-mile U.S. Exclusive Economic Zone (EEZ) boundary (for eggs and larvae); and water column and all bottom habitat from shoreline to a depth of meters (for juveniles and adults);
- Coral Reef Ecosystem: Water column and all bottom substrate down to 100 meters depth from shoreline out to EEZ boundary;
- Crustaceans (lobsters/crab): Water column down to 150 meters depth from shoreline out to EEZ boundary (for eggs and larvae); and bottom from shoreline down to 100 meters depth (for juveniles and adults);
- Pelagics: water column down to 200 meters (for eggs and larvae) and 1,000 meters (for juveniles and adults) from shoreline out to EEZ boundary.

3. Essential Fish Habitat Evaluation

The Ala Wai Canal draft FR/EIS (USACE 2015) made the determination that the project will have no adverse effect on the EFH described above. The NMFS has stated that it believes that the project activities may adversely affect EFH in Mamala Bay due to potential increases in sedimentation and turbidity (Goldberg 2016). These potential indirect effects to marine resources proposed by the NMFS are plausible to the extent that the project activities could introduce quantities of sediment into the Ala Wai watershed sufficiently large that effects on the marine environment beyond the watershed could reasonably be anticipated.

The risk of discharge of sediment into the watershed at a particular project site would be related to the amount of soil or sediment disturbed during construction or maintenance activities, and to the proximity of those activities to a stream channel. Referring to the Table 1 summary of project structural components, components 1 through 4 involve no or very limited work within a stream channel, and earthwork that is confined to uplands. The Ala Wai Golf Course, Hausten Ditch, and Kanewai Field multi-purpose detention basins create basins that are outside the stream channel, and require at most minor modifications to portions of the existing stream banks to create spillways that would function during high-flow conditions. Component 5 involves installation of steel poles and an additional concrete pad within an existing concrete-lined portion of Manoa Stream, and would disturb no soil or sediment. Likewise, the compensatory mitigation features (components 12 and 13) involve the construction of small rock structures that within the stream channel that should require the disturbance of little or no soil or sediment.

Elements 6 through 11 are detention basins constructed within stream channels, and have the greatest potential for introducing sediment into the watershed during construction and maintenance in the absence of appropriate sediment management measures.

The following analysis of project impacts on water quality in general within the project area is extracted directly from Section 5.6 of the draft FR/EIS; the sources cited within the passage below are likewise provided in that document:

> *5.6.1.2 Environmental Setting*
> The quality of surface water and groundwater resources can be affected by a variety of pollutants, resulting from both natural and human-derived sources. Given the heavily developed nature of the Ala Wai Watershed, groundwater and surface water resources are especially vulnerable to contamination and other changes in quality, particularly within the urbanized areas. Following is a description of the existing quality of surface and groundwater resources within the Ala Wai Watershed.
>
> *Surface Water Quality*
> Numerous studies have investigated the extent of pollution in the water column and sediments within the Ala Wai Canal, with a few studies also sampling the main streams in the watershed. In general, these studies have identified problems related to bacteria, trace metals, nutrients, pesticides, toxic organics, and sediment (Edward K. Noda, 1992a, 1992b, and 1992c; Laws et al., 1993; DOH, 1997a; DOH, 2002; Anthony et al., 2004; De Carlo et al., 2004); these are briefly described below. In addition to these constituents, significant amounts of trash and debris are commonly observed in the streams and canals.
>
> • Bacteria: High levels of fecal coliform, enterococcus bacteria and other indicators of fecal pollution (e.g., *Clostridium perfringens*) have been detected in the Ala Wai Canal and streams,

particularly after runoff events (DOH, 1997a). Leptospirosis, a bacterial infection spread primarily through animals (e.g., rats), is another problem in tropical waters; cases in Hawai'i have been reported by people swimming in stream waters. Although no studies have been conducted to determine the degree of threat to public health, a blanket advisory has been issued for all fresh waters in the State (DOH, 2014).

• Trace Metals: Studies on dissolved and particulate trace metals in the Ala Wai Watershed by De Carlo et al. (2004) show elevated levels, with ongoing inputs of lead, zinc, copper, barium, and cobalt from urban sources and less significantly, inputs of arsenic, cadmium, and uranium from agricultural sources. Although the lead concentrations have been decreasing since leaded gasoline was phased out, there are still continued inputs believed to be linked to lead-based paint used in older homes and from brake pads and other automotive uses (De Carlo et al., 2004; Sutherland, 2000). High levels of copper and zinc also result from heavy use of these substances in automobile brake pads and tires. De Carlo et al. (2004) propose that road-deposited sediments may also contribute to the elevated concentrations of barium and cobalt in the lower watershed.

• Nutrients: Nitrogen and phosphorus concentrations in the streams and Canal have consistently exceeded the State water quality standards (DOH, 1997a). The highest nutrient levels have consistently been reported at the upper end of the Ala Wai Canal (near Kapahulu Avenue), which receives urban runoff from storm drain outfalls (Edward K. Noda, 1992b); however, high levels have also been documented in forested upper watershed areas (Yim and Dugan, 1975). Sources of nitrogen and phosphorus are soil erosion, animal wastes, fertilizers, automobile exhaust, food wastes, rotting vegetation, sewage, and specifically in the lower canal areas, illicit discharges from boats in the yacht harbor.

• Pesticides: The organochlorine compounds dieldrin, chlordane, and heptachlor were used for many decades as pesticides to control termites in Hawai'i, until they were phased out in the 1980s. As these compounds typically have low solubility, they are mostly transported through soil erosion and surface runoff, then accumulate with bottom sediments in the streams and move through the food chain (Brasher and Wolff, 2004). Because of their widespread use, dieldrin and chlordane have been detected in fish and stream bed sediment samples from Mānoa Stream at concentrations that exceed aquatic life and wildlife protection guidelines (Brasher and Anthony, 2000). In comparison to other streams sampled across the nation, urban streams on O'ahu (such as Mānoa Stream) had the highest concentrations of chlordane and dieldrin detected (Brasher and Wolff, 2004).28 Anthony et al. (2004) believe that, because of the persistence of dieldrin, soil and stream bed sediments in urban Honolulu serve as a long-term reservoir of dieldrin. Similarly, the valley-fill aquifer that contributes to low flows in Mānoa Stream may also be a persistent reservoir of dieldrin.

Most of the sampling efforts and analyses in the Ala Wai Watershed have concentrated on insecticides. Although not to the same degree, herbicides have also been detected in Mānoa Stream, with the most frequent detections involving prometon (in base flows) and bentazon (in storm runoff) (Anthony et al.,2004). Both of these herbicides are used in urban areas; bentazon is used for turfgrass, so detections are believed to represent wash off from soils during rainstorms (Anthony et al., 2004). It is not clear if detections of these herbicides pose any risk to aquatic life.

• Toxic Organics: Toxic organics include such compounds as volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), phthalates, polycyclic aromatic hydrocarbons (PAHs), and polychlorinated biphenyls (PCBs); these contaminants are commonly associated with products that are prevalent in urban areas, including gasoline compounds, construction materials, plastics, and vehicle exhaust. Similar to organochlorine pesticides, many of these compounds, particularly SVOCs and PCBs, have low solubility and are transported through soil erosion and surface runoff, ultimately moving up the food chain via benthic algae and invertebrates (Brasher and Wolff, 2004).

• Sediment: The Ala Wai Canal generally serves as a sink for the watershed, capturing sediment that is transported via its tributary streams, a function presumably provided by the former coastal wetlands in this area. Historical accounts reference large quantities of sediment being deposited in the nearshore waters during storm events (Weigel, 2008), as occurs in other steep tropical environments, but the natural background erosion and transport rates are not known. Nevertheless, input of fine sediment is believed to have increased over time because of feral pig wallows and shallow-rooted exotic vegetation in the upper watershed, eroding channel banks, and runoff from adjacent urban areas. Sediment loading contributes to habitat degradation in the streams and in the nearshore marine environment by smothering substrate, filling interstitial spaces, and harming coral reef communities. Calculations of the sedimentation rate in the Ala Wai Canal over time have been relatively consistent, ranging between approximately 7,000 to 8,000 cubic meters per year (m^3/yr) (Gonzalez, 1971; Laws et al., 1993; McMurty, 1995). The most recent dredging effort was conducted in 2002 and 2003, during which approximately 141,440 m3 of sediment was removed from the Ala Wai Canal and the lower portion of the Mānoa–Pālolo Drainage Canal (D. Imada, personal communication, June 14, 2010).

Other parameters that are important to water quality in streams include temperature, pH and dissolved oxygen. Temperature is an important biological parameter, and is tied closely to water flow and shading by riparian vegetation. Temperature records comparing urban and forested streams on O‘ahu indicate that urban streams have a higher mean temperatures and much greater diurnal and seasonal swings in temperature as compared with forested streams (AECOS, 2010; Brasher, 2003). Dissolved oxygen and pH levels are temperature dependent, with reduced quality in waters with stagnant flow and warm temperatures. In general, neither low dissolved oxygen nor deviant pH levels occur in the natural stream reaches in the watershed (AECOS, 2010). However, channel modifications that result in stagnation and/or high temperature fluctuations can lead to detrimental dissolved oxygen and pH levels, in some cases leading to eutrophication, particularly in the Ala Wai Canal (AECOS, 2010; Laws et al., 1993).

Water Quality Standards

Specific water quality criteria have been promulgated in HAR Section 11-54, which, if met, are designed to allow water bodies to achieve designated beneficial uses. Water bodies that do not achieve the criteria are designated as “impaired” and are placed on the Clean Water Act Section 303(d) List of Impaired Waters. Based on the data presented in the 2014 State of Hawai’i Water Quality Monitoring and Assessment Report (DOH, 2014), several locations within the Ala Wai Watershed have been designated as impaired water bodies, including the three major streams and the Ala Wai Canal. Mānoa Stream is listed for total nitrogen, nitrate and nitrite nitrogen, total phosphorus, turbidity, dieldrin, and chlordane. Pālolo Stream is listed for trash, and Makiki Stream is listed for total nitrogen and total phosphorus. The Ala Wai Canal is listed for total nitrogen, nitrate and nitrite nitrogen, total phosphorus, turbidity, enterococci, pathogens, metals, suspended solids, and organochlorine pesticides. For each water body on the Section 303(d) list, a Total Maximum Daily Load (TMDL) must be developed to bring that water body into compliance with water quality standards. To date, the only TMDLs that have been developed are for nitrogen and phosphorus in the Ala Wai Canal. Development of the remaining TMDLs has been designated by the State of Hawai'i Department of Health (DOH) as a low priority (DOH, 2014).

Groundwater Quality

The quality of groundwater can be affected by contamination from both natural and anthropogenic sources; chemical leaching and saltwater intrusion are two common sources of contamination. Chemical leaching occurs when residual contaminants such as petrochemicals or pesticides percolate from the surface soil layers into the freshwater lens. Saltwater intrusion can occur when brackish water infiltrates the freshwater lens, often caused by overpumping (or improper pumping) of the aquifer (CWRM, 2008a). The Hawai'i Groundwater Protection Program (GWPP), administered by the DOH Safe Drinking Water Branch, is focused on assessment of water quality and development of pollution prevention and protection measures. As part of the program, a groundwater contamination map is maintained to identify drinking water wells, nonpotable wells, and fresh water springs where contaminants have been detected (DOH, 2015). The map identifies dieldrin as the only contaminant detected within the three wells sampled within the watershed. The detection levels ranged from 0.01 to 0.03 parts per billion (ppb), which are below DOH and Federal drinking water standards.

5.6.2 Impacts and Mitigation

Effects on water quality were considered to be significant if implementation of an alternative plan would result in any of the following:

- Substantially degrade surface water quality such that it would violate water quality standards, contribute to exceedance of aquatic life guidelines, or otherwise impair beneficial uses;
- Substantially increase contaminant levels in the groundwater;

The potential effects to water quality that could result from implementation of the alternatives, measures that would be conducted to mitigate those effects, and the resulting degree of impact are discussed in the following subsections.

5.6.2.1 No Action Alternative

Under the No Action Alternative, no Federally sponsored flood risk management measures would be constructed. Although potential construction-related impacts to water quality would not occur, nor would the potential long-term benefits associated with the capture and removal of flood-related debris and sediment via the debris and detention features. Input of sediment (such as that caused by erosion of the near-stream and upper watershed areas) and transport of sediment-bound contaminants is generally expected to continue at the same rate, as the factors that influence erosion (e.g., invasive species cover in the upper watershed) are already widespread. Based on the existing TMDLs, it is expected that nutrient levels in the watershed would be reduced, although the extent to which the reductions are achieved cannot be predicted. Given the persistence of dieldrin and other pesticides, inputs from long-term reservoirs are expected to continue over time. Although there are ongoing discussions about the need to reduce anthropogenic sources of contaminants (e.g., use of heavy metals in brake pads and tires), the extent to which regulatory restrictions would be established at either the Federal or State level are unknown. As such, significant reductions for the range of contaminants in the watershed are not expected for the future without-project conditions. It is assumed that the Canal would continue to be dredged at approximately the same rate, or at least once every 25 years, and as such, the sediment and associated contaminants that accumulate in the Canal would continue to accumulate and be removed at approximately the current rate.

5.6.2.2 Tentatively Selected Plan (Alternative 3A-2.2)

In addition to impacting soil resources and channel stability, construction-related erosion could increase the delivery of sediment and associated pollutants via stormwater runoff, which could temporarily affect water quality in the streams and downstream receiving waters. Although sediment-bound pollutants are known to occur throughout the watershed (particularly in the urbanized areas), none of the soils that would be exposed by construction are expected to contain excessive levels of contamination. In general, construction of the flood risk measures would involve placement of imported materials, with only minimal amounts of excavation. All materials used to construct the measures would be from approved sources, and would be clean and free of contaminants. Areas requiring excavation (e.g., for the Waiʻōmaʻo detention basin, and to create the spillway for the Kanewai detention basin and the Ala Wai Golf Course detention basin) are either located in the upper watershed and/or in undeveloped open space areas, which are not subject to significant inputs of roadway sediments or other anthropogenic contaminants, such that a significant increase in pollutant delivery to the streams is not expected as a result of construction. As further discussed in Section 5.12, none of the measure locations are known to contain hazardous or toxic waste. In addition, the proposed project would require the storage and use of some hazardous materials, which if handled inappropriately, could result in an accidental spill or inadvertent discharge to the streams or groundwater. In particular, construction activities would involve the use of heavy equipment, cranes, compactors, and other construction equipment that use petroleum products such as fuels, lubricants, hydraulic fluids, and coolants, all of which are detrimental to water quality.

As construction would disturb more than 1 acre of land, the project would be regulated under the State's NPDES [National Pollutant Discharge Elimination System] stormwater program, which requires preparation of a SWPPP [Stormwater Pollution Prevention Plan] to obtain permit coverage. The objective of a SWPPP is to describe the measures that would be implemented to prevent sedimentation, erosion, and stormwater contamination, in compliance with the requirements of the NPDES program. … Preparation and implementation of the SWPPP, as well as adherence to other requirements of the NPDES program, would reduce the potential construction-related water quality impacts to a less-than-significant level; no mitigation is required.

Once constructed, the structures themselves are not expected to contribute pollutants to the streams or otherwise measurably affect water quality. The detention structures would be comprised of compacted, earthen berms with concrete or grouted rip-rap spillways; the debris catchment structures would be comprised of a concrete pad with metal posts; the floodwalls would be comprised of concrete walls; and the mitigation measures would be comprised of grouted stone. All materials used to construct the measures would be from approved sources, and would be clean and free of contaminants. Although the debris and detention basins may slightly reduce riparian shading (e.g., vegetation management around the perimeter of the detention berms), they are not expected to contribute to any measurable changes in water temperature, nor pH or dissolved oxygen levels.

Over the long term, the project features are not expected to increase channel or bank erosion, or otherwise contribute to sediment and/or contaminant inputs to the streams, such that water quality conditions are generally expected to be commensurate with the existing condition. During flood conditions, the flood risk management measures are designed to either detain or contain stream flows within and directly adjacent to the waterways; the project includes features to maintain stormwater delivery (e.g., pumps associated with the Ala Wai Canal floodwalls), but would not significantly alter the quality, quantity, or pattern of stormwater inputs to the streams and/or Canal.

The detention basins would function to temporarily hold stream flows, slowly releasing them within the streams and Canal. To the extent that contaminants are present in the detention areas (particularly within the multipurpose detention areas, which may be subject to herbicide applications), detained water could flush contaminants into the streams, thus contributing to degraded water quality conditions. Conversely, contaminants in the water column or stream sediments could be deposited in the detention basins, thus transferring contamination into those area. However, the multi-purpose detention features are located within areas that are already subject to flooding under the existing without project condition, such that the project is not expected to substantially increase delivery of contaminants to the streams beyond that which already occurs or otherwise alter the location or degree of water quality contaminants. Similarly, in-stream detention in the upper reaches of the watershed is not expected to substantially increase mobilization of any contaminants beyond the existing condition. As such, the potential for water-quality impacts associated with detention of flood waters is expected to be less than significant.

Although the structures are not designed to capture sediment (with the exception of the Ala Wai Golf Course detention basin), some degree of sediment deposition is expected to occur within the detention basins, particularly during periods of inundation associated with flood stage flows. As previously described, sediment and debris (including trash and other man-made debris) that accumulates within the debris and detention features would be removed as part of the routine O&M activities and properly disposed of at an approved, offsite location that is qualified to accept the material. Removal of these materials from the debris and detention basins is anticipated to provide some degree of water quality benefit to downstream areas. As the structures are not explicitly designed to capture sediment, the quantity of sediment and any associated pollutants to be removed has not been quantified. Given the anticipated sediment capture in the debris and detention basins, in combination with the Canal's function as a sediment sink, the project is not expected to increase (and could possibly decrease) sediment delivery to the nearshore waters.

The worst scenario for impacts to EFH would arguably be a catastrophic rainfall that forced high volumes of water, sediment, contaminants, and debris unimpeded out of the watershed and through the Ala Wai Canal into the marine environment. The Ala Wai Canal project is designed to reduce the risk of just such a scenario, albeit for different purposes (i.e., protection of human life and property).

4. Water Quality Regulatory Framework

The passage above describes how the project and its potential to affect water quality will be subject to the requirements of Section 402 of the Clean Water Act and the NPDES. The State of Hawaii NPDES permit program is administered by the Department of Health Clean Water Branch; more information on this department and its mission is available at the website http://health.hawaii.gov/cwb/. Among other NPDES permit requirements, a SWPPP must be prepared and approved for the project activities, detailing the measures to be followed to control the introduction of sediment and pollutants into waterways. Because such sediment management measures must be closely integrated with the construction techniques and project sequence that will be developed by the construction contractor, the contractor is generally tasked with developing the project SWPPP as part of its pre-construction requirements. In other words, the exact best management practices (BMPs) and other sediment mitigation measures that will be employed during construction are not known at this time.

The State of Hawaii Clean Water Branch also administers the State's Water Quality Certification (WQC) Program, under Section 401 of the Clean Water Act. The objective of the program is to ensure that any Federally permitted activity will not adversely impact the existing uses, designated uses, and applicable water quality criteria of the receiving State waters. A Section 401 WQC will be requested from the State prior to construction; generally, the State will not issue a WQC until the project technical design is at an advanced stage.

In addition to complying with these Clean Water Act requirements, the project will also undergo review under the Hawaii Coastal Zone Management (CZM) Program (http://planning.hawaii.gov/czm/). This review process examines, among other things, the project's potential impact on water quality, erosion, and the coastal environment.

The Corps will be developing a Maintenance Plan at a later stage of pre-construction design. The O&M activities will be subject to applicable water quality regulations.

5. Sediment Management & Mitigation Measures

As stated above, the exact sediment management measures that will be employed during construction and maintenance have not yet been developed at this stage of project planning. However, the draft FR/EIS describes a number of measures that are likely to be incorporated into contract requirements and maintenance plans. One of the more important of these is the ability to temporarily divert stream-flow and dewater a chosen section of stream channel, so that construction machinery working within the stream channel are not disturbing stream sediments within flowing water. Sand bags or a cofferdam can be used to isolate the work area and to concentrate upstream flows into a large-diameter pipe. The pipe would extend downstream, thus allowing the stream flow to bypass the construction area and maintain downstream flows. The outfall of the pipe would be carefully sited to avoid the potential for erosion. This temporary dewatering tactic has been used to good effect on other projects, such as migration passage barrier removal on Waihe'e Stream by the State of Hawaii Division of Aquatic Resources.

Other measures and best management practices (BMPs) described in the draft FR/EIS or under consideration by the Corps include:

- Limiting construction activities within the stream channels to low-flow conditions/seasons. In addition to minimizing the extent of dewatering required, this would also serve to minimize the potential to disrupt migration of native species;

- Sequencing construction activities to limit the extent of exposed soil at any given time, and minimizing the extent and duration of work with stream channels;

- Using appropriate vehicles and equipment for all stages of construction and adequately training construction crews to avoid and minimize impacts to the aquatic environment;

- Requiring an adaptive management approach to sediment management, in which standard construction site BMPs such as silt fencing, coir logs, and mulch are continually evaluated, reinforced, or replaced as the construction progresses;

- Requiring an emergency response plan to protect exposed earth from an unexpected rainfalls.

6. Summary and Determination

- The Ala Wai Canal Project has the potential to adversely affect EFH only as an extension of its potential to affect water quality within the watershed.

- The project's potential to affect water quality will be strictly regulated under the Clean Water Act and other applicable requirements. The intent and expected effect of the sediment management measures applied to meet those requirements will be to reduce project impacts to water quality to insignificant levels.

The project activities will be short-term, closely controlled events in the context of an urban watershed that is subject to numerous uncontrolled, poorly assessed discharges. The connection between the project activities within the watershed and essential fish habitat in the marine environment will be tenuous to the point of being indiscernible. The Corps of Engineers determines that the project activities will not have an adverse effect on EFH.

7. References.

Goldberg, Stuart (NMFS). Email dated 14 March 2016, subject: Ala Wai EFH determination.

U.S. Army Corps of Engineers (USACE). 2015. Draft Feasibility Study with Integrated Environmental Impact Statement, Ala Wai Canal Project, Oahu, Hawaii. August 2015.

Western Pacific Regional Fishery Management Council (WPRFMC). 2009a. Fishery Ecosystem Plan for the Hawaii Archipelago. 24 September 2009.

WPRFMC. 2009b. Fishery Ecosystem Plan for Pacific Pelagic Fisheries of the Western Pacific Region. 24 September 2009.