Tafuna, American Samoa
Flood Risk Management Study

Draft Integrated Feasibility Report and Environmental Assessment

January 2022

US Army Corps of Engineers
Honolulu District

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Tafuna Flood Risk Management Study,

American Samoa

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

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ACRONYMS

AEP Annual Exceedance Probability **MMPA** Marine Mammal Protection Act **CAA** Clean Air Act **MSA** Magnuson-Stevens Fishery Conservation and Management Ac
CEQ Council on Environmental Quality **NAAQS** National Ambient Air Quality Standards

Cfs Cubic feet per second **NED** National Economic Development **CWA** Clean Water Act **NEPA** National Environmental Policy Act **CZMA** Coastal Zone Management Act **NMFS** National Marine Fisheries Service **ESA** Endangered Species Act **NNBF** Natural and Nature-Based Feature **EC** Environmental Commitment **NOAA** National Oceanic and Atmospheric Administration
EQ Environmental Quality **NPEDS** National Pollutant Discharge Elimination System
EFH Essential Fish Habitat **O&M** Operations and Maintenance
FEMA Federal Emergency Management Agency **OMRRR** Operations, Maintenance, Repair, Replacement and Rehabilitation.
FONSI Finding of No Significant Impact **OSE** Other Social Effects **FRM** Flood Risk Management **PED** preconstruction, engineering and design
FWCA Fish and Wildlife Coordination Act **TAAQS** Territory AAQS
HEC-HMS Hydrologic Engineering Center's Hydrologic Modeling System
RED Regional Economic Development

HPA Historic Preservation Act **TMDL** Total Maximum Daily Loads
IFR/EA Integrated Feasibility Report and Environmental Assessment **TSP** Tentatively Selected Plan **USACE** U.S. Army Corp of Engineers
LERRD Lands, easements, rights-of way, relocations, and disposal areas

Lf Linear feet **USFWS** United States Fish and Wildlife Service **MBTA** Migratory Bird Treaty Act

VdB Vibration Decibels **WoUS** Waters of the U.S.

EXECUTIVE SUMMARY

The U.S. Army Corps of Engineers (USACE), Honolulu District, has prepared a Draft Integrated Feasibility Report and Environmental Assessment (IFR/EA) for the Tafuna Flood Risk Management (FRM) Feasibility Study, located on the island of Tutuila in the U.S. Territory of American Samoa, for which the American Samoa Government, represented by the American Samoa Department of Public Works, is the non-Federal sponsor. This IFR/EA, evaluates, and discloses impacts that would result from the implementation of potential FRM measures for critical areas within the Tafuna area of the island of Tutuila (the proposed study area); in accordance with federal law, regulation, and procedures the IFR/EA identifies flood hazards and analyses a series of potential alternatives, including the "No Action" alternative, to address flood risk in the proposed study area.

The study is authorized under Section 444 of the Water Resources Development Act of 1996, as amended. This report documents the plan formulation process to select a Tentatively Selected Plan (TSP), along with environmental, engineering, and cost analyses of the TSP, which will allow additional design and construction to proceed following approval of this report.

The Territory of American Samoa is located approximately 2,600 miles southwest of Honolulu, Hawaii. The study area is situated in the Western District of Tutuila within Tualauta County, in the northeast section of the Tafuna-Leone Plain. Tualauta County is the largest, most populated county in American Samoa, and includes the villages of Malaeimi, Tafuna, and Nuuuili.

The purpose of the study is to evaluate flooding problems and identify potential flood risk reduction alternatives within the Tafuna area on the island of Tutuila in the U.S. Territory of American Samoa, specifically along waterways that meet the minimum flow velocity of 800 cfs (Engineer Regulation (ER) 1165-2-21). The Study is needed because flooding experienced in the Tafuna area results from intense rainfall and the lack of well-defined stream channels. Typically, the streams are incapable of supporting small flood events such as a 10 percent annual exceedance probability (AEP) flow. Flooding is exacerbated by development encroaching onto the floodplain, obstructions such as thick vegetation, and constrictions at bridges and culverts.

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

The TSP is Alternative C: Taumata Flood Barrier and Nonstructural Improvements. This alternative includes the construction of approximately 2,400 linear feet of barrier with an average height of seven ft (from ground), on the Taumata Stream. The nonstructural component of this alternative will include dry floodproofing 38 nonresidential buildings and elevating 242 residential structures (assumes 100 percent participation rate). At the FY 2022 discount rate of 2.5 percent, the total project first cost of the TSP is approximately $138 million with a benefit-to cost ratio of 1.6.

The TSP (Alternative C) is the National Economic Development (NED) Plan. Alternative C reduces damages by approximately 81% with fewer residual damages compared to other structural alternatives and has higher NED benefits compared to other structural alternatives.

Due to the limited nature of construction disturbance, the activities of the Proposed Action are not expected to cause any long-term adverse environmental effects. Environmental commitments (ECs) and best management practices (BMPs) would be implemented to ensure that potential construction-related effects are avoided, minimized, and/or reduced to a less than significant level. Impacts to certain resources are not anticipated for the Proposed Action and, therefore, no additional minimization measures are proposed for these resources (see Sec. 6.9 Environmental Commitments). No compensatory mitigation is required.

The American Samoa Government supports Alternative C as the TSP. Alignment for the support was coordinated with the Governor of American Samoa. The public will have the opportunity to review and comment on this draft report during the 30- day public review period, which will begin in January 2022. A virtual public meeting is planned for February 2022 to present the TSP and allow the public to respond and ask questions. The final report is scheduled to be complete in 2023.

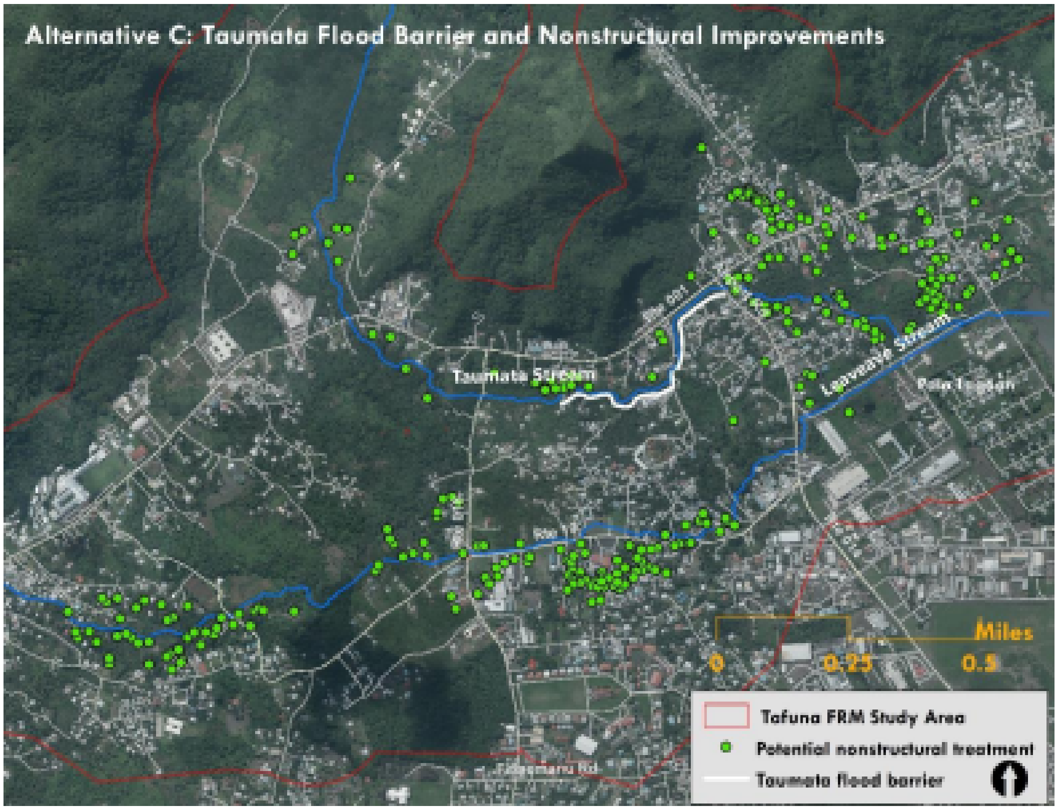

Figure 1: Alternative C, Tentatively Selected Plan

1 Introduction

This is the draft Integrated Feasibility Report and Environmental Assessment (IFR/EA) for the Tafuna Flood Risk Management (FRM) Study. The Honolulu District of the Pacific Ocean Division of USACE is the Lead Federal Agency. The American Samoa Government is the non Federal sponsor for the study, represented by the Department of Public Works.

The study area is located within a heavily populated area of Tutuila Island known as the Tafuna Leone Plain. Properties within the Tafuna-Leone Plain include residential and non-residential structures (e.g., commercial and government buildings), main roads, drinking water wells, churches, and school facilities and are susceptible to frequent flooding.

The Study is being conducted to address flood risk within the Tafuna-Leone Plain. The Tafuna Leone Plain experiences intense rainfall, and most stream channels are shallow and undefined.

The streams are typically incapable of supporting small flood events such as a 10 percent annual exceedance Probability (AEP) event. Flooding is intensified due to thick vegetation within channels, flat topography, constrictions at bridges and culverts, and encroaching development into the floodplain areas.

1.1 USACE Planning Process

The USACE uses a six-step planning process, which includes the following steps:

- Specification of water and related land resources problems and opportunities (relevant to the planning setting) associated with the federal objective and specific state and local concerns
- Inventory, forecast, and analysis of water and related land resource conditions within the planning area relevant to the identified problems and opportunities
- Formulation of alternative plans
- Evaluation of the effects of the alternative plans
- Comparison of alternative plans
- Selection of a Tentatively Selected Plan tentatively selected plan based upon the comparison of alternative plans

This IFR/EA will mirror the process noted above, beginning with defining the problems and opportunities and culminating in the selection and description of a Tentatively Selected Plan. This IFR/EA discusses and discloses environmental effects, beneficial or adverse, that may result from proposed project in compliance with the National Environmental Policy Act (NEPA) of 1969 (42 United States Code Section 4321 et seq.); the Council on Environmental Quality (CEQ) (regulations published in 40 Code of Federal Regulations Part 1500 et seq.; and USACE procedures for implementing NEPA published in 33 CFR Part 230. This IFR/EA also documents project compliance with other applicable Federal environmental laws, regulations, and requirements.

1.2 Study Purpose, Need and Scope *

The purpose of the study is to evaluate flooding problems and identify potential flood risk reduction alternatives within the Tafuna area on the island of Tutuila in the U.S. Territory of American Samoa, specifically along waterways that meet the minimum flow velocity of 800 cfs requirement (Engineer Regulation (ER) 1165-2-21). The Study is needed because flooding

experienced in the Tafuna area results from intense rainfall and the lack of well-defined stream channels. Typically, the streams are incapable of supporting small flood events such as a 10 percent AEP flow. Flooding is exacerbated due to encroaching development onto the floodplain, obstructions such as thick vegetation, and constrictions at bridges and culverts.

The study scope includes a series of potential alternative plans focused on flood-risk management by identifying flood hazards and potential FRM measures for critical areas within the Tafuna-Leone Plain area. Alternatives were developed in consideration of study area problems and opportunities as well as study objectives and constraints with respect to the four evaluation criteria described in the Principles and Guidelines (completeness, effectiveness, efficiency, and acceptability). The analysis of the alternative plans that address FRM needs was conducted to identify the National Economic Development (NED) Plan. The NED plan is the Tentatively Selected Plan (TSP), and the results of this analysis are documented in this decision document, which will serve as the basis for project construction authorization.

Notwithstanding Section 105(a) of the Water Resources Development Act of 1986 (33 U.S.C. 2215(a)), which specifies the cost-sharing requirements generally applicable to feasibility studies, Title IV of the Additional Supplemental Appropriations for Disaster Relief Act, 2019, Public Law 116-20, enacted June 6, 2019 (hereinafter "FY 19 Supplemental"), authorizes the Government to conduct the Study at full Federal expense to the extent that appropriations provided under the Investigations heading of the FY 19 Supplemental are available and used for such purpose.

1.3 Study Authority

This study is being conducted under the authority of Section 444 of the Water Resources Development Act of 1996 (as amended by Section 207 of the Water Resources Development Act of 1999) authorizes flood damage reduction studies to be conducted in American Samoa. The authority states:

"The Secretary may conduct studies in the interests of water resource development including navigation, flood damage reduction, and environmental restoration in that part of the Pacific region that includes American Samoa, Guam, and the Commonwealth of the Northern Mariana Islands."

1.4 Location and Description of the Study Area *

The study area is located in the mid-South Pacific Ocean on the island of Tutuila in the unincorporated U.S. territory of American Samoa (Figure 2). American Samoa is part of the Samoan Islands archipelago in Polynesia, located approximately 2,300 miles southwest of the Hawaiian Islands. It includes five volcanic islands and two coral atolls. Tutuila (55 square miles) is the largest and most populated island in American Samoa, with a population of 55,876 (2000 U.S. Census). The study area is situated in the Western District of Tutuila within Tualauta County, in the northeast section of the Tafuna-Leone Plain. Tualauta County is the largest, most populated county in American Samoa, estimated at 19,519 according to the 2015 Household Income and Expenditure Survey report (American Samoa Department of Commerce), and includes the villages of Malaeimi, Tafuna, and Nuuuili. Tualauta County experienced a large population increase and has the highest number of housing units with over 4,000 units according to the 2010 U.S. Census.

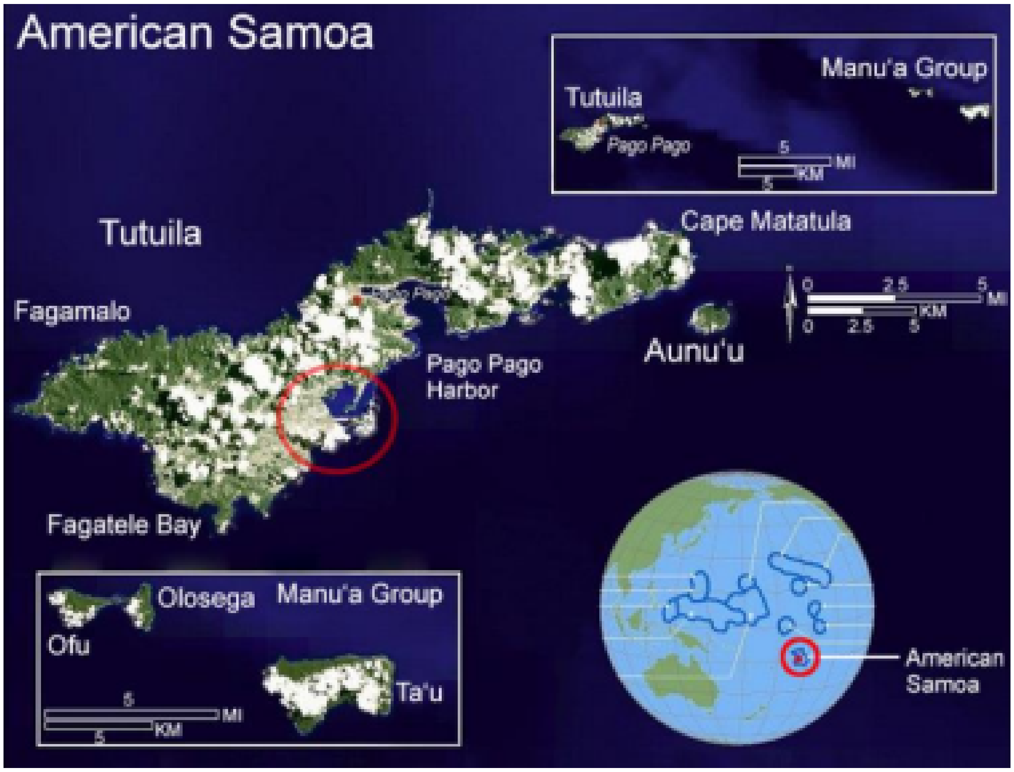

Figure 2: Project location map

The natural environment of the study area comprises two major physiographic zones of the Tafuna-Leone Plain: a) the lava delta of the Tafuna-Leone Plain; and b) the lowland mountain slopes inland of the Tafuna-Leone Plain (Figure 2). The lave delta of Tafuna-Leone Plain is the largest area of Tutuila in acreage with relatively flat slopes. Several watersheds contribute to flows to and/or are contained within the Tafuna-Leone Plain. The upper watershed portions (upstream of Route 1 Highway) that drain the mountainsides have well-defined stream cross sections, while the lower watershed portions that drain the drier alluvial plains (downstream of Route 1 Highway) have poorly defined drainageways.

The study area is located in the Vaitele-Taumata Stream sub-drainage of the Nu'uuli Pala Watershed (6.7 square miles), and includes Taumata, Vaitele, Leaveave, Mapusagatuai, Leaveave, and Puna streams that drain the southwest slopes of Tuasivitasi Ridge, located on the northwest side of the watershed. At the end of Mapusagatuai Stream, flow continues northeast towards Taumata Stream. Flow from the upper watersheds drains east towards the shoreline at Pala Lagoon, north of Pago Pago International Airport. Elevations range from 1,200 ft mean sea level on the Tuasivitasi Ridge in Malaeimi Valley to 0 ft mean sea level at the coastal shoreline. Leaveave, Taumata, Mapusagatuai, and Vaitele streams all originate in the mountains that line the northern edge of the Tafuna-Leone Plain (Figure 3).

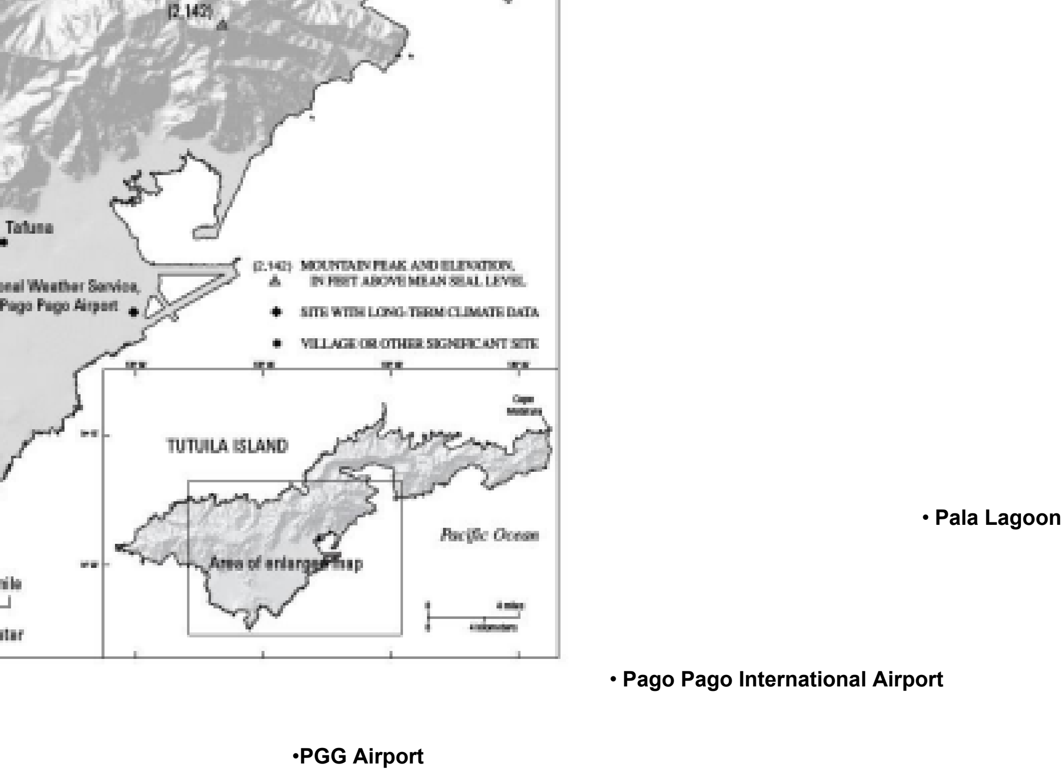

Figure 3: The Tafuna-Leone Plain and surrounding areas, Tutuila, American Samoa (from Izuka et al 2007). The approximate study area is indicated by the dashed outline

Per ER 1165-2-21, urban water damage problems associated with a natural stream or modified natural waterway may be addressed under the FRM authorities downstream from the point where the flood discharge of such a stream or waterway within an urban area is greater than 800 cubic ft per second (cfs) for the 10 percent flood. A hydraulic analysis was done of all streams, tributaries and drainage areas within the project area to identify those which met the criteria outlined in ER 1165-2-21. In accordance with ER 1165-2-21, the study area for this IFR/EA study was further refined to only include Leaveave, Taumata, and Vaitele streams which have flows greater than 800 cfs (Figure 4). Taumata and Leaveave streams are tributaries to Vaitele Stream. Further details of each stream are described below:

- Taumata Stream is the largest tributary to Vaitele Stream and is normally dry except during the rainy season. Taumata Stream drains approximately 1.82 square miles, which includes Mapusagatuai Stream basin, and has approximately 2.27 miles of stream bed. Above Route 1 Highway, the stream is heavily vegetated and has a gradual slope of 0.5 percent. Between the Route 1 Highway bridge and the confluence with Vaitele Stream, Taumata Steam meanders through residential areas, fording several low road crossings.
- Leaveave Stream originates from the north-west portion of the Tafuna Plain along the Tuasivitasi Ridge and drains 1.21 square miles. Above Route 1 Highway, the stream has defined channels with an average slope of 1.9 percent. Approximately 1,000 ft below the highway bridge, low stream flows enter a depressed area and seep into the porous substrate. Flooding is exacerbated due to heavy vegetation in the overbanks, development encroachment, and cultivation. Approximately 2,800 ft downstream of the highway bridge, Leaveave Stream virtually disappears due to heavy vegetation and flat

terrain. Residential encroachment into the lower alluvial plain in Tafuna occurs frequently due to the lack of a readily identified stream channel.

- Vaitele Stream originates from Tuasivitasi Ridge along the northeast corner of the Tafuna Plain before discharging into Pala Lagoon. The Vaitele Stream drains approximately 0.58 square miles and has about two miles of stream bed along the main stem. Above Route 1 Highway, the slope of the stream bed is approximately 1.5 percent and flattens out to 1.0 percent just below the confluence with Leaveave Stream. Residential homes line the stream banks above Route 1 Highway. Below the highway, the stream is heavily vegetated up to the mouth. The American Samoa Government correctional facility is also located along the right bank near the stream mouth.

Figure 4: Taumata, Leaveave, and Vaitele streams

Because of the lack of defined stream channels in their lower reaches on the Tafuna Plain, Leaveave, Taumata and Vaitele Streams all experience overland sheet flow and nuisance, shallow flooding that generally occurs only during or immediately after heavy rainfall.

1.5 Previous Studies

The USACE completed previous work within the study area and vicinity, including a 1994 study under the Planning Assistance to States program as well as several Floodplain Management Services studies:

Flood Hazard Study, Tafunafou, Tutuila, American Samoa. Pacific Ocean Division (1977). U.S. Army Corps of Engineers. The report evaluated the hydrologic and hydraulic characteristics of the streams and drainageways in the Tafuna area. The findings from this study were adopted by the Federal Emergency Management Agency (FEMA) in May 1991 and used to develop the 1 percent AEP floodplain for the Tafuna area.

Tafuna-Leone Plain Drainage Study: Tutuila, American Samoa. Pacific Ocean Division (1994). U.S. Army Corps of Engineers. The study identified the characteristics and flow paths of the major streams and drainage ways in the Tafuna-Leone Plain. The information was intended to provide a basis for understanding the magnitude and causes of the existing flood problems in the area and was used by FEMA for the Flood Insurance Rate Maps for Tafuna.

Hydrologic and Hydraulic Engineering Analysis Tafuna Study Area. Honolulu District (2016). U.S. Army Corps of Engineers. This report presented the methodology used and the results of the floodplain management study of the Leaveave Drainageway and Drainageway 2 in Tutuila, American Samoa. The Hydrologic Engineering Center's Hydrologic Modeling System (HEC HMS) software was used to create a hydrologic model and determine the discharge-frequency relationships at key points in the study area.

Hydrologic and Hydraulic Engineering Analysis Tafuna Study Area. Honolulu District (2019). U.S. Army Corps of Engineers. This report presents the methodology used and the results of the floodplain management study of Drainageway 4, 5, and Unnamed Stream 15 in Tutuila, American Samoa. The HEC-HMS software was used to create a hydrologic model and determine the discharge-frequency relationships at key points in the study area. Two dimensional (2-D) modeling was completed for Drainageway 4, 5, and Unnamed Stream 15.

1.6 Problems and Opportunities

1.6.1 Overview of Flooding Challenges

The Tafuna-Leone Plain has a history of flooding issues as population continues to develop and live on the alluvial plain beneath steep mountains that receive significant rainfall. Below, the reader will find a summary of recent large storm events and associated damages:

- Tropical Cyclone Gita caused significant flooding throughout American Samoa. Rainfall exceeded 6 inches in Pago Pago and more than 800 people were displaced from their homes throughout the islands. The damage estimate across the Territory was $7 million. A Presidential Disaster Declaration was issued on March 2, 2018.
- Torrential rainfall of greater than 21 inches from July 29 to August 03, 2014 caused overflowing of streams, severe flooding in low lying areas and roadways, and caused landslides along mountainous areas throughout the Island of Tutuila.
- In January 2004, Tropical Cyclone Heta's high winds, high surf, and heavy rainfall caused flooding, mudslides, and landslides throughout the Territory. Approximately 13.03 inches of rainfall caused an estimated $25.9 million in damages. A Presidential Disaster Declaration was issued on January 13, 2004 (Damage Report 1506).
- Typhoon Esau caused flooding, landslides, and mudslides in May 2003. American Samoa received more than 23 inches of rainfall and nearly 4,500 individuals required assistance. Damages across the Territory were estimated at $12 million. A presidential Disaster Declaration was issued on June 6, 2003.

Flooding is an increasing issue throughout the Tafuna-Leone Plain, and a number of factors exacerbate this problem. Steep terrain in some areas results in high velocity stream flow. Shallow or ill-defined stream channels can rapidly overflow, leading to overbank flooding and urban development exaggerates these flooding extremes, since grading of the land can promote changes in drainage direction in streams. Development may also lead to increases in impervious surfaces, thus reducing drainage capacity. In some cases, stream channels were redirected or moved to accommodate buildings, which caused sharp bends in the stream flow. Inadequately

sized culverts are unable to accommodate stream flows during intense rainfall, causing a backup of floodwaters.

Within the study area, there are approximately 545 structures in the 0.2 percent AEP event floodplain. The total value of damageable property, structures, and contents, within the 0.2 percent AEP floodplain is approximately $210.5 million. The study area experiences significant flooding from both large storm events and frequent smaller events. Figure 5 shows flooding within the study area (along Route 19/Fagaima Road and Leaveave Stream during a relatively small event (estimated below an 0.05% AEP event) in 2020.

Figure 5: Flooding within the study area (Department of Public Works)

1.6.2 Problems

The problem statements are based on information gathered during scoping and supported by information documented in past reports:

- Significant storm events (e.g., typhoons), as well as frequent smaller events, result in economic damages to residential, commercial, and critical infrastructure and cause road closures.
- Flooding has intensified due to encroaching development into the floodplains, and is compounded by small, shallow channels, obstructed by thick vegetation, as well as constrictions from bridges and culverts.
- Flooding affects public safety and health (e.g., contaminated drinking water) and has potential environmental impacts (e.g., increasing turbidity in Pala Lagoon as debris and trash moves through the watershed).

1.6.3 Opportunities

Opportunities to address the problems include the following:

- Increase community resiliency to flood events
- Improve public health and safety

- Improve local understanding of flood risk; improve community education/outreach to cultivate resiliency
- Reduce maintenance costs from storm damages to critical infrastructure such as roads, schools, and churches
- Improve emergency response during flood events

1.7 Objectives and Constraints

1.7.1 Planning Objective

The planning objectives for the study include the following for the 50-year period of analysis starting in 2030:

- Reduce flood risks to property and critical infrastructure during rain events in the Tafuna Leone Plain for the 50-year period of analysis
- Reduce risk to life safety during rain events in the Tafuna-Leone Plain for the 50-year period of analysis

1.7.2 Planning Constraints

The following are the identified study constraints:

- USACE Policy constrains riverine flood risk studies to those areas which experience flow rates at or above 800 cfs at a 10 year event in accordance with ER 1165-2-216. • Mangroves in American Samoa are considered a threatened vegetation and to the extent possible impacts should be avoided or mitigated.

1.7.3 Planning Consideration

The following consideration is identified for the study: American Samoa's communal land system may present land ownership challenges during formulation, evaluation, and implementation of alternatives. Cumulative parcel ownership data does not exist in American Samoa, making real estate considerations of alternatives based on ownership difficult to pinpoint. Early and substantial coordination with the sponsor and multiple landowners will be required.

2 Summary of Existing Conditions

The central portion of the Tafuna-Leone Plain located within its lower alluvial portion is an area of focus for many government agencies due to the potential for aggravated flood problems and the increasing rate of development in the area.

2.1 Period of Analysis

The period of analysis for this study is 50 years, beginning in 2030, which is the estimated timeframe of when construction will be completed and benefits from the flood risk reduction measures will be realized.

2.2 General Setting

The Tafuna-Leone plain experiences intense rainfall, and most stream channels are shallow and undefined. The streams are typically incapable of supporting small flood events such as a 10% AEP event. Flooding is intensified due to thick vegetation within channels, flat topography, constrictions at bridges and culverts, and encroaching development into the floodplain areas. The distribution of land use classification is shown in Figure 6. See Section 3.6 Environmental Effects and Consequences and Appendix A Hydrology and Hydraulics for additional information on both existing and future without conditions. For the purposes of this integrated report the Existing Conditions section also represents the Affected Environment for NEPA purposes. The FWOP condition is also representative of the No Action Alternative for NEPA analyses.

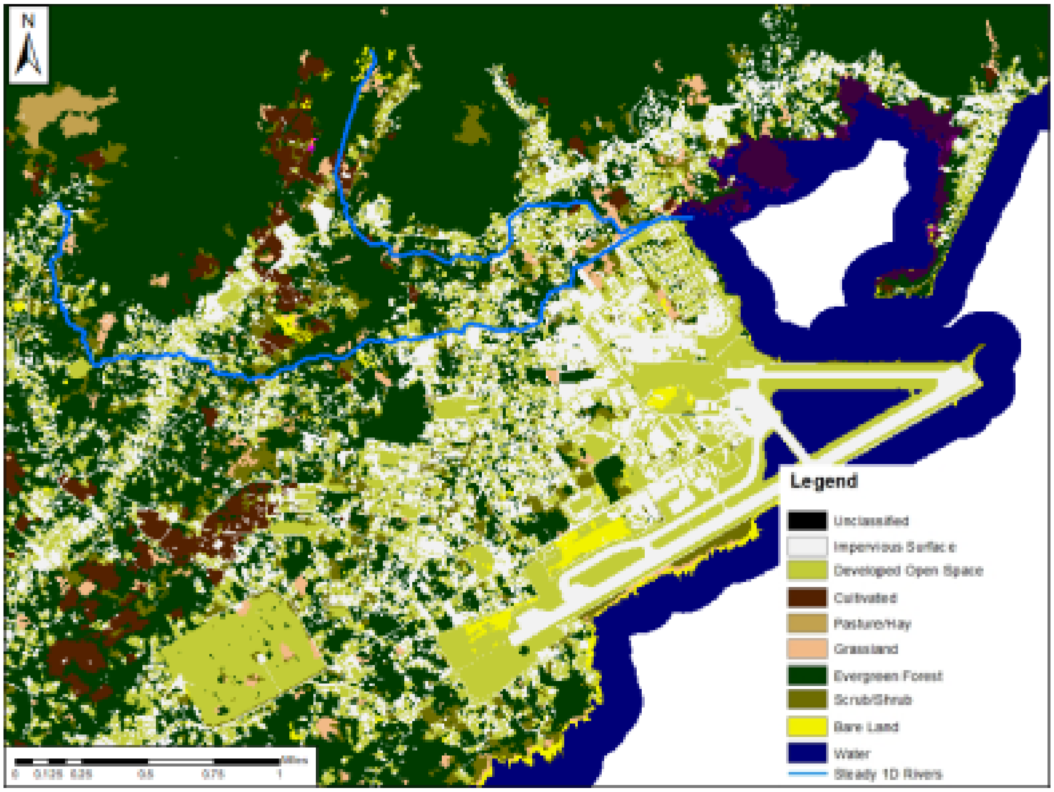

Figure 6: Tafuna-Leone Plain land use classification (NOAA OCM C-CAP Land Cover Data, 2010)

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Per ER 1165-2-21, urban water damage problems associated with a natural stream or modified natural waterway may be addressed under the FRM authorities downstream from the point where the flood discharge of such a stream or waterway within an urban area is greater than 800 cfs for the 10 percent AEP flood event. A hydraulic analysis was conducted on all streams, tributaries, and drainages in the watershed to identify the flow rates. In accordance with ER 1165-2-21, the study area is limited to the following streams:

- Leaveave Stream
- Taumata Stream
- Vaitele Stream

Under the future without-out project condition, flood risk and flood-related damages will remain, with overtopping of the corresponding streams continuing within the coastal plain.

2.3 Natural Environment

The natural environment of the study area includes the terrestrial habitats, aquatic habitats, threatened and endangered species, and cultural and archaeological resources found in the area, as well as its aesthetic qualities. A complete description of the affected natural environment for these resource types is provided in Section 3.6 Environmental Effects and Consequences * under the Environmental Effects and Consequences section.

The study area is located on the Tafuna-Leone Plain, the largest area of relatively flat land on

the island of Tutuila that extends from the base of the mountains towards the coast in south-western Tutuila. Most of the island's industry and much of its population is located on the plain's relatively extensive flat areas (Izuka et al 2007). The study area includes the following villages along Route 1 road from west to east: Pavai'a'i, Faleniu, Mesepa, Malaeimi to a part of Nu'uuli. Along Route
19 from the west to east are settlement of Koko Land, Tafuna village and settlement of Ottoville along the south-bound Route 18.

Within the study area, vegetation is primarily a mix of urban cultivated land and secondary scrub, an intermediate type of vegetation that occurs when cultivated land is abandoned and allowed to revert to natural forest. From an environmental perspective, water quality is a prominent concern
in the study area. Most of the island's wells and pumps for groundwater distribution are found in the Tafuna-Leone plain, which is also where most residents and businesses are located. Surface water from streams, traditionally used as the primary potable water, is compromised by development along riparian areas, causing sedimentation, increased erosion, and nutrient loading from animal and human waste (e.g., piggeries and faulty septic tanks). Along the f ringing lagoons and coastal shoreline, poor water quality threatens nearby mangroves, wetlands, and fringing coral reefs. The construction of the Pago Pago International Airport significantly altered natural circulation patterns in the Pala Lagoon, permanently affecting water quality and adversely impacting plants and marine wildlife.

2.4 Physical Environment

The physical environment of the study area includes its hydrology, geomorphology, water resources, and air quality. A complete description of the affected physical environment for these resource types is provided in 3.6 Environmental Effects and Consequences *.

The island of Tutuila is of volcanic origin and characterized by steep mountainsides, small valleys, and a narrow coastal fringe of relatively level land. The island is essentially the top of a composite volcano rising three miles from the ocean floor. The highest peak (Matafao Peak) is approximately 2,142 ft, and the land slopes steeply from the tops of the mountain ridges down to the ocean (FEMA 2008). The study area is situated mostly on a basaltic lava delta on the southern side of western Tutuila known as the Tafuna-Leone Plain (Tafuna Plain; see Figure 3), the largest area on the island with relatively flat slopes.

Intense rainfall and the lack of well-defined stream channels contribute to the flooding experienced in the study area. A greater potential for flooding exists in the village areas where the streams are incapable of supporting small flood events such as a 10 percent AEP flow. Flooding is intensified due to small channel sizes obstructed by thick vegetation, flat areas, constrictions from bridges and culverts, and encroaching development into the floodplain.

Under the future without-out project condition, flood risk will continue to be intensified by the physical environment in the study area.

2.5 Built Environment

The built environment of the study area is characterized by resources as they pertain to public health, noise, socioeconomics and environmental Justice, land use, utilities, public services, traffic, and recreational outlets. A complete description of the affected built environment for these resource types is provided in Section 3.6 Environmental Effects and Consequences *.

The village of Tafuna is the largest village in population and also has the largest concentration of businesses in American Samoa. It is also one of the few places in American Samoa that allows for the private purchase of land, which has encouraged development within the local area. Nu'uuli village is the fifth-largest village in land area in American Samoa and the second largest on Tutuila Island. It straddles the line between the Eastern District and the Western District and, therefore, is the only village in American Samoa that occupies two districts. Nu'uuli village is a shopping district that is home to South Pacific Traders, Nu'uuli Shopping Center, Aiga Supermarket and many more shops.

On Tutuila, concentrations of community assets are within the developed and populated lowland areas like the Tafuna Plain (Figure 7). Community assets are critical infrastructure and facilities important to the character and function of a community immediately following a major flood event, including locations with dense populations and high social vulnerability (Dobson et al. 2021).

Figure 7. Community Asset Index for the Island of Tutuila (source: Dobson et al 2021)

Within the study area, The American Samoa Department of Public Works is planning a local drainage improvement project - the Route 19 Flood Mitigation Project. The proposed project will construct a drainage system in the village of Fagaima where it is constantly flooded during heavy rainfall. The drainage improvements are designed for a storm event of 5% AEP flood frequency event and include construction of a single box culvert along Route 19 (also referred to as Fagaima Road). See Figure 8 for the approximate location and extent of the Route 19 Flood Mitigation Project.

Under the future without-out project condition, Tafuna is assumed to remain the largest village in population with the largest concentration of businesses making the study area vulnerable to flood risk.

Figure 8: RTE 19/Fagaima Road flood mitigation project

2.6 Sea Level Rise and Subsidence

Relative sea level rise is a combination of a global change in sea level with subsidence, or sinking, of the tectonic plates. This phenomenon is occurring in American Samoa and was hastened by a powerful combination of near-simultaneous fault and thrust earthquakes that occurred in the Tonga Trench in September 2009.

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2.6.1 Subsidence

Based on Pago Harbor tide gauge data, this event caused Tutuila to initially rise about 2 to 3 inches at the time of the earthquake event, and then sink down about 7 to 9 inches over the next 2 to 3 years due to "relaxation from the earthquake deformation" (Scientific American, 2010; National Science Foundation, 2010).

The ongoing subsidence is estimated to be occurring at a rate of about 0.3 to 0.6 inches per year and is expected to continue in addition to anticipated climate-related sea level rise. The rate and extent of subsidence also contribute to uncertainty and will require monitoring over time to help inform relative sea level change estimates (Han et. al., 2019)

2.6.2 Sea Level Rise

Based on results from the USACE Sea Level Change Calculator (Figure 9, Table 1), sea level rise estimates range from 2.6 to 5.4 ft above relative mean sea level by the year 2080 and, 4.0 to 11.0 feet above relative mean sea level by 2130. It is important to keep in mind that these rates include a high margin of error (+/- 9.8 mm per year; 0.03 feet) based on uncertainty due to the strong influence of El Nino-Southern Oscillation forcing in the region. See Appendix A Hydrology

and Hydraulics for additional detail on sea level rise and subsidence information for the study area.

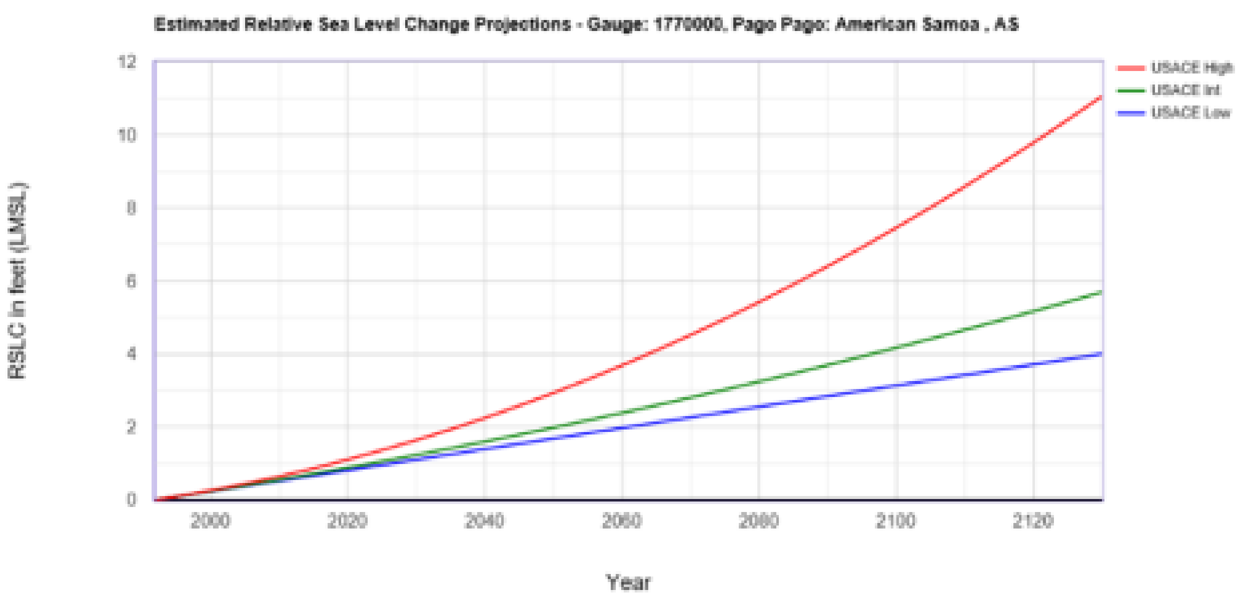

Figure 9: USACE Sea Level Change Curve Calculator, Pago Pago: American Samoa

Table 1: Estimated relative rea level change projections, Pago Pago, American Samoa

Year	Low (ft)	Intermediate (ft)	High (ft)
2030	1.112	1.24	2.256

2080	2.562	3.251	5.433
2130	4.012	5.705	11.072

2.7 Economic Environment

The study area has a history of flooding issues as the population continues to grow in the alluvial plain beneath steep mountains that receive significant rainfall. Flooding within the study area occurs relatively frequently, and significant flooding occurred numerous times within the past 20 years, including in 2003 (Typhoon Esau), 2004 (Tropical Cyclone Heta), 2014 (torrential rainfall), and 2018 (Tropical Cyclone Gita). Flooding from these storms caused millions of dollars in damages (American Samoa Hazard Mitigation Plan, 2020).

There are approximately 545 structures (both residential and non-residential) located within the 0.2 percent AEP floodplain. In addition to residential and non-residential structures, there are critical facilities such as major roads (e.g., Route 1 and 19), schools and churches. Figure 10 shows the study's structure inventory and 0.2 percent AEP future without-project floodplain.

Under the future without-out project condition, Tafuna remains the economic hub for business, government and infrastructure in American Samoa.

For a discussion on socioeconomics and environmental justice within the study area see Section 3.6.13 Socioeconomics and Environmental Justice.

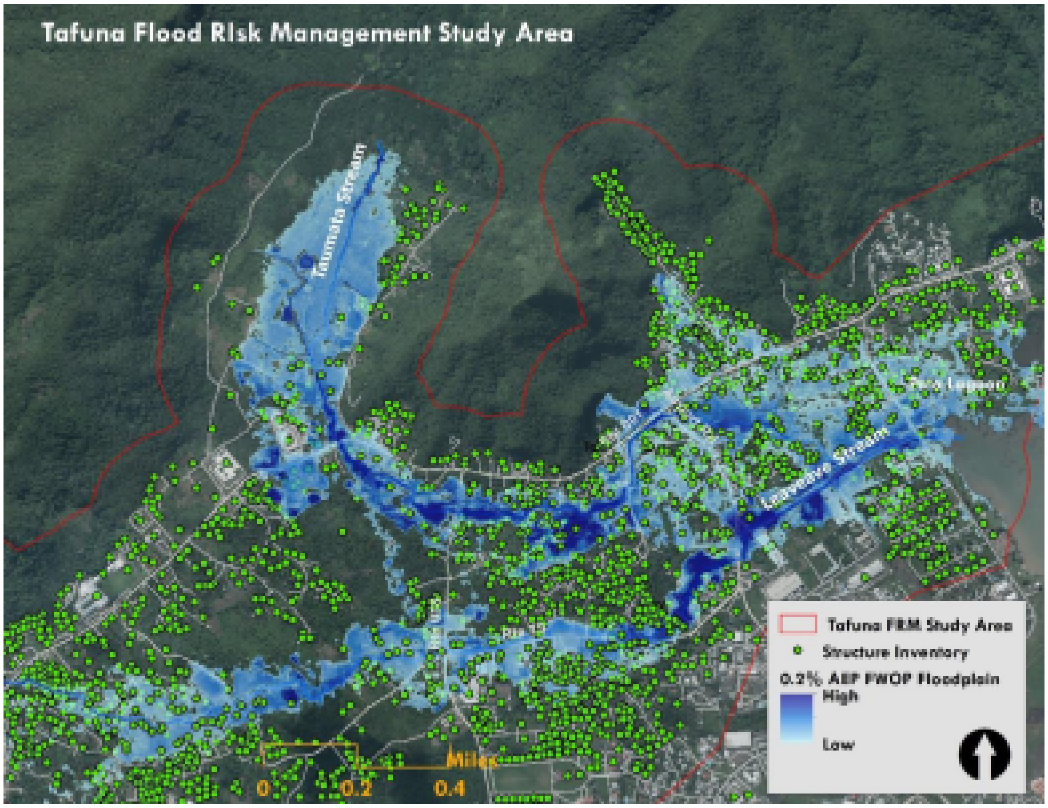

Figure 10: 0.2 percent AEP floodplain and structure inventory

2.7.1 Population and Housing

Historic and current population estimates for the study area are summarized in Table 2. From 2010 to 2020, the overall population of American Samoa declined by 10.5 percent. During the same time period, the population of Tafuna village remained very stable, rising by only 43.

Table 2: Historic and current population estimates

Area	Population		Total Change	Annualized Change Over Decade
	2010	2020	2020-2010	
Tafuna	7,945	7,988	43	+0.05%
American Samoa	55,519	47,710	-5,809	-1.1%

Source: 2018 American Samoa Statistical Yearbook and 2020 U.S. Census

Table 3 summarizes existing housing and household data for the study area. Because many areas of American Samoa lost housing units, the Tafuna Village alone was responsible for over half of net growth in housing units. The overall vacancy rate for Tualauta County, where Tafuna is located, was 12.0 percent in 2010, with a vacancy rate for rental units of only 5.4 percent. Tafuna had the highest average occupants per room for both owners and renters within

Tualauta County.

Table 3: Estimated occupied and vacant housing units

Area	Total Housing Units		New Units	% Change
	2010	2020		
Tafuna	1,428	1,914	486	+34.0%
Tualauta County	4,080	5,304	1,224	+30.0%
American Samoa	10,963	11,807	844	+7.7%

Source: 2020 U.S. Census

Additional information on population, housing, socioeconomic conditions and environmental justice is located in Section 3.6.13 Socioeconomics and Environmental Justice.

2.7.2 Employment and Key Industries

Employment data by industry for American Samoa and Tualauta County are summarized in Table 4. Social services, government, and manufacturing are the three largest industries within the County. The breakdown of industries is very similar between the County and the Territory. Tualauta County is incredibly important to the American Samoa economy, with more than 35 percent of all employment and nearly 50 percent of employment in several industries.

Table 4: Employment by industry for American Samoa

Industry	Tualauta County	Percent	American Samoa	Percent
Agriculture, Fishing, Mining	102	1.6%	501	3.0%
Construction	461	7.3%	1,096	6.6%
Manufacturing	1,034	16.4%	2,753	16.5%
Wholesale	171	2.7%	335	2.0%
Retail	713	11.3%	1,614	9.7%
Transportation	444	7.0%	1,100	6.6%
Information	151	2.4%	385	2.3%
Finance, Insurance, Real Estate	192	3.0%	391	2.3%

Management, Administration	157	2.5%	330	2.0%
Education, Health, Social Services	1,213	19.2%	3,324	19.9%
Arts, Entertainment, Food Service, Tourism	420	6.7%	932	5.6%
Other Services	321	5.1%	626	3.7%
Public Administration	898	14.2%	3,229	19.3%
Military	30	0.5%	87	0.5%
Total	**6,307**	**100.0%**	**16,703**	**100.0%**

Source: 2018 American Samoa Statistical Yearbook

3 Plan Formulation *

This chapter presents results of the first step of the planning process, the specification of water and related land resources problems and opportunities in the study area. It also establishes the planning objectives and constraints, which are the basis for formulation of alternative plans and outlines the evolution of alternatives from the initial to final array. In its entirety, chapter 3 serves to meet the requirements of the NEPA alternatives analysis.

3.1 Planning Framework

Plan formulation is the process of building alternative plans that meet planning objectives and avoid planning constraints. Alternative plans are a set of one or more management measures functioning together to address one or more planning objectives. Alternatives were developed in consideration of study area problems and opportunities as well as study objectives and constraints with respect to the four evaluation criteria described in the Principles and Guidelines (completeness, effectiveness, efficiency, and acceptability).

Completeness is the extent to which a given alternative plan provides and accounts for all necessary investments or other actions to ensure the realization of the planned effects.
Effectiveness is the extent to which an alternative plan alleviates the specified problems and achieves the specified opportunities.
Efficiency is the extent to which an alternative plan is a cost-effective means of alleviating the specified problems and realizing the specified opportunities, consistent with protecting the nation‘s environment.
Acceptability is the workability and viability of an alternative plan with respect to acceptance by State and local entities, tribes, and the public and compatibility with existing laws, regulations, and public policies.

3.2 Management Measures and Screening

3.2.1 Management Measures

A management measure is a feature or activity that can be implemented at a specific geographic site to address one or more planning objectives. A preliminary list of structural and nonstructural management measures is included below. Note: (*) denotes a measure that was screened out.

Nonstructural Measures

- Floodplain Zoning: Place restrictions on land usage in the areas surrounding a river by preventing or limiting development within flood zones. In addition, specific building standards and construction materials may be required to reduce potential flood damages.
- Flood Warning Systems/Evacuation Routes: Alert the community or key officials of imminent hazardous flooding conditions.
- Property Buyouts or Relocations*: Acquire lands and structures either by purchase or through the powers of eminent domain.
- Flood Proofing: Seal structures from water damage by waterproofing walls and floors and installing floodgates at entry points.
- Elevating Structures: Lift the building from its foundation and raise it above the flood level.
- Flood Warning System and Evacuation Routes: Provide accurate information to allow individuals and decision-makers to make informed decisions about whether to take

emergency action (e.g., evacuation) during a flood event, and document a plan identifying evacuation routes and temporary refuge facilities.

- Debris and Trash Removal: Remove debris and trash from the river channel to increase channel conveyance.
- Vegetation Management: Remove native or non-native vegetation from the river channel to increase channel conveyance.
- Education and/or Communication: Develop resilience-focused resources, tools, and/or education programs, designed for use by local communities and governments.
- Comprehensive Stormwater Management Plan: Develop a strategy for implementing a sustainable approach to managing stormwater runoff and protecting waterways.

Structural Measures

- Improve Existing Roadways, Bridges, and Culverts: actions directed at improving conveyance within the study area.
- Detention Basins (Surface and/or Sub-surface): Create temporary storage facilities to collect flood flows during larger storm events; operate to manage storm flow. This measure could also include natural and nature-based features (NNBF) like wetland creation or restoration, low flow swales, and/or utilizing impervious surfaces.
- Diversion / Bypass Structures*: Create diversion structures (weirs, etc.) to divert high flows to less densely populated areas.
- Infiltration System*: Construct shallow excavations lined with fabric and filled with stone to create underground reservoirs for stormwater runoff.
- Flood Barrier: Construct levees, berms, and/or flood walls.
- Ring Walls or Berms*: Construct small ring wall or berm around the exterior of a single

structure or small group of structures.
- Grade Control Structure*: Install concrete- or boulder-filled trenches at changes in slope to manage bed erosion.
- Channel Improvements: Install lining, realign, widen, or deepen stream channels to increase flow capacities.

3.2.2 Screening of Measures

Screening is the process of eliminating, based on planning criteria, those measures that will not be carried forward for consideration. Completeness, effectiveness, efficiency, and acceptability are the four evaluation criteria specified in the CEQ Principles and Guidelines (Paragraph 1.6.2(c)) in the evaluation and screening of alternative plans. Measures considered in any planning study should meet minimum subjective standards of these criteria to qualify for further consideration and comparison with other plans.

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

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

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

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

Table 5 provides the results of the screening evaluation based on the criteria described above. Additional detail is provided, following the table, summarizing the rationale for measure elimination.

Table 5: Measure screening evaluation

Measure	Retained/ Eliminated	Completeness	Effectiveness	Efficiency	Acceptability
Nonstructural					
Flood Warning System/Evacuation Routes	Retained	Low	Med	High	High
Property Buyouts or Relocations	*Eliminated*	*High*	*High*	*Low*	Low
Flood Proofing	Retained	Med	Med	Med	Med
Elevating Structures	Retained	Med	Med	Med	Med

Debris and Trash Removal	Retained	Med	Low	High	High
Vegetation Management	Retained	Med	Low	High	Med
Education and/or Communication	Retained	Low	Med	High	High
Comprehensive Stormwater Management Plan	*Eliminated*	Med	Med	High	Med
Structural					
Improve existing roadways, bridges, and culverts	Retained	Med	Med	Med	High
Detention Basins	Retained	Med	Med	High	Med
Diversion / Bypass Structures	*Eliminated*	Med	Low	Med	Med
Infiltration System	*Eliminated*	Low	Low	Med	Med
Flood Barrier	Retained	High	High	High	Med
Ring Walls or Berms	*Eliminated*	Low	Low	Med	Med
Grade Control Structure	*Eliminated*	Low	Low	Med	Med
Channel Improvements	Retained	Med	Med	Med	High

Buyouts and relocation of structures were screened out from further consideration because of the challenges of implementation. Due to the communal land ownership system, in many areas of the watershed clear delineation of property boundaries do not exist. Without the necessary parcel data to identify extents and useability, buyout or relocation analysis is problematic. It is likely more realistic and practical to elevate or floodproof. Buyouts and relocation of structures were screened out from further consideration because of the challenges of implementation and lack of economic feasibility. According to the American Samoa Government, approximately 90% of land in American Samoa is communal land. Communal land is an integral part of the social organization and is tied to both the kinship system and village organization. The cognatic descent group (‘âiga) are the “owners” of the land. Rights to land use come with membership in the descent group. Due to the communal land ownership system, in many areas of the

watershed clear ownership and title records do not exist. Without the necessary ownership data to determine property owner consensus, buyout or relocation analysis is problematic. It is likely more realistic and practical to elevate or flood proof structures.

Comprehensive Stormwater Management Plan was screened out because it would require analysis on waterways which do not meet the 800 cfs requirement and are outside the scope of this study. Comprehensive Stormwater Management Plan, study and development is being recommended in the USACE American Samoa Post-disaster Watershed Assessment (anticipated final Watershed Plan available July 2022).

Education and/or Communication is carried forward but will not be considered as part of an alternative because it is inherent in all implemented Flood Risk Management projects constructed with USACE. As part of the Agreement to implement, education and communication such as a Floodplain Management Plan, participation in the National Flood Insurance Program, and mandatory communication requirements with the community are obligations of the nonfederal sponsor.

Ring walls/berms were screened out because they do not directly address the study objectives. They would help protect groundwater wells, but were deemed an ineffective solution, because flood water seeps underground and circumvents above-ground features.

An infiltration system was screened out for not meeting the planning objectives to reduce flood risk during rain events over the 50-year period of analysis, as well as reducing life safety risk during rain events. As a standalone measure, an infiltration system is more appropriate to facilitate groundwater recharge and is therefore not an FRM measure.

A diversion/bypass structure was screened out as it did not meet the planning objectives. There was no obvious area within, or within proximity to, the study area that would be a good site to detain or convey the diverted water. Without such a site, the flood risk would be transferred further down the watershed, potentially to a more densely populated built up area. The lack of defined channels also makes this measure a challenge to implement because of the additional flows associated with diversions and bypasses.

Grade control structures were also screened out for not meeting the planning objectives. Grade control structures are intended to control flows in areas with steep topography with well-defined channels. They would not be effective given the relatively flat and shallow stream channels within the study area.

3.3 Initial Array of Alternatives

Alternative plans are a set of one or more management measures functioning together to address one or more planning objectives. An initial array of alternative plans was formulated by combining retained management measures. For nonstructural measures, it was assumed that one or more nonstructural measures will likely be added to any alternative carried forward into the focused array. However, as both a nonstructural measure and a standalone alternative, the study team carried forward both dry flood proofing (non-residential structures) and elevating (residential structures).

The study team developed the Initial Array of Alternatives after a site visit in January 2020. Table 6 provides a both the Initial Array of Alternatives (August 2021) and a reformulated list of alternatives (August 2021) that was developed as the study evolved. Then, the study team conducted a qualitative evaluation of the alternatives identified in Table 6 to get to the Final Array of Alternatives. Special consideration was given to alternatives that minimize real estate impacts (e.g., leveraging existing roads and FRM structures) due to anticipated challenges related to land ownership and the non-federal sponsor's ability to acquire the necessary Lands, Easements, Rights-of-Way, Relocations and Disposal (LERRDs).

Table 6: Tafuna Flood Risk Management Study initial array of alternatives

Initial Array of Alternatives (August 2020)	Reformulated Alternatives (August 2021)
A: No Action	**A:** No Action
B: Nonstructural	**B:** Leaveave Stream – Detention and Conveyance
C: Existing Roads and Structures	**C:** Taumata Stream – Conveyance
D: Detention Basin(s)	**D:** Combined Taumata and Leaveave streams (Structural)
E: Conveyance	**E:** Nonstructural (Dry Flood Proof, Only Commercial)
F: Conveyance/Detention Combination	**F:** Nonstructural Taumata (Elevate Residential/ Dry Flood Proof Commercial)
G: Structural/Nonstructural Combination	**G**: Nonstructural Leaveave (Elevate Residential/ Dry Flood Proof Commercial)
	H: Nonstructural combined Leaveave and Taumata (Elevate Residential/ Dry Flood Proof Commercial)

During early iterations of investigating structural measures, the study team evaluated the potential to include detention basins as a FRM measure and potential NNBF. NNBF are landscape features that are used to provide engineering functions relevant to FRM, while producing additional economic, environmental, and/or social benefits. Examples of NNBF include vegetated environments such as freshwater wetlands. It is recognized that a strategy that combines NNBF with nonstructural and structural measures represents an integrated approach to FRM that can deliver a broad array of ecosystem goods and services to local communities. Several “pilot” locations were explored in the Kokoland vicinity along the Leaveave Stream and select areas along Taumata Stream (Figure 11). However, when modeled in HEC-RAS, the it was concluded that detention basins were not effective measures, having limited ability to improve residual floodplains. There were also water quality concerns. It was noted that the soils in the study area tend to be highly porous and the water in the detention basins would eventually enter the productive Tafuna-Leone Plain groundwater wells and thus could be a potential health a safety issue. So, detention basins were not carried forward to the final array of alternatives. All other structural measures identified above were carried forward.

The reformulated alternatives (August 2021) took the approach of looking at each stream separately (Leaveave and Taumata streams) for potential federal interest. Based on initial HEC-

RAS modeling runs and economic analysis, it was concluded that the study area is relatively similar in its flooding characteristics (widespread shallow flooding with low velocities) and structure types and values were similar throughout. Thus, it did not make sense to proceed with the approach of evaluating each stream separately.

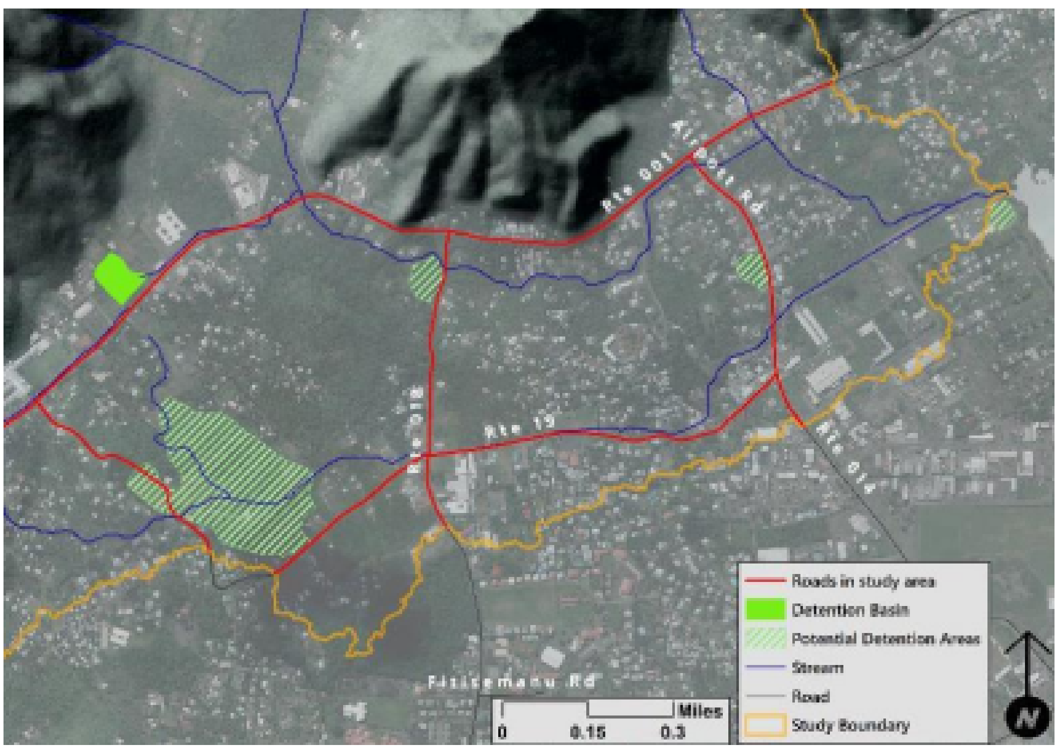

Figure 11: Detention basin alternative

The qualitative evaluation of the initial array of alternatives yielded the following conclusions:

- Flooding is widespread and shallow (particularly in areas of more dense population)
- Channel conveyance improvements were more effective than detention options
- Alternatives were not impacted by future changes in seal level rise as they are largely outside the tidal influence zone

3.4 Final Array of Alternatives

Based on the rationale and findings noted in Section 3.3, the Final Array of Alternatives were developed. Upon evaluation of the Final Array of Alternatives, it was concluded that channel conveyance improvements (e.g., channel widening, vegetation removal, etc.) yielded limited FRM benefits. Flood barriers were included as a potential measure in the Final Array of Alternatives, despite the known real estate challenges, because of the anticipated effectiveness in improving FRM in the study area. The final array of alternatives includes:

- Alternative A: No Action Alternative
- Alternative B: Channel Conveyance Improvements (Leaveave and Taumata Streams) • Alternative B1: Channel Conveyance Improvements and Flood Barriers (Leaveave and Taumata Streams)
- Alternative C: Taumata Flood Barrier and Nonstructural Improvements

- Alternative D: Nonstructural Improvements

3.4.1 Alternative A: No Action Alternative

The No-Action Alternative is synonymous with no federal action. This alternative is analyzed as the future without-project condition for comparison with the action alternatives. Detailed discussion on FWOP can be found in Section 2 .

3.4.2 Alternative B: Channel Conveyance Improvements

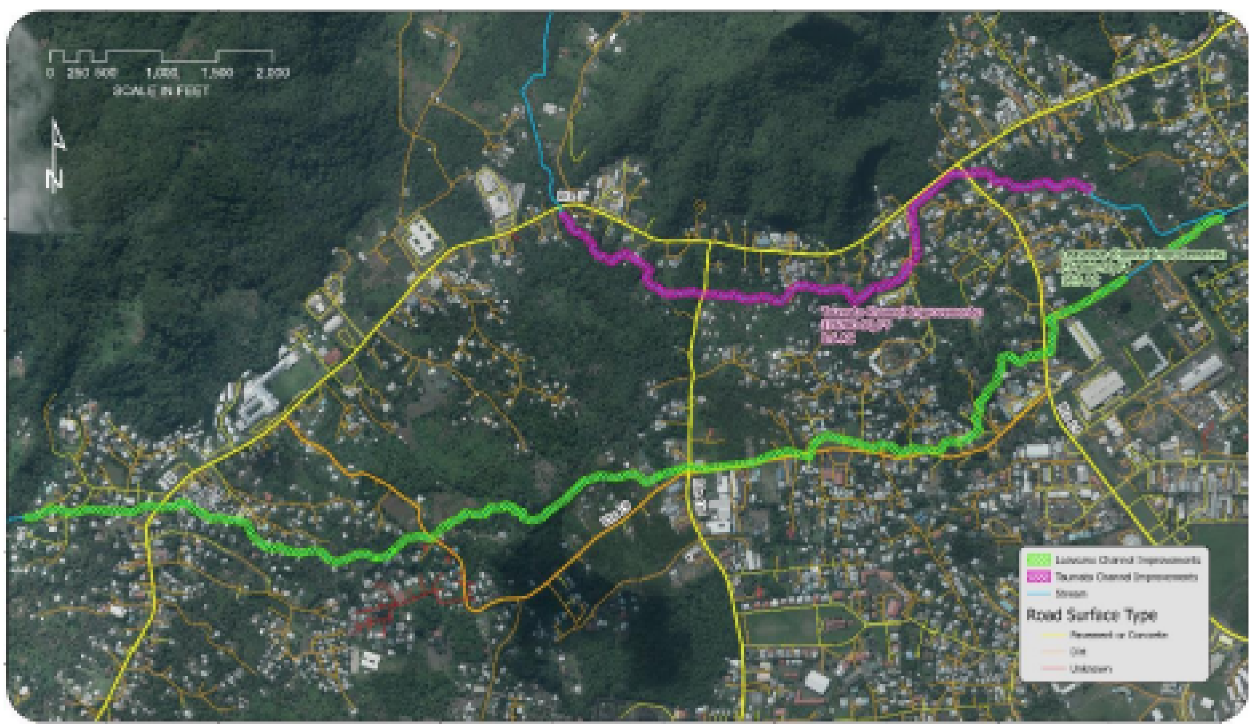

Figure 12: Alternative B channel conveyance improvements

Alternative B includes approximately 6,340 ft of channel conveyance on Taumata Stream and 13,120 ft of channel conveyance on Leaveave Stream. This alternative includes vegetation removal and conveyance improvements such as excavation of material to create a uniform channel with a varying bottom width of five to 20 ft and a two to one side slope.

The minimum estimated real estate requirements for Alternative B are:

- Leaveave Channel Improvements: 17.3 acres of channel improvement easements
- Taumata Channel Improvements: 8.6 aces of channel improvement easements
- Staging, access, construction: 11.2 acres of temporary work area easements (two years)

Figure 13 provides a floodplain comparison between the 4 percent AEP future without-project conditions and Alternative B. Based on the modeled results, channel conveyance improvements provided very little FRM benefits, as the future without-project and with-project floodplains are nearly identical.

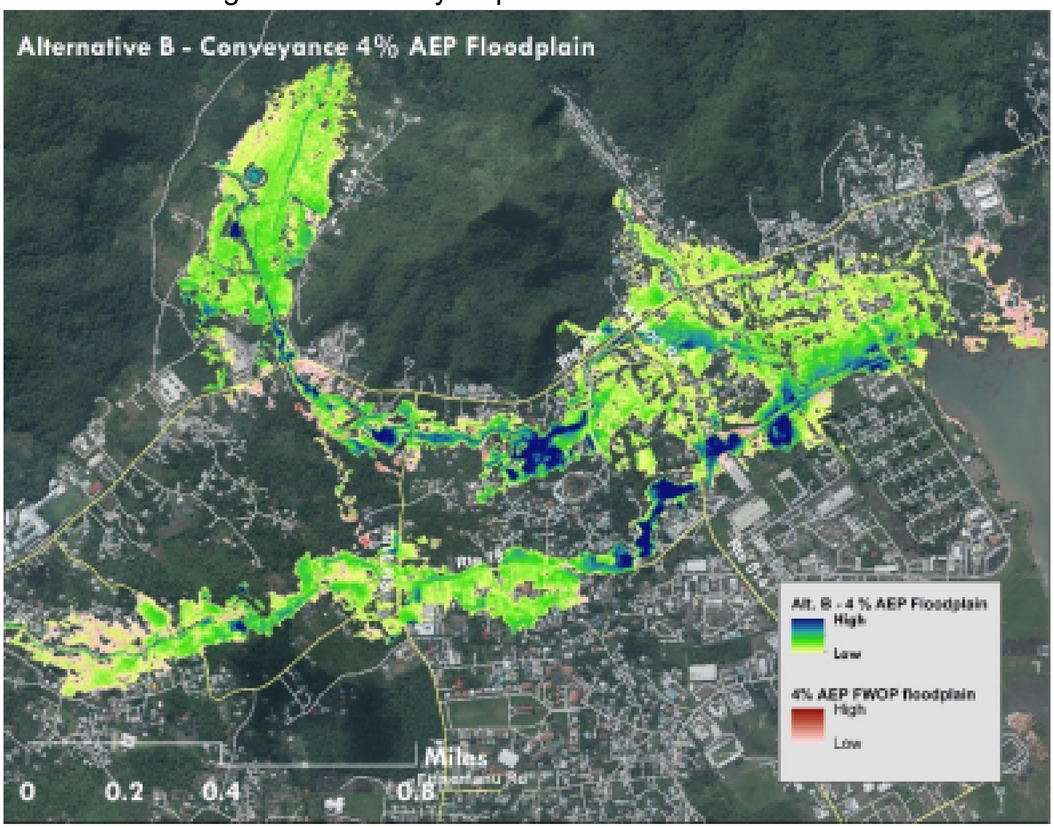

Figure 13: Alternative B: future without-project and with-project floodplain comparison

3.4.3 Alternative B1: Channel Conveyance Improvements and Flood Barriers

Alternative B1 (Figure 14) includes the conveyance improvements described in Alternative B above plus construction of a flood barrier. There is approximately 2,400 linear ft (lf) of barrier with an average height of seven ft (from ground elevation) on the Taumata stream and approximately 3,400 lf of barrier with an average height of five ft (from ground elevation) on Leaveave stream.

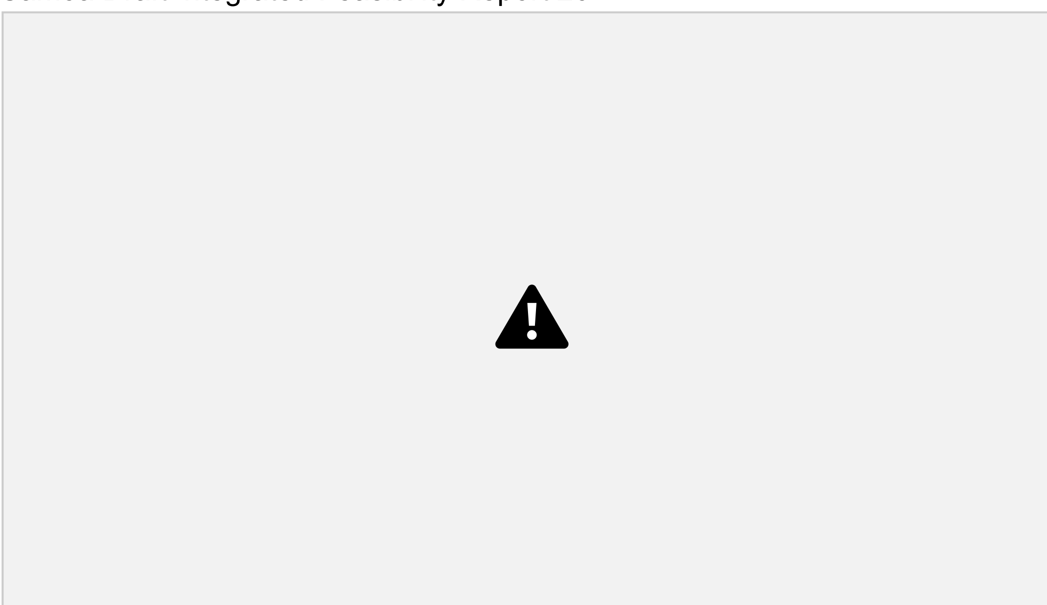

Figure 14: Alternative B1 channel conveyance improvements and flood barriers

The minimum estimated real estate requirements for Alternative B are:

- Leaveave Channel Improvements: 17.3 acres of channel improvement easements
- Leaveave Flood Barrier: 2.3 acres of flood protection levee easements
- Taumata Channel Improvements: 8.6 aces of channel improvement easements
- Taumata Flood Barrier: 2.3 acres of flood protection levee easements
- Staging, access, construction: 14.4 acres of temporary work area easements (two years)

Figure 15 provides a floodplain comparison between the 4 percent AEP future without-project conditions and Alternative B1. Alternative B1 is more effective at reducing flood risk, specifically in areas adjacent to the flood barriers. The flood barriers are expected to provide FRM for structures located along the right bank of Leaveave and Taumata streams.

Figure 15: Alternative B1 future without-project and with-project floodplain comparison

3.4.4 Alternative C: Taumata Flood Barrier and Nonstructural Improvements

Alternative C (Figure 15) includes the construction of approximately 2,400 lf of barrier with an average height of seven ft (from ground), on Taumata Stream. The nonstructural component of this alternative will include dry floodproofing 38 nonresidential buildings and elevating 242 residential structures (assumes 100% participation rate) as these structures will not receive flood protection from the Taumata Stream flood barrier. Participation in the alternative will be voluntary for residences identified in the study area. For additional details about the nonstructural analysis or methodology, refer to Section 3.4.5.1.

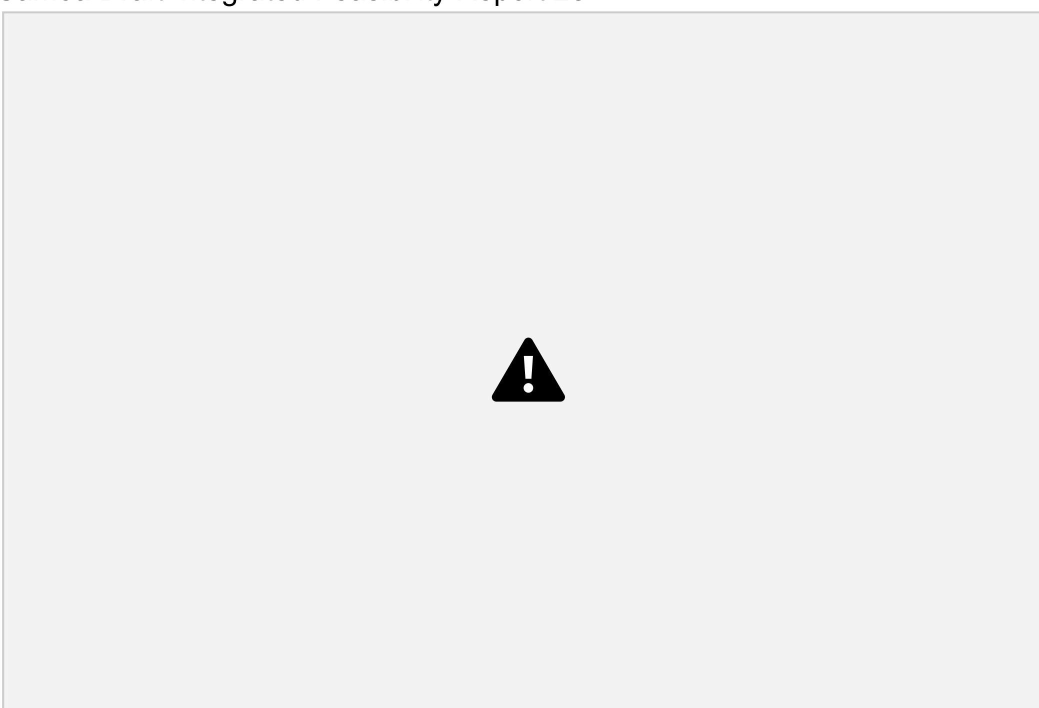

Figure 16: Alternative C Taumata flood barrier and nonstructural improvements

Alternative C includes the construction of approximately 2,400 lf of barrier with an average height of seven ft (from ground) on Taumata Stream. The nonstructural component will include dry floodproofing 38 nonresidential buildings and elevating 242 residential structures (assumes 100% participation rate) as these structures will not receive flood protection from the Taumata Stream flood barrier. For additional details about the nonstructural analysis or methodology, refer to Section 3.4.5.1.

The minimum estimated real estate requirements for Alternative C are:

- Taumata Flood Barrier: 2.3 acres of flood protection levee easements • Staging, access, construction: 1.8 acres of temporary work area easements (two years)

Additional real estate requirement agreements associated with the voluntary participation include:

- Floodproofing: 38 structures, Right of Entry agreements and flood proofing agreements
- Elevating: 242 residences, Right of Entry agreements and flood proofing agreements

Figure 17 provides an illustration of the structures that will receive anticipated benefit from the construction of the Taumata flood barrier (labeled with white points) and the 280 candidate structures for either dry flood proofing (nonresidential structures) or elevating (residential structures) represented by the orange points.

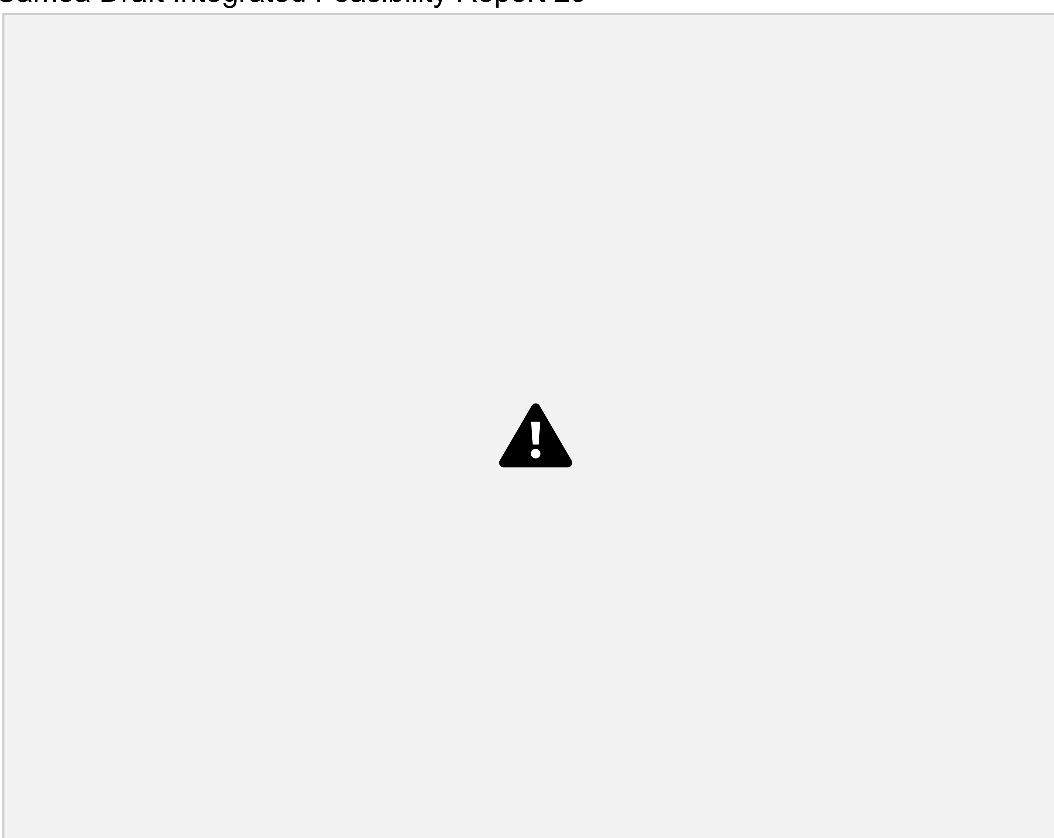

Figure 17: Alternative C candidate structures for nonstructural improvements

3.4.5 Alternative D: Nonstructural Improvements

Alternative D (Figure 17) includes only nonstructural measures. Preliminary benefit-cost analysis evaluations (see Section 3.4.5.2 for additional detail) show that nonstructural measures affecting 312 structures can provide FRM benefits comparable to a structural improvement plan. At this stage of the study, dry floodproofing 40 nonresidential structures and elevating 272 residential structures is assumed to be the most effective nonstructural solution given the frequency and depth of flooding. This alternative is different than Alternative C because it includes additional structures damaged as a result of not constructing the Taumata flood barrier. This number represents the maximum number of structures for planning purposes. Additional analysis is necessary on-site to identify eligibility, validate existing conditions of structures, as well as the need for nonstructural improvements. Participation in the alternative will be voluntary for residences identified in the study area. The aggregation methodology and participation rate sensitivity analysis for Alternate D are described below in Sections 3.4.5.1 and 3.4.5.2.

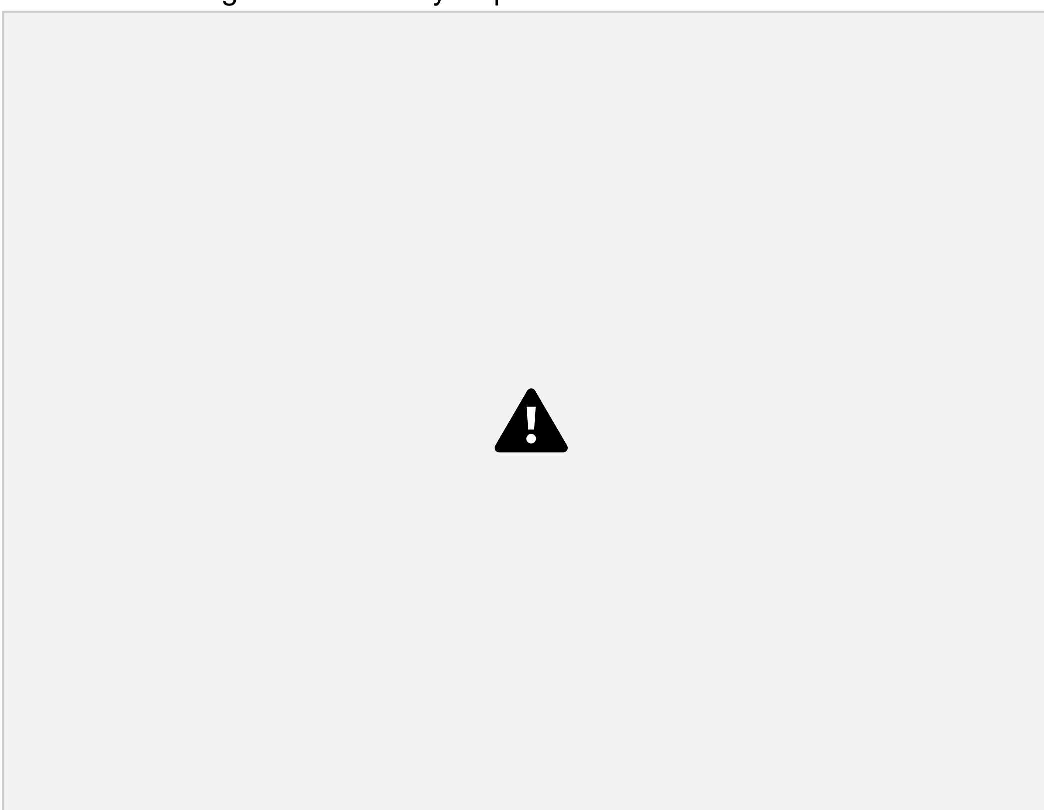

Figure 18: Alternative D nonstructural improvements

The minimum estimated real estate requirements for Alternative D are:

- Staging: 0.5 acres of temporary work area easements (two years)

Additional real estate requirements agreements associated with the voluntary participation include:

• Floodproofing: 40 structures, Right of Entry agreements and flood proofing agreements
• Elevating: 272 residences, Right of Entry agreements and flood proofing agreements

3.4.5.1 Nonstructural Analysis, Aggregation and Participation Rate

The nonstructural FRM measures considered for this study are: 1) dry floodproofing nonresidential structures and 2) elevation of residential structures. Dry floodproofing consists of waterproofing the structure to prevent flood waters from entering. Only dry floodproofing was considered for non-residential structures, while elevation was considered for residential structures. Elevation is a measure that raises a structure's first floor elevation to an elevation that is at least equal or greater than a design water surface elevation.

The nonstructural aggregation methodology was determined by grouping structures based on their potential flood risk and then selecting the grouping that reasonably maximizes net-benefits. The nonstructural aggregation analysis consisted of grouping the study's structure inventory into four groups based on flood risk associated with the ten, four, two and one percent AEP event floodplains. A benefit-cost analysis was performed on each of the four AEP event floodplains listed above. Table 7 shows the results of this aggregation analysis. The 10 percent AEP

floodplain grouping maximized net-benefits. As such, it was carried forward for all nonstructural alternatives (Alternatives C and D).

Table 7: Nonstructural aggregation analysis results

Assumes 100% participation rate, Oct 2020 price level in $1000's				
	10% AEP	**4% AEP**	**2% AEP**	**1% AEP**
First Cost	131,346	163,925	180,059	191,874
Equivalent Annual Benefits	6,643	7,023	7,194	7,266
Average Annual Cost	4,631	5,780	6,349	6,765s
Net Benefits	2,012	1,244	846	501
BCR	1.4	1.2	1.1	1.1
Total Number of Structures	312	388	429	465
Residential	272	335	367	396
Non-Residential	40	53	62	69

3.4.5.2 Participation Rate Sensitivity Analysis

A sensitivity analysis for the participation rates was completed to determine how benefit-cost metrics will be affected by changes in participation rates. The sensitivity analysis evaluated

50,000 combinations of the 312 structures using three participation rate scenarios (25, 50 and 75 percent). Table 8 shows the range of benefit-cost metrics and results of the sensitivity analysis. The results demonstrate that for all three of the assumed participation rates, nonstructural measures have positive net benefits for most summary statistics; the exception is the minimum estimated net benefit value for the 25 percent participation rate. It is assumed that if the exception scenario is realized neither the federal or nonfederal partner will invest in the project as it is cost prohibitive and clearly not supported by the community. The BCR and/or Net Benefits will change with each additional scenario run under the different rates, however, they will remain within the range of minimum to maximum. Under this particular set of combinations the hlighted cells indicate the highest value for that statistic.

Table 8: Results of the nonstructural participation rate sensitivity analysis on 10% AEP floodplain

Oct 2020 price level in $1000's

Participation Rate	Metric	Minimum	25% Percentile	Median	75% Percentile	Maximum
25%	BCR	0.71	1.26	1.37	1.49	2.16
	Net Benefits	-247	$291	$426	$566	$1,365
50%	BCR	1.01	1.31	1.38	1.45	1.74
	Net Benefits	18	$706	$865	$1,025	$1,761
75%	BCR	1.13	1.34	1.38	1.42	1.62
	Net Benefits	$428	$1,164	$1,305	$1,437	$2,020

Alternative C and D each have a nonstructural component which requires comparison for NED benefit-cost analysis. For purposes of this analyses and evaluating federal interest (Section 3.5.1 Federal Objective), a 100 percent participation rate was used to compare Alternatives C and D. It

was assumed that if the participation rate is less than 100 percent, consistent evaluation was a concern because there was no identical way to identify non-participating structures that would be left out of the analysis. Given the issues associated with basing the analysis on a lower participation rate, using the 100 percent rate is preferable, particularly for the Tafuna FRM study, where the sensitivity analysis shows (Table 8) the project is justified, and NED Plan determination is not significantly impacted under the lower participation rates.

All nonstructural results presented in the subsequent sections of this report assume that 100 percent of the structures contained in the 10 percent AEP floodplain will receive dry flood roofing protection (non-residential structures) or will be elevated (residential structures). This assumption will be refined as the study moves into feasibility level design.

Plan Evaluation and Selection

3.5 Plan Evaluation

The following sections describe the evaluation and comparison of the final array of alternatives. **3.5.1 Federal Objective**

The NED analysis reflects FRM benefits associated with reduced flood damages to structures, their contents, vehicles, and the avoidance of post-flood clean-up costs. Table 9 shows a summary of results for Alternatives B, B1, C, and D. Alternative C reasonably maximizes net benefits at $2.78 million (highlighted in grey).

Table 9: Summary results of final array of alternatives (Oct 2021 price level, $1,000)

Item	ALTERNATIVE				
	A	B	B1	C	D
Expected Annual Damages 2030 Base Year	8,961	9,178	7,233	1,677	1,922
Expected Annual Damages 2079 Future Year	9,494	9,154	6,861	1,777	2,001
Equivalent Annual Damages, 50-Year Period of Analysis, 2.25% Discount Rate	9,178	9,168	7,081	1,718	1,954
Equivalent Average Annual Benefits (AAB), 50-Year Period of Analysis, 2.25% Discount Rate	0	10	2,097	7,461	7,224
Project First Costs	0	27,641	47,345	136,628	141,272
Interest During Construction	0	154	665	1,531	394
Total Economic Costs	0	27,795	48,010	138,159	141,665
Average Annual Costs @ 50-year period of analysis and 2.25%	0	932	1,609	4,631	4,748
Annual operations, maintenance, repair, replacement, and rehabilitation (OMRRR)	0	146	244	46	0*
Total Average Annual Costs	0	1,078	1,853	4,677	4,748
Net Benefits	--	-1,068	244	2,784	2,476
Benefit-to-Cost Ratio (BCR)	--	0.01	1.1	1.6	1.5

** no OMRRR cost was included for nonstructural measures*

3.5.2 Contribution to Objectives and Avoid Constraints

This section evaluates the alternatives considering the study's objectives (to reduce flood risks to property, critical infrastructure, and life safety in the study area). The following conclusions were drawn from the hydrology and hydraulics analyses and the economic analysis:

- Alternative B is not effective at reducing damages and induces damages in certain reaches when compared to Alternative A (no action).
- Alternatives B1, C, and D are effective in reducing damages in most study reaches when compared to Alternative A.
- The Taumata Stream flood barrier in Alternatives B1 and C is effective at reducing damages along the right bank in close proximity to the flood barrier's extent, where damages only occur at the 0.2 percent AEP event.
- The nonstructural alternatives (Alternative C and D) are the most effective alternatives in terms of preventing damages throughout the study area.
- Alternative B1 which combines channel conveyance and flood barrier along Taumata and Leaveave streams is expected to best reduce flooding on the roads, significantly improving physical safety in the residential communities along both streams.
- Alternative C minimizes negative impacts to mangroves. The Taumata flood barrier improves water quality by limiting amount of water flowing through residential and commercial areas; Construction could result in short-term water quality impacts, but these would be minimized through BMPs.

Table 10: Assessment of achieving the study's objectives and constraints

Alternative	**Property**	**Critical Infrastructure (roads)**	**Life safety**	**Minimize water quality impacts to mangroves**
Alternative A: No Action	Low	Low	Low	Low
Alternative B: Channel Conveyance Improvements	Low	Low	Low	Low
Alternative B1: Channel Conveyance Improvements and Flood Barriers	Medium	High	High	Low
Alternative C: Taumata Flood Barrier and Nonstructural Improvements	High	Medium	Medium	High

Alternative D: Nonstructural Improvements	High	Low	Low	Low

3.5.3 Principles and Guidelines Criteria

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

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

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

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

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

Table 11 compares the focused of alternatives against these criteria using qualitative (e.g., high, medium, and low) criteria.

Table 11: Planning and Guidelines criteria evaluation of alternatives

Alternative	Completeness	Effectiveness	Efficiency	Acceptability
Alternative A: No Action	Low	Low	Low	Low
Alternative B: Channel Conveyance Improvements	Medium	Low	High	Medium
Alternative B1: Channel Conveyance Improvements and Flood Barriers	High	High	Medium	Low
Alternative C: Taumata Flood Barrier and Nonstructural	High	High	Low	High

Improvements				
Alternative D: Nonstructural Improvements	Medium	Medium	Low	High

The No Action Alternative is not complete, effective, efficient, or acceptable. This plan does not alleviate specified problems, does not meet study objectives, and is not a cost-effective solution to address the problem.

Alternative B is a complete and efficient plan. However, it less effectively addresses FRM problems compared to other structural alternatives with minimal reduction of annual damages and significant residual damages under the future with-project condition compared to other structural alternatives. A significant amount of residual flooding/damages still occurs even with the project in place, and the chance of flooding in any given year, as represented by AEP, is not significantly reduced as compared to the without-project condition (e.g., there is a 20 percent AEP floodplain with Alternative B in place, indicating flooding from a 20 percent AEP event or smaller). In addition, there are some acceptability concerns, particularly regarding in-stream improvements, which may have negative environmental impacts and be less acceptable in terms of compatibility with existing environmental compliance regulations. Finally, Alternative B is less efficient at reducing flood risk compared to other alternatives, with fewer net benefits compared to Alternative B1, C, and D.

Alternative B1 is a complete and effective plan. It is more effective than Alternative B because of the addition flood barriers along both Leaveave and Taumata streams. In addition, this plan is less acceptable due to the instream improvements noted above, as well as that the construction of a flood barrier along Leaveave (Route 19) a major thoroughfare. There would also be relatively high amounts of private property impacts associated with construction of the flood barrier. This plan has a positive benefit to cost ratio; however, for the reasons noted above, the study team screened out Alternative B1 from further analysis.

Alternative C is a complete, effective, and acceptable plan. This plan reduces damages by approximately 81 percent with fewer residual damages compared to other alternatives and has higher NED benefits compared to other alternatives as well. As a result of this analysis, Alternative C was carried forward for further evaluation.

Alternative D is a complete and effective plan. Significant residual flooding/damages still exists with the project in place and the chance of flooding in any given year (i.e., AEP) is not reduced as compared to the without-project. Structures would be protected (either dry flood proofed or elevated); however, residual flooding of the roads and community would still exist. This plan has a positive benefit to cost ratio and was carried forward for further evaluation.

3.5.4 System of Accounts

In January 2021, a policy memorandum was issued by the Assistant Secretary of the Army for Civil Works (ASA(CW)) directing study teams to identify and analyze benefits in total and equally across a full range of benefit categories. The intent of this directive is for teams to comprehensively evaluate benefits including equal consideration of economic, environmental, and social categories. To meet the intent of this memo, the final array of alternatives was assessed to identify benefits across four categories: NED, Regional Economic Development (RED), Other Social Effects (OSE), and Environmental Quality (EQ).

The **NED** account displays changes in the economic value of the national output of goods and services.

The **RED** account registers changes in the distribution of regional economic activity that result from each alternative plan. Evaluations of regional effects are to be carried out using nationally consistent projections of income, employment, output, and population.

The **OSE** account registers plan effects from perspectives that are relevant to the planning process, but are not reflected in the other three accounts.

The **EQ** account displays non-monetary effects on significant natural and cultural

resources. *3.5.4.1 National Economic Development*

The NED plan is the plan that reasonably maximizes NED benefits, consistent with the federal objective described in Section 1.7.1Planning Objective.**Error! Reference source not found.** Table 12 summarizes the results, which include expected annual damages and benefits for both the base year and most likely future year conditions, and equivalent annual damages and benefits.

Table 12: Summary of results, final array of alternatives (October 2021 price level, $1000)

Item	**Alternative**				
	Alt. A: No Action	**Alt. B: Channel Conveyance**	**Alt. B1: Channel Conveyance, Flood Barriers**	**Alt. C: Taumata Flood Barrier, Nonstructural**	**Alt D. Nonstructural**
Expected Annual Damages	8,961	9,178	7,233	1,677	1,922

Item	**Alternative**				
	Alt. A: No Action	**Alt. B: Channel Conveyance**	**Alt. B1: Channel Conveyance, Flood Barriers**	**Alt. C: Taumata Flood Barrier, Nonstructu**	**Alt D. Nonstructural**

				ral	
2030 Base Year					
Expected Annual Damages 2079 Future Year	9,494	9,154	6,861	1,777	2,001
Equivalent Annual Damages, 50-Year Period of Analysis, 2.50% Discount Rate	9,178	9,168	7,081	1,718	1,954
Equivalent Average Annual Benefits, 50-Year Period of Analysis, 2.50% Discount Rate	0	10	2,097	7,461	7,224
Project First Costs	0	29,126	49,087	138,386	143,072
Interest During Construction @ 2.25%	0	163	689	1,551	399
Total Economic Costs	0	29,289	49,776	139,937	143,470
Average Annual Costs @ 50-year period of analysis and 2.25%	0	982	1,668	4,690	4,809
Annual OMRR&R	0	146	244	46	TBD
Total Average Annual Costs	0	1,128	1,912	4,736	4,809

Net Benefits	--	-1,118	185	2,724	2,415
BCR	--	0.01	1.1	1.6	1.5

Based on the analysis presented above, Alternative C: Taumata Flood Barrier and Nonstructural Improvements is the NED plan that maximizes NED benefits.

3.5.4.2 Regional Economic Development

USACE's Regional Economic System (RECONS) is a certified regional economic modeling tool designed to provide estimates of regional economic impacts and contributions associated with USACE projects and programs. Regional impacts and contributions are measured as economic output, jobs, income, and value added. Estimates are provided simultaneously for three

geographic impact areas: local, state, and national. While the RECONS software can be used for the American Territories (e.g., Guam, Saipan, and American Samoa) located within the Pacific Ocean Division region, the software does not include the built-in data/input parameters required to actually perform the RED assessment for these areas. However, RECONS does cover the State of Hawaii. As such, the study team used the Big Island of Hawaii (Hawaii County) as a proxy area for the Tutuila Island (American Samoa). These two islands have similar population numbers to assess regional impacts associated with each alternative. Table 13**Error! Reference source not found.** presents the RED benefits for the final array based on RECONS modeling. Based on the RECONS results, Alternative D has the highest RED benefits for the final array of alternatives. Nearly 970 full-time equivalent jobs would be produced for American Samoa with a local direct impact of approximately $93.6 million. Based on the analysis presented above, Alternative D maximizes benefits in the RED category.

Table 13: RED benefits for the final array of alternatives

Category	**Alternative**				
	No Action	**Alt. B: Channel Conveyance**	**Alt. B1: Channel Conveyance, Flood Barriers**	**Alt. C: Taumata Flood Barrier, Nonstructural**	**Alt D. Nonstructural**
Full-Time Equivalent Jobs	0	190	325	941	972
Local Direct Impact	$0	$18.3M	$31.4M	$90.5M	$93.6M

3.5.4.3 Other Social Effects

The OSE analysis is one of the four accounts evaluated in USACE water resource planning. The OSE account displays the effects of a proposed intervention, such as a FRM project, on social aspects such as well-being that are integral to personal and community definitions of satisfaction and happiness (Dunning/Master Day LLC & Durden/USACE,2009). The OSE account evaluates the beneficial and adverse effects water resource plans have on social well-being (USACE, Appendix D, 2004). This section begins with a discussion of aspects that highlight the social profiles within the study area followed by a consideration of social effects of a project and a matrix that compares the social effects across the alternatives.

3.5.4.3.1 Social Landscape of the Area

The study area consists of a mix of traditional villages and non-traditional settlements, presenting some nuances for considering social effects of a FRM project. The Tafuna-Leone Plain commonly refers to the flat region nestled in the mountains and stretches towards the coast in south-western Tutuila Island. Tafuna was initially a village established on the coast with most of the land acreage left untouched. Traditional knowledge holds that it was at the Tafuna coast where the Sa'o (high chief) Fonoti arrived in his va'a (canoe) and founded the village (Personal Comm. , 2021). The village was relocated inland during World War II (WWII) to accommodate the construction of the Pago Pago International Airport on the coast. The airport construction was accompanied by the cutting of roads and clearing of acres of bush for material storage at the airport site (Stover, 1999).

The events of WWII and the designated location of the airport not only altered the physical landscape but also the social landscape of Tafuna village and the greater Tafuna-Leone Plain. Widespread interest for developing the area for homes, gardens and churches soon followed. Tafuna also attracted commercial interests to set up businesses. Some local government

services either relocated from the capital of Pago Pago or set up a branch in Tafuna. The land rush in the years following WWII coincided with the application of adverse possession land rights first introduced in 1901 by US Naval Administration (Kruse, 2019). Tracts of communal land were transferred from the fa'amatai (chiefly institution) to individually owned land. This, in part, led to the emergence of settlements in areas that were previously under the jurisdiction of traditional Tafuna village, an anomaly to American Samoa. More information on the land tenure system is discussed in the next section. For the purposes of this report, "settlements" refer to neighborhoods that are without a village governing structure. Settlements include Ottoville where Trade Winds Hotel (one of the two main hotels in the Territory) is located. In 2002, the Pele U.S. Army Reserve Center broke ground just outside the airport (Overson, 2019). Today, the village of Tafuna still exists within the sub-urban settlements of greater Tafuna area. Characteristics of traditional villages and settlements affect the evaluation of social effects in the study area. An assessment of these characteristics is consistent with the policy directive on the comprehensive documentation of benefits which directs study teams to consider urban, rural and community impacts (SACW, 2021).

For the purposes of this analysis, traditional villages have four foundational characteristics: a village council (Fono a Matai/Fono), an appointed mayor (Pulenu'u), a central field that serves similar functions to a town-hall (Malae). The fourth characteristic of a traditional village is a set of salutations of the chiefly titles, historic traditions or "charter" summarized in Fa'alupega (Meleisea, 1987 p. 6). Settlements are areas of individually owned land without the four characteristics of a traditional village. The study area consists of the following villages along Route 1 road from west to east: Pavai'a'i, Faleniu, Mesepa, Malaeimi to a part of Nu'uuli. Along Route 19 from the west to east are settlement of Koko Land, Tafuna village and settlement of Ottoville along the south-bound Route 18.

3.5.4.3.2 Land Tenure

The preceding sub-section mentioned two categories of land ownership: communal lands and individually owned lands. Historically, all lands in the Territory were native (communal) lands (Crocombe, 1987; Kruse, 2019). Kruse further describes communal lands as specific tracts of large, medium and small lands collectively owned by an extended family ('aiga) within a village (nu'u) that were demarcated by settlement, cultivation and virgin bush lands where natural features of rivers and hills were understood as boundary markers (p.75). Family clans, descendants of family lines and successors to the chief (matai) title have direct interest in the communal lands as they would be considered as part-owners.

Individually owned lands evolved out of the adverse land possession land rights instituted by the Naval Administration. Individually owned lands was subsequently established as a land tenure classification by the court. These individually owned lands are not subject to authority nor the stewardship of the matai and family clans. Moreover, the individually owned land registrants are not bound to any cultural obligation to communal sharing, distribution and as mentioned above, village governance. The differences between communal and individually owned lands influence social factors: social connectedness and cultural identity. The OSE analysis assumes to the reasonable extent that social connectedness and cultural identity is more present in communal lands than areas of individually owned lands. Freehold land are those lands that may be sold or transferred. This land tenure classification at present, remains a small portion of registered lands because freehold land was granted by the International Claims Commission in Apia (capital of present-day independent Samoa) prior to the U.S. taking possession of eastern Samoa.

There are five land ownership categories currently recognized by the Office of the Territorial Registrar. These are: 1) Communal Land, 2) Individually Owned Land, 3) Government-Owned Land, 4) Church Owned Land and 5) Freehold Land. About 8,000 acres of land in the Territory are registered, of which 27 percent is Communal Land, 25.7 percent is individually owned land, 21 percent is government owned followed by church owned and freehold lands representing 13 percent each (American Samoa DOC, 2019, p. 86).

The majority of individually owned lands are in the Tafuna-Leone Plain. Compared to the rest of Tutuila Island, the Tafuna-Leone Plain is flat and favorable for residential and commercial development. In the absence of FRM measures, the potential for future development and growth is limited. Residents would be subjected to future floods and damages.

3.5.4.3.3 Life Safety

The study team assessed and identified potential risks to life safety in the initial stages of the study in accordance with USACE guidance for incorporation of life safety into flood and coastal storm risk management studies (Planning Bulletin 2019-04). A qualitative review of historical reports and discussions with the local sponsor determined that historical and existing flooding do not significantly impact life safety. Results of the existing conditions run on LifeSim 2.0

showed no significant life loss. LifeSim modeling for the alternatives to evaluate breaching and overtopping scenarios will be conducted and incorporated into the final report.

3.5.4.3.4 Health Safety

An important basic human need is for personal and group safety (Maslow 1943). While flooding events in the existing conditions have reported a low significant impact on life loss, flooding still negatively impacts health and safety. Flooding damages that result in unsafe or unhealthy conditions, can cause stress and dissatisfaction among those affected.

Flooding events pose threats to the physical health and safety of residents. Road closures due to flooding cut access to essential services and places of employment. In some cases, people would decide to walk the flooded roads to avoid missing work or to get to an area less flooded and still accessible by public transportation. These conditions negatively impact mental and physical health. Alternatives B1 and C are expected to reduce the duration and depth of flooding can reduce these negative impacts on health and safety.

3.5.4.3.5 Social Connectedness

Social connectedness refers to the intricate social networks within which individuals interact; these networks provide meaning and structure to life (Dunning and Durden, 2009). These social networks comprise of families and community members cultivating an array of diverse voluntary associations the World Bank call “civic infrastructures.” These civic infrastructures can provide individuals with greater opportunities for connectedness, communication, and reciprocity, as well as support for times of need. These civic infrastructures are simply known as villages in American Samoa. For the non-traditional settlements, these civic infrastructures take form within the church congregations. Alternatives that reduce flooding at key places for these community gatherings such as the malae and churches can support social connectedness.

When social connectedness is strengthened, community members are more active in aiding those vulnerable individuals or groups, thereby increasing community resilience. Social connectedness is typically on display during post-disaster recovery efforts when churches assist their congregation members and when village council selects a group of men as labor to rebuild homes of those affected.

3.5.4.3.6 Cultural Identity

A FRM project that reduces disruptions to daily life and cultural activities in villages supports retaining or enhancing cultural identity in the study area. It should also be noted that family clans build graves for their relatives on their lands. This is true for both communal and individually owned lands. Senior matai are laid to rest in communal land and their graves serve as a cultural monument in the village. While nonstructural alternatives would not alleviate damages to these graves, the structural alternatives are expected to reduce damages and contribute to preserving grave sites.

3.5.4.3.7 Other Social Effects Comparison

This analysis adapts a practical framework developed by Weiss, Prakash and Amarakoon for OSE evaluation. The framework consists of a scoring system and planning matrix to aid in the evaluation of OSE impacts of the formulated alternatives on the communities in the study area. The social factors considered are reflective of issues that are important to communities in the study area and the impacts of the alternatives. From each of these social factors, metrics are developed. Social factors are not easily quantified; therefore, a scoring system with a scale of -3 to +3 is developed. Where -3 indicates significant negative effects on a particular metric, and +3 indicates a significant positive effect. Figure 19**Error! Reference source not found.** below presents the scores and associated description in relation to the without-project alternative (future without-project or no action). The score is an assessment of the relative impact an alternative would have on a particular metric in relation to the No Action Alternative.

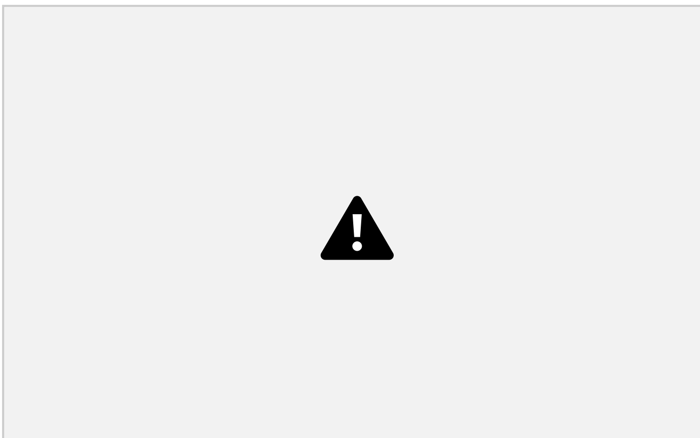

Figure 19. Key to scoring metrics (Weiss et al. 2013)

Weiss et. Al. propose that it may be appropriate for FRM studies to modify the evaluation of metrics to assess OSE impacts to a community both during a flood event and in daily (non-event) life. While acknowledging the rationale for this delineation, this analysis currently evaluates the OSE impacts during flood events only (Table 14**Error! Reference source not found.**). Modifications to the evaluation will be revisited following the public review period of the draft report and will be incorporated into the final report. For the purposes of this matrix, the future without-project condition is considered a neutral point and is, therefore, omitted from the scoring evaluation. To be clear, the OSE impacts in the future without-project condition are discussed qualitatively in preceding sub-sections. The OSE matrix is presented below with preliminary

scoring based upon the study team's judgement and subject to modification following stakeholder meetings anticipated in early 2022.

Table 14: Other Social Effects matrix

Social Factor and Metrics	**Alt B: Channel Conveyance**	**Alt B1: Flood Barrier and Channel Conveyance**	**Alt C: Combined Structural and Non-Structural**	**Alt D: Non Structural**
Health and Safety				
Mental Health	1	1	1	1

Physical Health	2	2	1	1
Physical Safety	1	3	2	1
Social Connectedness				
Community Cohesion	1	1	0	0
Community Facilities	1	2	1	0
Identity				
Cultural Identity	1	2	1	0
Community Identity	1	2	1	0
Social Vulnerability and Resiliency				
Residents of Study Area	1	1	1	1
Socially Vulnerable Groups	0	1	-1	-1
Total Score	8	15	7	3

3.5.4.3.7.1 Other Social Effects Summary

From an OSE perspective, alternative B1 has the highest score of 15 followed by alternatives B and C with total scores of 8 and 7 respectively. Alternative D scored the lowest with a score of 3. Alternative B1, which combines channel conveyance and flood barrier along Taumata and Leaveave streams is expected to reduce flooding on the roads and, therefore, significantly improving physical safety in the residential communities along both streams. Alternative B1 is also expected to moderately strengthen cultural identity because the flood barriers are expected to reduce flooding to grave sites that have cultural value to residents. Moreover, the reduced flooding to roads and areas like malae would reduce disruption to cultural events and, therefore, support cultural identity.

3.5.4.4 Environmental Quality

The purpose of the Environmental Quality (EQ) evaluation process is to identify significant beneficial and adverse effects of alternative plans on significant EQ resources. Beneficial effects in the EQ account are favorable changes in the ecological, aesthetic, and cultural attributes of natural and cultural resources. Adverse effects in the EQ account are unfavorable changes in the ecological, aesthetic, and cultural attributes of natural and cultural resources. Consideration of EQ effects is required by the NEPA (*42 USC § 4321 et seq.*) and requires federal agencies to integrate environmental values into their decision-making processes by considering the environmental impacts of their proposed actions and reasonable alternatives to those actions.

The analyses provided in Chapter 4 provides an assessment of the resources in the affected environment. This includes a comparison of the effects (or impacts) of each alternative plan relative to the No Action (future without-project) conditions. For those resources that may be

adversely affected, measures that would be implemented to mitigate the potential effects are then described. The approach taken for mitigation follows the recommended steps set forth by the President's CEQ in the NEPA regulations (40 CFR Part 1508.20 [a-e]), and includes (in order of preference) avoidance, minimization, and compensation.

Chapter 4 focuses evaluation and analysis on the following 14 resource categories in the affected environment (in order):

- Hydrology, Hydraulics, Geomorphology
- Terrestrial Habitats and Species
- Aquatic Habitats and Species
- Threatened and Endangered Species
- Cultural, Historic, and Archaeological Resources
- Water Resources and Quality
- Air Quality
- Public Health and Environmental Hazards
- Noise and Vibration
- Socioeconomics and Environmental Justice
- Land Use, Utilities and Public Services
- Traffic and Circulation
- Recreation
- Aesthetics

A summary of potential effects for the four action alternatives is below.

Table 15: Alternative B summary of potential effects

	Significant adverse effect	**Insignificant effects due to mitigation**	**Insignificant effects**	**Resource unaffected by action**
Aesthetics	☐	☒	☐	☐
Air quality	☐	☐	☒	☐
Aquatic resources/wetlands/hydrology	☒	☐	☐	☐
Fish and wildlife habitat	☐	☒	☒	☐
Threatened/Endangered species	☐	☐	☒	☒
Historic properties/cultural resources	☐	☒	☐	☐

Hazardous, toxic & radioactive waste	☐	☒	☐	☐
Land use	☐	☐	☒	☐
Noise levels	☐	☒	☐	☐
Traffic	☐	☒	☒	☐
Environmental justice	☐	☐	☒	☐
Geological Hazards	☐	☐	☐	☒
Water quality	☒	☐	☐	☐
Climate change	☐	☐	☒	☐

Table 16: Alternative B1 summary of potential effects

	Significant adverse effect	**Insignificant effects due to mitigation**	**Insignificant effects**	**Resource unaffected by action**
Aesthetics	☐	☒	☐	☐
Air quality	☐	☐	☒	☐
Aquatic resources/wetlands/hydrology	☒	☐	☐	☐
Fish and wildlife habitat	☐	☒	☐	☐
Threatened/Endangered species	☐	☐	☒	☒
Historic properties/cultural resources	☐	☒	☐	☐
Hazardous, toxic & radioactive waste	☐	☒	☐	☐
Land use	☐	☒	☐	☐
Noise levels	☐	☒	☐	☐
Traffic	☐	☒	☐	☐
Environmental justice	☐	☐	☒	☐
Geological Hazards	☐	☐	☐	☒
Water quality	☒	☐	☐	☐
Climate change	☐	☐	☒	☐

Table 17: Alternative C summary of potential effects

	Significant adverse effect	Insignificant effects due to mitigation	Insignificant effects	Resource unaffected by action
Aesthetics	☐	☒	☐	☐
Air quality	☐	☐	☒	☐
Aquatic resources/wetlands/hydrology	☐	☒	☐	☐
Fish and wildlife habitat	☐	☐	☒	☐
Threatened/Endangered species	☐	☐	☒	☐
Historic properties/cultural resources	☐	☒	☐	☐
Hazardous, toxic & radioactive waste	☐	☒	☐	☐
Land use	☐	☐	☒	☐
Noise levels	☐	☒	☐	☐
Traffic	☐	☒	☐	☐
Environmental justice	☐	☐	☒	☐
Geological Hazards	☐	☐	☐	☒
Water quality	☐	☒	☐	☐
Climate change	☐	☐	☒	☐

Table 18: Alternative D summary of potential effects

	Significant adverse effect	Insignificant effects due to mitigation	Insignificant effects	Resource unaffected by action
Aesthetics	☐	☒	☐	☐
Air quality	☐	☐	☒	☐
Aquatic resources/wetlands/hydrology	☐	☐	☐	☒

Fish and wildlife habitat	☐	☐	☐	☒
Threatened/Endangered species	☐	☐	☐	☒
Historic properties/cultural resources	☐	☐	☒	☐
Hazardous, toxic & radioactive waste	☐	☐	☒	☐
Land use	☐	☐	☒	☐
Noise levels	☐	☐	☒	☐
Traffic	☐	☐	☒	☐
Environmental justice	☐	☐	☒	☐
Geological Hazards	☐	☐	☐	☒
Water quality	☐	☐	☐	☒
Climate change	☐	☐	☒	☐

Alternative C maximizes benefits in the EQ account. The Taumata flood barrier would improve water quality by limiting the amount of water flowing through residential and commercial areas; and indirectly providing positive benefits to aquatic species in Pala Lagoon. Alternative C also has the smallest footprint compared to the other structural alternatives (Alternatives B and B1) and has the smallest potential impact on cultural resources and minimal aesthetics impacts.

3.5.4.5 Summary of Comprehensive Benefits

Table 19**Error! Reference source not found.** presents a summary of the comprehensive benefits evaluation across these four categories. The NED and RED accounts include quantitative evaluation of each alternative using traditional NED and RED evaluation criteria (e.g., net benefits, number of full-time equivalent jobs, etc.), while the OSE and EQ accounts include a qualitative ranking for the final array.

The following alternatives maximize benefits in each of the respective accounts (i.e., NED, RED, OSE, and EQ):

- Alternative C maximizes benefits under the NED account
- Alternative D maximizes benefits under the RED account
- Alternative B1 maximizes benefits under the OSE account
- Alternative C maximizes benefits under EQ account

Alternative C maximizes benefits across all four accounts, as it is the leader in both the NED and EQ accounts and ranks second in both the RED and OSE accounts. Floodwall could potentially affect traditional cultural properties and historic properties; there is also a potential for inadvertent discoveries; and has a much smaller footprint than Alt B and B1 which could reduce impacts to cultural resources.

Table 19: Comprehensive benefits for final array of alternatives

Benefits Category	**Alternative**				
	No Action	**Alt. B: Channel Conveyance**	**Alt. B1: Channel Conveya nce , Flood Barriers**	**Alt. C: Taumata Flood Barrier, Nonstructural**	**Alt D. Nonstructural**
NED					
Net Benefits	$0	$-1,118	$185,000	$2.7M	$2.4M
BCR	N/A	0.01	1.1	1.6	1.5
Total Project First Cost	$0	$27.6M	$47.3M	$136M	$141M
RED					
Full-Time Equivalent Jobs	0	190	325	941	972
Local Direct Impact	$0	$18.3M	$31.4M	$90.5M	$93.6M
OSE					
Health and Safety Social Connectedne ss and Identify Social Vulnerability and Environmen tal Justice	No benefit	Minimal benefits, and alternative induces flooding in areas	Moderat ely strengthe n cultural identity (reduce flooding to grave sites, malae and main roads)	Minimally strengthen cultural identity (reduce flooding to grave sites, malae and main roads) with construction Taumata flood barrier	Minimal benefit
EQ					
Ecological – Physical					

Air Quality	No benefit	Conveyance improvements could affect water discharge volumes and affect water quality of Pala Lagoon; water quality impacts could be longer term that Alt C.	Largest footprint; any water quality benefit of floodwall as for Alt C negated by conveyance improvement s; water quality impacts could be longer term than Alt C	Flood barrier improves water quality by limiting amount of water flowing through residential and commercial areas; Construction could result in short-term water quality impacts, but these would be minimized through BMPs	No benefit
Floodplains					
Water Quality					
Water Resources					
Soil Resources					
Ecological – Biological					
Aquatic Habitats and Species	No benefit	No benefit	No benefit	Flood barrier may provide some degree of water quality improvement to benefit indirectly aquatic species in Pala Lagoon.	No benefit
Terrestrial Habitats and Species					
Threatened and Endangered Species					
Long-Term Productivity					

Cultural Resources	No benefit	Conveyance improvements could potentially affect traditional cultural properties (TCPs) and historic properties, but less than Alt B1	Has the largest footprint of all alternatives which could increase impacts to cultural resources	Floodwall could potentially affect traditional cultural properties and historic properties; there is also a potential for inadvertent discoveries; has a much smaller footprint than Alt B and B1, which could reduce impacts to cultural resources.	No benefit, floodproofing and raising could potentially involve historic structures.
Aesthetic	No benefit	No benefit	Has largest floodwall footprint and most aesthetic impact	Floodwall only on one stream which would reduce aesthetic impact compared to Alt B1	Could negatively affect aesthetics of existing structures.

3.6 Environmental Effects and Consequences *

3.6.1 Affected Environment (40 CFR 1502.15) and Environmental Consequences (40 CFR 1502.16

3.6.2 Introduction

This chapter provides the existing conditions for each of the resources that could be affected by implementing any of the final array of alternatives proposed (i.e., the affected environment). Existing conditions are the physical, chemical, biological, and sociological characteristics of the study area. The spatial scale of analysis focuses on the Nu'uuli Pala Watershed and surrounding environment. The assessment of environmental effects is based on a comparison of conditions with and without implementation of the TSP and a reasonable range of alternatives; in this case, the final array of alternatives are formulated through the alternative analysis process (summarized in Section 3) and are compared to the No-Action Alternative. The time scale for analysis is a 50-year period starting in 2030. The information presented was derived primarily from government data, reports and scientific literature.

3.6.2.1 Determining Significance Under NEPA

The NEPA is a Federal law applicable to all Federal agencies, including USACE. NEPA review is required if the proposed activity meets the NEPA thresholds at 40 CFR 1501.1. The NEPA process is intended to promote better agency decisions by ensuring high-quality environmental information is available to agency officials and the public before the agency decides whether and

how to undertake a federal action. While NEPA does not require an agency to achieve particular environmental results, it does require an agency to take a hard look at the potential environmental impacts of a proposed federal action.

Under NEPA, USACE works closely with other Federal agencies and Territorial, and local governments; public and private organizations; and the public to better understand these potential environmental impacts. The USACE enacted its own NEPA implementing regulations to review a proposed action for impacts and effects. The level of appropriate NEPA review is dependent on the significance of effects. Under NEPA many different factors are evaluated to determine the significance of effects in the natural, economic, and social environments such as:

- Endangered or sensitive species and their habitats
- Cultural resources
- Floodplains and wetlands
- Noise levels, water quality and air quality
- Human health and safety
- Social and economic impacts to communities

The appropriate NEPA documentation for a particular proposed project or action depends largely on the significance, in terms of context and intensity, of the project's potential environmental impacts. For the proposed project, an Environmental Assessment (EA) will be prepared because the significance of environmental impact is not clear. An EA is a document that provides sufficient information on the potential environmental effects of the proposed action and any alternatives, if necessary. If after preparing the EA, it is determined that the impact of the proposed project will be significant, an Environmental Impact Statement (EIS) will be prepared. If a finding of no significant impact (FONSI) is determined after completion of the EA, the EA will be considered sufficient documentation under NEPA. A draft FONSI is included in the Environmental Appendix to document the draft EA, if the final EA identifies significant impacts, a record of decision (ROD) will accompany a final EIS.

3.6.2.2 Effect Determinations Used in This Report

The analysis of project effects or impacts (i.e., environmental consequences) involves the comparison and assessment of the effects of each alternative plan relative to the No Action (future without-project) conditions in accordance with 40 CFR 1501.3(b) and 1508.1(g). Project impacts may be permanent or temporary (Table 20), adverse or beneficial, and include both direct and indirect effects. Direct effects are caused by the action and occur at the same time and place; indirect effects are caused by the action and are later in time or farther removed in a spatial context (distance from the source of the effect), but are still reasonably foreseeable. For those resources that may be adversely affected, measures that would be implemented to mitigate the potential impacts are described. The approach taken for mitigation follows the recommended steps set forth by the President's CEQ in the NEPA regulations (40 CFR Part 40 CFR 1508.1), and includes (in order of preference) avoidance, minimization, and compensation.

Criteria were identified for each resource to assist with evaluation of the potential for significant adverse effects; the criteria are based on the definitions of significance and the specific considerations identified for NEPA (40 CFR 1508.1), as well as other standards of professional practice.

Table 20: Summary of permanent and temporary impacts (in acres) by action alternative

Alternative Plan	***Alternative B: Channel Conveyance Improvements***		**Alternative B1: Channel Conveyance Improvements + Flood Barriers**	***Alternative C: Taumata Stream Flood Barrier + Non-structural Improvements***	***Alternativ e D: Non structural Improvements***
Permanent Impacts (acres)	17.3 (Leaveave) 8.6 (Taumata)		17.3 (Leaveave) 8.6 (Taumata) 2.3 (Leaveave barrier) 2.3 (Taumata barrier)	2.3 (Taumata barrier)	NA
Temporary Impacts (acres)	11.2 (staging, access, construction)	11.2 (staging, access, construction)	14.4 (staging, access, construction)	1.3 (access) 0.5 (staging)	0.5 (staging)

3.6.2.3 Chapter Structure

This chapter focuses on evaluation and analysis of the following 14 resource categories in the Affected Environment (in order):

- Hydrology, Hydraulics, Geomorphology
- Terrestrial Habitats and Species
- Aquatic Habitats and Species
- Threatened and Endangered Species
- Cultural, Historic, and Archaeological Resources
- Water Resources and Quality
- Air Quality
- Public Health and Environmental Hazards
- Noise and Vibration
- Socioeconomics and Environmental Justice
- Land Use, Utilities and Public Services
- Traffic and Circulation

- Recreation
- Aesthetics

For each resource in the Affected Environment, the existing conditions within the study area are described with a summary of historic conditions where applicable. This is followed by comparison of the effects (or impacts) of each alternative plan relative to the No Action (future without project) conditions. For those resources that may be adversely affected, measures that would be implemented to mitigate the potential effects are then described. The approach taken for mitigation follows the recommended steps set forth by the President's CEQ in the NEPA regulations (40 CFR Part 40 CFR 1508.1), and includes (in order of preference) avoidance, minimization, and compensation.

In addition to the Affected Environment description, this chapter also describes the regulatory setting, as appropriate. Key regulatory compliance activities are described in the subsections below, as appropriate. Additional detail regarding applicable regulations, policies, and compliance is provided in Section 5 Environmental Compliance * of this integrated report, as well as Appendix C Environmental Resources.

3.6.2.4 Scope of Environmental Analysis

The analysis of effects uses the Affected Environment description as the baseline to identify changes to the resource under future with- and without-project conditions. For most resources, the area of concern is generally limited to the construction limits or area where environmental resources may be directly affected by project-related activities. However, for some resources, the indirect project-related effects must be considered within the context of the surrounding area. For example, the evaluation of land use, aesthetics, noise, traffic, and socioeconomics also includes the surrounding area. Potential effects relative to resources that occur across a broader area, climate, geology, and air quality, were considered at a regional scale. Although environmental conditions are generally subject to some change over time, most of these resources are not expected to change significantly under the without-project condition over the period of analysis. However, any changes expected in the future-without-project condition are described.

The comparison of the effects of each alternative plan relative to the No Action (future without project) conditions considers adverse or beneficial effects, as well as both direct and indirect effects. Direct effects are caused by the action and occur at the same time and place; indirect effects are caused by the action and are later in time or farther removed in distance, but are still reasonably foreseeable.

3.6.2.5 Summary of Significance Determinations

Based on the significance criteria presented for each resource, the analysis presented for each resource concludes the degree of potential impact as one of the following: • Beneficial. This effect would provide benefit to the environment as defined for that resource.

- No Effect. This effect would cause no discernible change in the environment as measured by the applicable significance criteria; therefore, no mitigation would be required.
- Less than Significant. This effect would cause no substantial adverse change in the environment as measured by the applicable significance criteria; in general, no

mitigation would be required (but in some cases may be incorporated as a best practice or to meet other regulatory requirements).

- Significant. This effect would cause a substantial adverse change in the physical conditions of the environment or as otherwise defined based on the significance criteria. Effects determined to be significant fall into two categories: those for which there is feasible mitigation available that would avoid or reduce the environmental effects to less than-significant levels, and those for which there is either no feasible mitigation available or for which, even with implementation of feasible mitigation measures, there would remain a significant adverse effect on the environment. Those effects that cannot be reduced to a less-than-significant by mitigation are identified as significant and unavoidable.

3.6.3 Resources Screened from Detailed Analysis

No resource categories were screened from a detailed data analysis. However, the level of detail in the description of each resource corresponds to the magnitude of the potential direct, indirect, or cumulative impacts on each alternative, focuses only on significant resources that are potentially affected by the alternatives, and have the most material bearing on the decision making process.

3.6.4 Hydrology, Hydraulics, Geomorphology

3.6.4.1 Affected Environment

3.6.4.1.1 Geology and Soils

The study area is situated mostly in the geological formation known as the Tafuna-Leone Plain (Figure 20) the largest area on the island with relatively flat slopes. The Tafuna-Leone Plain is a basaltic lava delta on the southern side of western Tutuila that originates from the final period of volcanism on the island, probably during the early Holocene (Clark & Wright 1995; Stearns 1944), positioned between the older interior mountains and the Pacific Ocean. At this particular location on Tutuila, the interior mountains relate to Pago Volcanics that date to the Pleistocene (Stearns 1944; McDougall 1985), between 1.01 and 1.54 million years ago (Nunn 1998). The formation of the Tafuna-Leone Plain occurred probably less than 100,000 years ago and is considered to be part of the Leone Volcanics series in American Samoa (Stearns 1944).

The Tafuna-Leone Plain is composed of highly permeable lava flows inter-laced with ash beds (Stearns 1944). It is believed to have been created by a late-stage eruption, which covered a former barrier reef. The predominant rock types are basaltic with lesser amounts of trachyte and andesite. Recent-appearing basaltic tuffs and lava have formed a broad, flat plain on the southwest side of the island from calcareous sand, coralline gravel, and reef rock that is considered to be very permeable (Izuka et al. 2007). The soils of the valleys and coastal fringe are classified as clayey to sandy and vary from poorly drained to excessively drained. The soils on the Tafuna-Leone Plain are generally considered well drained and are predominantly gently sloping (POD 1994).

The volcanic rocks that cover the surface of the Tafuna-Leone Plain and overlie parts of the southern flank of the mountains to the north include lava flows and pyroclastic deposits (ash, cinder, and breccia). Most of the pyroclastic deposits form a line of cones that extend from the coast to the crest of the mountains in the north. Because of the relatively recent formation of the Tafuna-Leone Plain, soil development is not as advanced as in other parts of the island. Typically, deposits range from 60 to 155 centimeters (cm) in depth below the ground surface, and often include large quantities of rock. Rock outcrops are also common. Deposits are of volcanic origin and, therefore, clayey.

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Tafuna-Leone Plain

Tafuna-Leone Plain

Figure 20: Simplified Geologic Map (A) and Diagram (B) of the Tafuna-Leone Plain (Izuka et al. 2007)

This aquifer below the plain holds a fresh groundwater body (or basal lens) that floats on top of salt water within the underlying rock due to the density contrast between fresh and salt water. The plain's aquifers make the region favorable for groundwater development, and about half of the island's total water production is sourced from about thirty wells on the plain. However, the high permeability also makes the basal lens in this area thin and susceptible to saltwater intrusion if over-exploited.

3.6.4.1.2 Geologic Hazard

Geologic hazards on Tutuila include landslides, volcanic eruptions, earthquakes, cyclones, and tsunamis. Landslides are primarily caused by gravity acting on overly steep slopes. However, many other factors, such as saturation by rainfall, removal of deep-rooted vegetation, and erosion by water channels, contribute to the occurrence of landslides. On Tutuila, landslides often occur when heavy rainfall saturates unstable earth on the island's steep slopes (FEMA 2008).

The only active volcano in the American Samoa region is the volcanic seamount Vanilulu'u located approximately 100 miles east of Tutuila. The Ofu-Olosega volcano last erupted in 1866, and other volcanoes in the region have been silent for thousands of years. No active volcanoes exist on the island; however, many craters are still visible on the landscape (FEMA 2008).

Earthquakes in American Samoa mainly originate from the Tonga Trench, approximately 120 miles southwest of Tutuila. Earthquakes can be precursors to volcanic activity but generally do not present a seismic threat to the islands (FEMA 2008). Tsunamis (huge water waves) that affect Tutuila are generated by earthquakes from fault movements along the Tonga Trench, the Pacific Rim in the Aleutian Islands, South America, and other locations.

3.6.4.1.3 Hydrology

Hydrologic and hydraulic modeling studies were conducted to estimate a range of peak stream flow discharges and associated water surface elevations that could occur in the study area as a result of potential storm events. These models built upon previous models and incorporated up-to-date topographic and hydro-meteorological data. Per ER-1165-2-21, only the area that met the 800 cfs requirement were analyzed, which included the Taumata, Leaveave and Vaitele streams that are located within the larger Nu'uuli Pala Watershed (Figure 21). Hydrologic and hydraulic models were updated for those reaches. More detailed information regarding the hydrologic modeling can be found in Appendix A Hydrology and Hydraulics.

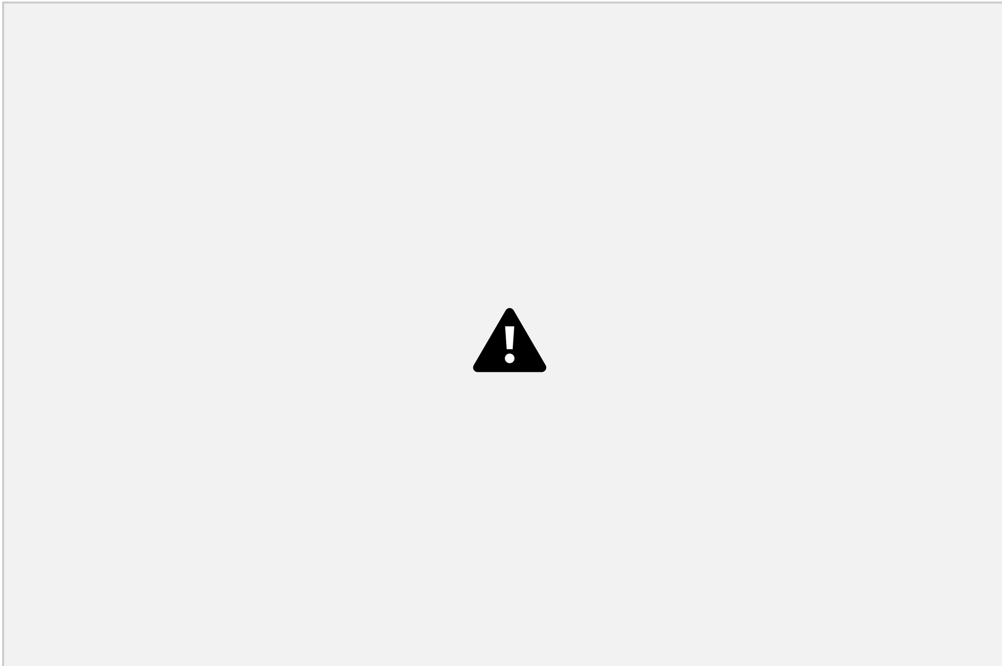

Figure 21: Taumata, Leaveave, and Vaitele streams

Discharge-frequency relationships at key points in the study area were determined by developing rainfall-runoff models using the HEC-HMS. The HEC-HMS model was used to simulate various storm events. The resulting peak discharges at each sub-basin within the Leaveave Drainageway are presented in Table 21.

Table 21. 2016 computed flow discharges at sub-basins in the Leaveave drainageway

Sub-Basin Element	**Peak Flow Discharges (cfs)**							
	50% ACE	**20% ACE**	**10% ACE**	**4% ACE**	**2% ACE**	**1% ACE**	**0.5% ACE**	**0.2% ACE**
Leaveave 1	209	329	426	568	682	801	924	1,100
Leaveave 2	30.0	57.7	82.3	119	149	181	214	261
Leaveave 3	178	290	379	508	612	724	840	1,000
Leaveave 4	100	148	187	242	286	332	379	445
Leaveave 5	50.8	73.1	90.6	115	135	155	176	205

Leaveave 6	27.7	51.8	73.0	105	132	161	191	235
Leaveave 7	53.2	88.4	118	163	198	237	277	334
Leaveave 8	106	153	190	244	286	329	374	435
Mapusagatuai 1	107	162	205	266	314	366	420	494
Mapusagatuai 2	102	146	180	227	264	303	342	396
Mapusagatuai 3	63.5	100	129	172	206	243	280	332
Taumata 1	296	523	709	981	1,210	1,450	1,700	2,050
Taumata 2	191	356	497	709	883	1,070	1,260	1,540
Taumata 3	77.1	105	127	157	181	205	230	264
Taumata 3b	48.0	72.3	91.8	120	143	166	190	224
Taumata 4	8.8	16.4	23.0	32.9	41.0	49.7	58.8	71.6
Taumata 5	52.6	83.9	109	145	174	205	237	282
Taumata 6	78.6	122	156	205	244	284	326	385
Taumata 7	37.7	53.1	65.3	82.1	95.5	110	124	144
Vaitele 1	200	317	410	544	650	762	879	1,040
Vaitele 2	90.5	143	185	245	293	345	398	473
Vaitele 3	40.5	65.9	86.2	115	139	163	188	224
Vaitele 4	36.2	52.4	65.5	83.8	98.3	113	129	150
Vaitele 5	10.7	16.9	22.0	29.2	34.9	40.9	47.2	55.9
Vaitele 6	33.7	47.2	58.1	73.2	85.0	97.3	110	127

3.6.4.1.4 Hydraulics

Hydraulic models using both one-dimensional (1D) and two-dimensional (2D) unsteady flow analysis were created for this study using HEC-RAS software (version 5.0.7). Peak flow rates were used to represent the amount of water in the system for the 50, 20, ten, four, two, one, 0.5 and 0.2 percent AEP events (8 profiles), and the corresponding flow data was input to the appropriate cross sections as lateral inflow or uniform lateral flow.

Consistent with ER 1100-2-8162, sea level rise was incorporated into the downstream boundary condition. A downstream stage hydrograph of 4.28 ft was used as the downstream boundary condition in all future without- and with-project conditions model runs. This was determined using the low-rate estimate at the 50-year period of analysis and taking into the account the high margin of error on the user entry rate, which was more conservative than the rates built into the USACE calculator.

Consistent with the USACE Engineering Circular (EC) 1165-2-212 and Engineering and Construction Bulletin (ECB) 2013-27, three scenarios (low, intermediate, and high) were modeled to define the future without-project hydrologic and hydraulic conditions, with each scenario defined based on the corresponding rate of change in the input conditions. Low is considered the best-case scenario (with a continuation in the current trends for sea-level rise and rainfall intensity), intermediate is the most probable scenario, and high is considered the worst case scenario. The modeling inputs for these three scenarios are summarized in Appendix A Hydrology and Hydraulics.

3.6.4.2 Alternative A: No Action Alternative

As no features would be constructed, there would be no project-related activities that would affect geomorphology. The physical conditions within each of the measure locations would be expected to be generally commensurate with the current onsite conditions. Erosional processes are expected to continue across the watershed, especially in areas of potential hazards, including steep slopes and high annual rainfall. Given the potential for more intense episodes of rainfall, these events could potentially occur on a more frequent basis.

The upper watersheds of the streams that contribute to the study area are primarily comprised of undeveloped, steep mountainous terrain. No significant changes to land use in the upper watershed (e.g., logging, large-scale agriculture) are expected in these areas that would alter flood hydrology to significantly influence the study area.

Because of increased precipitation due to climate change, these contributing watersheds are forecast to experience greater impacts from flooding under future conditions, increasing the risk to life safety, existing structures, critical infrastructure, and development expected to occupy the floodplain in the future. Traffic delays, school closures, decreased public service, and commercial and industrial business closures are also forecast to occur for events more frequent than roughly the ten percent AEP flood event. No effects to geomorphology, hydrology, or hydraulics and are expected under the No Action Alternative.

3.6.4.3 Alternative B: Channel Conveyance Improvements (Taumata and Leaveave Streams)

This alternative would involve work within both Leaveave and Taumata streams and proposed measures are designed to improve conveyance on these streams so as to reduce the risk of flooding This alternative is not expected to significantly affect drainage patterns. None of these measures would permanently obstruct or change the course of a waterway or substantially modify the existing floodplain. However, they would involve placement of fill material (e.g., compacted fill, grouted riprap) within the stream channels, which are Waters of the U.S. (refer to draft 404(b)(1) analysis in Appendix C Environmental Resources). Because Leaveave and Taumata streams are tributary to Vaitele Stream, which drains to the Pala Lagoon, water volumes and peak water velocities entering Pala Lagoon could be expected to increase temporarily during rain events.

The HEC-RAS hydraulic modeling results demonstrate the beneficial impact of the flood reduction measures for this alternative; however, this alternative can be expected to measurably affect hydrologic conditions within the watershed by affecting peak flow discharges during flood events (i.e., peak flow discharges are expected to be greater than with those described for the No Action Alternative), but these effects would be temporally episodic in nature and would cause no substantial adverse change in the environment as measured by the applicable significance criteria. As such, a less than significant effect to hydrology, hydraulics, and geomorphology would be expected under Alternative B.

3.6.4.4 Alternative B1: Channel Conveyance Improvements and Flood Barriers (Leaveave and Taumata Streams)

Alternative B1 would have the same effect of improved conveyance and have the same requirements for construction as described for Alternative B. In comparison to Alternative B, addition of flood barriers along Taumata and Leaveave streams would be expected to contain

even more floodwaters within the Leaveave and Taumata channels, increase localized water surface elevations, and temporarily increase localized stream velocities and water volumes when water is flowing over the no action alternative. Effects would generally be as described for Alternative B but presumably would be greater due the addition of the flood barriers.

3.6.4.5 Alternative C: Taumata Flood Barrier and Nonstructural Improvements

Alternative C would involve implementation of both structural (i.e., flood barrier along Taumata Stream) and nonstructural measures (i.e., dry floodproofing and elevating structures). The HEC RAS hydraulic modeling results demonstrate the beneficial impact of the flood-reduction measures for this alternative to the 1-percent ACE floodplain. Although the overall potential for flood damage reduction associated with Alternative C is not expected to be as great as that associated with Alternative B and B1, Alternative C is still expected to provide a significant beneficial impact relative to reduced potential for flooding in the watershed.

A flood barrier would contain more flood waters within the Taumata channel where the depth of flooding is most severe, increasing water surface elevations over the no action alternative and increase stream velocities. Alternative C is not expected to measurably affect hydrologic conditions within the watershed; as such, peak flow discharges are expected to be commensurate with those described for the No Action Alternative. To the extent possible, Alternative C takes advantage of existing cleared areas that can be used for staging and access for project activities. Construction of the flood barrier that would involve ground disturbance, but the site is located in a highly disturbed environment. Nonstructural measures would not affect the geomorphology, hydrology, and hydraulics within the study area.

As such, a less than significant effect to hydraulics and hydrology would be expected under Alternative C. Alternative C is expected to reduce losses due to flooding; however, residual risks still exist within the watershed. While sea level changes were considered during the plan formulation process, uncertainty with those projections exist and risk remains, specifically due to the potential for a changing climate (see the Climate Risk Register Appendix A Hydrology and Hydraulics).

3.6.4.6 Alternative D: Nonstructural Improvements

Alternative D is a completely non-structural solution; therefore, there are no effects to geomorphology, hydrology, and hydraulics and are expected under Alternative D as this is a fully nonstructural solution.

3.6.4.7 Mitigation

Effects on geomorphology (including geology, seismicity, and soil conditions) were considered to be significant if implementation of an alternative would result in any of the following:

- Substantially alter an important natural geologic feature
- Cause substantial soil erosion
- Increase exposure of people or structures to seismic-related hazards
- Substantially contribute to an increased potential for (or otherwise be affected by) an onsite or offsite landslide/debris flow, subsidence, liquefaction, or collapse

Because the potential effects to geomorphology (including geology, seismicity, and soil conditions) that could result from implementation of the alternatives would be less than

significant and cause no substantial adverse change in the environment as measured by the applicable significance criteria, no mitigation would be required.

Effects on hydrology and hydraulics were considered to be significant if implementation of an alternative would result in any of the following

- Significantly change drainage patterns within the watershed
- Substantially increase the extent, frequency or duration of flooding
- Create or contribute to runoff that would exceed the capacity of existing or planned stormwater drainage system

The potential effects to hydrology and hydraulics that could result from implementation of the alternatives would be less than significant and cause no substantial adverse change in the environment as measured by the applicable significance criteria, and no mitigation would be required.

3.6.5 Terrestrial Habitats and Species

3.6.5.1 Affected Environment

The overall diversity of terrestrial species in American Samoa is relatively low due to the Territory's small total land area and the remote location of the archipelago. The general absence of species radiations are characteristic of most isolated archipelagoes of the central and eastern Pacific (Craig 2002). Despite this, and with the exception of Hawai'i, the native Samoan flora is the largest in Polynesia consisting of 550 angiosperm species in 300 genera and 228 pteridophyte species (Whistler 2002).

The terrestrial flora and fauna in American Samoa are mostly indigenous, with representatives on nearby archipelagoes. The flora of these islands is similar to, but less diverse than, the flora of continental areas of Southeast Asia. Endemic species in the Samoan Archipelago include one bird (Samoan Starling, *Aplonis atrifusca*), a few species of land snails, and about 32 percent of local plant species.

3.6.5.1.1 Vegetation and Land Use

The study area is a complex mosaic of vegetation and land use types that are a result of natural characteristics (e.g., topography, soil type, distance from the sea), natural disturbance events (e.g., weather), and anthropogenic activities. Tropical cyclones are common in American Samoa, often inflicting significant damage to the landscape, especially the vegetation. Other natural disturbances include prehistoric volcanic eruptions. Soil erosion is prevalent on steep volcanic soil slopes and areas cleared by humans for agricultural production and roads (Cole et al., 1988; Mueller-Dombois & Fosberg, 1998; Donnegan et al., 2004). Almost all vegetation in American Samoa has been altered after several thousand years of subsistence agriculture greatly reducing the area of native forests (Mueller-Dombois and Fosberg 1998).

The Tafuna-Leone Plain, like nearly the entire Samoan archipelago, was historically covered by tropical rainforest vegetation (montane and lowland) before the arrival of the Polynesians some 3,000 years ago (Liu et al. 2011; Mueller-Dombois and Fosberg 1998). Tropical rainforest is characterized by irregularly closed canopies. Montane rain forest is found at high elevations, often on steep slopes (>1,640 feet elevation), and in areas with high precipitation. The dominant canopy species is the native *Dysoxylum huntii* (maota mea). The higher-elevation montane

forests tend to be less impacted by severe weather events and the steep slopes inhibit cultivation. Montane forest and lowland forest tend to form a continuum, blending into each other along gradual environmental gradients. The main distinction between montane and lowland rainforest is that the former is typically dominated by a single species (*Dysoxylum huntii*), while the latter is dominated by several other species (Whistler 2002).

Lowland rain forest can occur on mountain ridges, slopes, in valleys, and on lowland lava flows. The lava flow lowland rainforest is characterized by tree species in adapted to rocky lava flow areas with little soil and low water-holding capacity. Lava flow lowland rainforests sit directly above important aquifers from which present-day communities in American Samoa receive most of their drinking water. These forests highlighted by tall and enormous giant banyan (*Ficus* spp.) and tava (*Pometia pinnata*) trees. Extensive lowland lava flow forest once existed on the Tafuna Leone Plain, but has been largely replaced by urban development and coconut plantations (Donnegan et al. 2001). As the market for coconut has declined, former plantations have been abandoned and are slowly converting to secondary vegetation with mixed agro-forest.

Today, the Tafuna-Leone Plain is best classified as a managed landscape and is either used for residential activities or subsistence farming. Vegetation is primarily a mix of agriculture, urban cultivated land, and urban built-up areas, with smaller areas of secondary scrub (Liu et al. 2011). The occasional large banyan tree *(aoa; Ficus obliqua* or *Ficus prolixa)* is still also encountered. Despite the rocky and clayey deposits on the Tafuna-Leone Plain, the vegetation is dense, but has been highly influenced by recent human activities. Urban cultivated land includes all vegetated areas within a general urban boundary (e.g., simple gardens, parks, sports fields, and lawns). Urban built-up land refers to impervious urban surfaces such as houses and paved roads. Commercial enterprises have dramatically increased on the Tafuna-Leone Plain to serve the needs of the increasing number of residents.

Vegetation types in the study area include secondary forest and scrub, agriculture, urban cultivated land, and urban built-up areas (Liu et al. 2011). The upper watersheds of Leaveave, Taumata, Mapusagatuai, and Vaitele streams that originate in the mountains that line the northern edge of the Tafuna-Leone Plain are a mix of secondary forest and scrub on the steeper slopes interspersed with agriculture on the valley floors. Secondary forest is classified as a disturbed vegetation class. The most characteristic tree of these forests, which cover much of Tutuila, especially on the south-facing slopes on the south side of the island, is tavai (*Rhus taitensis*). Other common species include toi (*Alphitonia zizyphoides*), maota (*Dysoxylum maota*), lopa (*Adenanthera pavonina*), and moso’oi (*Cananga odorata*). Rhus secondary forest can often be identified by its smooth, even canopy (Figure 22). In comparison, primary rainforest tends to be dominated by a mixture of species and an uneven canopy.

Figure 22: Typical Rhus-dominated secondary forest canopy structure in American Samoa (C. Solek)

Secondary scrub is generally an intermediate type of vegetation that occurs when cultivated land is abandoned and allowed to revert to natural forest (Figure 23). It is usually dominated by laupata (*Macaranga harveyana*), soga (*Pipturus argenteus*), fau (*Hibiscus tiliaceus*), and other small trees that require sunlight for establishment and growth. It can be very difficult to distinguish secondary scrub from agriculture in some cases due to the overlap of plant species. Agricultural lands refer to vegetated land used for agricultural purposes at a relatively large scale for commercial production, such as coconut (niu; *Cocos nucifera),* banana *(*fa'i*; Musa paradisiaca)*, breadfruit *(*'ulu; *Artocarpus sp.),* papaya *(*esi; *Carica papaya),* and ta'amu *(Alocasia macrorrhiza).* In American Samoa, abandoned agricultural land quickly becomes overrun by secondary scrub type vegetation, but coconuts, bananas, and breadfruit often persist. Similarly, secondary scrub vegetation, most common around villages and farms, can quickly be converted to agriculture or other uses, but may retain some secondary scrub vegetation, vegetable plantations, and cow pasture (Liu et al. 2011). In American Samoa, abandoned agriculture land, if left undisturbed for a long period, eventually reverts to a taller canopy forest that in its early stages is dominated by tall secondary forest species.

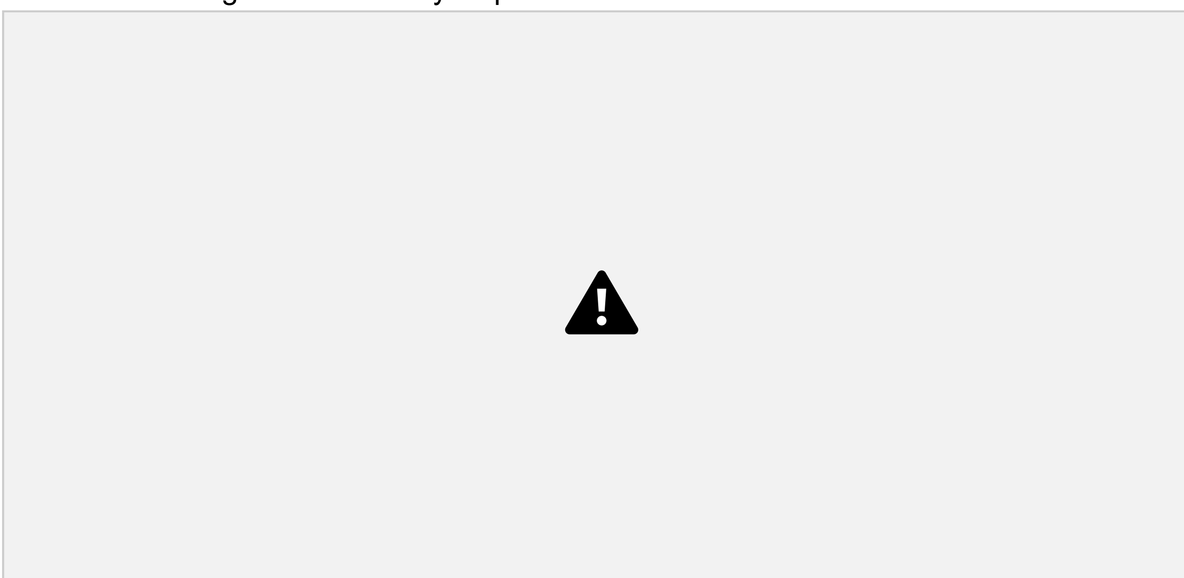

Figure 23: Typical secondary scrub vegetation in American Samoa (C. Solek)

3.6.5.1.2 Terrestrial Wildlife

Due to American Samoa's small size and remote location in the Pacific Ocean, the diversity of terrestrial flora and fauna is naturally very low to include 25 resident or migratory land and water birds, 20 resident seabirds, three native mammals (all bats), three skinks, and one gecko. The native terrestrial invertebrate fauna of American Samoa, including insects, is far less known than other taxa. All other terrestrial species present have been either historically introduced by early Polynesians (e.g., Polynesian rat, chickens, and pigs) or are considered modern introductions (i.e., after western colonization).

Two species of native fruit bats, the White-naped fruit bat or *pe'a fanua* (*Pteropus tonganus)* and the endemic Samoan fruit bat or *pe'a vao* (*Pteropus samoensis),* are found in American Samoa. Neither species is currently listed as endangered or threatened by the USFWS. The Tongan fruit bat has a wide range and presumed large population in the Pacific. The population of the Samoan fruit bat in American Samoa has increased following a ban on hunting, but reliance on mature forest makes long-term species survival dependent on protection of the limited mature forest remaining and continued hunting restrictions. The small insect-eating sheath-tailed bat or *pe'ape'avai* (*Emballonura semicaudata*) is cave dwelling species listed as an endangered (USFS 2016). The species is perhaps locally extinct due to the effects of Cyclone Ofa in 1990 and known caves that formerly supported this species on Tutuila are almost deserted. None of these bat species would not be expected within the project area due to lack of (mature) primary forest habitat and close proximity to human presence.

As in other Pacific islands, the native land snail biodiversity is high in American Samoa. There are reportedly 42 species of native land snails and 15 non-native species recorded from American Samoa (Cowie 1998), of which many of the native species are endemic. Invasive, non native plants can modify native habitat and render it unsuitable for native snail species (Hadfield 1986). Few native snails have been observed in disturbed areas of habitat outside of protected area boundaries (Cowie 2001; Cowie, personal communication). A discussion of threatened and endangered land snails is included in Section 3.6.7.1.1 Land Snails.

Introduced terrestrial species that are common on Tutuila includes the two invertebrates, the giant African snail or *sisi aferika (Achatina fulica*) and the predatory land snail (*Euglandina rosea*), one amphibian, the cane or marine toad (*Rhinella marinus*), and three introduced species of birds: red-vented bulbul or *manu palagi* (*Pycnonotus cafer)*, common myna or *maina fanua (Acridotheres tristis)*, and jungle myna or *maina vao (Acridotheres fuscus).* These species are now abundant all over Tutuila and common in nearly every village. Another non-native bird, the *rock* dove or *lupe palagi* (*Columba livia)* is occasionally reported as a vagrant to Tutuila (i.e., a species that appears outside its normal range).

Introduced terrestrial mammals include three species of rats, Polynesian rat (*Rattus exulans*), Roof rat (*Rattus rattus*), Norway rat (*Rattus norvegicus*), the house mouse (*Mus musculus),* and domestic pigs, dogs and cats. All are modern introductions with the exception of Polynesian rats, dogs, and pigs which are considered Polynesian introductions. Domestic pigs that have gone feral are especially destructive to native habitats by rooting for food and creating wallows, facilitating the spread of non-native plants.

The project area can be expected to provide habitat for a variety of terrestrial wildlife; however, given the highly disturbed nature of the landscape and vegetation, introduced (non-native) species, especially birds and plants, are expected to dominate due to the lack of native primary forest, residential and commercial development, and ubiquitous human presence. Human development is intimately tied to habitat modification and can lead to increased encroachment of disturbed habitats, increased spread of non-native plant and animal species (e.g., rats), and increased human activity, all of which tend not to benefit native species.

3.6.5.2 Alternative A: No Action Alternative

Under the No Action Alternative, no FRM measures would be implemented and as such, project related impacts to biological resources would not occur. In the absence of FRM measures, it is anticipated that areas adjacent to the stream would continue to be subject to periodic flooding.

In general, future climate changes are expected to result in habitat loss and degradation, decreased biodiversity (including extinction of endangered species and loss or migration of native species), and spread of invasive species. However, these conditions are already prolific within the watershed; therefore, it is expected that the future without-project conditions would be commensurate with existing conditions. Specifically, it is expected that the study area would continue to be characterized by a suite of non-native (including invasive) species that typically occur in disturbed habitats on Tutuila. While there may be some changes in localized conditions over time, the overall species composition and habitat structure is not expected to change dramatically over the period of analysis.

Based on the extent of private land holdings, existing urbanization, and developments within the Nu'uuli Pala Watershed, and more specifically along its streams, it is expected that further development would be minimal. Although some limited re-development may occur in the neighborhoods throughout the watershed, it is not expected to substantially affect current biological resources. With respect to instream habitat, it is assumed that there would be no significant changes in the extent and degree of channel modifications.

No significant negative effects to terrestrial vegetation or wildlife species are expected under the No Action Alternative. It is expected that non-native species will continue to predominate within the study area, and perhaps increase as development continues.

3.6.5.3 Alternative B: Channel Conveyance Improvements (Taumata and Leaveave Streams)

Implementation of Alternative B would result in 17.3 acres and 8.6 acres of permanent impacts from channel conveyance improvements made to Leaveave and Taumata streams, respectively. Staging and access for construction work areas would result in 11.2 acres of temporary impacts. Modification to channels through conveyance improvements and trimming of riparian vegetation within the construction limits (including any associated staging and access roads) would result in direct loss of instream and riparian vegetation at both the Leaveave and Taumata stream sites. Vegetation would be permanently displaced within the footprint of the conveyance improvement area and access roads (as needed to provide long-term operations and maintenance (O&M).

The study areas along Leaveave and Taumata streams are located in a developed and populated area of the Tafuna-Leone Plain. Vegetation types include secondary forest, secondary scrub, agriculture, urban cultivated land, and urban built-up areas. Introduced terrestrial wildlife species are expected to dominate. Construction activities related to Alternative B would temporarily affect the presence of terrestrial wildlife in terms of noise, vibration, and human presence. This may cause wildlife to leave the study area during construction activities. Species could move to other available areas during the construction.

Effects to terrestrial vegetation and wildlife under Alternative B would be less than significant and would cause no substantial adverse change in the environment as measured by the applicable significance criteria; in general, no mitigation would be required (but in some cases, best management practices (BMPs) would need to be incorporated to meet other regulatory requirements.)

3.6.5.4 Alternative B1: Channel Conveyance Improvements and Flood Barriers (Leaveave and Taumata Streams)

Same as Alternative B, Alternative B1 would result in 17.3 acres and 8.6 acres of permanent impacts from channel conveyance improvements made to Leaveave and Taumata Stream, respectively. In addition, Alternative B1 would result in an additional 2.3 acres of permanent impacts at each site due to construction of the respective flood barrier (4.6 acres total). Temporary impacts would require 14.4 acres for staging, access, and construction activities.

Modification to channels through conveyance improvements and trimming of riparian vegetation within the construction limits (including any associated staging and access roads) would result in direct loss of instream and riparian vegetation at both the Leaveave and Taumata Stream sites. Vegetation would be permanently displaced within the footprint of the conveyance improvement area and access roads (as needed to provide long-term O&M). Vegetation would be permanently displaced within the footprint of the flood barrier) and access road (as needed to provide long term O&M). The addition of the flood barriers along Leaveave and Taumata streams would require the removal of a larger quantity more vegetation than compared to Alternative B.

The study areas along Leaveave and Taumata streams are in a developed and populated area of the Tafuna-Leone Plain. Vegetation types include secondary forest and scrub, agriculture, urban cultivated land, and urban built-up areas. Introduced terrestrial wildlife species are expected to dominate. Construction activities related to Alternative B would temporarily affect the

presence of terrestrial wildlife in terms of noise, vibration, and human presence. This may cause wildlife to leave the study area during construction activities. Species could move to other available areas during the construction. Effects to terrestrial vegetation and wildlife species under Alternative B would be less than significant and would cause no substantial adverse change in the environment.

3.6.5.5 Alternative C: Taumata Flood Barrier and Nonstructural Improvements

Alternative C would result in 2.3 acres of permanent impacts from construction of a flood barrier along Taumata Stream. Temporary impacts would require 1.8 acres for staging, access, and construction activities. The effects of Alternative C on terrestrial vegetation and wildlife are expected to be less than Alternatives B and B1 as only a flood barrier would be constructed along Taumata Stream under this alternative (no conveyance capacity improvements would be made). A smaller area of vegetation would be removed in total (only along the footprint of the barrier placed along Taumata Stream), resulting in a reduced effect on terrestrial species. Effects to terrestrial vegetation and wildlife species under Alternative C would be less than significant and would cause no substantial adverse change in the environment.

3.6.5.6 Alternative D: Nonstructural Improvements

No effects to terrestrial vegetation and wildlife species are expected under Alternative D as this is a fully non-structural solution.

3.6.5.7 Mitigation

Effects on terrestrial biological resources were considered significant if implementation of an alternative plan would result in any of the following:

- Substantial loss of native species
- Reduced habitat availability or degradation of habitat suitability of a magnitude and/or duration that could substantially affect a native species population
- Substantial interference with the movement of migratory species
- Introduction or contribute to the substantial spread of an invasive species

Because the potential effects to terrestrial biological resources that could result from implementation of the alternatives would be less than significant and cause no substantial adverse change in the environment as measured by the applicable significance criteria, no mitigation would be required. Any areas temporarily disturbed or where terrestrial vegetation is removed (e.g., staging areas) would be expected to quickly recover given the climate, long growing season, and available seed bank.

However, as alternative B, B1, and C could each result in some loss of terrestrial vegetation from clearing and grubbing activities, especially at staging areas, a best management practice could include revegetation of any temporarily impacted area with landscaped vegetation replaced in kind and any non-native species replaced with suitable native species (where practicable).

3.6.6 Aquatic Habitats and Species

3.6.6.1 Affected Environment

Aquatic habitats include freshwater and marine environments and cover wetland and riparian habitat. In American Samoa, the diversity of aquatic marine species is remarkably high relative

to terrestrial habitats, with 890 species of coral reef fish, over 200 coral species, and a rich assemblage of other invertebrates (Craig et al. 2005).

3.6.6.1.1 Wetlands

Jurisdictional wetland Waters of the US (WoUS), as defined by the Clean Water Act (CWA), are found within the study area. Wetlands include various vegetation communities that grow within saturated conditions. Wetlands are areas where water covers the soil or is present either at or near the surface of the soil all year or for varying periods of time during the year, including during the growing season (USEPA 2021). The prolonged presence of water creates conditions that favor the growth of specially adapted plants (hydrophytes) and promote the development of characteristic wetland (hydric) soils. Wetlands may support both aquatic and terrestrial species.

Mangrove wetlands in American Samoa are found only on Tutuila and Aunu’u Islands and include tidal fringing and interior/partially enclosed basin forests. They are typically found in sheltered coastal lagoons and protected areas near stream mouths where freshwater enters the ocean. The Nu’uuli Pala Lagoon contains the largest mangrove wetland on Tutuila. In American Samoa, mangrove wetlands are considered a threatened vegetation type. Mangrove systems are a source of energy for food chains that occur within the forest as well as adjacent lagoons

(Lugo and Snedaker 1974). Mangrove leaf detritus is an important source of energy as bacteria and fungi that consume detritus are in turn, consumed by mixed trophic herbivores and carnivores (Odum and Heald 1975). Maintaining water quality conditions within the mangrove forest and lagoon contributes to ensuring the pathways of mangrove leaf-litter energy flow would remain stable.

The Nu'uuli Pala Lagoon (lagoon) is a shallow estuarine body of water and the only large, enclosed lagoon on Tutuila. The lagoon is roughly circular, approximately one mile in diameter, and has a surface area of approximately 1.2 square miles. Two-thirds of the lagoon is relatively flat and shallow, with depths ranging from 1 to 5 ft, depending on the tidal stage. The bottom is a muddy, coral sand to silty mud, and the water column is usually turbid. Three mangrove species occur: oriental mangrove (*Bruguiera gymnorrhiza*) is the dominant species, red mangrove (*Rhizophora mangle*) can be found along seaward margins, and the puzzlenut tree (*Xylocarpus moluccensis*) is rare. Other mangrove forest associates include beach hibiscus (*Hibiscus tiliaceus*), fish-poison tree (*Barringtonia asiatica*), and Tahitian chesnut (*Inocarpus fagifer*). Mangrove forests thrive in brackish water conditions, and provide critical habitat for a variety of fish, invertebrate, and mollusk species.

Figure 24. Nu'uuli Pala Lagoon on Tutuila (view to North and Matafao Peak, C. Solek)

Estuarine conditions in the lagoon are created by the influx of water from two main streams and from numerous springs near its western and northern shores. The lagoon receives surface runoff from a large portion of the Tafuna Plain, including the village of Nu’uuli, and parts of Tafuna, Faleniu, Malaeimi, and Mesepa among other areas. The combined population of these villages as of 2011 was estimated at 15,424, or approximately 28 percent of the total population of American Samoa (ASG 2011). During the 1960s, the lagoon’s natural circulation patterns were heavily altered through the creation of the airport (Scott 1993). Prior to construction of the airport, the Lagoon reportedly supported American Samoa’s most productive shellfish beds (Clark 2018).

The construction of the runways directly affected the Pala Lagoon through the removal of dredge material to create new land and the artificial restriction of ocean water exchange through the narrow channel between the airport runway and Coconut Point (Figure 25). Subsequent dredging and filling also disrupted longshore drift, prevented sand replenishment along the coast, and contributed to possible erosion at Coconut Point (Clark 2018). The lagoon was further impacted in the 1960s by the conversion of approximately 33% of the original mangrove vegetation to upland through dewatering (NOAA 2009).

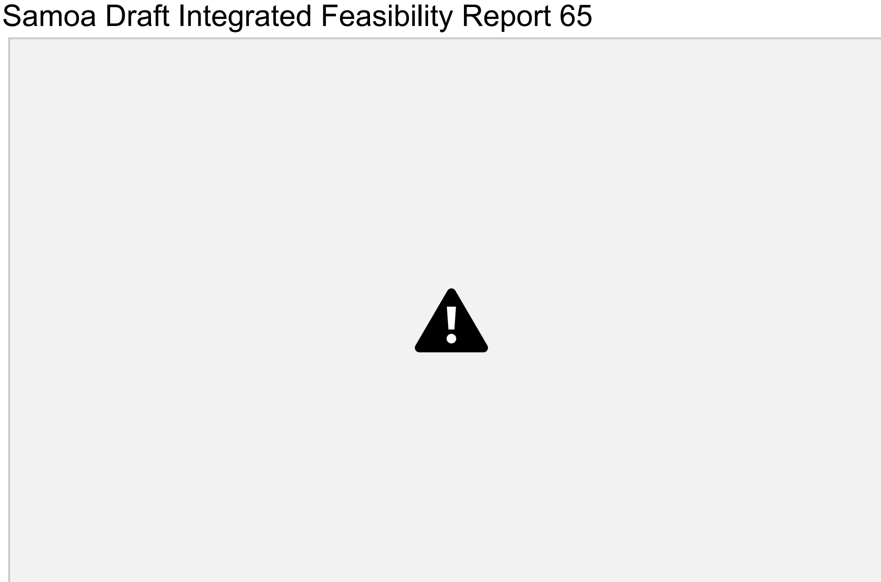

Figure 25. (Left) Pala Lagoon in 1973 After Airport Construction and (Right) How impacts Could Have Been Avoided if the Runway Had Been Located Inland from the Coast (Clark 2018)

The Nu'uuli Pala Lagoon was designated a Special Management Area (SMA) and is comprised of, 77 percent un-colonized sediments, 13 percent emergent wetland vegetation (including mangroves), and two percent coral (NOAA 2009; Figure 26). Excluding open water areas, the lagoon covers 123 acres of which approximately 100 acres are Oriental mangrove (*Bruguiera gymnorrhiza* (L.) Lam) and Red mangrove (*Rhizophora mangle*). There is also a narrow strip of saltwater marsh within the lagoon. The puzzlenut tree or e'ile'i (*Xylocarpus moluccensisor*) is reported in small numbers on the lagoon edge of Coconut Point. It is speculated that this species also exists along the northern shore of the lagoon (Sustainable Forestry Initiative Inc. 2019).

Figure 26. Benthic Cover Types in the Nu'uuli Pala Lagoon (NOAA 2019)

3.6.6.1.2 Riparian Vegetation

Riparian areas are considered transitional zones between wetland and upland (terrestrial) vegetation types. Riparian typically refers to the zone of vegetation adjacent to rivers and streams, including the vegetation found along riverbanks and adjacent floodplains. Riparian habitats are generally characterized by soils and vegetation that require free and unbound water. Riparian areas can include wetland and upland species (NRC 2002).

The riparian areas associated with streams in American Samoa are of very limited extent, being restricted to the margins of the streams and to channels of intermittent streams. Falaga (*Barringtonia samoensis*), a medium-sized tree closely related to the dominant coastal forest tree, the fish-poison tree or futu (*Barringtonia asiatica*), is commonly found along mountain streams (Whistler 1976).

The riparian vegetation in virtually all lowlands areas adjacent to streams on Tutuila, including all streams with the study area, has been affected by human activities and are highly managed habitats. Lowland riparian areas support both native and nonnative trees, many of which were planted by humans and are maintained for food, shade, beauty, wind breaks, building materials, medicine, shoreline protection, boundary markers, etc. Most lowland riparian areas tend to be dominated by non-native para grass (*Brachiaria mutica*, Coix sp.) and canna lily (*Canna sp*.), as well as many other weedy species found in wetland taro patches. In most cases, the terminal and lower reaches of streams have been partially cleared of riparian growth, particularly where the stream flows through a village or populated area (USACE 1981).

3.6.6.1.3 Aquatic Freshwater Invertebrates

The biota of streams and other waterbodies in American Samoa include freshwater mollusks, crustaceans, insects, and fish. Current threats to the native freshwater biota of Tutuila include 1) clearing of land for additional agricultural production, particularly on steep slopes, which results in increased sedimentation; 2) stream channel alteration as a result of road construction activities, which can result in impaired connectivity for diadromous species; and 3) relatively lax biosecurity protocols at the ports and airport, which may allow future introduction of new aquatic invasive species.

3.6.6.1.3.1 Freshwater Mollusks, Shrimp and Crabs

No comprehensive survey of freshwater mollusks has been conducted in American Samoa in at least 15 years, the most recent survey being that of Haynes (2001). Of the native freshwater mollusks known in the Samoan archipelago, only 23 occur in American Samoa, six of which are found on Tutuila. There is only one endemic freshwater mollusk, the freshwater snail *Melanoides brenchleyi delicatula,* currently documented from Tutuila *(*Polhemus 2020). Freshwater shrimps are common elements of stream communities, and overall, the freshwater shrimp assemblage found in American Samoa consists entirely of widespread, diadromous species, none of which appear to be at risk within the Territory. No endemic species are present. Freshwater shrimps are represented by two families, containing four genera and nine species. The family Atyidae is composed of small-sized species that largely inhabit the stream benthos, and Palaemonidae, which are much larger species that forage in the water column in stream pools.

Freshwater crabs have been only sporadically collected from streams in American Samoa and their overall distribution is likely to be underestimated. Two species in the family Varunidae, *Ptychognathus pusillus* Heller and *Ptychognathus reidelii* (Milne Edwards) have been reported from streams on Tutuila (USACE 1981).

3.6.6.1.3.2 Freshwater Fish

The freshwater fishes occurring in American Samoa streams include diadromous species that spend their adult stages in freshwater and their immature stages in marine environments and euryhaline species that are predominantly marine, but able to move up streams for varying distances at any life stage, depending on barriers and flow stage. The euryhaline species are all widespread forms that are not strictly linked to stream environments.

Twenty-nine species of freshwater fish are known from Tutuila, with three species in the family Anguillidae (freshwater eels), four species in the family Eleotridae (sleepers), ten species in the species in the family Gobiidae (gobies), two species in the family Syngnathidae (pipefishes), and two species in the family Kuhliidae (flagtails) in as well as seven other itinerant species. The flagtail *Kuhlia salelea* Schultz appears to be the only freshwater fish species endemic to the Samoa archipelago (Randall & Randall 2001).

There are currently five introduced freshwater fish species known from streams on Tutuila, consisting of three species of mosquitofishes, one cyprinid (goldfish), and one cichlid (Mozambique tilapia).

3.6.6.1.3.3 Freshwater Aquatic Insects

The documented freshwater aquatic insect biota of American Samoa consists of 30 species, including two species of flies (Diptera), nine species of aquatic true bugs (Heteroptera), and 19 species of dragonflies and damselflies (Odonata). Of these 30 species, nine are endemic to the Samoan Islands and three are strictly endemic to the island of Tutuila. Because they have been extensively surveyed, the majority of the known locally endemic freshwater insect species in American Samoa are dragonflies and damselflies. In many cases, the endemic species inhabit only a particular section of a watershed, often the upper reaches.

3.6.6.1.3.4 Aquatic Marine Species

In contrast to terrestrial species, the diversity of marine species in American Samoa is high to include 961 species of coral reef fishes, over 250 species of corals, two species of marine sea turtles, and several species of marine mammals, including whales and dolphins. Most native species are closely related to those in Indonesia.

The Nu'uuli Pala Lagoon supports an abundance of fish and aquatic invertebrates, some of which are still occasionally harvested for food. Survey data indicate a general gradient of all species, with the greatest diversity of organisms found at the outer coral reef edge at the mouth of the lagoon and the lowest diversity on the mud flats and inner lagoon shore. Although the biota of the inner lagoon is generally lacking in diversity, the inner lagoon does serve as an important nursery and spawning ground for various fish and invertebrate species.

Common invertebrates include various species of bivalve mollusks and echinoderms (e.g., starfish, sea urchins, sea cucumbers). The scyphozoan (jellyfish) *Cassiopeia sp*., the holothurians (sea cucumbers) *Stichopus sp*. and *Actinopyga sp*., the gastropods *Littorina sp.* and *Nerita plicata*, the mangrove oyster *Isogamon sp*., the edible clam *Gafrarium tumidum,* abundant in the muddy bottom along the north shore (Glude 1972), mantis shrimps Lysiosquilla sp., fiddler crabs Uca sp., land crabs Cardisoma sp., and the mangrove crab Scylla serrata (Yamasaki et al. 1985). These species are generally distributed in a similar pattern as corals, with diversity greatest found on the reef flats at the mouth of the lagoon at Coconut Point and the fewest species found the inner lagoon.

Due to the low salinity and high turbidity of the lagoon water, corals are virtually non-existent within the inner lagoon, although there is some live coral in and around the entrance channel. Reef corals, dominated by thickets of staghorn *Acropora sp*., flourish in most areas at the outer Airport-Coconut Point region at all depths and cover large areas near the mouth of the lagoon, presumably due to the good circulation and exchange of water and the proximity to more favorable open ocean conditions. The large fringing reef flat adjacent to the outer Airport Coconut Point is perhaps the largest and widest reef in American Samoa and extends for some distance down the coast to the east from Pala Lagoon. This reef probably extended west from the present lagoon entrance prior to the construction of the airport.

The bathymetric features of the lagoon are largely responsible for the restrictive circulation patterns in the shallow basin, which likely accounts for the distribution patterns and abundance of corals within the lagoon. Runoff to this portion of the lagoon from villages adjacent to the shoreline, in addition to poor water circulation, may have some limiting effect. However, the lack of hard substrate in this area may be the most limiting factor and inhibits recruitment by larval corals that are not able colonize finer sediment substrates, like sand or silty mud.

The inner basin is shallower, larger, and more isolated from ocean circulation than areas close to the lagoon's the open ocean mouth. The mean depth of this mostly sediment covered flat is less than three ft deep. The flora here is dominated by the red algae Acanthophora spicifera, which covers much of the muddy and sandy bottom of the lagoon. Other algae include the green algae Caulerpa sp. and the brown algae Dictyota sp. and Padina sp (Volk 1993). The calcareous green algae Halimeda sp. and the sea grass Halophila minor occur on the sandflats bordering Coconut Point (at the lagoon mouth). Small springs along the rocky western shore of the lagoon support dense mats of the filamentous algae Enteromorpha sp. (Yamasaki et al. 1985).

Yamasaki et al. (1985) found a surprisingly high diversity of fish species in the inner lagoon and a great abundance of mullet (Mugilidae). These authors also found an abundance of small predatory fish, notably juvenile Sphyraena barracuda (great barracuda) and *Caranx ignobilis* (giant trevally).

3.6.6.1.3.5 Other aquatic species

Marine turtles are occasionally reported in the Lagoon, probably Hawksbill (*Eretmochelys imbricata*). See Section 3.6.7 Threatened and Endangered Species.

3.6.6.2 Alternative A: No Action Alternative

Under the No Action Alternative, no FRM measures would be implemented and as such, project related impacts to aquatic habitat or species would not occur. In the absence of FRM measures, it is anticipated that areas adjacent to the stream would continue to periodically flood.

Under the No Action Alternative, continued development within the floodplain could exacerbate loss or degradation of existing wetlands and riparian areas within the study area. Habitat restoration and conservation efforts by local and federal agencies may offset some of these impacts but are limited due to floodplain development and private property or communal land tenure restrictions.

Overall, wetland and riparian vegetation is expected to remain stable or slightly decline under this alternative if development in the watershed continues on current pace. Similar to the effects

on terrestrial species, future climate changes are expected to result in habitat loss and degradation, decreased biodiversity (including extinction of endangered species and loss or migration of native species), and spread of invasive species. However, these conditions are presumably already occurring within the watershed; therefore, it is expected that the future without-project conditions would be commensurate with existing conditions. No significant negative effects to aquatic habitat or species are expected under the No Action Alternative.

3.6.6.3 Alternative B: Channel Conveyance Improvements (Taumata and Leaveave Streams)

Under Alternative B, instream alternations in the form of channel conveyance improvements would be conducted along 6,340 ft of Taumata Stream and 13,120 ft of Leaveave Stream to result in 17.3 acres and 8.6 acres of permanent impacts to Taumata and Leaveave streams, respectively. Staging and access for construction work areas would result in 11.2 acres of temporary impacts.

Alternative B would require work within the active stream channels and impact both aquatic instream (in channel) and riparian habitat, both of which could directly and indirectly affect aquatic biota (primarily to freshwater fish, amphibians, and aquatic insects). Both Taumata and Leaveave Stream are non-perennial streams and do not support a perennial stream biota (presumably fewer species diversity and abundance are expected). In addition, as previously discussed, most of the vegetation along these streams is highly disturbed and comprised of non native species (both flora and fauna), some native species presumably still exist in the proposed study area and could be impacted by project activities.

Direct potential impacts to aquatic species as a result of instream construction activities could include injury, death, or possible entrainment. Habitat impacts are primarily expected to occur as a result of instream channel excavation work and any associated vegetation removal, permanently increasing the extent of vegetation removal adjacent to both streams where it provides habitat and water quality benefits. Vegetation would presumably need to be removed along both banks of each stream, impacting approximately 2.2 acres of riparian habitat adjacent to Taumata Stream and approximately 3.6 acres of riparian habitat along Leaveave streams.

Riparian trees provide downed wood and roots to the stream that provide habitat aquatic organisms. Loss of this vegetative cover can impact both breeding and feeding habitat. Alteration to stream channels can also result in impaired connectivity for diadromous species *(*Polhemus 2020) and contribute to the spread of aquatic invasive species. Removal of riparian vegetation and compaction of soil by heavy equipment can contribute to increased surface runoff and lead to water quality issues.

The preconstruction, engineering and design (PED) and construction phases for the proposed Project will need to incorporate measures and/or best practices to avoid and minimize potential impacts to aquatic vegetation. Design-related efforts could include reduction of the project footprint (including temporary impact and staging areas) to the greatest extent practicable and incorporation of design features that maintain passage for native stream biota (especially at transition points). For example, any scour protection features proposed at transitions could be designed in such a way as to avoid the creation of potential barriers to the longitudinal (upstream-downstream) movement of aquatic biota along the stream channel.

BMPs implemented during design and construction would align with the American Samoa Erosion and Sediment Control (ESC) Field Guide ver. 2.0 (Horsley Witten Group, Inc. 2019) and could include, but are not limited to, proper construction sequencing, installation of sediment

barriers (e.g., silt fencing, turbidity curtains), tree protection methods, and implementation of bank stabilization practices (e.g., erosion control blankets). Implementation of the practices ensure compliance with the Territorial Environmental Quality Act, Title 24 Water Quality Standards, Pollution Control (A.S.A.C. § 24.0208). Under these regulations, the American Samoa Environmental protection Agency (ASEPA) is required to "prevent negative impacts to receiving waters and ground waters as a result of disruption in natural drainage patterns caused by development."

Additional recommended protocols and BMPs are expected to include the following:

- Minimize the extent and duration of instream work to the extent practicable ▪ Limit construction activities within the stream channels to periods when they do not contain flowing water
- Although not anticipated, should dewatering of the construction area be required at any time, proper dewatering techniques would be implemented. (Ex. sandbags or cofferdam could be used to isolate the work area and to concentrate upstream flows)
- If pumps are to be used to dewater the construction area, it would need to be properly screened to preclude entrapment of fish and the area would need to be adequately inspected to ensure no fish or other aquatic organisms are stranded.

However, even with these avoidance and minimization efforts, the proposed project would still result in some unavoidable impacts to aquatic habitat. Disturbed locations, such as temporary construction areas, would need to be restored to as close as possible to their previous condition. All exposed soils would be expected to revegetate quickly through natural recruitment processes over time due to the tropical climate and existing seed bank. However, some of the most disturbed areas may need to be planted with native vegetation or an appropriate species to reduce immediate soil erosion and protect/stabilize any exposed slopes from subsequent flow events. Native vegetation to be planted may include herbs, shrubs and trees. Performance criteria, performance monitoring, and adaptive management would be required over time to ensure successful establishment of any planted materials.

Reduced water quality conditions in the form of temporarily elevated turbidity levels. We anticipate that a limited amount of suspended sediments may be mobilized during project dam removal construction activities, including coffer dam installation and removal.

As part of the long-term project O&M activities would be required to keep the FRM infrastructure in proper working order; in-stream O&M activities would include periodic sediment/debris removal from the channels. BMPs would be implemented (as appropriate), such that impacts are expected to be less than significant.

The non-federal sponsor would operate and maintain the project. Depending on the level of vegetation maintenance conducted, stream banks may become revegetated with native shrubs and trees over time. However, mitigation would still be necessary because removing the stream bank vegetation would potentially have negative effects to water quality. With mitigation, the effect of Alternative B on aquatic vegetation would be less than significant.

3.6.6.4 Alternative B1: Channel Conveyance Improvements and Flood Barriers (Leaveave and Taumata Streams)

Impacts to aquatic vegetation and organisms from Alternative B1 would be as described Alternative B. In addition, Alternative B1 would add approximately 2,400 lf of flood barrier with an average height of seven ft (from ground elevation) on the Taumata Stream and approximately 3,400 lf of barrier with an average height of five ft (from ground elevation) on the Leaveeave Stream. The addition of a flood barrier along both Leaveave and Taumata streams would result in a larger project footprint and the removal of a larger area (approximately 0.7 additional acres) of riparian vegetation than in comparison to Alternative B. With mitigation (as described for Alternative B), effects to aquatic habitat and species under Alternative B1 would be less than significant and would cause no substantial adverse change in the environment.

3.6.6.5 Alternative C: Taumata Flood Barrier and Nonstructural Improvements

Alternative C result in a much smaller project footprint that either Alternative B or B1. No instream improvements would be made to either Leaveave or Taumata Stream and no flood barrier would be constructed along Leaveave Stream under Alternative C. This would result in a smaller area of impact (approximately 2.4 acres) and fewer impacts to aquatic vegetation in terms of removal. With mitigation, as described for Alternative B in terms of revegetation and returning the area to its previous condition, effects to aquatic habitat and species under Alternative C would be less than significant and would cause no substantial adverse change in the environment.

3.6.6.6 Alternative D: Nonstructural Improvements

No effects to aquatic habitat or species are expected under Alternative D as this is a fully non structural solution.

3.6.6.7 Mitigation

Effects on aquatic habitats and species were considered significant if implementation of an alternative plan would result in any of the following:

- Substantial loss of native species
- Reduction of habitat availability or degradation of habitat suitability of a magnitude and/or duration that could substantially affect a native species population
- Substantially interference with the movement of migratory species
- Introduction of or contribution to the substantial spread of an invasive species

The potential effects to aquatic habitat and species that could result from implementation of Alternative B and B1 would cause substantial adverse change in the environment in terms of reduced habitat availability from loss of vegetation from instream conveyance improvements (for both alternatives) and installation of flood barriers for alternative B1. There is also the possibility of indirect impacts to upstream or downstream aquatic faunal passage, particularly if obstructions to the stream channel are created with conveyance improvements and floodwall construction

Mitigation requirements or commitments would need to be undertaken to avoid significant impacts. These would be in the form of best management practices (mostly in the form of revegetation) to offset aquatic habitat loss. Other best management practices could include, but are not limited to, proper construction sequencing, installation of sediment barriers (e.g., silt fencing, turbidity curtains), tree protection methods, implementation of bank stabilization practices (e.g., erosion control blankets) would be needed to offset indirect impacts to downstream habitats (i.e., Pala Lagoon). Also see Polhemus 2022 in Appendix C

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Alternative C as currently proposed poses minimal threat to aquatic organisms provided that similar best management practices are followed during construction of all project elements. However, given the presence of native diadromous fish and prawn species in this system, any obstructions to the stream channel created during the course of floodwall construction for Alternative C would need to be avoided.

3.6.7 Threatened and Endangered Species

Plant and animal species are designated as threatened or endangered because of their overall rarity, endangerment, unique habitat requirements, and/or restricted distribution as defined by the USFWS or NMFS. In general, it is a combination of these factors that leads to this designation. Threatened and endangered species include those listed by the NMFS and USFWS (Skinner and Pavlik 1994).

3.6.7.1 Affected Environment

Pursuant to Section 7 of the Endangered Species Act (ESA) of 1973 (16 U.S.C. 1531 et seq.), USACE requested technical assistance from the U.S. Fish and Wildlife Service (USFWS) on April 2, 2020 and received the following list of species listed or proposed for listing under both National Marine Fisheries Service (NMFS) and USFWS jurisdiction (Table 22) that may be present on or in the vicinity of the proposed project location, as well as confirmation that there is no designated or proposed federally designated critical habitat occurring within the immediate vicinity of the proposed study area (Reference Number: 01EPIF00-2020-SL-0253). This list has been recently been verified by the USFWS.

Table 22: Federally listed and proposed species within the study area

Common Name	**Scientific Name**	**Status**	**USACE Determination**
striped Eua snail or Tutuila tree snail	*Eua zebrina**	E	No Effect
Land snail	*Ostodes strigatus**	E	No Effect
green sea turtle (lauamei ena`ena)	*Chelonia mydas*	E	May Effect
hawksbill sea turtle (laumei uga)	*Eretmochelys imbricata*	E	May Effect
E = endangered, T = threatened * endemic to American Samoa			

The proposed study area includes all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action. For this reason, the proposed study area includes a portion of the Nu’uli Pala Lagoon.

3.6.7.1.1 Land Snails

Two species of endemic land snails (sisi totolo in Samoan) on American Samoa are listed as endangered. Neither of these species are expected to occur within the study area due to lack of habitat or presumed extinction.

- *Eua zebrina* Gould 1847 is a tree snail known from mature, native forest areas on Tutuila and Ofu Island in the Manua Group in American Samoa (Figure 27). The species was once considered abundant in the Territory, but now known only from a few locations. It is still considered the most common species of the native land snails in American Samoa.

- *Ostodes strigatus* Gould 1847 is an endemic land snail to Tutuila found on the ground in forest areas with heavy tree cover. The species is now presumed extinct on Tutuila (Cowie, personal communication)

Habitat destruction and modification are probably the greatest threats to native land snails in American Samoa. Urban and suburban habitats (like the study area) are unsuitable for most native snail species that have evolved in the absence of humans. Deforestation and clearing of land have destroyed native forests that support native snails. The spread of invasive plants and predation by introduced predators (e.g., rats, non-native predatory snails, introduced ants) have also contributed to the decline of the native snail fauna of American Samoa.

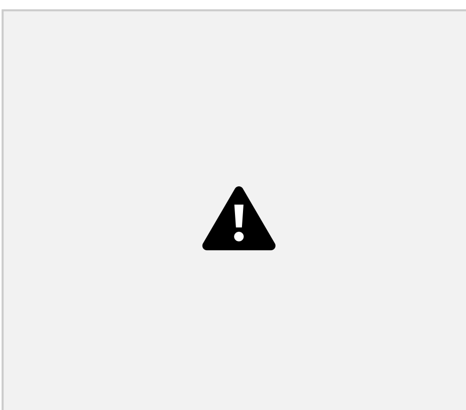

Figure 27: Tutuila tree snail (Eua zebriana)

3.6.7.1.2 Sea Turtles

Sea turtles (or Laumei in Samoan) in American Samoa include the endangered hawksbill sea turtle (*Eretmochelys imbricata*) (US DOC NOAA ONMS 2012) and the endangered green sea turtle (*Chelonia mydas)* (81 FR 20058). Both species are globally distributed throughout tropical and sub-tropical zones. Locally, juveniles of both species are commonly found in near-shore coral reef habitats in American Samoa. It has been assumed that only hawksbills nest on beaches of Tutuila, Aunu'u and the Manua Islands (Craig 2009); however, recent tagging work by American Samoa Department of Marine and Wildlife Resources between and the National Park of American Samoa have confirmed that substantial proportions of turtles nesting on Ofu are green turtles. There is no designated critical habitat for either species in American Samoa.

3.6.7.1.2.1 Hawksbill Sea Turtle

Hawksbill sea turtles have been documented throughout the Pacific. A relatively small number of hawksbill turtles live year-round in American Samoa. The sandy beaches on American Samoa provide nesting habitat, including approximately 10 miles of sandy beaches on Tutuila Island (Tuato'o-Bartley et al. 1993). Tutuila supported an estimated 50 nesting f emale per year through the 1990s (NMFS and USFWS 1998). However, recent monitoring studies conducted by the American Samoa Department of Marine and Wildlife Resources between 2005 and 2010 indicate that fewer than 30 females nest on the beaches of American Samoa (NMFS and USFWS 2013). No nesting of the species has been reported from the vicinity of the study area, although sea turtles, presumably hawksbill, were historically reported in the lagoon (Volk 1993).