Aua Watershed Management Plan 2023-2028

February 2024

Prepared for:
The Aua Village
American Samoa Coral Reef Advisory Group
NOAA Coral Reef Conservation Program

Prepared by:
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Enhancing community resilience with green infrastructure & sustainable land use planning.

ACKNOWLEDGEMENTS

This project was funded through the National Oceanic and Atmospheric Administration's (NOAA) Coral Reef Conservation Program, U.S. Department of the Commerce (DOC) Contract No. EA133C-17-BA-0054/1305M221FNCNPO410. The statements, findings, conclusions, and recommendations are those of the author and do not necessarily reflect the views of NOAA, the NOAA Coral Reef Conservation Program or the U.S. Department of Commerce.

Without the input and guidance of the Aua Village Council and former mayor Muaiavaona Fofoga Pila, this management plan would not have been possible. Fa'afetai to Jewel Tuiasosopo, Fatima Sauafea-Leau, and Fuamai Tago for creating opportunities for community and agency engagement during this process and for critical logistics support. Special thanks to Denis Sene, Tualagi Gaoteote, Ioakimo Makiasi, Christianera Tuitele, Maria Telei, Georgina Faiga, Grace Felise, Lava Grohse, Taotasi Archie Soliai, Adam Miles, Selaina Tuimavave, Tina Mataafa, Trevor Kaitu'u, Warren Seva'aetasi, Kimbaru McGuire-WooChing, Nerisa Taua, Alphina Liusamoa, Blazusky Tupuola, Reuben Siatu'u, Dympna Pangilinan, Fidel Aguila, and Andre Milford for meeting with our team, providing information, and, in some cases, participating in field assessments. In addition, Joy Smith and Bernardo Vargas-Angel willingly shared monitoring data relevant to watershed contributions impacting nearshore health.

SUGGESTED CITATION

Horsley Witten Group. 2024. Aua Watershed Management Plan 2023-2028. Prepared for American Samoa Coral Reef Advisory Group, the Village of Aua, and the NOAA Coral Reef Conservation Program. pp.

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EXECUTIVE SUMMARY

The Aua watershed was identified by the American Samoa Coral Reef Advisory Group (CRAG) and NOAA as a priority area for management. Located on the eastern shore of Pago Pago harbor, the watershed encompasses the forested slopes around Rainmaker Mountain, the Aua Village, the critical Rt 006 cross-island connector, as well as the longest continuously monitored coral reef transect in the world. Unfortunately, the impact of land-based sources of pollution is reflected in negative trends observed in coastal water quality and reef health. Monitoring shows that: 1) Aua's beach consistently exceeds bacteria levels, 2) the streams are impaired for nutrients, turbidity, dissolved oxygen, and pH; and 3) reefs are impacted by high turbidity and dissolved inorganic nitrogen. In addition, almost half of Village structures are within the 100-yr flood zone. Flood vulnerabilities are exacerbated due to the loss of natural stream and wetland capacity to handle runoff volumes and clogging (or submergence) of existing drainage infrastructure. Conditions will continue to worsen with 1.5 - 3.5 feet of relative sea level rise that is expected in the next 50 years.

Past efforts to expand sewer service to Aua, improve piggery waste management, remediate contamination from fuel tank leaks, and study coastal road protection alternatives were important steps in restoring watershed health. Additional management options have been identified in collaboration with NOAA, local agencies, and Village leaders. The Aua Watershed Management Plan offers a roadmap for achieving four watershed goals:

1. **Continue to reduce land-based sources of sediment, nutrients, and bacteria by implementing at least 5 priority projects.** Priority actions include continued trash and debris removal, elimination of remaining wastewater discharges; stabilization of slopes and exposed soils (related to utility improvements and unpaved roads and driveways); continued water quality monitoring, and retrofits at the school and Mormon Church.
2. **Improve Aua Village's resiliency to climate change through sustainable development initiatives that account for a 50-yr planning horizon.** Focus on critical and routine maintenance of existing drainage infrastructure; two key culvert replacements; redesign of Onesosopo Park; and a Village-wide land use to address worsening flood hazards.
3. **Restore Aua's natural watershed function by enhancing 25% of remaining wetland, stream, and shoreline habitats.** Key projects include the central wetland restoration, residential riparian buffer enhancement, and demonstrating a hybrid approach to shoreline stabilization.
4. **Promote watershed education and community engagement in management efforts by conducting 5 public activities each year.** Priorities include Village-led actions (e.g., trash cleanups and native plantings); K-8 lesson plans; trainings; and annual progress reporting.

A total investment of approximately $7M in the Aua watershed is needed for advancing these efforts over the next 5 years. Management goals and priorities should be reassessed in 2028 and updated to reflect changing priorities. Key implementation champions include Village residents, DMWR, DPW, ASPA, ASCC-FE, AS-EPA, CZM, and CRAG.

INTRODUCTION

The Aua watershed was identified by CRAG and the NOAA Coral Reef Conservation Program as a priority area for watershed planning due to its extensive community engagement, high density of developed lands, and the deteriorated conditions along the adjacent coral reef (DMWR-CRAG et al., 2021).

The purpose of this watershed management plan is to identify key sources of, and solutions to, land-based sources of pollution impacting the nearshore ecosystems. This plan summarizes existing conditions and management priorities for improving watershed health over the next 5-10 years. The watershed plan is intended to provide implementable actions for agencies and for Aua Village residents. The recommendations provided herein are derived from a combination of information gathered from a review of previous studies, monitoring data, and mapping; observations made during on-island field assessments; and input gained from local agencies, watershed residents, and the Aua Village Council. This plan recognizes the integral role of Village leaders and residents for effective management of watershed resources.

The Watershed

The Aua watershed is located along the eastern side of Pago Pago Harbor on Tutuila and is, technically, one of several subwatersheds comprising the Pago Pago Outer Harbor watershed (AS-EPA watershed 24B). A watershed is typically defined as the land area that drains to a given body of water when it rains; in Aua, rainfall amounts to over 150 inches annually. The 395-acre (0.62-square mile) watershed extends from Leasi Point southward to Aua Point and encompasses the central Aua Village (**Figure 1**). The Aua watershed contributes surface drainage from Olo Ridge down to the harbor via five main streams: Leasi, Matagimalie, Suaia, Lalolamauta, and Antauo (**Map 1**). For the purposes of this report, the watershed boundary is limited to the official delineation used by AS-EPA (Wright, 2016); however, portions of the Village extend beyond the watershed boundary and are included in the management plan.

Figure 1. Location of the Aua watershed on Tutuila.

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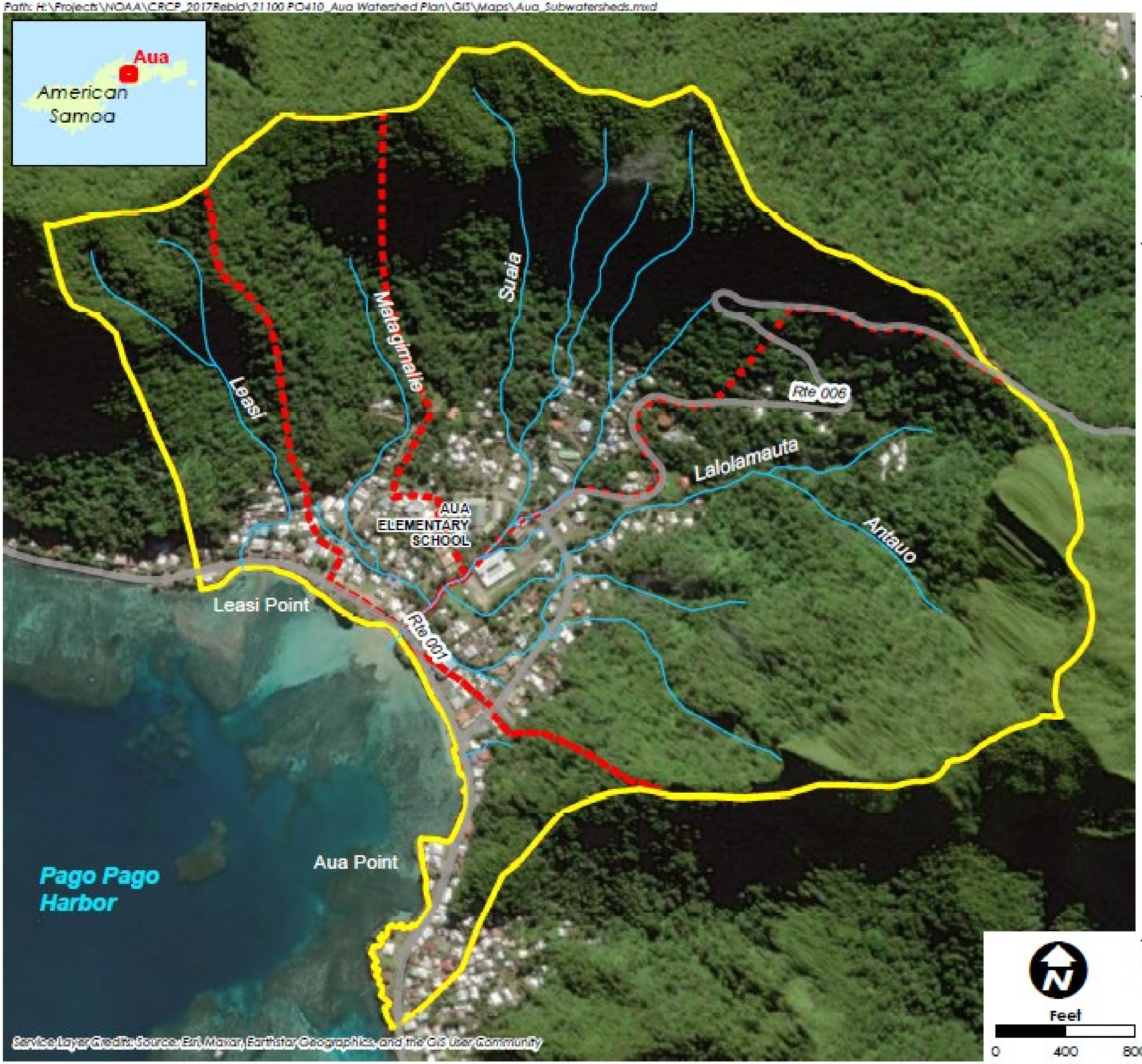


Horsley Witten Group
Sustainable Environmental Solutions

Date: 1/25/2023
Data Sources: USGS, ESRI, unless otherwise indicated by (HW)

This map is for informational purposes and may not be suitable for legal, engineering, or surveying purposes.

Streams (HW 2022)
Roads
Subwatersheds (HW 2022)
Watershed (HW 2022 modified from PacIOOS)

Map 1
Aua Watershed.

The watershed is mostly forested (88%) in the headwaters, with (11%) residential and commercial urban land consolidated in the central village and along the coast (**Figure 2**). The Aua watershed has approximately 8% impervious cover (30 acres),which is in the range of where impacts from development are expected to be seen on the hydrology, water quality, and biological health of small watersheds. Just under an acre of remaining wetlands exists in the urban core, including small wetlands associated with streams and a tidal mangrove wetland at the confluence of the Lalolamauta, Suaia, and Matagimalie streams.

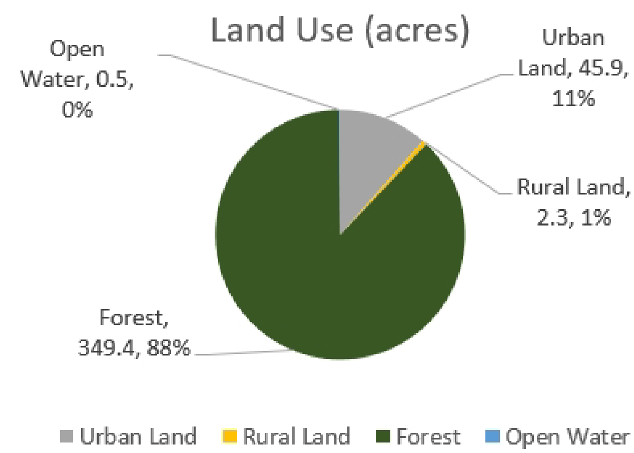


Figure 2. Land Use Distribution in Aua Watershed

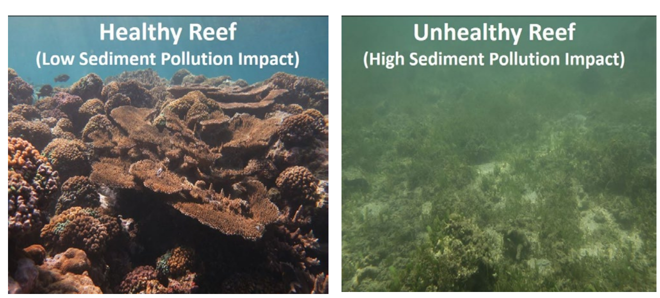
Streams and nearshore waters in Aua are impaired for total nitrogen, total phosphorus, turbidity, dissolved oxygen, and pH. Beach monitoring sites have bacteria levels that exceed the threshold for swimming safety. Historic sources of pollution in the watershed include residual fuel oil leakage dating back to World War II, septic system failure, piggery waste, household trash, and unmanaged stormwater runoff. Recently, ASPA connected 100% of home and business septic systems in Aua to the Utulei Wastewater Treatment Facility on the southwestern side of Pago Pago Harbor. While expected to result in long-term water quality improvements, this major construction project proved to be a significant source of unmanaged sediment loading to streams and the nearshore environment.

Field observations and stakeholder input identified drainage improvements, watershed education, wetland restoration, and better land use management as key restoration opportunities. Pollutant modeling suggests that better wastewater treatment and erosion control could have a marked effect on water quality.

A fixed shoreline marker denotes the location of the famous Aua coral reef monitoring transect.

The Reef

The Aua coral reef is reportedly the world's longest continuously studied reef survey transect, originally established in 1917 by Alfred Mayor (Kaust, 2021). When the coral transect was first studied, it was in pristine condition. However, much of the reef has severely degraded over the course of the 20th century due to human activity. A recent study of the impacts of sedimentation on the reef in 2022 by NOAA, suggests that there is a strong correlation between the high concentration of sediment coming from the Aua watershed and poor health of the coral in the receiving waters—turbidity and biological indicators are worse closest to the mouth of Lalolamauta stream.



Photos comparing healthy and degraded conditions observed along the reef transect (from Joy Smith, 2022 NOAA)

Watershed Goals

The following watershed management goals were established to help improve the health of the watershed, Village, and coral reef over the next 5 years:

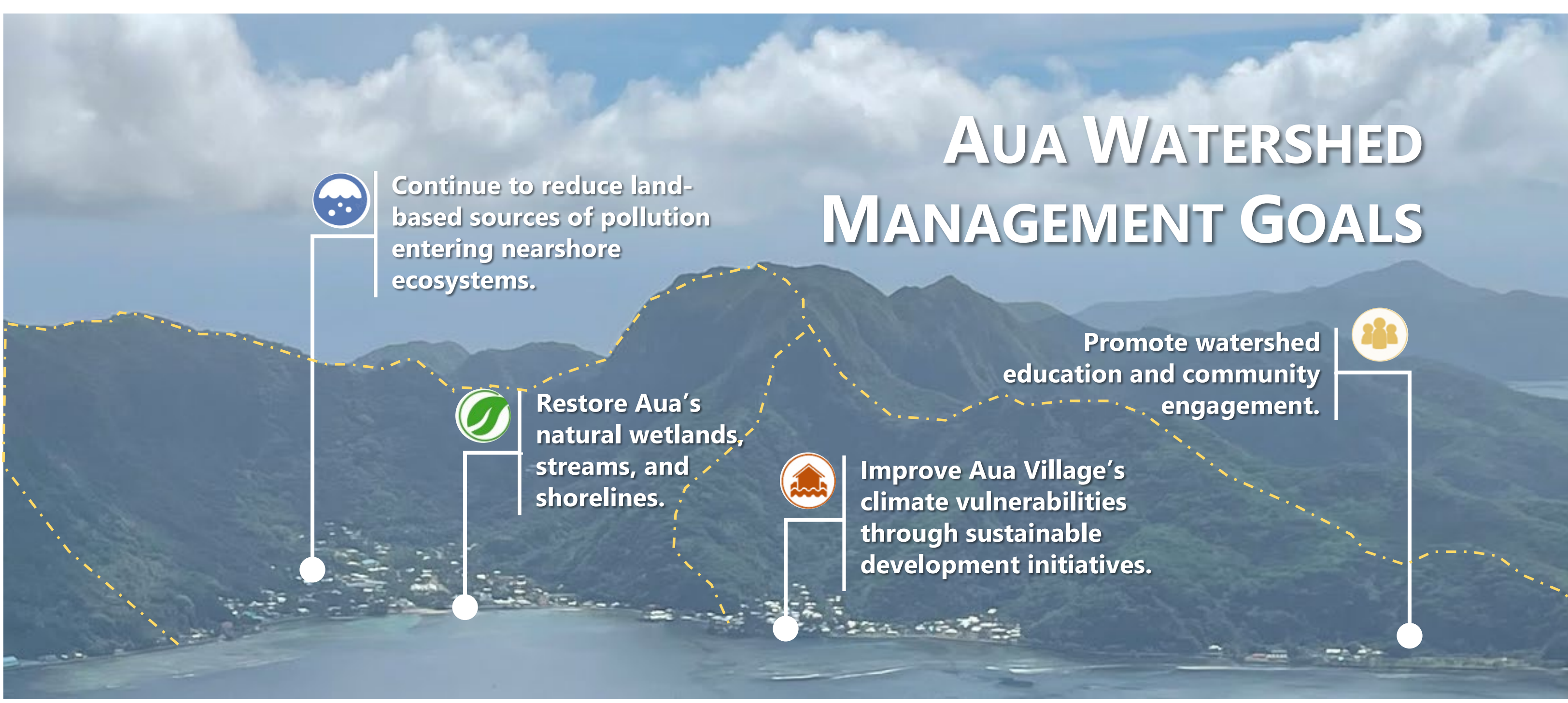
Goal 1. Continue to reduce land-based sources of sediment, nutrients, and/or bacteria by implementing 5 priority restoration projects. Aua's beaches, streams, and nearshore waters have repeatedly shown excessive concentrations of sediment, nutrients, and bacteria. While recent sewer hookups are anticipated to have a measurable effect on nutrient and bacteria reductions, remaining greywater discharges, erosion from construction activities and unpaved roads/driveways, unmanaged stormwater runoff, and groundwater contaminants are potential watershed sources of pollution. These pollutants could harm people and the aquatic biota and must be mitigated to the maximum extent possible. Modeling suggests it would be feasible to reduce existing TSS, nutrient, and bacteria loads by 30%, 70%, and 80%, respectively by implementing the measures identified here.

Goal 2. Improve Aua Village's resiliency to climate change through sustainable development initiatives that account for a 50-yr planning horizon. Many of the homes and buildings in Aua are prone to flooding impacts from storm surge and high intensity rainfall events due to low-lying topography, proximity to the coastline, undersized infrastructure, and unrestricted land development.

Based on the most recent (but old) FEMA mapping, approximately 30% of the developed area in the Village is within the 100-yr flood hazard zone. High scenario sea level rise plus storm surge predictions of 5 ft by 2075 equates to 28% of the developed area in Aua being underwater.

Goal 3. Restore Aua's natural watershed function by enhancing 25% of remaining wetland, stream, and shoreline habitats. Wetlands provide natural flood storage and act as filters for pollutants and trash. The central Aua wetlands have been filled overtime for development, with some estimates of nearly 65% reduction in size from historic extents. It is also estimated that 75% of Aua's 4,000 LF of shoreline has transitioned to a hard engineering slope. While armoring shorelines can protect the coastal road from erosion, it also deflects wave energy to other areas, scouring beaches and sacrificing coastal habitats. Much of the stream network within the Village has been narrowed, straightened, and armored, effectively reducing floodplain storage and contributing to channel scour and instream/buffer habitat loss.

Goal 4. Promote watershed education and community engagement by conducting 5 activities each year. The Aua Village has a strong community ethic, a school, and the highly-traveled Route 006—all offering opportunities for education and engagement. To foster an atmosphere of environmental advocacy, there needs to be consistent education and community engagement on an annual basis.



DMWR and AS-EPA staff participate in a stormwater retrofit training to improve management of runoff from impervious surfaces.

How to Use This Plan

This plan is organized into sections corresponding to each watershed goal, followed by a section on the overall implementation strategy. Each watershed goal includes a discussion of why the goal is important, a list of recommended actions and opportunities identified to address that goal, and a summary of the anticipated benefits and challenges of implementation. It is not expected that all the potential actions will be implemented; however, priority projects in the implementation strategy are identified as a preliminary plan for what might be feasible to achieve over the next few years. The strategy includes a planning level budget and schedule for implementation, possible sponsors, and proposed metrics for tracking and evaluating watershed management progress over time.

Attached to this report are several related documents with supplemental information:

Appendix A. Priority Project Concept Designs—includes a brief description and conceptual designs for priority structural projects. These "fact sheets" are intended to be support materials for grant applications and to inspire agencies to incorporate watershed objectives during future capital improvement projects in the Aua watershed.

Appendix B. Drainage Inventory Map—includes a drainage map showing locations of infrastructure and an inventory table that can be used for maintenance plan development.

Appendix C. Field Summary Memorandum—includes findings from field assessments, notes from Village Council and agency meetings, infrastructure mapping and condition inventory, and information gathered during training workshops conducted in October 2022. Attachments include initial site sketches and maps that can be referenced when projects are being considered for advanced design or when developing an infrastructure maintenance plan.

Appendix D. Pollutant Load Modeling Report—details modeling methods and assumptions used to estimate current pollutant loads and potential load reductions.

Appendix E. Aua Watershed Characterization Report—includes a consolidated review of previous reports, studies, and other information pertinent to the Aua watershed, such as hydrology, land use, geology and soils, habitat, and water quality. This is intended as reference material.

GOAL 1: REDUCE LAND-BASED SOURCES OF POLLUTION

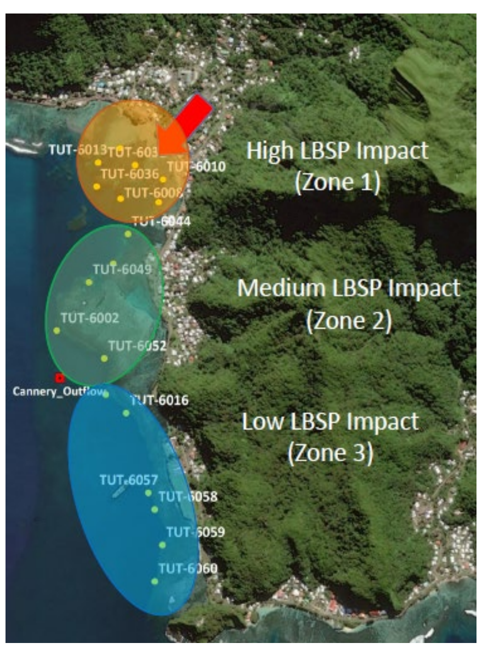
Continue to reduce land-based sources of sediment, nutrients, and/or bacteria by implementing 5 priority restoration projects.

PROBLEM

The five main streams in the Aua Watershed are impaired for total nitrogen, total phosphorus, turbidity, dissolved oxygen, and pH. Based on monitoring conducted by AS-EPA from 2016 to 2023, streams in the watershed also exceeded water quality standards for bacteria at nearly every date in which monitoring occurred. Likewise, the three locations along the Aua shoreline in which AS-EPA conducted monitoring between 2012-2022 were found to have bacteria levels in excess of water quality standards, especially at the outlet of Lalolamauta into the Aua embayment. This is consistent with water quality monitoring data collected by NOAA in 2023 (**Figure 3**), which found higher total suspended sediment (TSS) concentrations closer to the outlet of the Lalolamauta Stream than at other points along the Aua shore (Smith et al., 2023).

The high concentration of nutrients, sediment, and bacteria in the outflow of the streams in the Aua Watershed is likely to have a negative impact on the health of the coral reef. Coral has been observed to be scarcer near the outlet of Lalolamauta than farther away in the embayment (Smith et al., 2023). Coral bleaching has been observed at various points in the recent past, including a significant bleaching event in 1994 (USDA, 1995).

In 2022, ASPA completed Phase 1 of a sewer expansion project along the east side villages of Pago Pago Harbor (Package 5), connecting 100% of Aua(approximately 300 homes) to the Utulei Wastewater Treatment Plant. This represents a significant, long-term watershed restoration activity for reducing nutrient and bacteria loading; however, only pipes directly connected to former septic systems were connected to the sewer line (i.e., toilets, sinks, and showers).



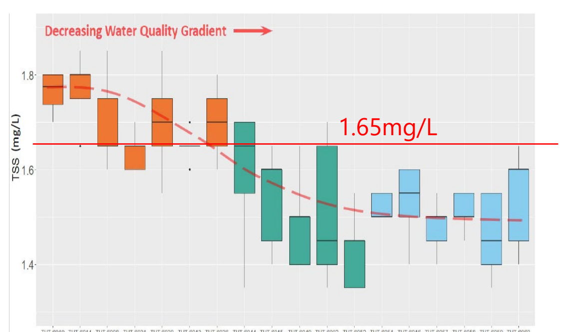


Figure 3. Total suspended solids measured along the Aua shoreline shows a clear gradient between high impact zone (orange) near the central stream discharge and stations further south. Coral, sediment, and fleshy macroalgae change when TSS is >1.65 mg/L (Smith et al., 2023)

Remaining pipes that discharged directly to the streams (e.g., laundry, outdoor toilets) were not connected to the sewer line. In addition, construction activities had a major impact on road conditions and the drainage network throughout Aua. Very few erosion and sediment control practices were in use at the time of the October 2022 Field Assessment. Nearly every stream, culvert, catch basin, and inlet located near active construction was observed to be full of sediment, contributing to flooding and pollution of waterbodies.

Another legacy source of pollution in Aua stems from fuel tanks installed during WWII by the United States Navy. In 1938 and 1939, the Navy constructed twelve 10,000-barrel above ground steel fuel storage tanks, 13 pump houses, and a 12-inch pipeline delivery system through Aua to the canneries (**Figure 4**). By 1945, the fuel tanks were partially dismantled/drained, with less than 5,000 barrels remaining post-war. The fuel farm area was re-graded and flat areas were overlain with 5 to 10 feet of volcanic cobble and boulders of various sizes for use as rock fill. As such, any tank remnants are expected to be buried under rock fill (ACOE, 2020). Between 1989 and 1991, it was confirmed that petroleum hydrocarbons were present in several areas of the village, including along transmission pipe along the coast (Chen-Fruean, 2019).

New sewer line cleanout installed at a home in Aua.

During those investigations, 9 of the 12 tanks were located (Tanks # 4-12); Tank # 7 could not be found, and Tanks # 1-3 were not part of the request for investigation. Large volumes of petroleum-impacted soil were encountered during investigations at the various tank sites. Subsequently, bioremediation by oxygen pellets and thermal treatment were used at different stages to treat the contamination. All active remediation efforts ceased in 1999 with the shutdown of the bioremediation system. Subsequently, on three

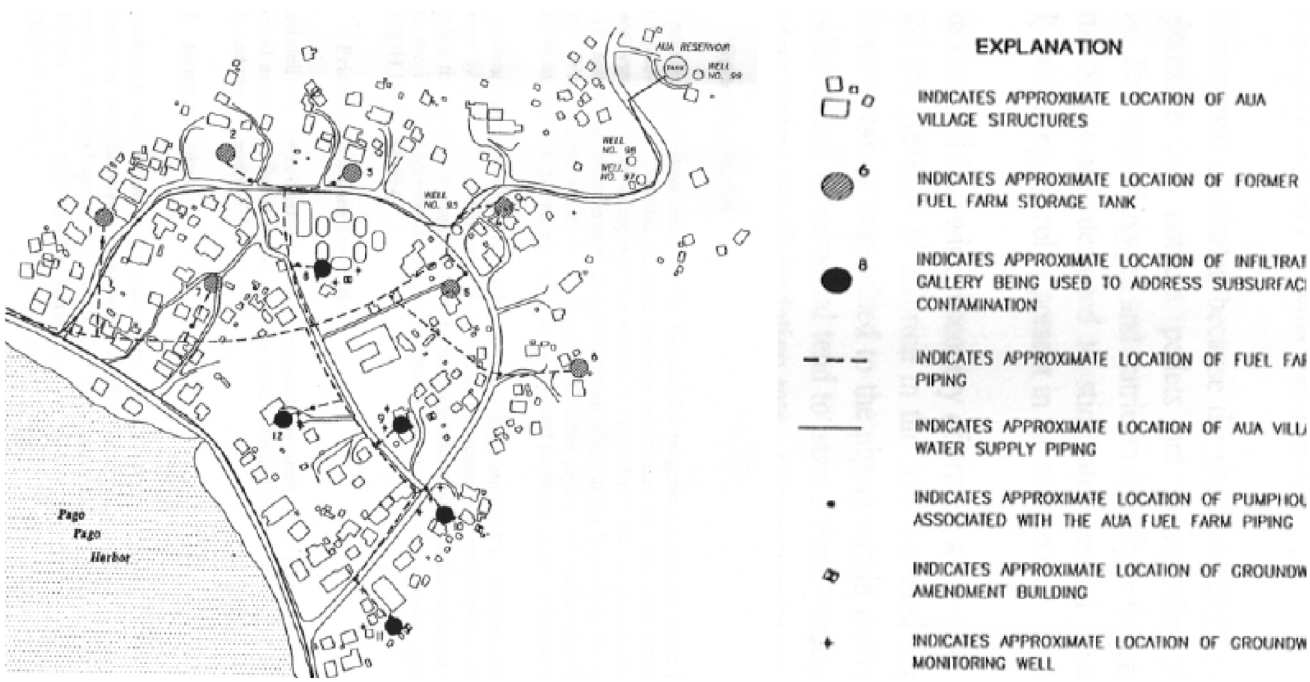


Figure 4. Locations of fuel tanks and distribution lines (US-EPA, 2011)

separate occasions between 2018-2021, construction activities exposed contaminated soils – most recently during the sewer line extension. Remediation efforts led by ERRG included thermal treatment (ex situ), reuse petroleum-contaminated soil, as well as in situ bioremediation and extensive (and ongoing) monitoring. ERRG has installed monitoring wells in the Village to better understand potential plume movement. More information is needed to better understand the overall impact of hydrocarbon contamination in the watershed and marine ecosystem.

Recommended Actions

Potential site-specific and village-wide opportunities to reduce land-based sources of pollution were identified (**Map 2**). Projects range from installing green stormwater infrastructure to clean runoff, to trash cleanups and pollution prevention activities, to continued removal of untreated wastewater discharges. **Appendix A** includes concept designs for several priority projects highlighted below. See **Appendix C** for more details on other candidate projects identified in the field. Recommended actions that can be taken by the Village are described below, as are projects that are more appropriate for agencies to implement.

Village-Led Actions

1.1 Trash Cleanups. Organize a volunteer program run through the Mayor's office to remove trash and debris at key collection/dumping locations on a quarterly or biannual basis. Identify various groups that may want to sponsor individual sites (e.g., school, baseball team). AS-EPA offers waste collection supplies for community groups to utilize, and it does appear that Aua has acquired waste removal supplies through AS-EPA in the recent past. Specific sites to focus on include:

- Suaia stream and Rt. 006 intersection,
- Channel by auto shop down to wetland,
- Matagimalie stream (lower)

1.2 Pollution Prevention & Debris Removal. In areas with high concentrations of oil and other potential contaminants (such as auto yards), businesses should develop pollution prevention plans to limit the proximity of sources of contaminants to waterbodies.

Location of chronic trash buildup in the stream to target during community stream cleanups.

- Site #12. Auto yard backs up to stream, car washing observed, staining on gravel, excessive trash and junk in stream and buffer. Develop pollution prevention plan for proper outdoor material storage and vehicle maintenance and cleanup stream.
- Site #1. Paved interior courtyard (residential/commercial) sees flooding due to high runoff volumes with small, constricted outlet. Exposed outdoor material storage could contribute pollutants via runoff. Replace/improve drainage path and outlet to stream (increase pipe size), pollution prevention (material covering & education).
- Village-wide. Continue to utilize AS-EPA financial support for removal and proper disposal of unneeded vehicles and appliances (every two years).

Help auto repair yard identify and implement low-cost pollution prevention options.

1.3 Erosion and Sediment Control on Roads and Driveways. Report observations of erosion or sediment buildup on roads or in drainage infrastructure to AS-EPA. Remove sediment, rocks, or other debris from clogged infrastructure if easily accessible. Report clogged drainage infrastructure to DPW. Look for opportunities to divert runoff onto the street from unpaved driveways or to stabilize surfaces with gravel or pavers. Refer to a guide to managing drainage on unpaved roads for more information on best practices.

Rutting of unpaved access road/driveway (Site #7) is Erosion gully along unpaved driveway. This could be fixed with regrading of surface to an insloped pitch and installation of a ditch.

1.4a Remaining Wastewater Discharge Inventory. The mayor should create an inventory of remaining residential & commercial wastewater discharges to streams or drainage network. The recent sewer expansion project only connected the pipe going to the septic system. Direct discharges of washwater from sinks, showers, laundry, etc. that were not originally going to the septic system are still discharging directly to streams or storm drain. These should be targeted for hookup to the new sewer line.

Agency-Led Actions

1.4b Remaining Wastewater Discharge Elimination. ASPA to connect laundry, outdoor toilets, and other sources of effluent wastewater/graywater that were not included in the 2022 sewer expansion work in Aua. Establish a subsidy program to cover the connection costs for village residents.

1.5a Stormwater Retrofits Along Roads. Where localized ponding occurs, in areas of excessive

Identify remaining discharges piped directly to stream. If this is laundry or sink/shower wash water, then it should be targeted for hook up to the new sewer line.

pavement, or where drain inlets and culverts are constantly clogging, green stormwater infrastructure can be installed within the road-right-of-way to capture stormwater runoff and filter out pollutants. A guide to green stormwater infrastructure in Pacific Islands can provide examples from the region of stormwater retrofit measures. Specific locations where retrofit opportunities were identified include:

- Unpaved driveways showing signs of erosion and contributing to clogging of infrastructure or sedimentation in streams should be stabilized. Driveways at sites #8a, b, and c, for example, could benefit from disconnection of rooftop/driveway runoff to rain gardens or cisterns, two-track driveway, and diversion berms at entrances.
- Site # 5. At the intersection of Route 006 and the Village loop road, there are two clogged inlets and excessively wide pavement. The bus stops here, but so does the water (i.e., ponding at inlets). After cleaning out inlets, confirm drainage pipe locations. Revegetate or widen channel flowing beside the Church to include some level of pretreatment at outlet structure that can be easily cleaned. Evaluate pavement reduction/retrofit options to treat runoff prior to discharge (e.g., traffic island bioretention).
- Site #4, at a key drain inlet on Route 006 at intersection with residential and small church road uphill from the loop road, there is a clogged catch basin causing severe road surface erosion and leading to additional blockages downhill. Clean the inlet (perhaps redesign to reduce blockage potential) and resurface the road with non-erosive materials. Look for options to provide

pretreatment, such as deep sump catch basin or runoff diversion to vegetated filter.

- Site #13 along Route 006 near the Catholic Church. This section of road was recently repaved by ASPA but was experiencing ponding due to improper road pitch. There are several opportunities along this road segment to install green infrastructure, such as bioswales and turnouts to treat and convey runoff. Ideally, road drainage should be improved, and water quality treatment added as part of all repaving efforts.
- Along Route 001, especially in areas where drain inlets discharge unmanaged runoff to ocean (e.g., across from #I-73 and near the outlet of Lalolamauta at Site #11). Look for opportunities to trap sediment or provide vegetative filters.
- Site #3. At the existing depression in front of a mini mart near the school. There is a collapsed culvert under a driveway, lots of trash, and an overflow to the stream. This area collects drainage from the mini-mart and portion of the road. The depression could be converted to a bioretention facility with added shade trees and improved aesthetics.

1.5b. Stormwater Retrofits at Parking lots and Public Facilities. When public facilities (such as schools) or parking areas are renovated or repaved, green stormwater infrastructure (GSI) can be used to capture stormwater runoff and filter out pollutants. Example locations include:

- Site #9 The Mormon Church discharges runoff from 1.5 acres of impervious cover directly to Lalolamauta Stream with no treatment. Use grassed areas to create bioretention or rain garden filters and tap into existing drainage system for overflow. Plant some trees for canopy cover. Clean trench drains.
- Site #2. The Aua Consolidated School (K-8) was recently renovated and paved. The site has over 1.5 acres of impervious cover that discharges untreated to open channels. The site generates a lot of heat given a lack of shade. Vehicle access to the interior of school is not safe for kids. The gym still floods at NW corner. Retrofit opportunities exist for tree filters/trenches, permeable pavers, and small rain gardens. Allow parking in rear and front lots only.

Consider permeable pavements and tree filters to clean and infiltrate stormwater at the school (site #2), while cooling temperatures and improving pedestrian safety.

Convert existing lawn area to vegetated filters that can clean parking lot runoff before discharging into existing storm drain at the Mormon Church Site #9.

Site #3 is a perfect location for a retrofit to take runoff from parking lot and road prior to discharge to stream.

- Site #16 Onesosopo Park offers an opportunity to demonstrate green stormwater infrastructure such as permeable pavements and rain gardens.
- Site #1 The paved parking/courtyard behind the laundromat across from the school could use an upgrade in pipe size and drainage features.

1.6 Erosion and Sediment Control for Public Construction Projects. Few ESC measures were observed as part of the active sewer extension project (some dust control and a few inlet protection devices were seen, but they were mostly ineffective). Perimeter controls around the staging area, along the roads, and near streams impacted by pipe and pump installations were absent. Inadequate inlet protection, dewatering filters, and temporary stream diversions resulted in clogged catch basins, culverts, and significant sediment deposition in streams and the nearshore environment. Reportedly, Phase I of construction was better, but ESC should be implemented for the full duration of land disturbance. Proper ESC measures are described in the 2019 American Samoa Erosion and Sediment Control Handbook. Other active and pending projects that will need to implement proper ESC measures in Aua include:

- Site # 6. The Aua water supply tank expansion project created a large, excavated slope cut and casting of erodible soils on the downslope side of the site. Stabilize and revegetate disturbed areas, particularly on the back wall where the cut is close to the guardrail along the upper road (Rt 006). Solutions may include retaining walls, gabion baskets, or planted terraces. There were no ESC measures deployed at the site.
- Future installation of water distribution lines is anticipated in concert with the water supply upgrades. This construction activity will need to provide appropriate ESC measures.
- Site #7. This steep, unpaved access road that leads to uppermost housing on Rt 006 was reportedly damaged during the sewer extension work. ASPA will need to fix the drainage on this road. There is gullying down surface and clogging inlet on main road due inability of runoff to get into the ditch on the insloped ditch.

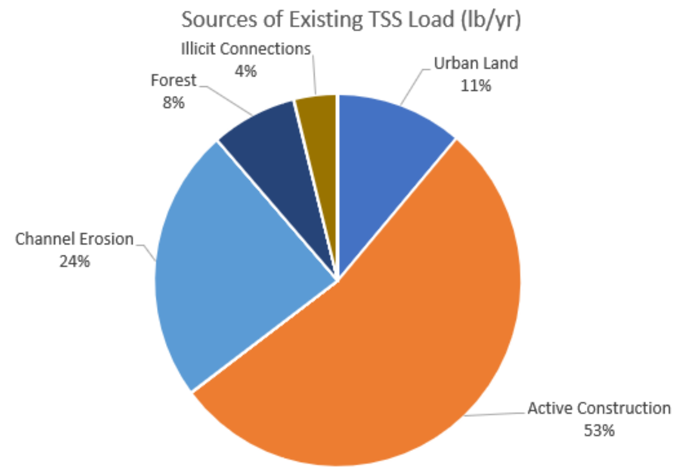
1.7 Continue beach and stream water quality monitoring. AS-EPA, NOAA, and others have collected water quality data (bacteria, sediment, nutrient) at fixed stations along the Aua shoreline, in major streams, and along nearshore transects for human and ecological health. This data record has not been adequately reported as trends over time or in relationship to coral health. A hydrocarbon assessment of the marine waters is warranted since PAHs and other hydrocarbons have known toxicity to corals and other reef organisms. Heavy metals may also need to be sampled below the automotive yard. AS-EPA and CRAG could compile and report on water quality data along with groundwater contaminant monitoring related to the fuel farm and coral health assessments. Long-term trends can be evaluated as watershed restoration projects are implemented.

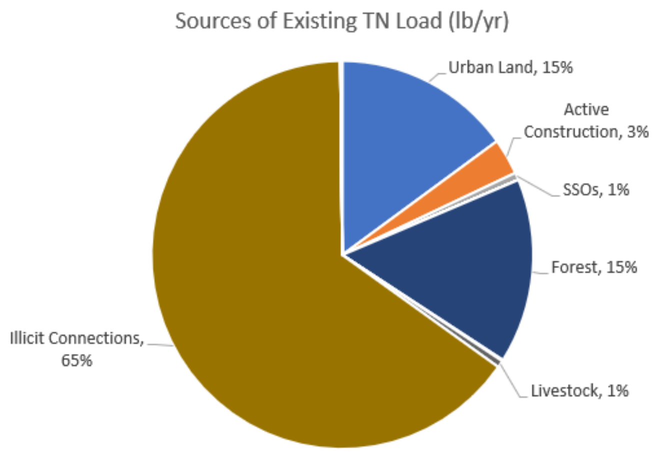
Cut slope close to edge of Rt. 006 behind water tank and other erodible soils at site should be stabilized (Site #6).

Inadequate erosion and sediment control during sewer extension work has led to extensive sedimentation in streams and turbid plumes in harbor (Site #15).

Restoration Potential

Annual pollutant removal rates were estimated for several of the actions described above using the Watershed Treatment Model (WTM) (see **Appendix D** for more details). The WTM is a spreadsheet model that uses runoff from urban and rural land use as the primary source of non-point source pollution. It also applies contributions from secondary sources (e.g., wastewater systems, livestock, and channel erosion) to estimate watershed loads for sediment, nutrients, and bacteria. The model allows for restoration actions (e.g., stormwater retrofits, erosion control programs, and sewer conversion) to be evaluated to predict the pollutant removal potential of implementation actions and future watershed conditions. **Figure 4** shows a breakdown of the sources of watershed-derived sediment, total nitrogen, and bacteria loading in Aua.





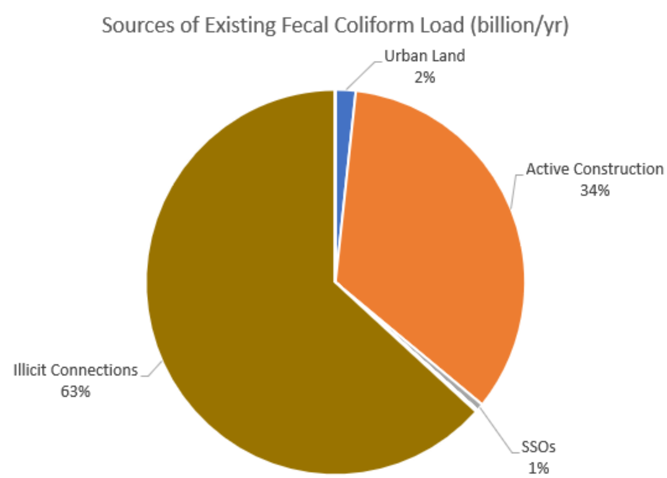


Figure 4. Allocation of loads across by land-based sources.

The WTM provides a relative evaluation of which restoration actions are likely to have the biggest impact on water quality. Expanded sewering and more stringent erosion and sediment control (ESC) during construction were modeled as the most effective measures for pollutant reduction in Aua. Modeling results support the following conclusions:

- Reductions from existing TSS, nutrient, and bacteria loads of 30%, 70%, and 80%, respectively, are anticipated if priority actions are implemented.
- Expanding sewer connections is one of the best actions for reducing nutrient (and bacteria) loads.
- An additional 65% reduction of the remaining nutrients and 70% of bacteria could be gained by eliminating the remaining graywater and illicit discharges (non-stormwater discharges directed to streams without treatment, like laundry and sinks).
- Lack of ESC during sewer construction resulted in an increase in sediment load. Poor ESC practices at Onesosopo Park alone (not including roads and pump locations) showed an 85% increase in TSS. Proper ESC may reduce future TSS by >25%.
- Since most runoff is ultimately conveyed to the central mangrove wetland, restoration of this system may have a big impacts on total watershed load reduction.
- Stormwater retrofits at the Aua Consolidated School and the Mormon Church will have the largest water quality improvement of all the stormwater retrofits proposed.

Figure 5 illustrates which proposed practices contribute the most to potential load reductions moving forward.

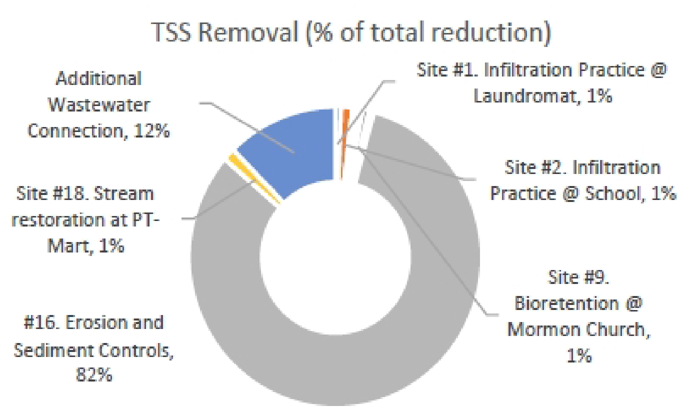
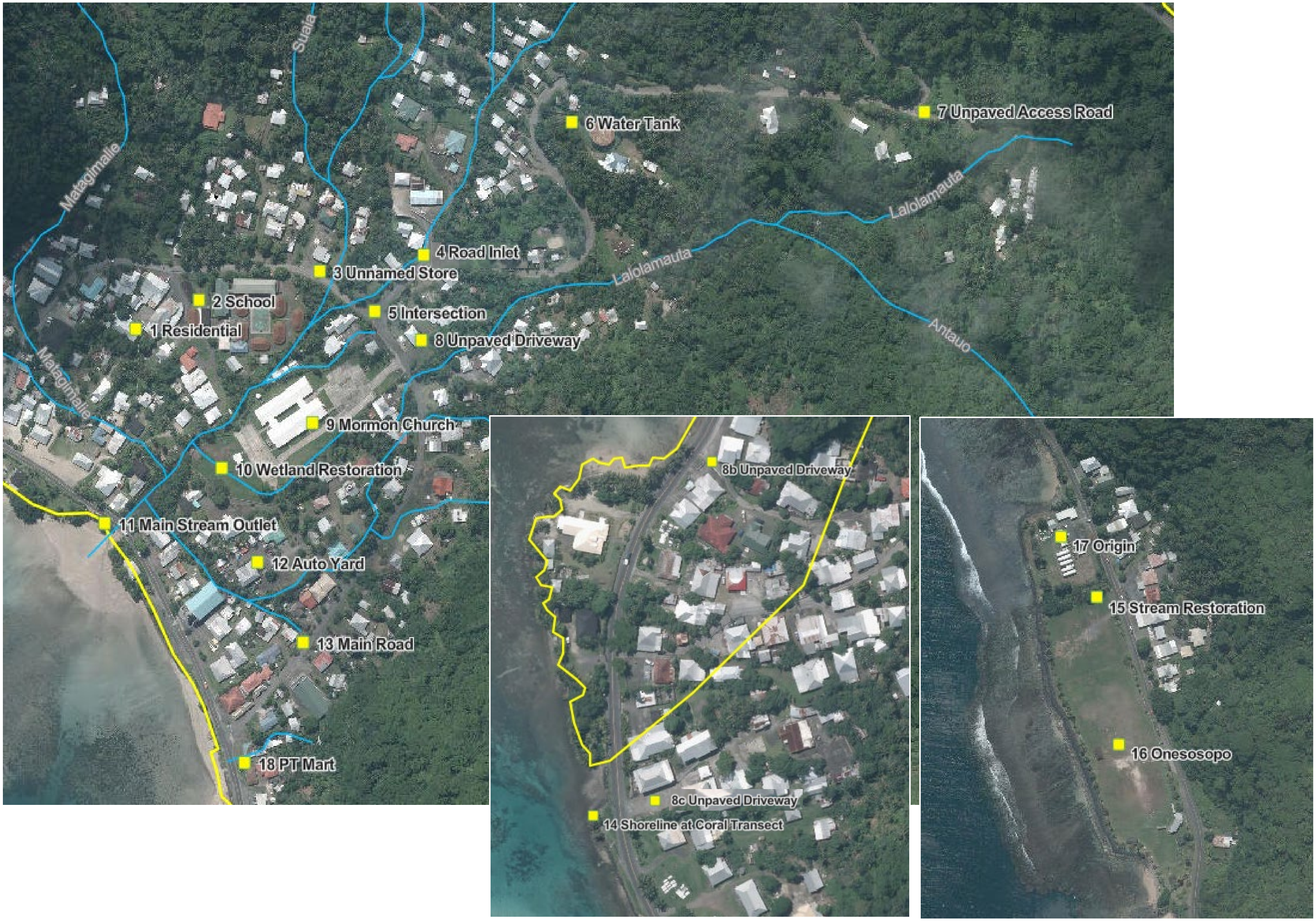


Figure 5. Relative effect of key restoration projects on TSS removal as a proportion of total potential TSS load reduction



Map 2. Potential Restoration Project Sites

GOAL 2: IMPROVE RESILIENCY AND SUSTAINABLE LAND USE

Improve Aua Village's resiliency to climate change through sustainable development initiatives that account for a 50-yr planning horizon.

PROBLEM

Due to a combination of sea level rise and island-wide subsidence, Tutuila is experiencing a rapid increase in relative high water levels. Since the September 2009 earthquake, the number of high water hours observed in the Pago Pago Harbor has dramatically increased and there is no expectation of a future trend reversal (**Figure 6**). Depending on different climate prediction scenarios, Tutuila could experience between 1.5 - 3.5 feet of relative sea level rise in the next 50 years (PIRCA, 2021), resulting in more portions of Aua being at risk of inundation. These predictions also include an increase in the number of annual extreme rainfall days (i.e., days with 1.5 inches of rain or more), which leads to more frequent inland flooding, erosion and sedimentation, and potential landslides.

Aua Village has significant flood hazard exposure across due to both precipitation-driven and coastal flooding. **Map 3** shows the 100-year flood extents, or the extents of flooding that have a 1% chance of occurring in any given year (FEMA, 2006). This is the flooding that would occur due to a storm reflecting high tide, storm surge, and stream flooding from rainfall. It is important to remember that the predicted flood extents are based on historic data and do not account for the impacts of subsidence or rainfall patterns experienced in recent years. Regardless, GIS analysis indicates that 203 buildings are currently located inside the 100-year flood zone, which is equivalent to 49% of all existing buildings in the watershed.

Map 4 shows the predicted extents of mean higher high water (MHHW) over the next 50 years under a high SLR scenario (PIRCA, 2021). The high water levels shown in this map are expected daily for 2035, 2050, 2065, and 2075. GIS analysis indicates that in addition to vulnerable sections of the coastal road, anywhere between 3 and 116 additional buildings are at risk of inundation from SLR alone through 2075 (**Table 1**).

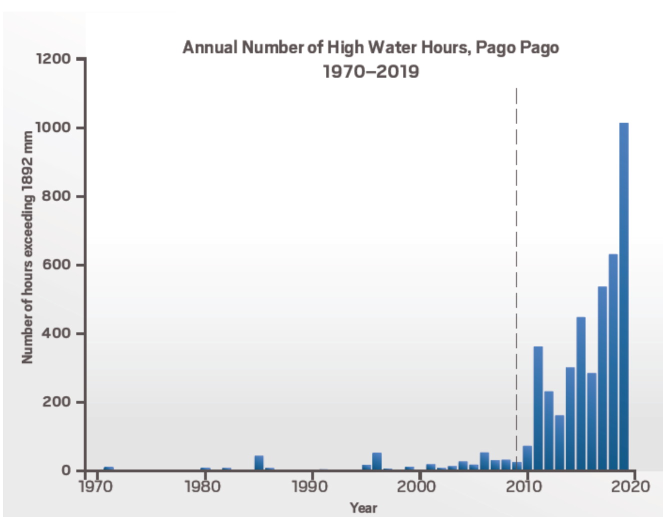


Figure 6.The annual number of high water hours at Pago Pago from 1970-2019. The high water threshold of 1892 mm is defined as the mean higher high water level plus one-third of the difference between that and the mean lower low water level. The dashed line indicates the occurrence of the 2009 earthquake and onset of subsidence (PIRCA, 2021).

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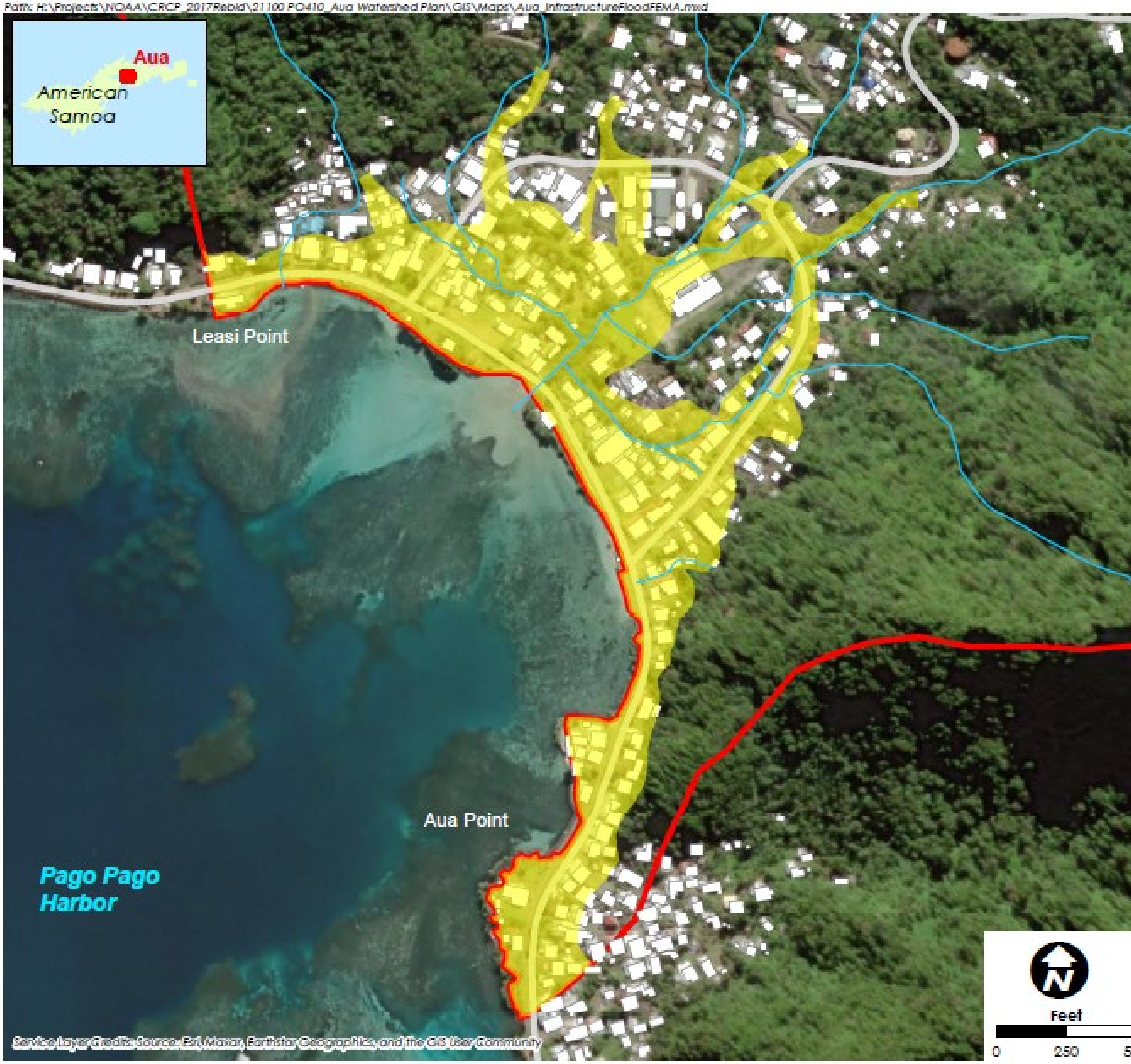

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Date: 7/26/2023
Data Sources: USGS, NOAA, FEMA, Open Street Map, unless otherwise indicated by (HW)

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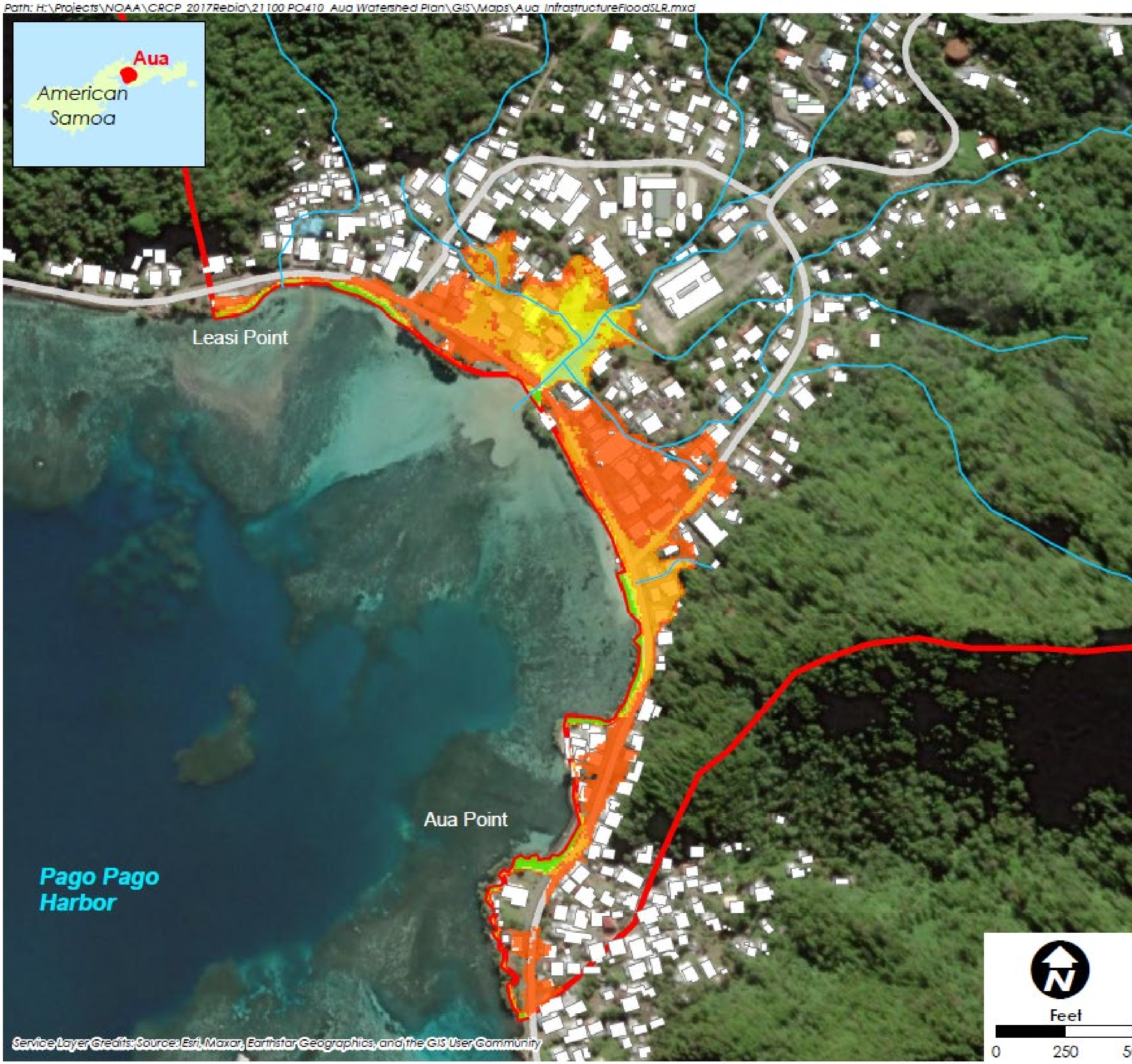
FEMA 100-Year Flood Zones (2006)
Streams (HW 2022)
Buildings (OSM)
Roads (HW)
Watershed (HW 2022)

Map 3
Infrastructure Vulnerable to Flooding - Present Day



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Data Sources: USGS, NOAA, ESRI, Army Corps of Engineers, Open Street Map, unless otherwise indicated by (HW)

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Sea Level Rise in feet above existing MHHW (High SLR Scenario, ACOE)

- 1ft (2035)
- 2ft (2050)
- 3ft (2065)
- 4ft (2075)
- 5ft (2075 + 1ft storm surge)
- Streams (HW 2022)
- Buildings (OSM)
- Roads (HW)
- Watershed (HW 2022)

Map 4
Infrastructure Vulnerable to Flooding - Sea Level Rise

Table 1. Number of existing buildings subject to inundation from SLR.

SLR Above Existing MHHW (ft)	Year	Inundated Buildings	Percent of Buildings in Watershed
1	2035	3	1%
2	2050	4	1%
3	2065	13	3%
4	2075	59	14%
5	2075 + 1' Storm Surge	116	28%

Along with the climate and subsidence related vulnerabilities, land use in Aua has become more densely developed since the 1990's. Urbanization in the Aua watershed is estimated to have increased from 7.2 acres (Kennedy et al., 1986) to over 30 acres today. If this is accurate, it would reflect almost a four-fold increase in watershed impervious cover to approximately 8% of the total watershed area. At this level of imperviousness, it is typical to see higher volumes of stormwater runoff causing localized flooding, increased pollution loads, and a reduction in groundwater recharge. Development patterns in the Village include new home construction or expansions and renovations to existing structures. Some new construction appears to be elevated and some includes the conversion of former foundations to family fales. Due to limitations on available space in the Village, development moving forward is expected to be a combination of redevelopment and infill and new construction moving up into the hillside.

Despite the increase in development activities, the population of Aua has been declining over recent years. As of 2020, the population of the village stood at 1,549 people, as compared to 2,077 people just 10 years prior. It remains to be seen if the population decline trend will reverse in upcoming years.

A lack of community planning for accommodating future development in the Village and to provide safeguards for new or existing structures in high-risk locations. Aua Village was identified in the 2020 Territory of American Samoa Hazard Mitigation Plan as having inland development susceptible to flooding. A lack of zoning, floodplain restrictions, and development standards make it difficult to manage urban growth and maintain important watershed services.

The narrow, unvegetated shorelines highlight the susceptibility of existing utility lines, Rt. 001, and flood-prone buildings are to damage from storm surge and SLR.

The Aua Village boundaries are constrained by the sea and surrounding mountains. Future development will involve infill and redevelopment or expansion up into the hillside.

New home construction/renovation activity occurring adjacent to stream and within the flood hazard zone.

These challenges are exacerbated given that:

- There are no requirements for onsite stormwater management.
- Property boundaries and setbacks are not visibly demarcated.
- Stream/wetland buffer protections do not appear to be consistently enforced (if there are regulatory protections).
- Residential construction frequently includes alterations to the stream corridors in Aua such as clearing, filling in the floodplain, channelization, and dumping.
- Erosion and sediment control is not required for small residential construction.

RECOMMENDED ACTIONS

Potential village-wide opportunities to increase resilience against environmental hazards are listed below. Projects include developing a comprehensive land use plan to limit exposure to flooding, designing park spaces, and establishing a robust infrastructure maintenance program.

Village-Led Actions

2.1 Onesosopo Park BluePrint. This park currently includes a bathroom, several covered shelters, an athletic field, and the construction staging area for the sewer extension project. The shoreline is mostly armored back by a row of palm trees. A redesign plan for the Onesosopo Park should be developed in coordination with DOC-CZM as a model for enhanced community sustainability. This site offers opportunities to improve recreational use, demonstrate green infrastructure and low-impact design techniques, and engage residents. Tree removal, more pavement, and additional structures has characterized recent upgrades at other coastal parks on Tutuila (Faga'alu, Lyons, etc.). Removal of vegetation increases localized temperatures and stormwater runoff, reduces habitat diversity, and adds hard infrastructure within vulnerable coastal zones. A collective vision for sustainable features at Onesosopo Park could result in a more resilient approach to open space management.

For a preliminary concept for what park improvements could look like, including an impervious parking area, rain garden and bioretention, expanded tree cover, and field renovations, see **Appendix A**. A challenge at

Onesosopo Park in used as staging area during 2022 sewer main expansion.

this location will be navigating constraints posed by fill materials consisting of contaminated sediments from the tank farm cleanup.

2.2 Stormwater Infrastructure Maintenance Program. Clogged drainage infrastructure can not only cause localized flooding, but can lead to road damage, public safety concerns, and stream erosion. Residents are the first ones to notice when drainage infrastructure stops working and have the most to gain by ensuring adequate maintenance. The Village should have the equipment and resources needed locally to conduct routine inspection and maintenance of watershed drainage infrastructure. An inventory of drainage infrastructure was completed in 2022 resulting in an assessment of over 70 drainage structures (e.g., culverts, catch basins, drain inlets, and outfalls), see **Appendix B** and **C**. Over 60% of the structures inspected needed attention, due to clogging or other damage (**Table 2**). Structures in need of maintenance or repair are shown in **Map 5** and online.

Table 2. Summary of structures in need of maintenance

Level of Maintenance	Culverts & Outfalls	Inlets & Catch Basins
Routine *Removal of sediment, debris, or vegetation from clogged pipes or inlets or sumps. Mostly can be handled locally.*	I-1 I-4 I-12 I-16* I-39 I-40 I-41 I-44 I-56 I-6	I-9 I-10 I-18 I-19 I-21 I-22 I-27 I-32 I-34 I-35 I-37 I-55 I-60 I-61 I-63 I-64* I-66 I-7 I-71 I-72 I-73
Repair *Moderate to severe damage that requires repair work. DPW action required.*	I-2 I-11 I-28 I-42 I-53 I-58 I-69	I-51* I-57
Replacement *to restore function or improve safety. DPW action.*	I-68* I-70	I-67*

**critical structures for immediate attention*

Map 5. Maintenance map for Aua drainage infrastructure

The Village Mayor and DPW should conduct an initial round of maintenance together, at least for the critical structures listed in Table 2. Lessons learned from this activity can then be applied to the development of a drainage maintenance plan for Aua. The Village should take the lead on coordinating with DPW and facilities managers from the school and the Mormon Church on a plan that will include the following elements:

- A division of responsibility for inspection and maintenance between the Mayor's office, school and church facility managers, and DPW. The Village could be responsible for inspection and routine maintenance with light equipment, whereas DPW would be responsible for more significant repairs and replacement actions.
- A schedule for annual or quarterly inspections and cleanouts, that includes provisions for emergency inspections after storms or maintenance in response to complaints.
- Onsite equipment or machinery required for grate and manhole access, sediment and trash removal, and vegetative maintenance .
- An annual budget for village and DPW maintenance operations.
- An inspection and maintenance log to track activities and identify key structures where chronic issues occur. A rough estimate of the amount of sediment (i.e., # of 5-gallon buckets) removed from structures would be helpful for reporting.
- Proper disposal procedures for accumulated sediment and debris removed from structures (do not dump into streams).
- A reporting procedure for residents to identify maintenance issues to the Mayor and similarly, a process for elevating significant maintenance issues to DPW.

Two clogged drain inlets on Route 006 are causing long-term ponding on the road (I-64, top), erosion, and sediment contributions to road inlets downhill (I-51, middle). A blocked culvert pipe at I-16 causes backup in the stream and contributes to flooding at PT-Mart and Laundry (bottom).

Agency-Led

2.3 Comprehensive Land Use Management Plan. Embark on a facilitated planning initiative to identify the future land use management and development guidelines necessary to reduce the Village's vulnerability to increasing flood hazards. DOC-CZM should contract a planning firm to facilitate development of a community-based plan that identifies: the future hazards (over the next 50 years), zoning criteria, sustainable construction practices, and regulations needed to reduce Village exposure in high risk areas. Land management in Aua is generally overseen by landed families or by the Village Council. It is critical that Village leaders and residents be involved in future land use planning. The process should identify relocation options for susceptible infrastructure, establish methods for renovating homes to reduce risk, and propose financing mechanisms to support redevelopment and retrofits.

2.4 Culvert Replacement. Replace undersized/submerged culverts, where possible. Additional site survey and hydraulic analyses will be required to advance these projects. There are already issues with submerged pipe outlets on the beach, and these drainages will become less functional as sea levels rise. Raising invert elevations to ensure positive drainage at current culvert locations on Route 001 will be challenging, if not infeasible without addressing the existing road location and elevation. Example culverts where removal of accumulated sediment and replacement of pipes with wider options may include:

- Site #15, Stream channel near Onesosopo Park
- Site #18, Stream channel near PT Mart and Laundromat

2.5 New Building and Renovation Resilient Design. Develop and distribute residential guidance material with information on building techniques that will reduce potential hazard exposure due to increased rainfall, coastal flooding, sea level rise, and subsidence. Once distributed, it is up to residents to apply these practices to home construction or renovation projects, when feasible. It is up to agencies and village leaders to encourage practices that reduce risk.

2.6 Landslide Risk Study. Consider conducting a study to evaluate landslide potential at steep upland locations in the Aua Watershed, especially along Route 006. A landslide risk evaluation should be used to inform decisions on where to focus or avoid upland development activities.

2.7 Origin Gas Tank Storage Safety Compliance. AS-EPA should ensure that operations at the gas tank storage facility complies with required safety provisions, particularly given the location in a residential area. Identify opportunities to increase safeguards at this site, which is vulnerable to coastal storms.

Culvert near Origin Gas that may be undersized.

Homes with an elevated first floor will be more resilient to flooding.

Origin gas storage tank facility sits next to the shoreline and across the street from residences.

GOAL 3: RESTORE AUA'S WETLANDS, STREAMS, AND SHORELINES

Restore Aua's natural watershed function by enhancing 25% of remaining wetland, stream, and shoreline habitats.

PROBLEM

Wetlands provide natural flood storage, create habitat diversity, and act as filters for pollutants and trash. As recently as 30 years ago, the Aua watershed reportedly contained over 9 acres of wetlands, including roughly 7 acres of freshwater wetlands along the stream corridor and 2 acres of saltwater mangroves (USDA, 1995). Based on village estimates, it is possible that the central wetland has experienced a 65% reduction in size from historic extents (**Figure 7**). The central wetland is estimated to be about 0.8 acres using present-day satellite imagery (Google Earth, 2016). The wetland is heavily impacted by sediment and fill, which erode into the wetland from nearly all upland portions of the watershed. The loss of Aua's central wetland is likely one of the major factors contributing to the impaired water quality at the outlet of Lalolamauta stream. As a result, the wetland has been characterized as having a low functional value in terms of flood control and storm protection; wildlife habitat; sediment trapping and pollutant abatement; or groundwater recharge (USDA, 1995).

Figure 7. Current (yellow) and an approximated past extent (red) of central wetland.

Streams and associated floodplains in Aua have been severely altered by human activity (i.e., channelized, encroached, rerouted around buildings). It was estimated 30 years ago that<1/4 of Aua's streams remained natural with unhardened banks (USDA, 1995). Downstream channel widths are generally narrower than in the headwaters, which is the opposite of natural conditions. Encroachment into or the complete loss of vegetated stream buffers within the central Village has also occurred, contributing to changes in stream habitat structures, nutrient processing dynamics, and bank stability. In a few instances, elevated culverts create barriers to fish, eel, shrimp, and other aquatic species passage. These metrics suggest that Aua has lost some of the flood storage and habitat services provided by unaltered systems, exacerbating the overbank flooding, channel erosion, and biodiversity issues. Aua is rated low to medium for fish and wildlife according to a 2021 Coastal Resilience Assessment (Dobson et al., 2021).

Remaining mangrove wetland in center of Village.

Likewise, the natural shoreline of Aua has been significantly altered through the installation of engineered shoreline protection in the form of stone pile slopes. Approximately 75% of the Aua's 4,000-foot shoreline has been converted to hard engineered slopes. Loss of the natural shoreline represents not only a loss of intertidal and nearshore habitats for marine and terrestrial species but can also contribute to the forfeiture of the Village's recreational beach space. Hard engineered slopes deflect wave energy downward and outward to other shoreline areas exacerbating beach loss and erosion of remaining natural shorelines.

Aua's former mayor, Muaiavaona Fofoga Pila, stands over an armored section of stream channel.

It is also becoming a standard practice on Tutuila to remove coastal trees during shoreline reinforcement projects due to the misguided belief that tree roots will destabilize engineered structures. The US Army Corps of Engineers identifies trees as a tool for shoreline protection, recognizing that root systems hold soils in place. Furthermore, the Corps recommends in many situations the integration of vegetation into hard structure solutions (USACE, 2022). Coastal trees also provide shade and heat protection, shoreline roosts for birds and bats, and that special Pacific island aesthetic.

Most of the Aua shoreline is armored with stone.

An inventory of armored and non-armored shoreline in Aua was documented during the October 2022 field assessment and is shown in **Map 6**.

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Horsley Witten Group
Sustainable Environmental Solutions

Date: 7/26/2023
Data Sources: USGS, NOAA, ESRI, American Samoa Power Authority, unless otherwise indicated by (HW)

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Streams (HW 2022)

Subwatersheds (HW 2022)

Watershed (HW 2022)

Shoreline

Armored

Non-Armored

Map 6
Armored Shoreline Areas

Recommended actions

Several potential site-specific and village-wide opportunities for wetland restoration, stream restoration and shoreline stabilization have been identified (see **Map 2**). **Appendix A** has initial concept designs for three habitat restoration projects, including wetland restoration and two shoreline stabilization projects.

Village-Led

3.1 Riparian Buffer Restoration. Remove trash and debris and replant vegetation within 25 ft of the edge of stream. A comprehensive stream assessment was not conducted as part of the watershed planning process; however, a more thorough inventory can be completed by residents to identify locations of impacted stream buffers and tackle small cleanup up and replanting projects. There are several highly visible and accessible locations to focus volunteer efforts:

- At the two stream channel crossings north of the school on Route 6 (near Sites #3 and #5),
- In the channel behind the laundry mat near the school (near Site #1)
- Behind the auto yard (near Site #12)
- West of the stream confluence behind the Mormon Church (near Site#9).

Locations where more extensive revegetation, bank stabilization, or floodplain enhancement opportunities exist can be supported by DWRM and other agencies.

Opportunities exist for residents to clean up trash and debris along stream banks in the Village and to replant the riparian buffer with native plants.

3.2 Participation in Mangrove and Shoreline Restoration Activities. Aua residents should be involved in the design and implementation of habitat restoration projects sponsored by agencies. At a minimum, Village chiefs should approve project designs, offer suggestions for engaging residents, and lend logistical support to implementation teams.

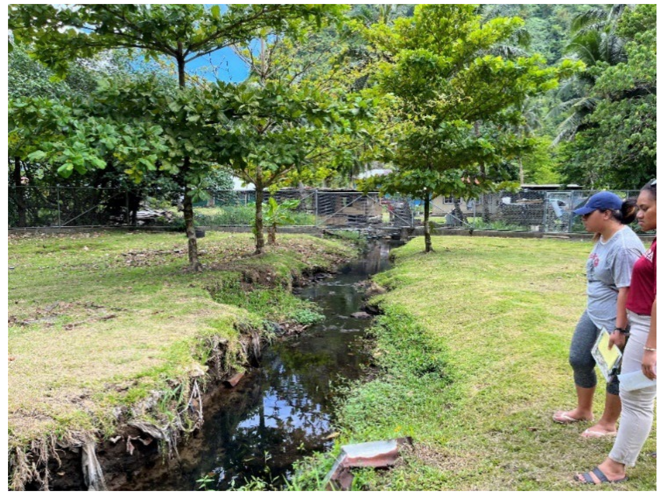
Armored streambank (left) and central wetland (right) along Lalolamauta Stream. This wetland has already been identified as a site for mangrove planting by the Governor's Office.

Agency-Led

3.3 Central Wetland Restoration. Space is at a premium, but there are Village-wide benefits to be achieved from expanded wetland capacity. There is one site that has been identified for wetland restoration—the grassy area south of the Mormon Church. This area was reported to have been part of the central wetland that was later filled. Less than half an acre remains free of structures between the central wetland and the Mormon Church—this spot could be one of the only feasible areas left to expand wetland capacity for flood storage, pollutant removal, and expanded biodiversity.

Expansion of the central wetland might involve excavating on either side of the stream channel is. The restored wetland areas would provide a total of 9,100 square feet of wetland habitat. These areas would be filled with native wetland plantings such as mangroves. Within the restoration area, Lalolamauta Stream would become a deeper sinuous baseflow channel. Floodable areas would be excavated next to the stream to provide flood storage during high flow events. A concept plan is provided in **Appendix A**.

If there is agreement from Village leaders and the family and church responsible for the land to advance this project, additional information will need to be gathered on physical hydrologic and hydraulic conditions up and downstream of this location, subsurface site conditions, site topographic survey and wetland delineation prior to advanced design. Modeling of predicted storage capacity and flows will be completed to quantify flood benefits. Baseline biological, water quality, and flow monitoring should be conducted to enable a robust evaluation of post-construction performance.



Area behind the Mormon Church for proposed wetland expansion.

3.4 Living Shoreline Stabilization. In locations identified as feasible for living shoreline applications or a hybrid approach using both "soft" and "hard" techniques, eroded shorelines can be repaired through a combination of vegetation, coir logs, and half-wall stone toe protection. A study should be conducted island-wide to determine the wave energy conditions along the shoreline to verify locations where more natural vegetated shoreline stabilization methods are sufficient, or where hybrid approaches are warranted in lieu of the traditional hard armoring.

Possible locations in Aua include (see **Appendix A**):

- Site #11, shoreline at Lalolamauta stream outlet
- Site #14, shoreline near coral transect marker

Section of shoreline near coral transect marker where a hybrid stabilization approach might be demonstrated.

GOAL 4: PROMOTE WATERSHED EDUCATION & ENGAGEMENT

Promote watershed education and community engagement in management efforts by conducting 5 public activities each year.

PROBLEM

There are no formal watershed education and outreach efforts currently underway in the Aua watershed, but the Aua Consolidated School is the home of the Rainmakers and Aua makes an ideal setting for watershed stewardship given its high visibility and traditional level of community involvement. In a listening session with Village residents and chiefs, community ownership over the watershed management plan was emphasized and capacity building was identified as a key element of successful implementation.

Educational materials and outreach programs related to marine and terrestrial ecosystems are already available through the AS Coral Reef Advisory Group, the American Samoa Community College Forest Extension, and other agencies. Dry compost piggery programs, erosion and sediment control trainings, and stormwater workshops have also been promoted through AS-EPA in the past. Regionally, there is a growing awareness of the benefits and technical guidance required for successful living shoreline approaches. There is also a robust science curriculum for various grade levels at the Aua Consolidated School. These existing resources can be leveraged to expand on watershed stewardship messaging and communication mechanisms to involve villagers in planning and restoration efforts.

Both Rainmakers are ideal candidates for promoting watershed awareness and participation in restoration efforts.

Recommended Actions

Village-wide opportunities exist to promote watershed education for students, residents, businesses, and the construction industry. Activities include the development of watershed lesson plans for K-8 science curricula, green infrastructure installation and maintenance, stream cleanups and riparian planting events, detection of non-stormwater discharges, and general watershed training for commercial businesses and construction professionals on pollution control.

Village-Led

Many opportunities for Aua residents and businesses to engage in watershed stewardship activities were identified previously (see Goals #1, 2, &3):

1.1 Volunteer trash cleanups.

1.2 Pollution prevention and debris removal at hotspot commercial sites.

1.3 Reporting of erosion and sedimentation issues and clogged drainage infrastructure.

1.4 Inventory of remaining non-stormwater discharges to streams or storm drains.

1.5 Participation in green stormwater infrastructure demonstration projects (planting).

2.1 Participation in the community design charette for Onesosopo Park improvements.

2.2 Conduct routine maintenance on drainage infrastructure.

2.3 Participate in the comprehensive land use management plan.

2.4 Apply resilient and sustainable design practices during home construction and renovation projects.

3.1 Restore riparian buffers.

3.2 Participate in mangrove and wetland planting projects.

3.5 Participate in shoreline planting projects.

4.1 Annual Reporting of Watershed Accomplishments. Designate a watershed champion (either the mayor, a rotating member of the Village Council, or community volunteers) to report to the Council and public on the annual achievements in watershed management. This individual would be able to inform the Village Council on the implementation of green infrastructure projects, community outreach events, the number of direct drains connected to the sewer, the success of the drainage infrastructure inspection and maintenance program, etc. Part of this reporting should include a tracking of the past year's flooding issues, status of monitoring (soil contamination, beach and stream water quality, and coral health), and any anticipated development/ renovation activities that might impact watershed conditions. These annual updates could be reported in the local newspaper and used to increase watershed awareness island wide. At the end of 5 years, these reports could be used to evaluate the implementation progress of the watershed plan.

Problem areas and recommended actions were identified by Village chiefs and residents.

Agency-Led

4.2 Develop Watershed Science K-8 Lesson Plans. Most science, technology, engineering, and math (STEM) curriculums include some lessons on the water cycle and climate change, but there may be an opportunity to expand watershed science lesson plans to cover additional grade-appropriate topics, such as the impacts of stormwater runoff; land-based sources of pollution and management solutions; careers in green infrastructure; and hazard mitigation and community resiliency. Department of Education, the Principal, or teachers at the Aua Consolidated School can reach out to on-island agencies and watershed professionals for help in developing lesson plans, adapting educational materials to local conditions, orchestrating field trips, and offering data collection activities that can inspire student science projects. Agencies like the Department of Marine and Wildlife Resource (DMWR), the Coral Reef Advisory Group (CRAG), and the American Samoa Community College Forestry Extension (ASCC-FE) could be helpful. Specific class activities might include:

- Delineating drainage areas in school yard with street chalk during dry weather and confirming flow path of runoff when it rains. Students can calculate the size of drainage catchments and runoff volumes for 1 inch of rainfall.
- Measuring air and stormwater runoff temperatures generated by paved surfaces.
- Installing a CoCoRaHs rain gauge and assigning students or classrooms to record, report, and analysis data using the program's online platform.
- Following the school's (or home) rainwater discharge to the ocean and identify potential sources of pollution and impacts on biological and human communities. Students might collect water samples at key locations and submit them to AS-EPA for lab analysis or use field test kits for measuring basic water quality parameters.
- Inviting guest speakers from DMWR, AS-EPA, DCO-CZM, ASPA, and DPW) to discuss watershed ecology, drinking and wastewater management, pollution control regulations, drainage infrastructure, or mitigating climate change.
- If the school wanted to pursue any of the proposed stormwater retrofits, students could participate in the design development process, installation, maintenance, and monitoring.
- Newly constructed GSI demonstration projects could be visited by classes, particularly during or after rainstorms, to see how stormwater infrastructure operates in real time.

Non-STEM lesson plans could also be explored to engage history, arts and literature, and civics classes with rainwater art projects, research on ancestral water management practices, regional watershed and natural resource governance, and watershed-themed poetry and creative writing. Once lesson plans are developed and used, they could be shared with other schools on Tutuila, and the GSI demonstration projects installed in Aua could be used as field trip destinations.

4.3 Raise Watershed Awareness with Signage. At highly visible locations or at demonstration project sites, consider installing permanent or temporary interpretive signage to explain watershed conditions and the benefit of management actions. Signage does not need to be intrusive given today's access to social media and online websites from phones. QR codes can be used to minimize the amount of information needed on signage. Possible locations include:

- Top of Olo Ridge or Route 006 watershed divide
- Aua Coral transect marker on Route 001
- The Aua Consolidated School
- Restoration projects at the Mormon Church
- Onesosopo Park
- Watershed map plaque at the top of Matafao or other NPS trails (outside of Aua)

4.4 Watershed Training. Tours and training sessions for government and Village leaders, agencies, engineers, landscape professionals, and builders can be designed around demonstration projects, particularly during construction and maintenance. After supporting the construction of GSI, partner agencies can use the GSI practice and watershed planning process developed in Aua as an example for other watersheds on Tutuila. TNC has already received funding from the National Fish and Wildlife Foundation to support agency training associated with the implementation of GSI in Aua.

Educational signage at the Community College describing a rain garden installation.

AS-EPA and DMWR participate in a training workshop.

IMPLEMENTATION STRATEGY

This management plan offers a variety of potential actions that can be taken to improve watershed health and community resilience, but it is not expected that all of these actions will be pursued or that they will remain priorities over time. To help achieve watershed management goals, the Village and partner agencies will need to identify an individual or establish a committee to coordinate management activities, secure funds, leverage partnerships, and report progress to residents.

PRIORITIZATION

A ranking matrix of key projects and recommended actions was developed to help prioritize actions for implementation. Each action was assigned a High, Medium, or Low classification for the following ranking factors:

- **Flood Reduction (L=1, M=2, H=3 pts)**: the impact of a project on reducing coastal and/or rain-based flooding.
- **Pollutant Removal (L=1, M=5, H=9 pts)**: the ability of a project to capture land-based sources of pollution. For structural projects, this estimate is based on load reductions from the WTM. For non-structural projects, this was a subjective assessment.
- **Co-Benefits (L=1, M=2, H=3 pts)**: the degree to which a project may provide other benefits such as shade, biodiversity, recreation, or safety.
- **Feasibility (L=1, M=2, H=3 pts)**: the extent to which a project or activity is easy to implement or construct, maintenance burden, and site ownership.
- **Visibility/Education (L=1, M=2, H=3 pts)**: the potential for a project to be seen by the public, used as a demonstration site, or provide watershed education.
- **Cost (L=3, M=2, H=1 pts)**: the relative expense of a project to implement and maintain.

Categories were weighted equally (3 points each), except for Pollutant Removal, which was given more weight (9 points) because the watershed plan was sponsored by NOAA CRCP specifically to reduce land-based sources of pollution on the coral reef. A total score was calculated for each activity for a maximum of 24 points. Each activity was then ranked sequentially based on its total score, with the highest rank assigned to the activity with the highest score. Projects with the same score were assigned the same rank. The top ranked activities are considered the highest priorities for implementation and are keystone of the implementation strategy. Tier II and III projects are also incorporated into the strategy but are pushed out in the schedule or allocated less funding. **Table 3** shows the resulting ranking matrix.

IMPLEMENTATION SCHEDULE & BUDGET

Table 4 outlines an initial strategy for watershed managers to consider. implementation over the next few years, including a planning level cost estimate and identification of potential lead agent(s).

Table 3. Project Prioritization Matrix

Project (Site #, where applicable)		Flood Reduction *L 1, M 2, H 3*	Pollutant Removal *L 1, M 5, H 9*	Co Benefits *L 1, M 2, H 3*	Feasibility *L 1, M 2, H 3*	Visibility/ Education *L 1, M 2, H 3*	Cost *L 3, M 2, H 1*	Overall Score *(6 24)*	Rank	Priority
20	Village-wide Trash Cleanup	L	H	H	H	H	L	22	1	
2	Aua Consolidated School K-8 Retrofits/Urban Tree Canopy	M	H	H	M	H	M	21	2	
9	Mormon Church Parking Retrofit	H	H	M	M	H	M	21	2	
16	Onesosopo Park Construction Site ESC & Park Masterplan	L	H	H	H	H	M	21	2	
15	Stream Restoration/culvert @ Onesosopo	H	H	H	M	H	H	21	2	
10	Central Wetland Restoration	H	H	H	L	H	H	20	3	
	Village Comp Land Use Management Plan	H	M	H	H	H	L	20	3	Tier 1
	Village-wide Wastewater & Graywater Management	L	H	H	H	H	H	20	3	
	Village-wide Infrastructure Maintenance Plan	H	M	H	H	H	L	20	3	
1	Paved Courtyard retrofit	H	H	M	M	L	M	19	4	
12	Auto Yard Hotspot Pollution Prevention	L	H	H	M	L	L	19	4	
6	Water Tank Stabilization and Revegetation	L	H	M	H	L	M	18	5	
8	Unpaved Road Maintenance	L	H	L	H	L	L	18	5	
18	PT Mart and Laundromat Stream Restoration & Culvert Replacement	H	M	H	M	M	H	16	7	
13	Route 006 GSI Retrofit	M	M	M	M	M	M	15	8	
11	Lalolamauta Outlet Retrofit & Living Shoreline	M	M	H	L	H	H	15	8	
3	Unnamed Store GSI Retrofit	M	M	M	M	M	M	15	8	Tier 2
	Village-wide New Building and Renovation Resilient Design Guide	H	L	H	H	H	M	15	8	
7	Unpaved Access Road Unpaved Road Maintenance	L	M	L	H	L	L	14	9	
	Watershed K-8 lesson plans	L	L	H	M	H	L	13	10	
	Watershed Training	L	L	M	M	H	L	12	11	
17	Origin Gas Storage Safety Compliance	L	L	H	H	L	L	12	11	
	Wetland Delineation	M	L	L	H	L	L	11	12	
5	Route 006 (Intersection) Retrofit	M	L	M	M	M	M	11	12	Tier 3
	Landslide Risk Study	L	L	H	M	L	L	11	12	
14	Coral Transect Shoreline Stabilization	L	L	H	M	H	H	11	12	
	Shoreline Hydrodynamic Study	L	L	H	M	L	M	10	13	

Table 4. Implementation Strategy & 5-YR Budget

Action	YR 1 2	YR 3 4	YR 5+	Lead
Continue to reduce land-based sources of sediment, nutrients, and/or bacteria by implementing 5 priority restoration projects.				
1.1 Trash Cleanups	At least two priority sites/year $2,500	At least two priority sites/year $2,500	At least two priority sites/year $2,500	Village
1.2 Pollution Prevention Plan	PPP development at auto yard $2,500 AS-EPA junk removal program $2,500	Implement PPP $10,000 AS-EPA junk removal program $2,500	Update PPP $2,500 AS-EPA junk removal program $2,500	AS-EPA; local businesses, EPA Region 9
1.4 Eliminate remaining non-stormwater discharges into stream or storm drain	Inventory & planning $100,000	75% connected $500,000	100% connected $300,000	Village Mayor; ASPA, NOAA, EPA, DOI
1.3 & 1.5 Construction of stormwater green infrastructure and unpaved road/driveway projects	Engineering and permitting for one priority project $50,000 Construction $200,000	Secure funding for 2 years, engineering and permitting $75,000 Construction $355,000 Maintenance $5,000	Engineering and permitting $100,000 Construction $400,000 Maintenance $10,000	Site Manager; DPW; CRAG; NOAA; DMWR
1.6 Ensure proper temporary ESC for public projects	Inspection and maintenance during water system upgrades $10,000	General inspection and repairs $5,000	General inspection and repairs $5,000	Village, AS-EPA, ASPA
1.7 Continued water quality monitoring program	$75,000	$75,000	$75,000	AS-EPA, CRAG
Subtotal	**$442,500**	**$1,030,000**	**$897,500**	***Goal 1 Total:* $2,37,000**
Improve Aua Village's resiliency to climate change through sustainable development initiatives that account for a 50-yr planning horizon.				
2.1 Onesosopo Park Blueprint	Community-led design plan in coordination with ASPA's closeout of staging area $50,000	Advanced design and fund raising $100,000	Construction $1.5M	Village and CZM, NFWF
2.2 Drainage infrastructure maintenance	Initial maintenance Plan/program development $15,000	Annual maintenance $15,000	Annual maintenance $20,000	Village Mayor and DPW
2.3 Comprehensive land use management plan	--	RFP and hire consultant $5,000	Plan development and adoption $250,000	CZM, DPW

Action	YR 1 2	YR 3 4	YR 5+	Lead
2.4 Culvert replacement	--	Study, design and permitting, baseline monitoring $250,000	Construction and monitoring $400,000	DPW, ASDOT
2.5 New construction and renovation designs	--	Guidance manual development $100,000	--	CRAG, DPW
2.6 Landslide risk study	Stabilize at water tank $50,000	--	Landslide study $600,000	ASPA
2.7 Origin gas safety check	$5,000	--	--	AS-EPA, Origin
Subtotal	***$120,000***	***$220,000***	***$2,370,000***	***Goal 2 Total:* $2,710,000**
Restore Aua's natural watershed function by enhancing 25% of remaining wetland, stream, and shoreline habitats.				
3.1- 3.2 Restoration support for volunteer participation in habitat planting projects	Planting $5,000	Planting $10,000	Planting $15,000	Village, DMWR, ASCC-FE, CRAG, NOAA
3.3 Wetland restoration	Surveys, design, and funding $75,000	Permitting and construction $450,000	Education, and Monitoring $125,000	ASCC-FE, CZM, DMWR, GBCO
3.4 Living shorelines	Conduct hydrodynamic study (island-wide) $250,000	Design, permitting, installation of at least one project $300,000	Demonstration education, and monitoring $50,000	DMWR, ASCC-FE, NOAA, NFWF
Subtotal	***$330,000***	***$1,010,000***	***$590,000***	***Goal 3 Total: $1,930,000***
Promote watershed education and community engagement in management efforts by conducting 5 public activities each year.				
4.1 Tracking and reporting of watershed accomplishments	$10,000	$10,000	$10,000	Village, CRAG, watershed or committee
4.2 Watershed-based lesson plans for K-8 students	Initial reaching out to school $5,000	2-4 lessons or field trip activities $15,000	2-4 lessons or field trip activities $20,000	School, Department of Education, CRAG
4.3 Signage	Identify locations $2,500	Design & install 1-2 $25,000	Desing and install additional $25,000	CRAG
4.4 Tours and Training	Training on maintenance $25,000	Conduct at first GSI install $25,000	Annual training $25,000	TNC, CRAG, DMWR, NOAA
Subtotal	***$42,500***	***$75,000***	***$80,000***	***Goal 4 Total: $197,500***
GRAND TOTAL	***$935,000 in Year 2***	***$2,335,000 in Year 4***	***$3,937,500 in Year 5+***	***TOTAL $7,207,500***

ASCC-FE – American Samoa Community College Forestry Extension
AS-EPA – American Samoa Environmental Protection Agency
ASPA – American Samoa Power Authority
CRAG – Coral Reef Advisory Group
CZM – Coastal Zone Management
DMWR – Department of Marine and Wildlife Resources
DPW – Department of Public Works
GBCO – Governor's Biodiversity and Conservation Office
NFWF – National Fish and Wildlife Foundation
NOAA – National Oceanic and Atmospheric Administration
TNC – The Nature Conservancy

Planning Projects

Implementing a planning project, like the Aua Comprehensive Land Use Management Plan should generally include the following activities:

Year 1: Getting Started

1. Gain approval from Aua Village Council.
2. Develop general approach and acquire project funding.
3. Hire a planner to facilitate the process.
4. Form a small working group to guide the process.

Year 2: Communications and Engagement

5. Compile and review existing information pertinent to the human and natural conditions in the Village, including population demographics, infrastructure and services, transportation plans, natural resources, coastal hazard mitigation, and economic drivers.
6. Generate maps with buildings and roads, utilities, (water, sewer, and storm drain), familial land boundaries, resource and hazards.
7. Establish communication platform to share information with residents and other stakeholders.
8. Facilitate several listening sessions to identify formative issues and visions for the Village.
9. Conduct a series of interviews and planning sessions with working group and Village Council
10. Identify goals for the plan and key policy, programs, and actions to achieve those goals.
11. Host public design charettes with residents to identify how the Village will look in the future through the lens of the plan goals.

Year 3: Putting the Vision to Paper

12. Develop draft Plan using the input from the working group and Village Council.
13. Share the draft plan with residents and agencies and revise based on comments.
14. Adopt the final plan. Roll it out- celebrate completion.

Year 4: Follow the Plan

15. Use the plan to inform Village land use decisions and to support policy and regulatory changes at the territorial level.

Structural Projects

As an example, structural engineering projects, such as a stormwater retrofit or the wetland restoration project may generally include the following tasks:

Year 1: Getting Started

1. Site selection with approval from Aua Village Council and site manager/family
2. Advance to 25% design with input from Council, stakeholders, and permitting authorities.
3. Develop cost estimate and acquire project funding, to hire Designer. Break costs out into design, permitting, construction, and maintenance.

Design Phase: 3-6 months (depends)

4. Conduct topographic survey, conduct hydrologic and hydraulic models, evaluate soils, conduct baseline monitoring (biota, water quality, flow parameters) etc. in proposed restoration area.
5. Develop permit-level design plans for wetland restoration. Present plans to Aua Village Council and gain approval.

Permitting Phase: 3- 6 months (depends)

6. Submit plans for permitting. NEPA permits may be required for federally funded projects.
7. Revise plans (if needed)
8. Upon permitting approval, advance plans to construction-level design. Present plans to Aua Village Council for final approval.

Construction: 3 months (depends)

9. Prepare bid package and put project out to bid. Do not necessarily go with the lowest bid, should balance price with qualifications.
10. Contractor selection and agreement on construction schedule, inspections and oversight, staging, planting, as-builts, and demobilization.
11. Host event to celebrate the beginning of construction for Aua residents.
12. Supervise construction process.
13. Once wetland and stream finish grade are achieved, invite residents to help plant native vegetation. Consult with ASCC-FE for plant species suggestions.

Maintenance and Monitoring: forever

14. Ensure plant establishment and function.
15. Conduct post-construction monitoring.
16. Conduct trainings and host public events.

Monitoring and Evaluation Plan

Tracking implementation progress can be challenging. A designated watershed coordinator (or committee) will likely be responsible for evaluating progress annually or every other year. If agency-led, consider developing a consolidated watershed implementation progress report for all the watersheds in American Samoa where watershed plans have been developed or are currently underway (Faga'alu, Vatia, Amanave, and Ofu). This could become part of the general reporting in AS-EPA's biannual Integrated Waters Report.

Table 5 summarizes recommended tracking metrics for each of the recommended goals/actions and provides a relative estimate of the level of effort required to track. Metrics in bold are the target metrics used to evaluate progress of plan implementation to achieve goals.

Table 5. Suggested implementation progress monitoring metrics

Watershed Goal	Watershed Action	Metric	Tracking Level of Effort
Continue to reduce land-based sources of sediment, nutrients, and/or bacteria by implementing 5 priority restoration projects. Target Metric: # of interventions implemented and improvement in water quality	1.1 Trash Cleanups	• **# cleanup events held/year** • # bags of trash removed	**Low**. Document date, location, attendance, and amount collected at each event. Post to social media. If funded through a grant, will need to include in final report to funder.
	1.2 Pollution Prevention Plan	• **# businesses with PPP plans developed** • Implementation of plans	**Low**. Identify # of businesses in advance (auto yard, laundry services), large construction projects. Check with business on status for reporting.
	1.4 Eliminate remaining non-stormwater discharges	• # direct pipes inventoried • # (or %) connected to sewer • Average $ per house	**Medium.** Mayor to keep map of structures inventoried (check sinks, showers, laundry, outhouse drains) and list of families and businesses eligible for ASPA hookup subsidy program. Date of hookup to sewer should be documented by ASPA or contractor. Include # in annual report. update map with completed projects.
	1.3 & 1.5 Construction of stormwater green infrastructure and unpaved road/driveway projects	• Completed plans • **# practices installed** • # volunteers and trainings • Maintenance plan • Volume and load reduction estimates • Area of impervious cover managed or removed • Length of unpaved road/driveway stabilized	**High**. Should be tracked annually by watershed coordinator in a running spreadsheet by practice. Area managed calculations and load estimates should be included in permit materials by engineer or applicant. Keep copy of plans on file or posted to watershed website.
	1.6 Ensure proper ESC for public construction projects	• **# of inspections** • Time required to implement remedial actions • # of complaints from residents	**High**. Agency should maintain record of inspection reports, dates, remedial actions taken, etc.
	1.7 WQ Monitoring	• # of stations, samples, parameters tested • Positive trends and **# of exceedances** • Annual reporting completed	**High.** Agency to collect samples, run analyses, and maintain data records. Could be reported as part of Integrated Waters Report.

Watershed Goal	Watershed Action	Metric	Tracking Level of Effort
Improve Aua Village's resiliency to climate change through sustainable development initiatives that account for a 50-yr planning horizon. Target Metric: Completed plan through 2075	2.1 Onesosopo Park BluePrint	• # of public design events held • # of individuals attending/providing input • Completion of plans and permitting • Construction progress • # of GSI practices, volume managed, # trees planted, etc.	**Low**. This will be relatively easy to document through the planning stage. Funders will want reporting of progress and metrics. Put this on the consultants hired to facilitate the process or conduct design work as part of their contracts. Keep copy of plans on file or posted to watershed website.
	2.2 Drainage infrastructure maintenance	• % of structures inspected/ maintained each year • Amount of accumulated sediment removed each year • Equipment purchased • Plan adoption and MOA between DPW and Village • **Identify infrastructure to be under additional strain in next 5, 20, and 50 years.**	**High**. No one does this. It's hard to track. The mayor and DPW to develop an inspection and maintenance log as part of the program development. It is possible to utilize online apps to record activities. You could start with the drainage inventory excel file, GIS layer. or Field Maps App.
	2.3 Comprehensive land use management plan	• # of public events held • # of individuals attending/providing input • Completion of plans and adoption • **Confirmation of 50-yr planning horizon and predicted hazards**	**Low**. This will be relatively easy to document through the planning stage. Funders will want reporting of progress and metrics. Put this on the consultants hired to facilitate the process as part of their contracts. Keep copy of report on file or posted to watershed website.
	2.4 Culvert replacement	• Hydraulic studies completed • Installations completed • # of backup days (pre and post) • # maintenance interventions required (pre and post)	**Low**. This will be relatively easy to document. Funders will want reporting of progress and metrics. Put this on the consultants hired to facilitate the process as part of their contracts. Keep copy of plans on file or posted to watershed website.
	2.5 New construction and renovation designs	• Completed guide • # attendees at public and agency workshop and training • # of copies distributed • **Design for 50-yr planning horizon**	**Low**. This will be relatively easy to document. Funders will want reporting of progress and metrics. Put this on the consultants hired to facilitate the process as part of their contracts. Keep copy of report on file or posted to watershed website.
	2.6 Landslide risk study	• Completed	**Low**. This will be easy to document if completed. Keep a copy of report on file or posted to watershed website.
	2.7 Confirm Origin gas tank storage safety compliance	• Completed	**Low**. This will be easy to document if completed.

Watershed Goal	Watershed Action	Metric	Tracking Level of Effort
Restore Aua's natural watershed function by enhancing 25% of remaining wetland, stream, and shoreline habitats. Target Metric: % of remaining habitat area improved	3.1- 3.2 Restoration support for volunteer engagement and participation in riparian and other habitat planting projects	• # of volunteer events held • # of participants • **Length of impacted stream buffer** • **Total area restored, length of riparian or shoreline** • # plants	**High.** DMWR will have to establish the footprint of remaining stream, wetland, and shoreline habitat. The watershed coordinator will have to keep track of activities that are completed. Some of the metrics can be put on the designers to calculate.
	3.3 Wetland restoration	• Plans submittals and approvals • **Total wetland area in Aua** • **# acres restored** • Volume, flow, and pollutant reductions • # of volunteers • # training workshops	
	3.4 Living shorelines	• #study completed • **Length of shoreline where living shoreline appropriate** • **Length of living shoreline installed here (and by others elsewhere)** • # trees planted • Annual erosion rate • # signs installed, outreach, or training events held	**Medium.** Mostly tracked by consultants hired to identify segments of remaining un-armored shoreline that is suitable, and design stabilization projects. DMWR will need to continue monitoring annual beach profiles to track erosion rates over time and the success of the project.
Promote watershed education and community engagement in management efforts by conducting 5 public activities each year. Target Metric: % of events/activities a year	4.1 Tracking and reporting of watershed accomplishments	• # of annual reports completed • **# and mode of distribution of findings (meetings, press, etc.)**	**Medium.** Watershed coordinator or committee responsible. There could be a lot of activities. Set up a tracking spreadsheet and reporting outline as a first step.
	4.2 Watershed-based lesson plans for K-8 students	• # of lesson plans completed • **# of times lessons used** • # of students engaged	**Low**. This will be relatively easy to document but will require commitment of teachers or principal to report for the first 5 years (may want to stop after that). Keep lesson plans on file or posted to watershed website.
	4.3 Signage	• # of signs designed and installed • # of related web or social media hits or downloads	**Low**. Easy to track. Keep copy of designs on file and contact info for fabricator and installer in case replacements or additional installs are needed.
	4.4 Tours and Training	• **# tours and trainings conducted** • # of audiences targeted • # of participants	**Medium.** Watershed coordinator or committee to keep track. Have designers of the projects develop tour and training materials. Keep copies on file and make videos for online posting.

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APPENDIX A:

PRIORITY CONCEPT DESIGNS

Table A1. Summary of key projects from Aua WMP

Site	Project Description	Planning Level $	Goals
Central Wetland Restoration	Restore the grassy area south of the Mormon Church to its previous condition as a wetland, continuous with the central wetland. Wetland restoration is expected to provide flood storage for stormwater, pollutant removal from influent streams, and habitat area for a diversity of species.	$650,000-$850,000	
Route 006 Roadway Improvements	Install green infrastructure, such as bioswales and turnouts, to treat and convey runoff along Route 006.	$100,000-$250,000	
Shoreline Stabilization Near Lalolamauta Outlet	Bolster the shoreline near the Lalolamauta outlet with a combination of "hard" boulder footings and "soft" vegetated banks and trees.	$350,000-$450,000	
Mormon Church Green Stormwater Infrastructure Retrofit	Create bioretention in the grassed areas along the driveway of the Mormon Church, tapping into the existing drainage system for overflow.	$75,000-$150,000	
Aua Consolidated School Green Stormwater Infrastructure Retrofit and Educational Programming	Install green infrastructure with trees to reduce the heat absorption of the school parking lot by providing shade. Green stormwater retrofits such as tree filters/tree trenches, permeable pavers, and a small rain garden could be installed. Development of K-8 watershed-related lesson plans and outdoor activities.	$250,000-$400,000	
Shoreline Stabilization at Coral Transect	Restore the shoreline using hybrid stabilization approach, combining a vegetated slope over a larger stone footing. Because the slope is steeper and taller than the Lalolamauta Outlet slope, a greater number of biodegradable coir fiber logs may be required.	$400,000-$500,000	
Onesosopo Park Masterplan	Incorporate community participation in planning a restored park area that incorporates elements of low impact design and green infrastructure.	$1.6M-$2.1M	

Goal #1 Reduce Land-Based Sources of Pollution

Goal #2 Create a Plan for Sustainable Development

Goal #3. Restore Aua's Natural Water Resources

Goal #4. Promote Watershed Education

Central Wetland Restoration

Project Summary	
Subwatershed	Lalolamauta Stream
Practice type	Wetland Restoration
Contributing Drainage Area	168.9 acres (includes inflow from Lalolamauta Stream); 13.8 IC acres (8%)
Benefits	Expected to reduce sediment loads, increase flood storage capacity, provide more diverse habitat
Ownership	Partial management by Village, famil,y and Mormon Church
Cost	$650K - $850K depending on easements, permitting, and disposal/reuse of excavated soil

Conditions

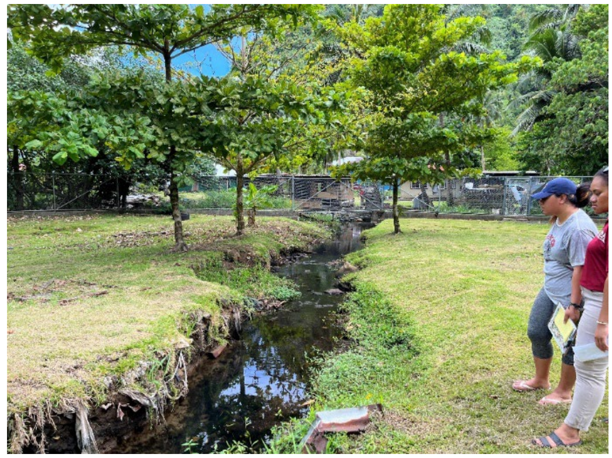
Though the exact boundaries of the central wetland are not delineated, Aua villagers conveyed that the wetland once extended into areas now occupied by the Aua auto yard and the CCCAS Church. The wetland is also heavily impacted by sediment and fill, which erode into the wetland from nearly all upland portions of the watershed. As a result, the wetland has been characterized as having a low functional value in terms of flood control and storm prevention; fish, shellfish, or wildlife habitat; sediment trapping and pollutant abatement; or groundwater recharge.

Concept

This project aims to restore the grassy area south of the Mormon Church to its previous condition as a wetland, continuous with the central wetland. Wetland restoration is expected to provide flood storage for stormwater, pollutant removal from influent streams, and habitat area for a diversity of species. Aua residents would be included in activities like planting mangroves and other riparian vegetation in and around the wetland.

Implementation Considerations

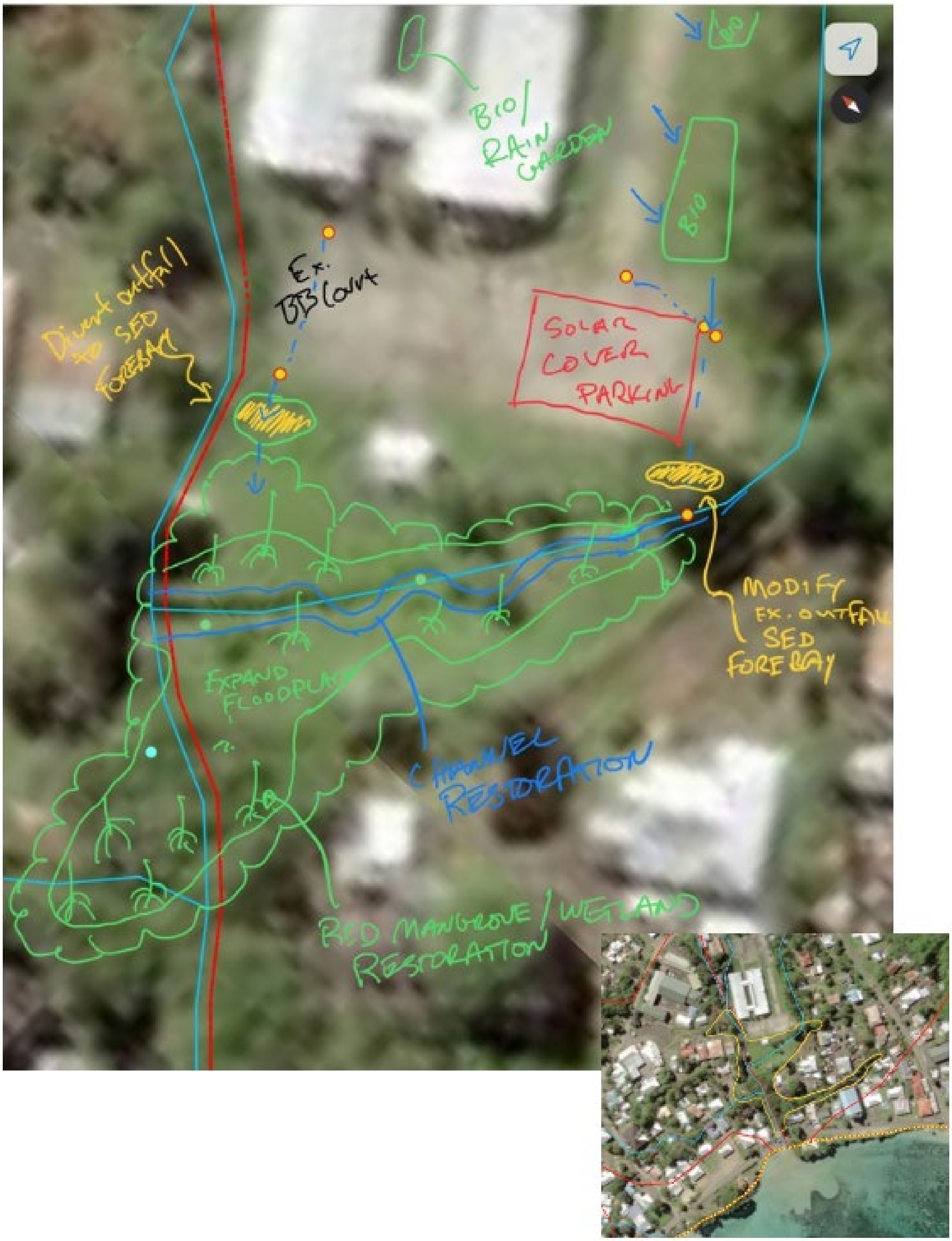
The central wetland is adjacent to private property, and restoration activities will require coordination between sponsoring agencies, the Village Council, and landowners. Restoration activities may benefit from coordination with other on-island agencies that are involved in wetland restoration work, such as the Governor's Biodiversity and Conservation Office. A field sketch and a schematic concept are shown below.



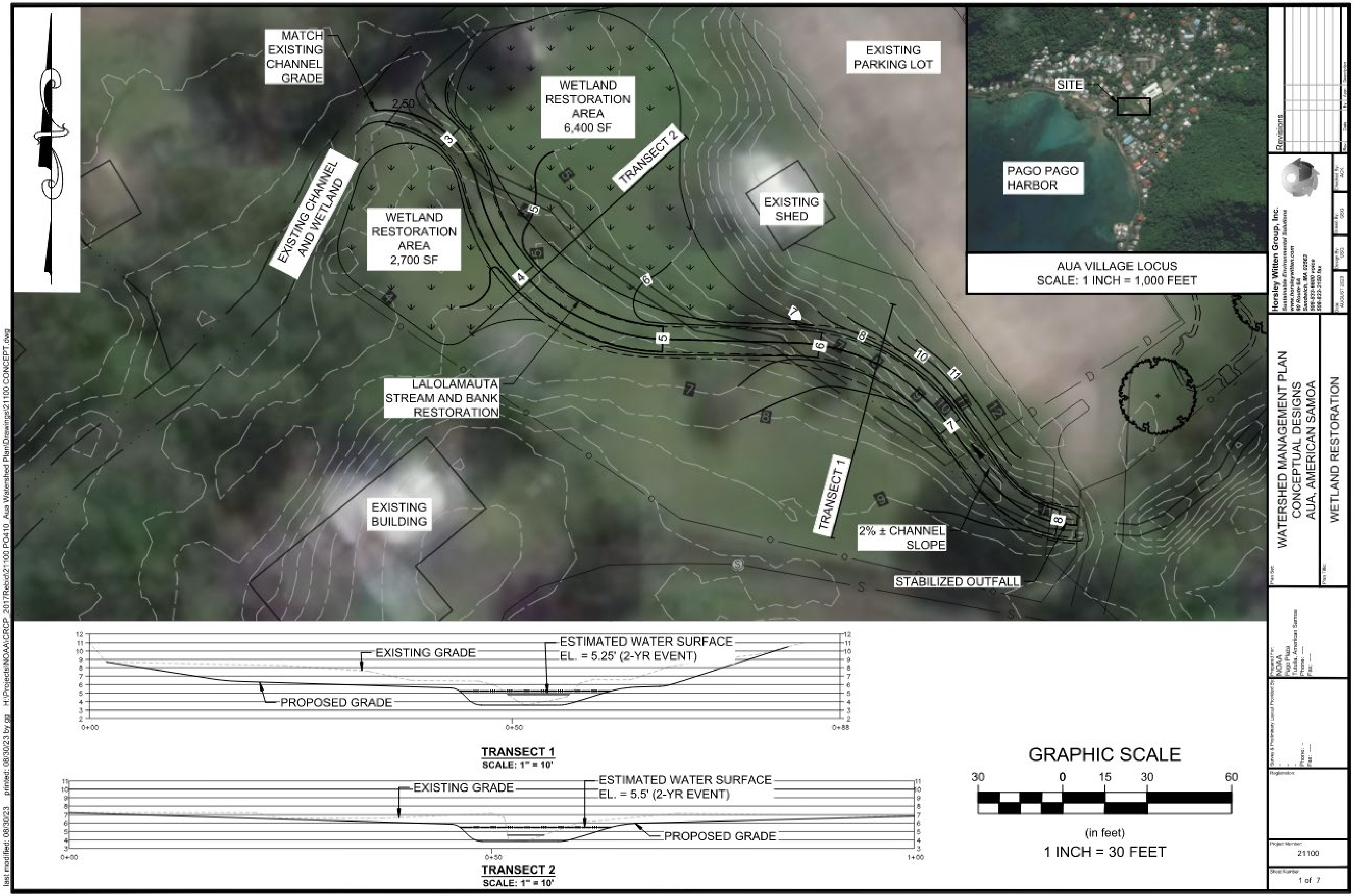
Former area of central wetland that has been heavily altered through infilling and channlization

Armored streambank (left) and central wetland (right) along Lalolamauta Stream

Inside the central wetland

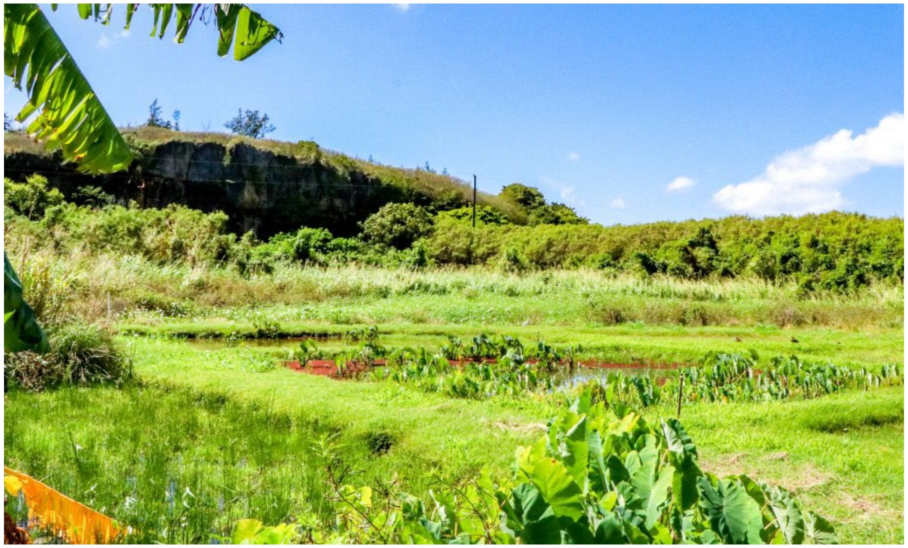


Field sketch of potential central wetland restoration extents and layout



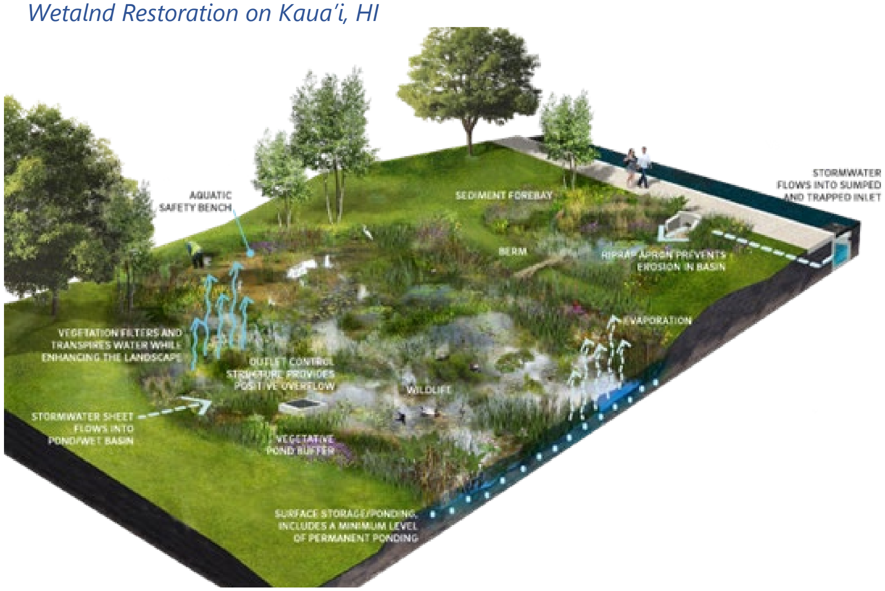
Schematic plan of potential central wetland restoration

Precedent Images – Wetland, Stream, and Shoreline Restoration



Wetalnd Restoration on Kaua'i, HI

Nursery for propogating mangroves for shoreline restoration projects – Saipan, CNMI



Constructed Wetland Schematic (from Philadelphia Water Department)

Route 006 Roadway Improvements

Project Summary	
Subwatershed	Lalolamauta Stream
Practice Type	Grass Channel
Contributing Drainage Area	0.8 acres; .44% impervious
Benefits	60% TSS reduction and improve road drainage to reduce ponding on road; demonstrate how to incorporate GSI into standard road improvement projects
Ownership	Public
Cost	$100K -$250K depending on culvert replacement, grade changes on recently repaved road, additional structures needed

Conditions

Route 006 was repaved by ASPA following the completion of the sewer main expansion project. Near the Catholic Church in Aua, improper road pitch of the resurfaced road caused ponding to occur after rainstorms.

Concept

There are several opportunities along this road segment to install green infrastructure, such as bioswales and turnouts, to treat and convey runoff. Ideally, road drainage should be improved and water quality treatment added as part of all repaving efforts.

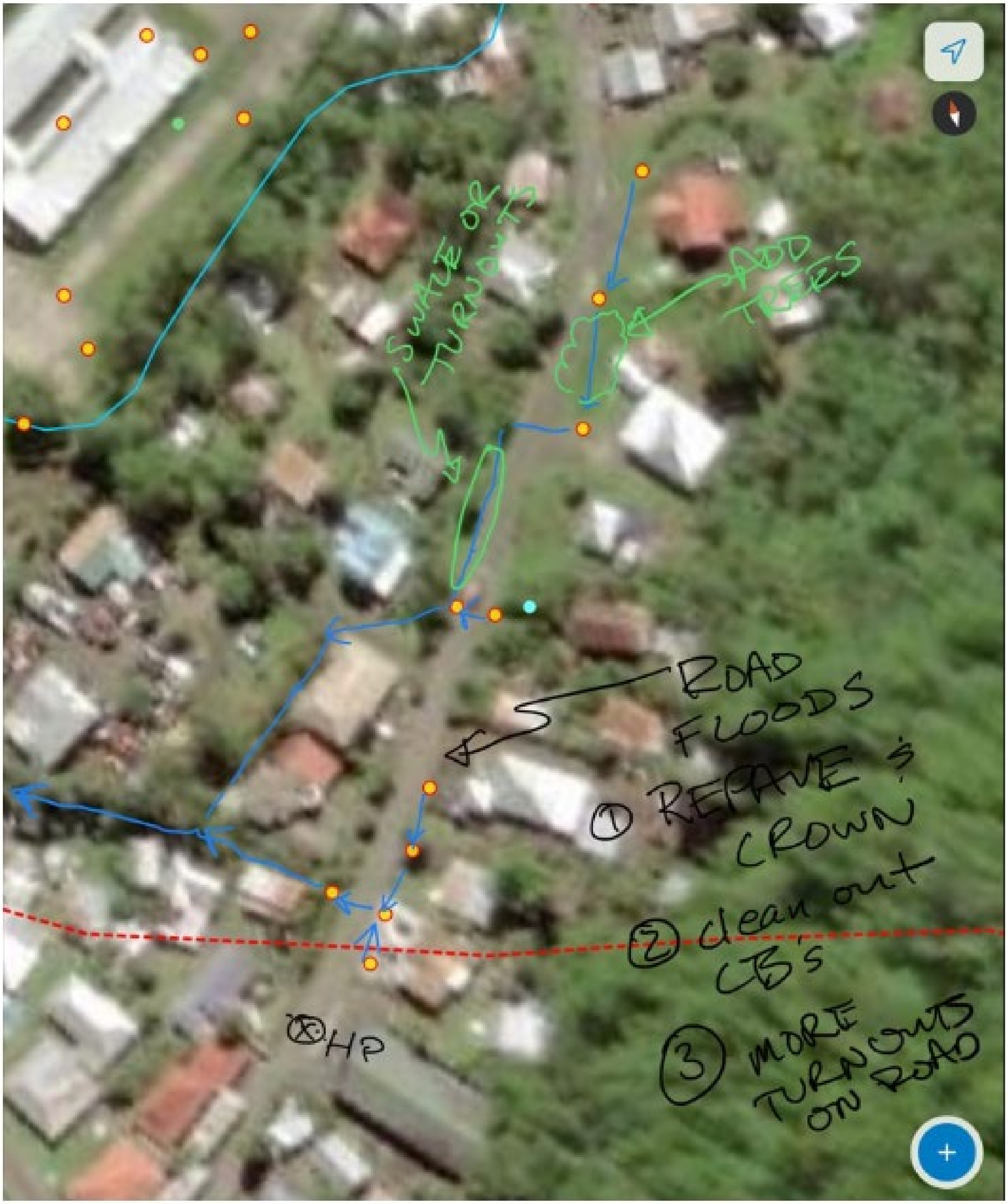
Implementation Considerations

Repaving and regrading efforts should be coordinated with DPW. If DPW repaves the roadway prior to design and installation of roadside green infrastructure, those designs should be bookmarked and incorporated into future roadway work.

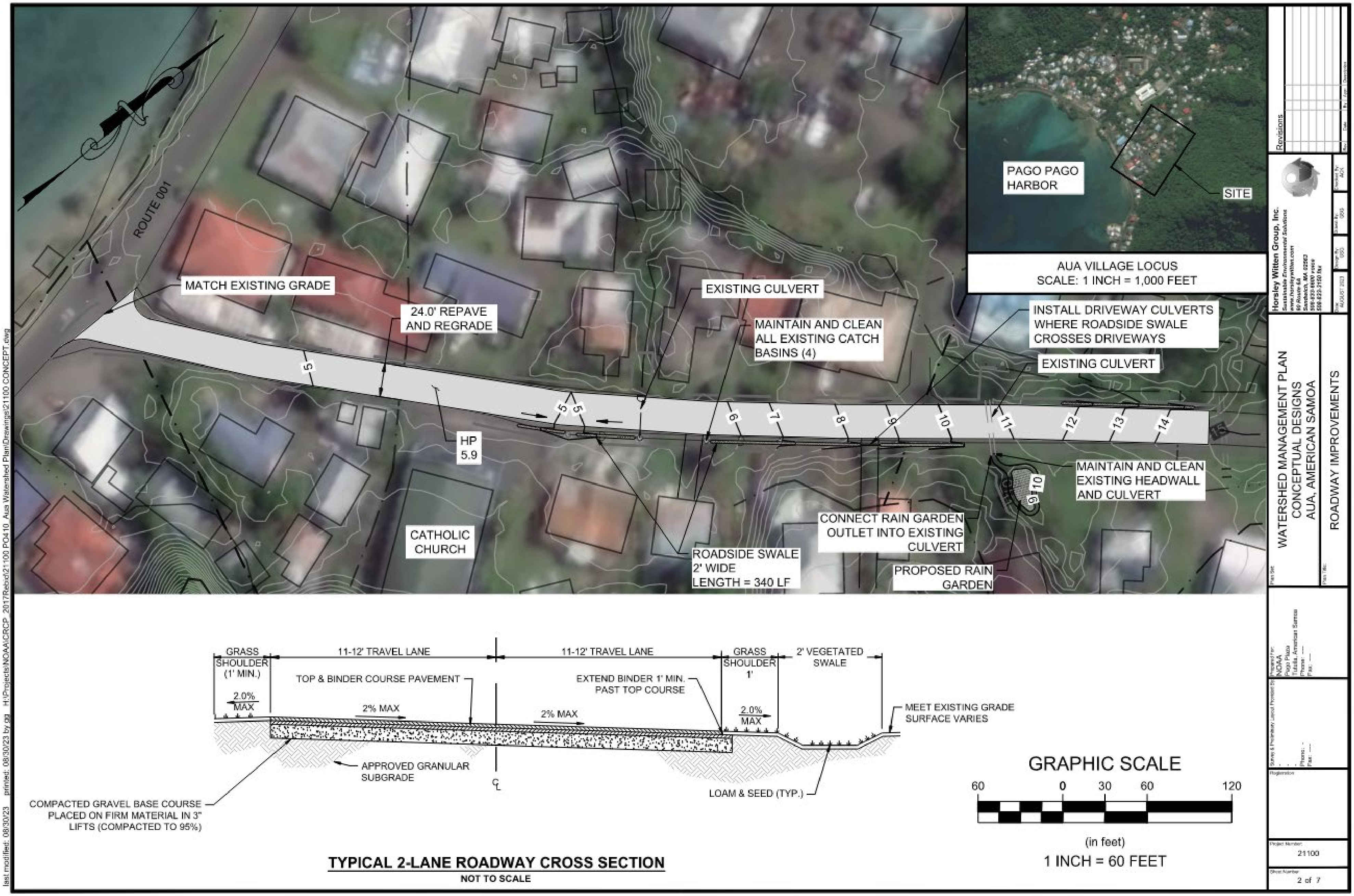
Ponded water along Route 006

A field sketch and a schematic concept are shown below.

Water ponding in front of Catholic Church and turbid water entering catch basin

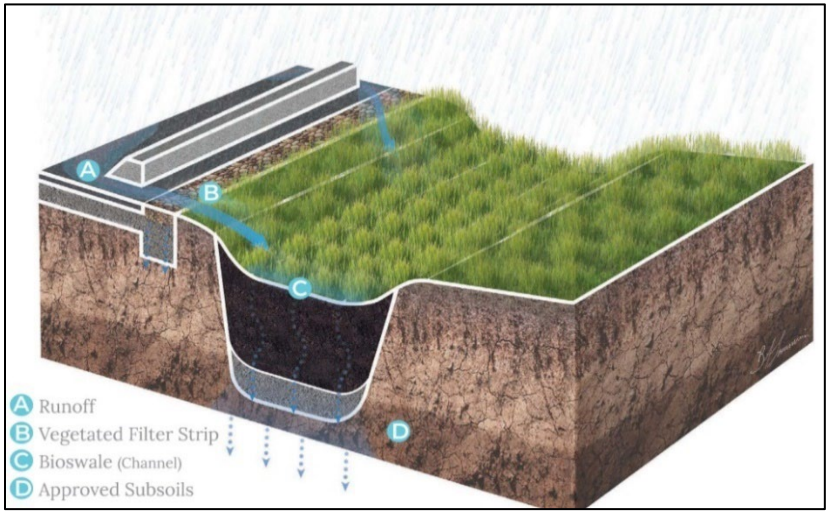


Field sketch of potential grass swale or turnouts along Route 006



Schematic plan of potential grass swale and roadway repaving along Route 006

Precedent Images – Grass Swale



Grass Swale Schematic

Grass Swale – St. Croix, USVI

Grass swale – Guam, CNMI

Shoreline Stabilization Near Lalolamauta Outlet

Project Summary	
Subwatershed	Lalolamauta Stream
Practice Type	Living Shoreline
Contributing Drainage Area	N/A
Benefits	Expected to reduce sediment loading from shoreline
Ownership	Public/Private
Cost	$350K -$450K depending on length, permitting complexity, training and education, and if additional studies are needed

Conditions

The natural shoreline of Aua has been significantly altered through the installation of engineered shoreline protection in the form of stone pile slopes. Loss of natural shoreline represents not only a loss of coastal habitat, but also a loss of beach area and of wave energy dissipation, since hard engineered slopes deflect wave energy to other areas in the embayment.

Near the outlet of Lalolamauta, a small section of shoreline along the embayment shows early signs of erosion. Due to the sheltered nature of this section of shoreline, a "soft" solution such as a living shoreline may be appropriate.

Concepts

The shoreline near the Lalolamauta outlet could be bolstered with a combination of "hard" boulder footings and "soft" vegetated banks and trees. Boulder footings provide a strong foundation for the overlying vegetation. The vegetation protects the slope from erosion, and provides habitat and shade.

Implementation Considerations

DPW has announced plans to replace the shoreline in front of the CCCAS Church with a hard-armored shoreline. Coordination with DPW may enable a larger footprint of living shoreline. The project may be used as a demonstration for other living shoreline projects in low-wave-energy segments of coast.

While working in the area, it may be opportune to install green stormwater infrastructure along Route 001 in order to capture land-based sources of pollution and limit erosion from runoff onto the beach.

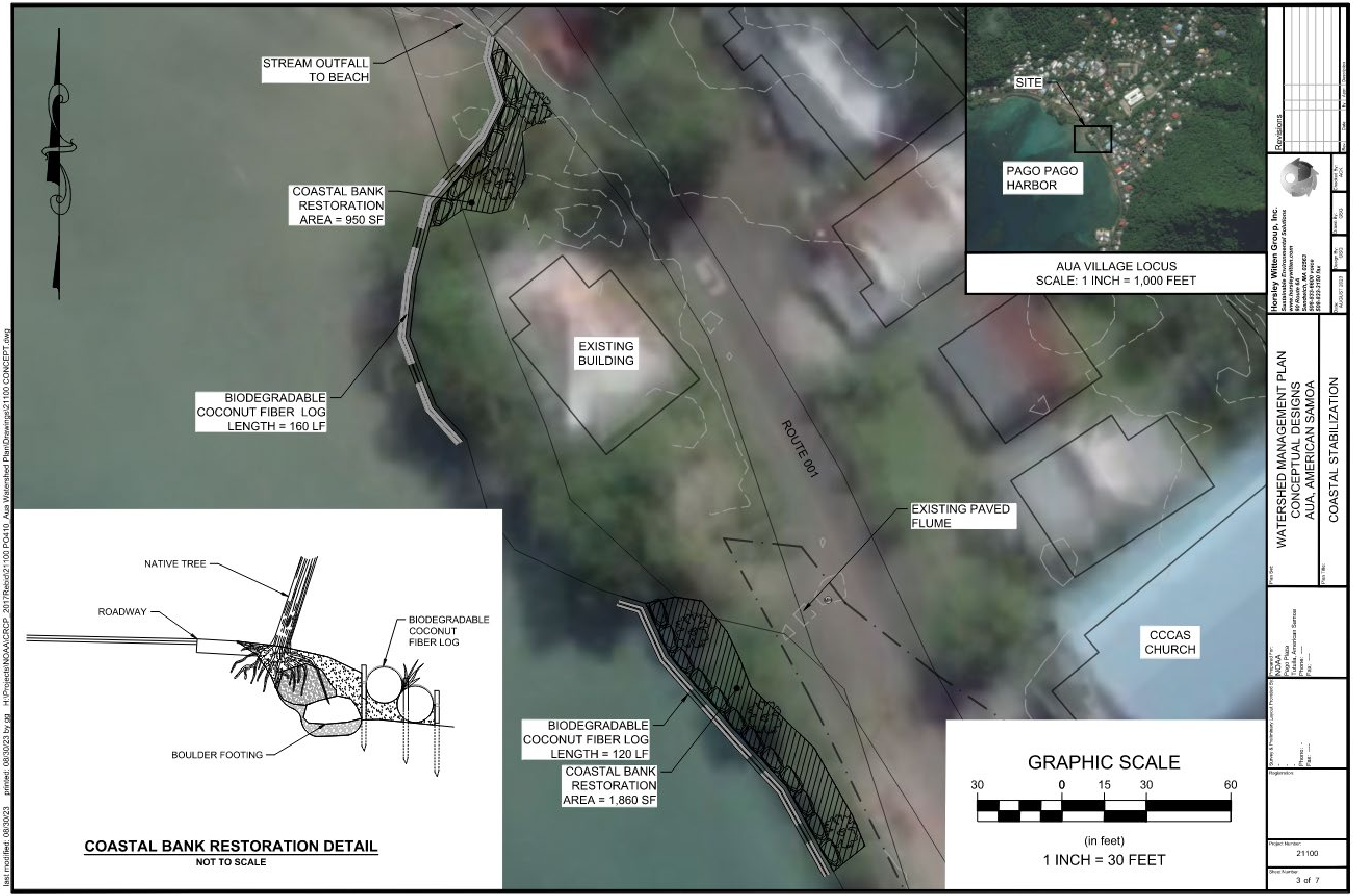
A field sketch and a schematic concept are shown below.

Moderate shoreline erosion at southeast edge of beach

Lawn area adjacent to beach

Moderate gullying along northwest edge of beach

Field sketch of potential living shoreline and green stormwater infrastructure near Lalolamauta outlet



Schematic plan of shoreline stabilization with living shoreline near Lalolamauta outlet

Precedent Images

Stacked coir fiber logs

Shoreline stabilization with integrated tree plantings.

Hybrid stabilization (hard and soft) techniques.

Mormon Church Stormwater Retrofit

Project Summary	
Subwatershed	Lalolamauta Stream
Practice Type	Rain Garden or Bioretention
Contributing Drainage Area	1.58 acres; 43% impervious
Practice Type	85% TSS
Ownership	Private
Cost	$75K-$150K depending on complexity of piping, educational activities, and coordination with wetland restoration

Conditions

The Mormon Church discharges runoff from 1.5 acres of impervious cover directly to Lalolamauta Stream with no treatment. There is little to no shade along the driveway or parking lot (which also serves as a basketball court). Stormwater infrastructure in the parking lot is not regularly maintained.

Concept

Grassed areas along the driveway could be used to create bioretention or rain garden filters, tapping into the existing drainage system for overflow. Trees could be planted along the driveway to provide shade and reduce heat absorption of paved surfaces.

Implementation Considerations

The Mormon Church is privately owned, and permission to install green stormwater infrastructure would be required in order to implement the proposed project.

Due to its high visibility, green stormwater infrastructure installed at the Church could be an effective demonstration or education project. If feasible, stormwater retrofits at the Church should be coordinated with wetland and stream restoration activities.

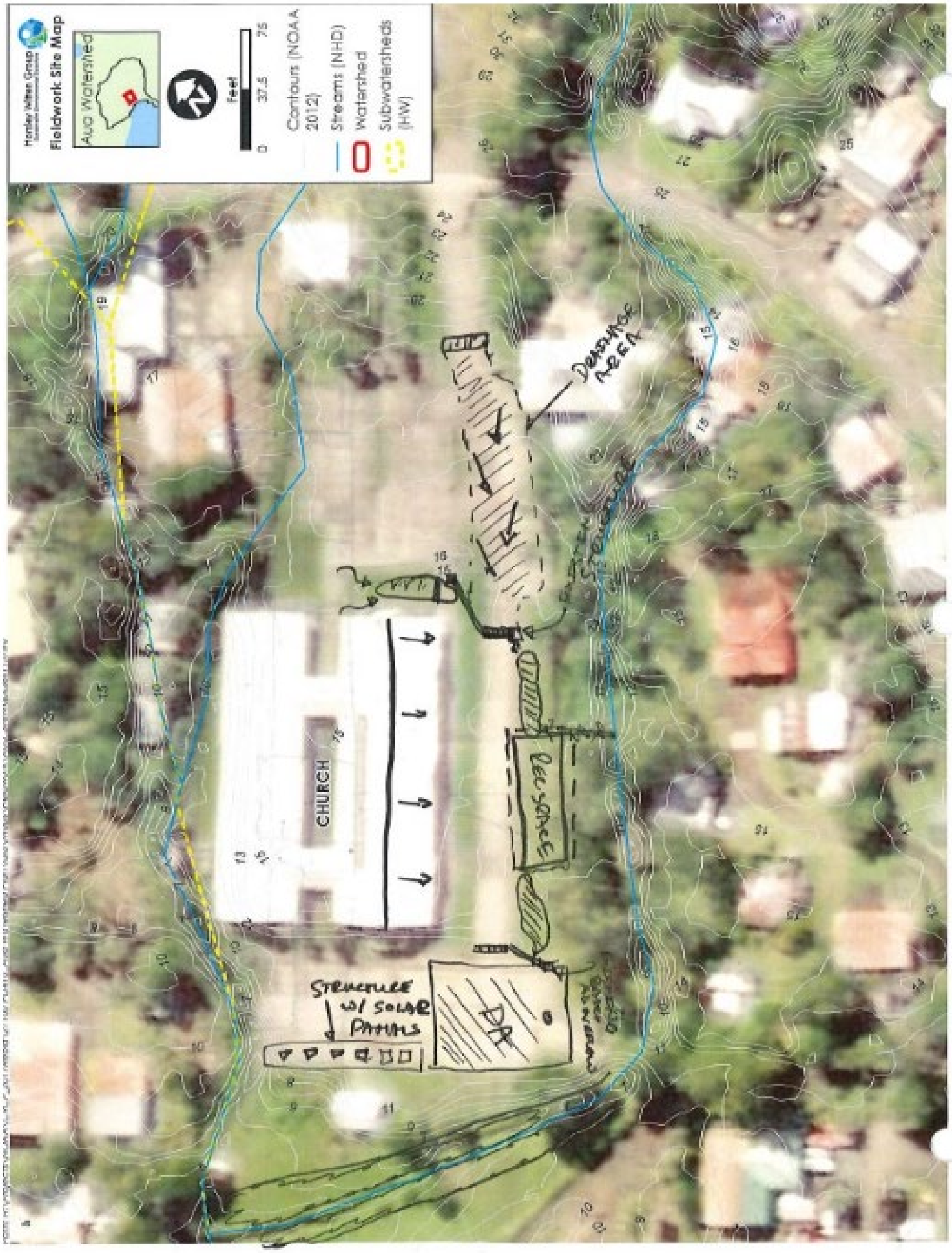
Field sketches and a schematic concept are shown below.

Lawn area offers opportunity for green stormwater infrastructure before discharging to storm drain

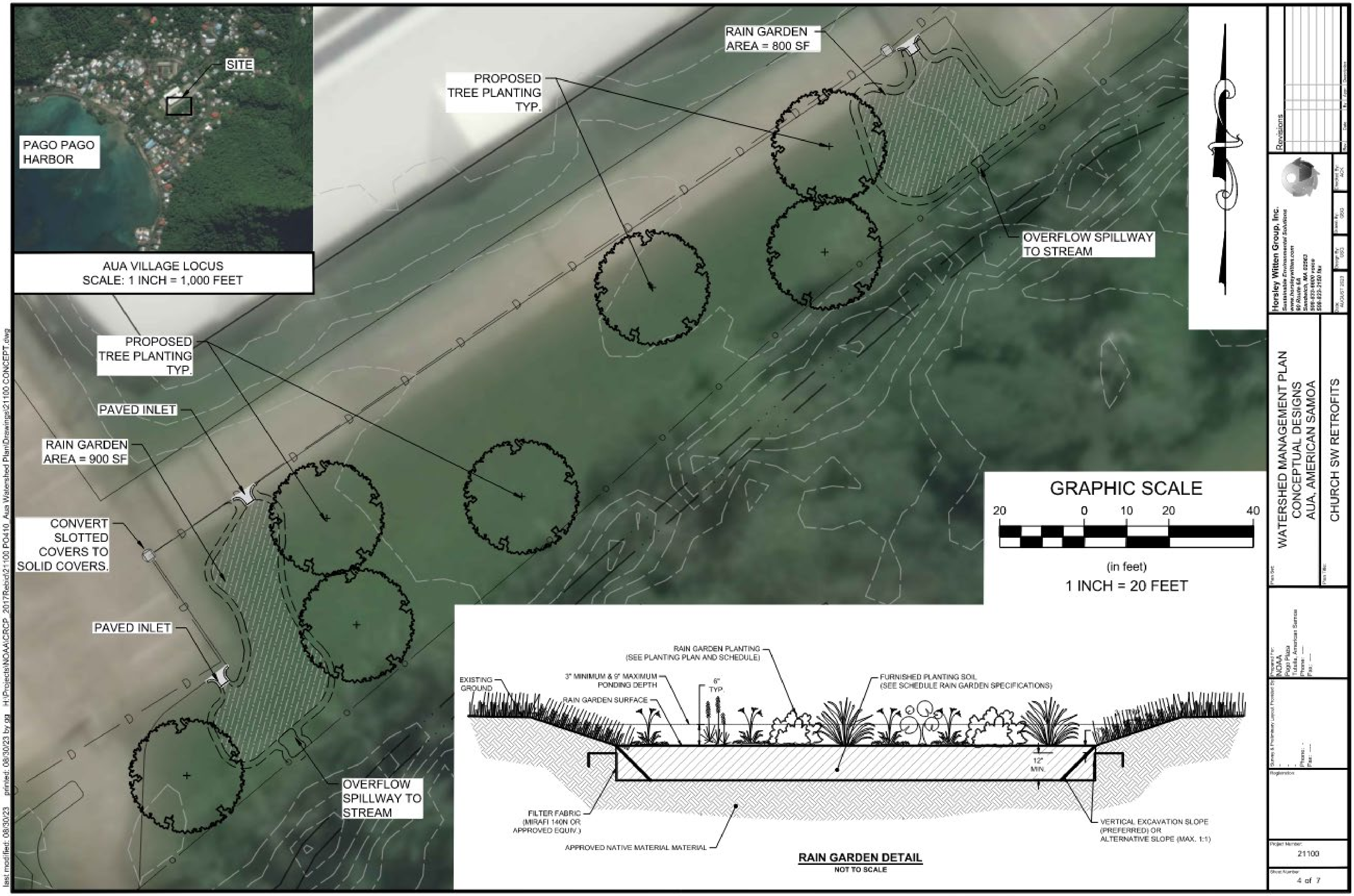
Paved parking and basketball court with little shade

Lawn area and channelized stream/infilled wetland in rear of church.

Initial field sketch of potential green stormwater infrastructure at Mormon Church

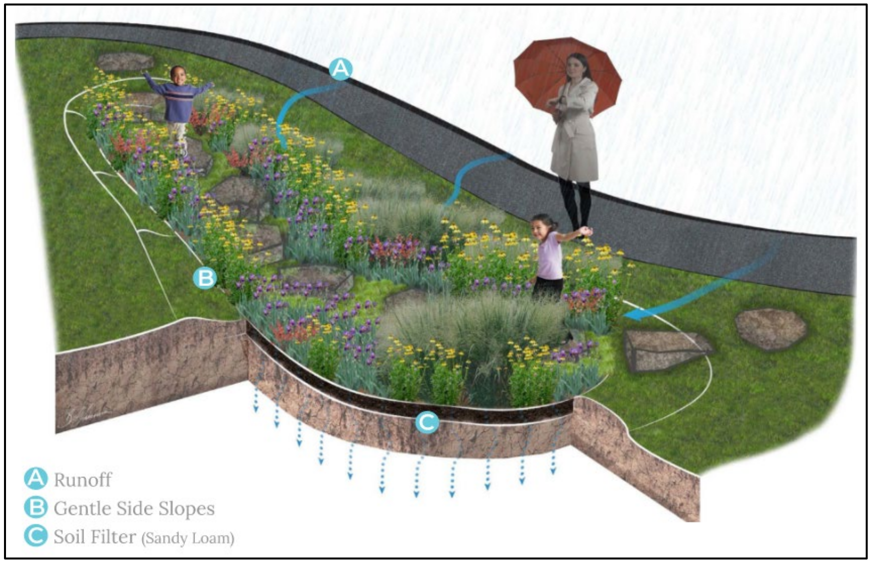


Advanced field sketch of potential green stormwater infrastructure at Mormon Church



Schematic plan of green stormwater infrastructure at the Mormon Church

Precedent Images – Rain Garden



Rain Garden Schematic

Rain Garden in Faga'alu Park – Faga'alu, American Samoa

Rain Garden at American Samoa EPA Building – Utulei, American Samoa

AUA CONSOLIDATED SCHOOL STORMWATER RETROFIT

Project Summary	
Subwatershed	Lalolamauta Stream
Practice Type	Tree Trench and (various)
Contributing Drainage Area	1.6 acres; 100% impervious
Benefits	95% TSS reduction from existing site, reduced heat island effects, education and involvement,
Ownership	public
Cost	$250K-$400K depending on project selected, educational activities,

Condition

The Aua Consolidated School (K-8) was recently renovated and paved. The site has over 1.5 acres of impervious cover that discharges untreated to open channels. The site generates a lot of heat given a lack of shade. Vehicle access to the interior of the school is not safe for kids. The gym floor floods at the northwest corner.

Concept

The proposed restoration concept features green stormwater retrofits such as tree filters/tree trenches, permeable pavers, and small rain gardens. Installation of green infrastructure with trees would reduce the heat absorption of the parking lot by providing shade. Limiting parking to rear and front lots could improve safety of schoolchildren and provide more area for green space or play.

Implementation Considerations

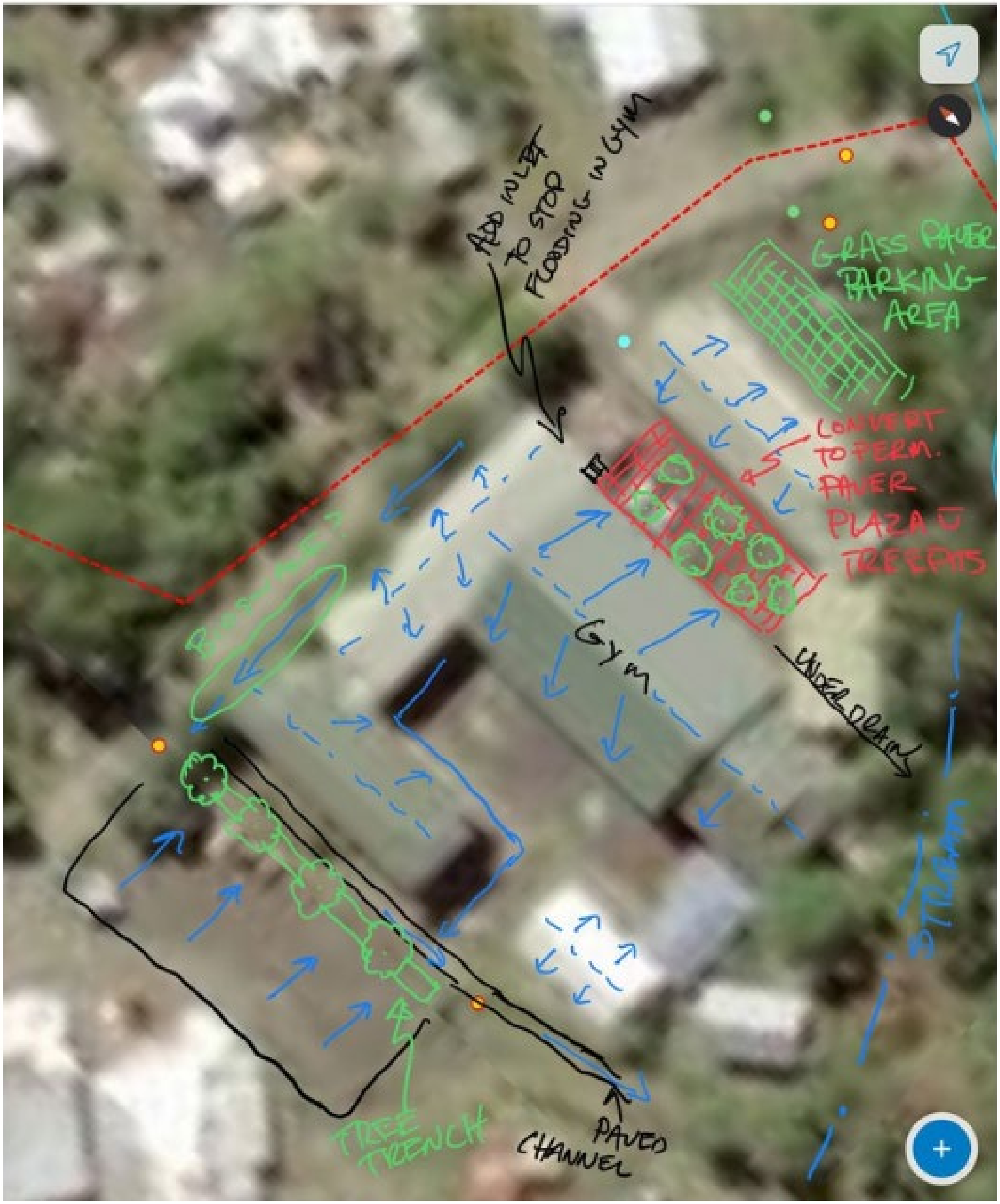
Because the school was very recently renovated, proposed stormwater retrofit designs should be advanced and bookmarked for the future. Similar stormwater retrofit techniques could be applied at other schools that are due for renovation. Any stormwater projects at schools should be coordinated with DPW for implementation.

Field sketches and a schematic concept are shown below.

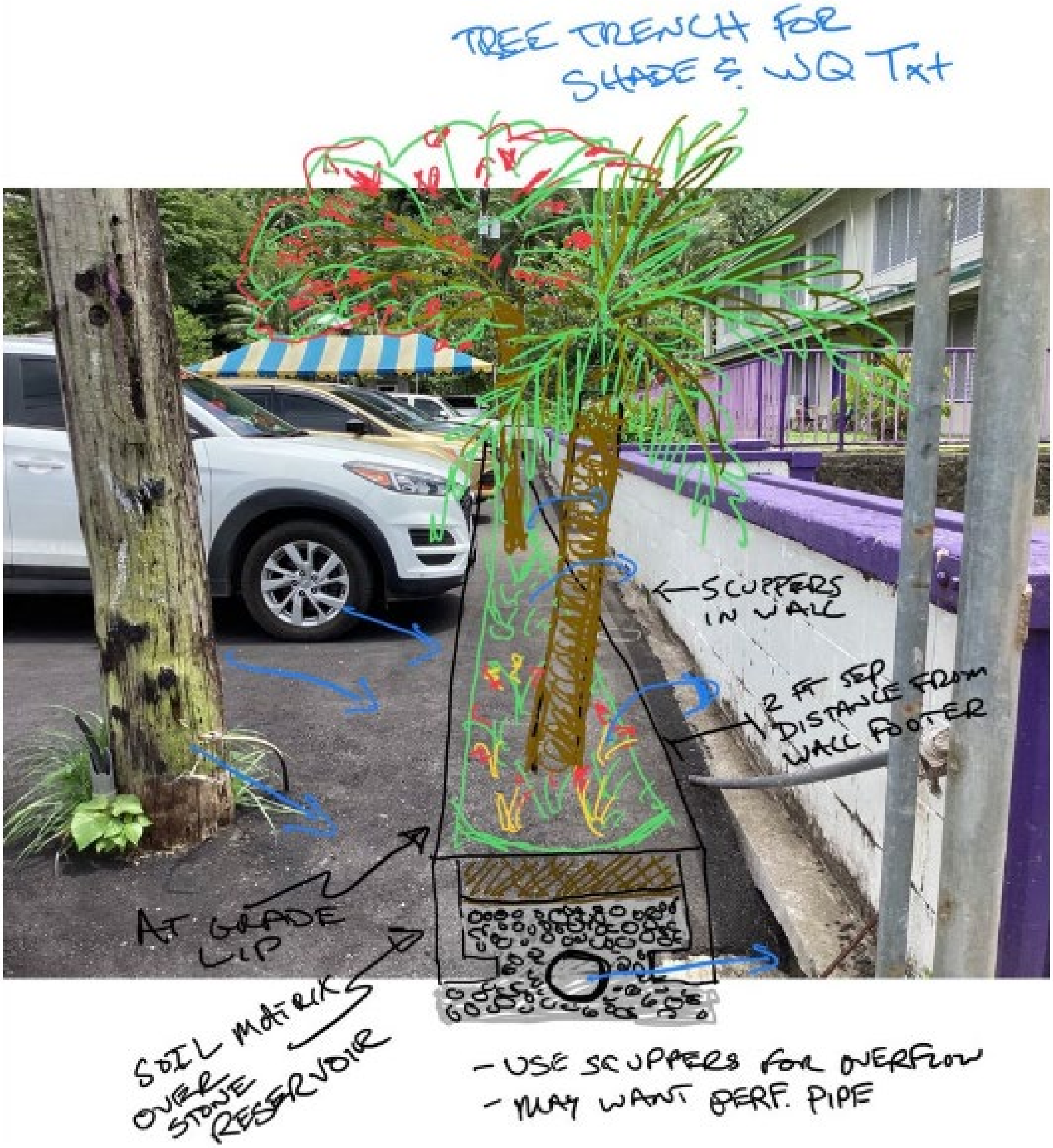
Entrance driveway and concrete-lined channel

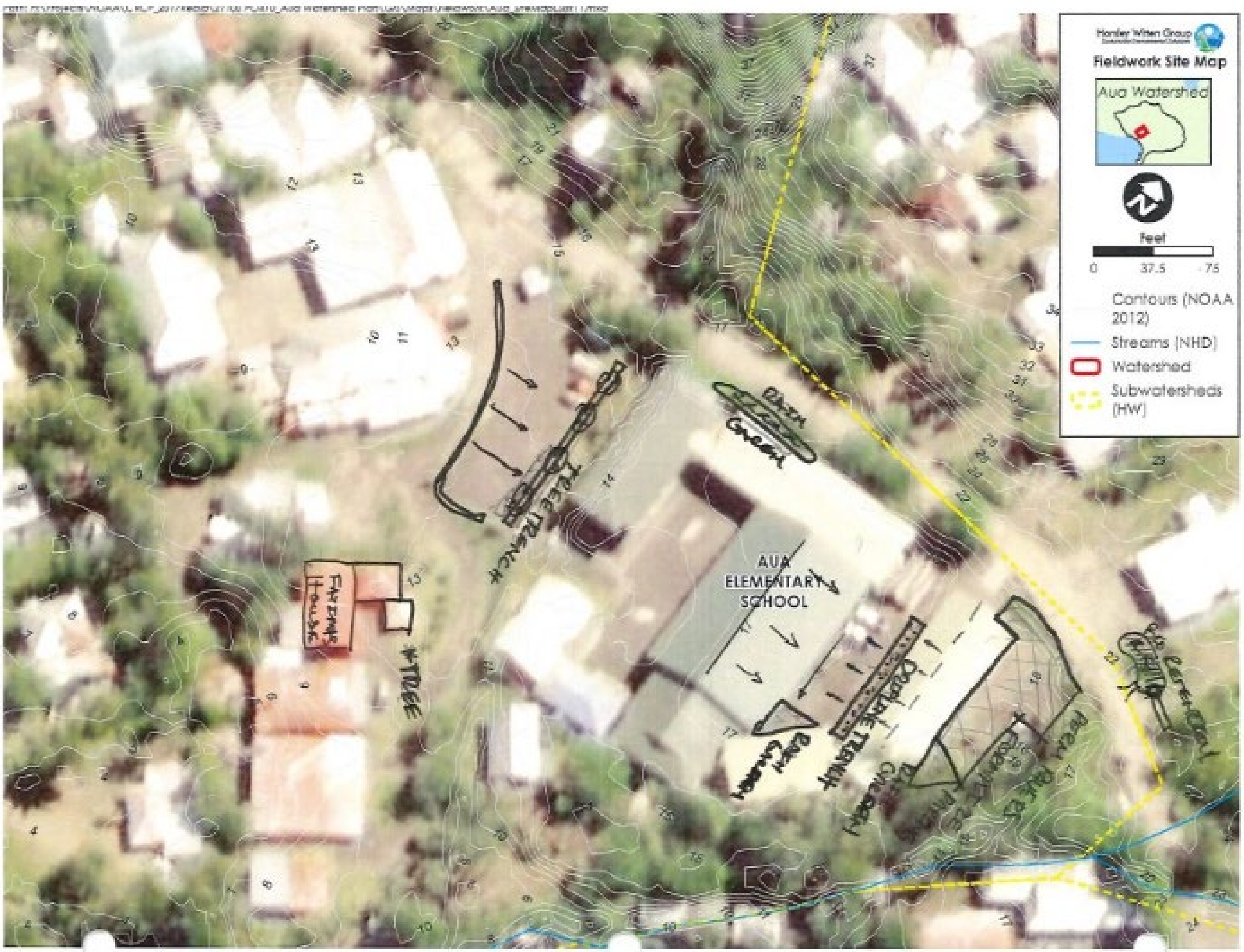
Paved flume drains to stream. Adjacent green space could be used for storage and treatment of stormwater runoff.

Rear parking and paved courtyard. Consider permeable pavement and tree filters to clean and infiltrate stormwater at the school, whil cooling temperatures and providing pedestrian safety.

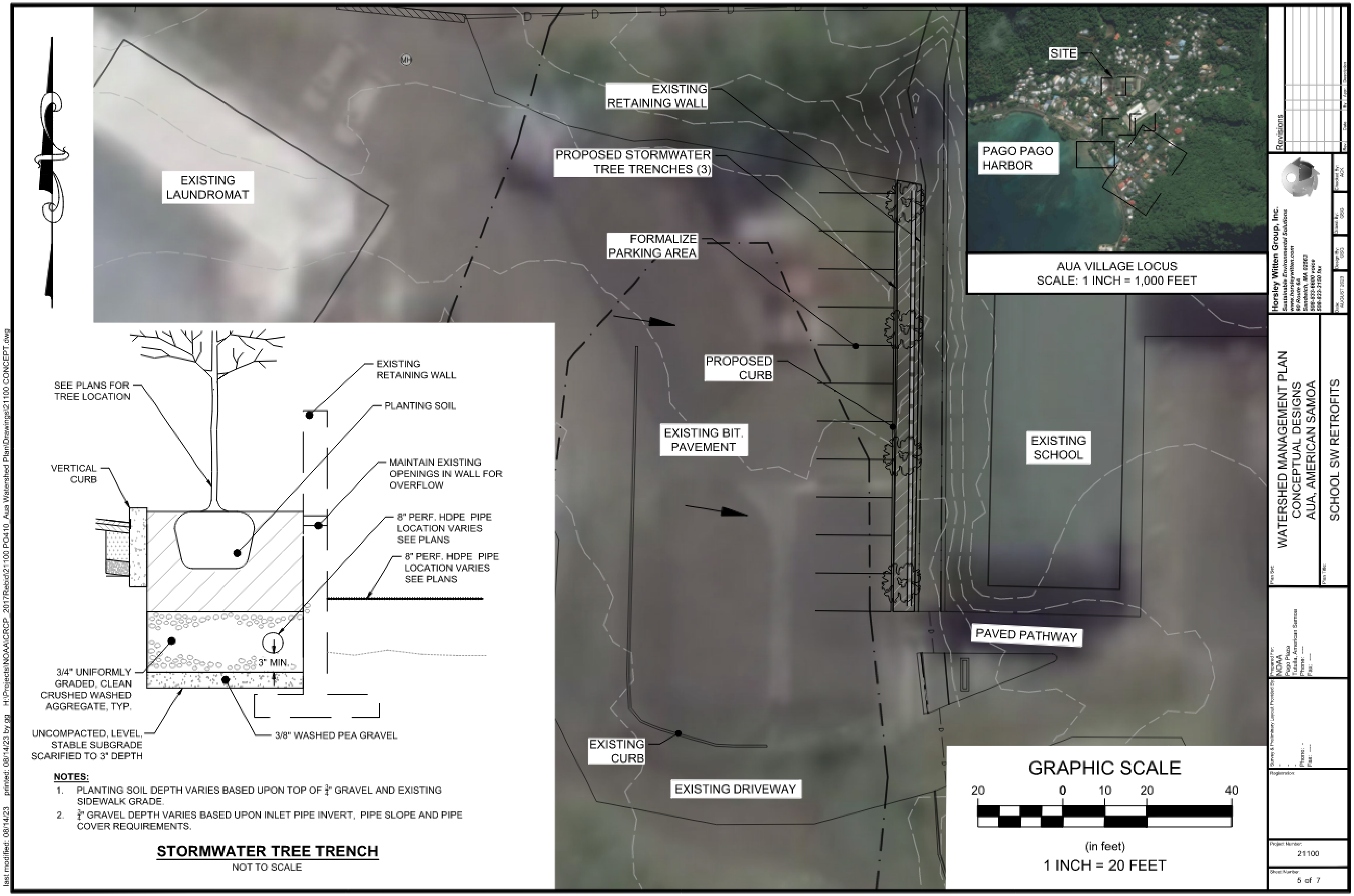


Initial field sketch of potential green stormwater infrastructure retrofits at the Aua Consolidated School


TREE TRENCH FOR
SHADE & WQ Txt
SCUPPERS
IN WALL
2 FT SEP
DISTANCE FROM
WALL FOOTER
AT GRADE
LIP
SOIL MATRIX
OVER
STONE
RESERVOIR
- USE SCUPPERS FOR OVERFLOW
- MAY WANT PERF. PIPE

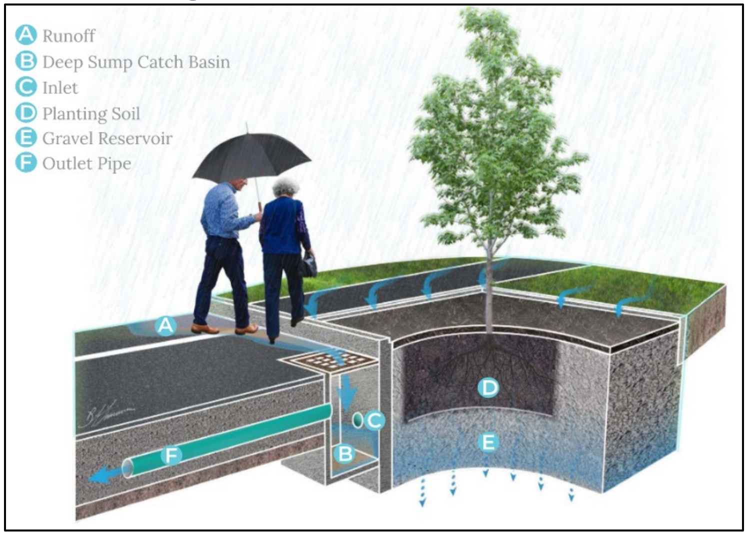


Advanced field sketch of potential green stormwater infrastructure retrofits at the Aua Consolidated School



Schematic plan of stormwater tree trench retrofit at the Aua Consolidated School

Precedent Images – Tree Trench

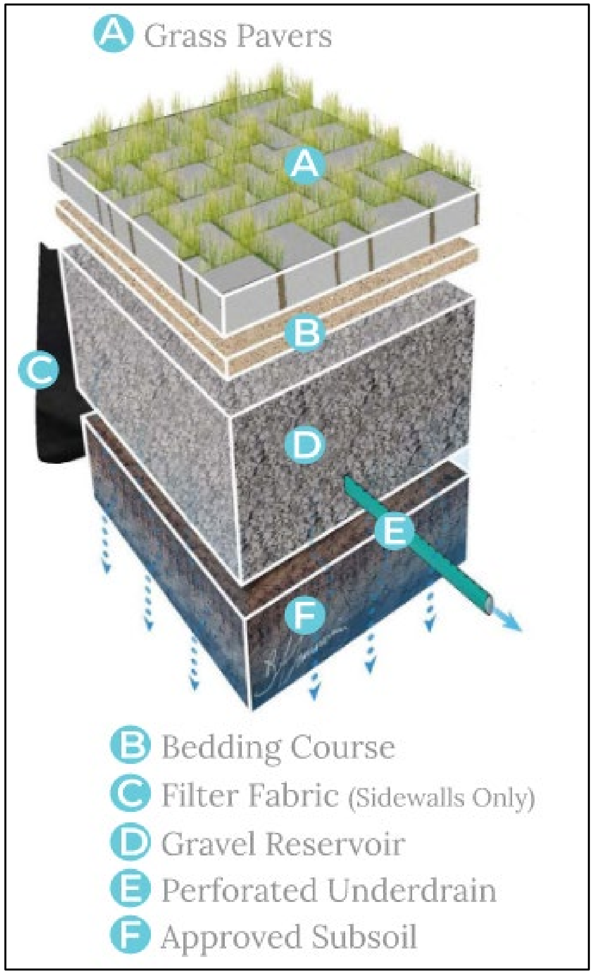


Tree Trench Schmatic

Tree Trench adjacent to parking area.

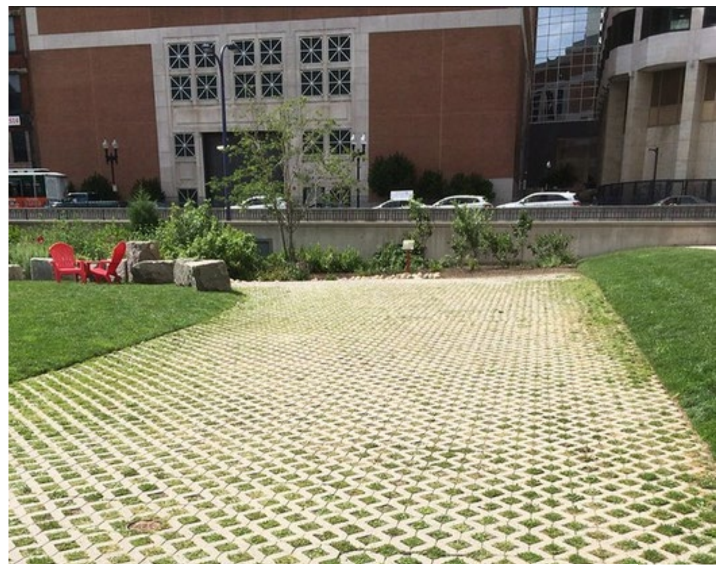
Tree Trench Gravel Reservoir During Construction – Watetown, MA

Precedent Images – Grass Pavers



Grass Pavers Schematic

Grass Pavers – American Samoa EPA, Utulei, American Samoa



Grass Pavers - Massachusetts

Shoreline Stabilization at Coral Transect

Project Summary	
Subwatershed	Aua Point
Practice Type	Living Shoreline
Contributing Drainage Area	N/A
Benefits	Demonstration of living shoreline techniques; shade; improved aesthetic; reduced shoreline erosion.
Ownership	Public
Cost	$400K - $500K depending on permitting complexity, education and training, and length of section.

Coral transect marker


Erosion of shoreline adjacent to coral transect marker

Condition

The shoreline near the Coral Transect marker is another area in which installation of a living shoreline may be a viable stabilization technique. Although the coral transect appears to receive slightly more wave action than the shoreline near the Lalolamauta Outlet (discussed above), it is within the area of the embayment in which the coral reef breaks up incoming waves to some extent.

Concept

Coastal stabilization along the coral transect marker is proposed to be achieved using the same principles of the shoreline near Lalolamauta: a vegetated slope overlying a larger stone footing. The shoreline is slightly steeper and taller near the coral transect marker, so a greater number of biodegradable coir fiber logs may be required to restore the degraded slope. The shoreline has a small buffer from the roadway, giving more space to achieve a suitable slope.

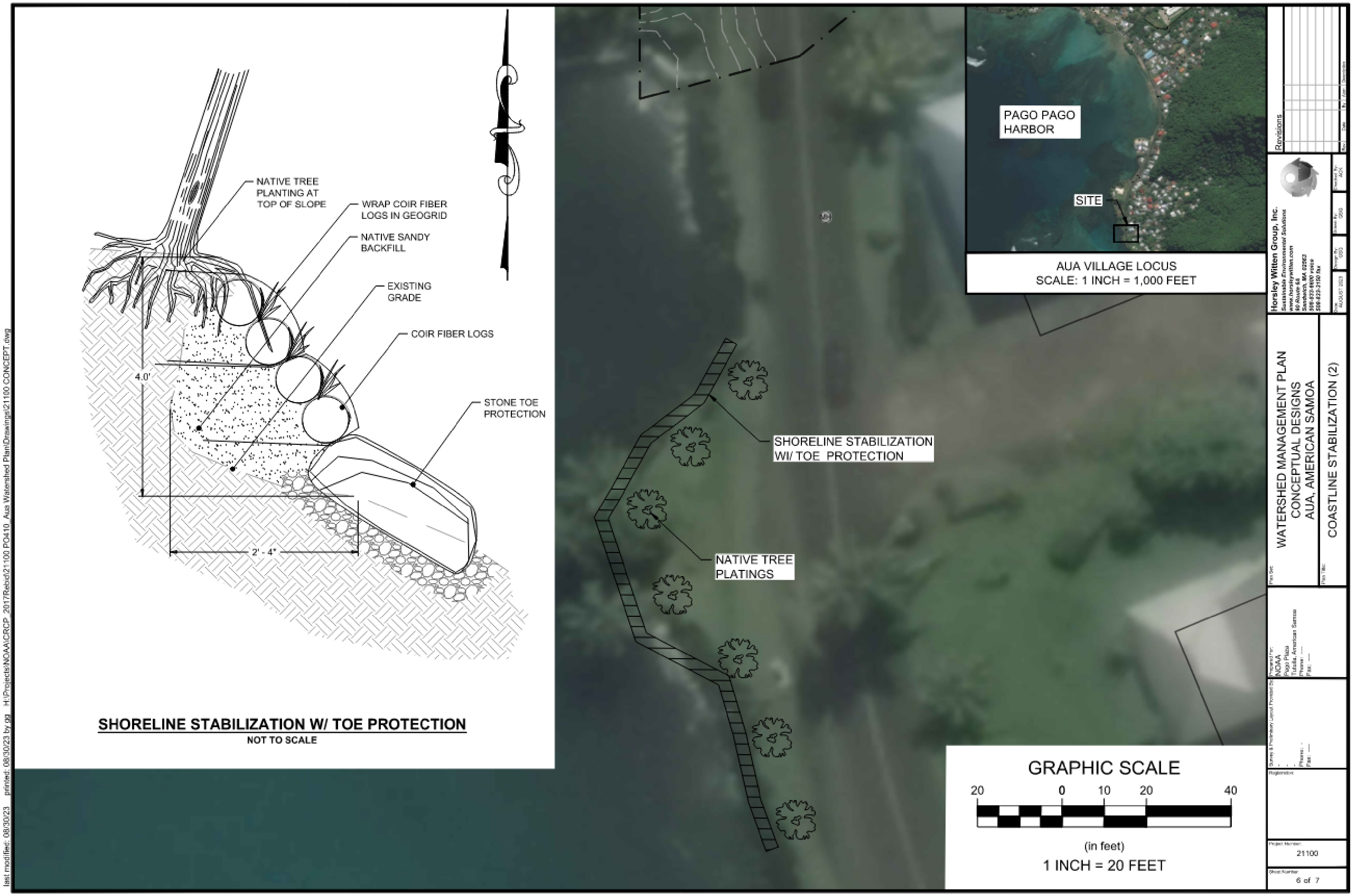
Implementation Considerations

For both shoreline projects, it would be beneficial to conduct a hydrodynamic study of the shoreline of Aua in order to understand the design constraints and requirements of coastal stabilization. This is of greater importance at the coral transect location, where the geometry of the coastline appears to expose the shore to slightly more wave energy than at the Lalolamauta Outlet.

Care should be given to protect the coral transect marker throughout any construction activities.

A field sketch and a schematic concept are shown below.

Field sketch of potential shoreline stabilization technique and other drainage improvements



Schematic plan of potential shoreline stabilization along the coral transect marker coastline

ONESOSOPO PARK PLAN

Project Summary	
Subwatershed	Aua Point
Practice Type	Erosion and sediment control; Rain garden; Stream restoration; Buffer restoration
Contributing Drainage Area	6.3 acres; 0.8 impervious acres (12%) (assumes installation of parking)
Benefits	50% TSS reduction minimum (varies by practice); demonstrate sustainable parks; improved recreation
Ownership	Public
Cost	$50K - $100K depending on extent of public engagement and level of design desired.

Conditions

Onesosopo Park was used as a staging and soil stockpile location during the ASPA sewer expansion project, which proved to be a significant source of unmanaged sediment loading to streams and the nearshore environment. Much of the park was disturbed, with little in the ways of erosion and sediment controls to keep materials contained on site.

The park is used more generally as a recreational area for sports. On the south side of Onesosopo park stands a fale.

Concept

As one of the few areas of open space and devoted recreational space in the watershed, Onesosopo Park offers a significant opportunity for community participation in planning what a restored park area could look like. It also offers an opportunity to incorporate elements of low impact design and green infrastructure into the park layout, which could serve as demonstrations or educational opportunities. The stream adjacent to the park could be restored following a high degree of sediment loading and human intervention.
By developing a masterplan for the park, Aua residents could ensure that the space remains open and minimize the impact of development that may be required to make the space more accessible.

Onesosopo Park in use as staging area during 2022 sewer main expansion.

Stockpiled stone with in adequate erosion controls near shoreline at Onesosopo Park

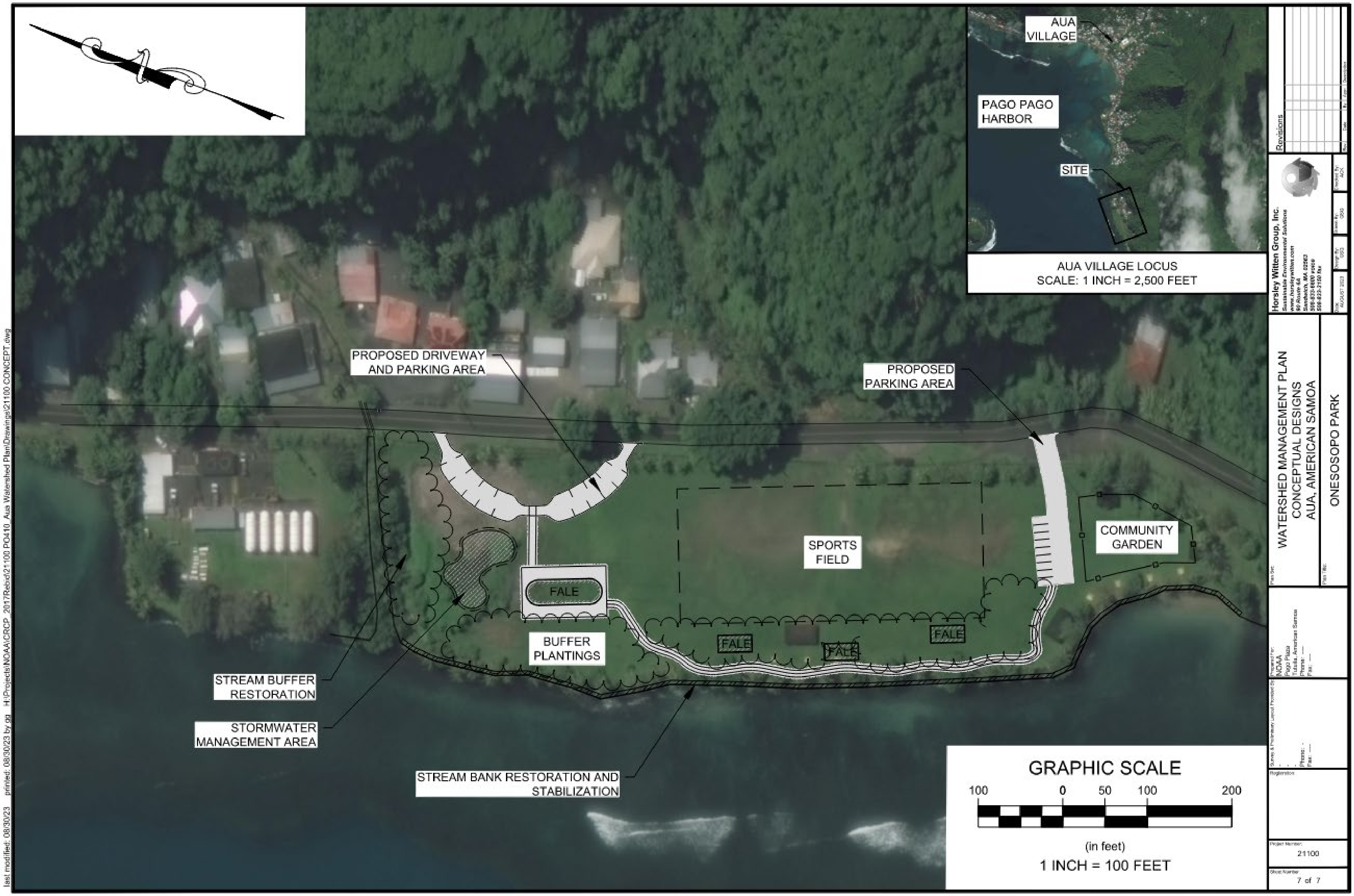
Implementation Considerations

As the largest communal space in Aua, it is critical that Aua residents be included in developing the park's masterplan.

Field sketches and a schematic concept are shown below

Field sketch of potential stream restoration at Onesosopo Park and restoration/safety activities nearby

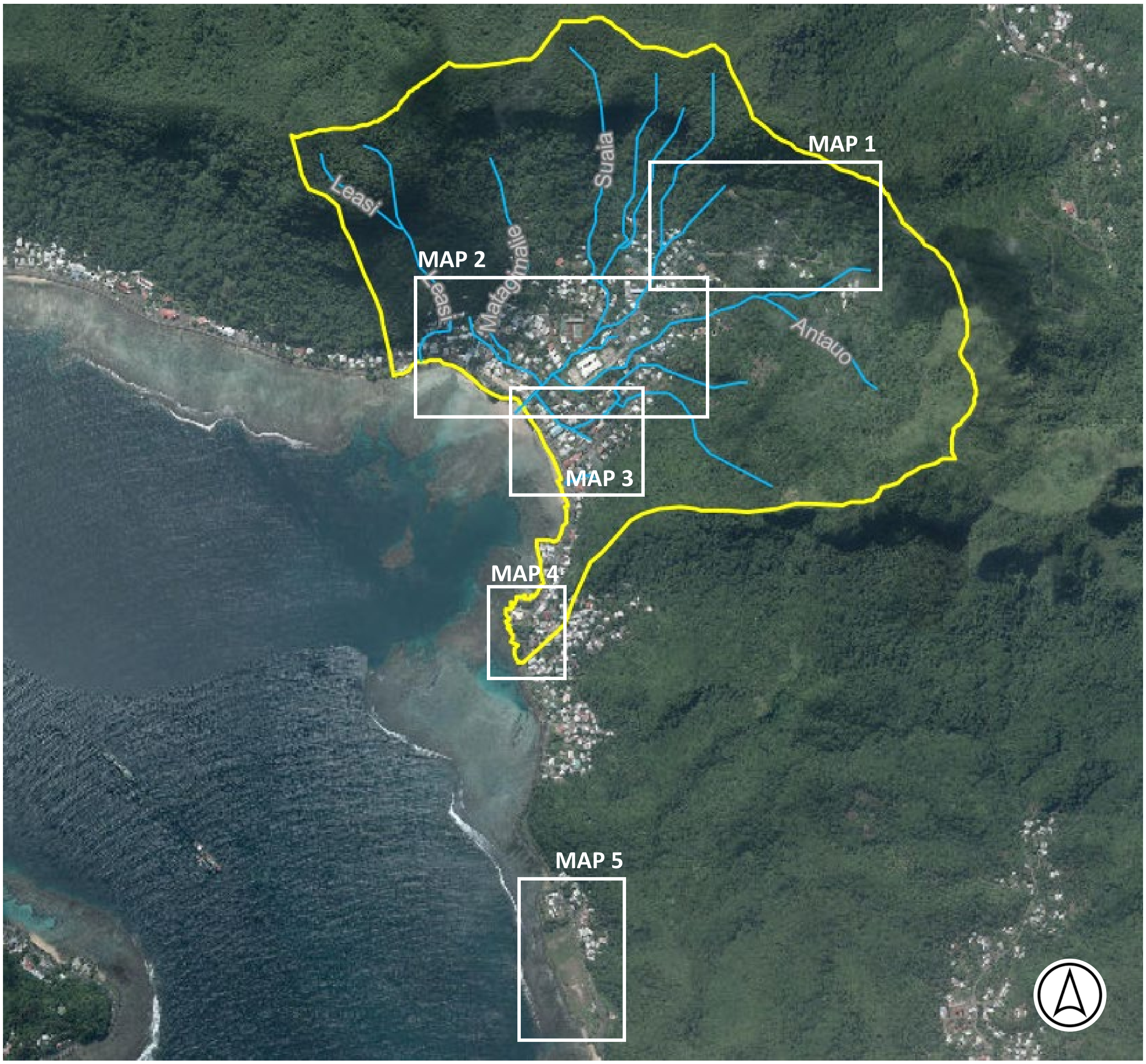
Field sketch of potential restoration activities and park programming at Onesosopo Park



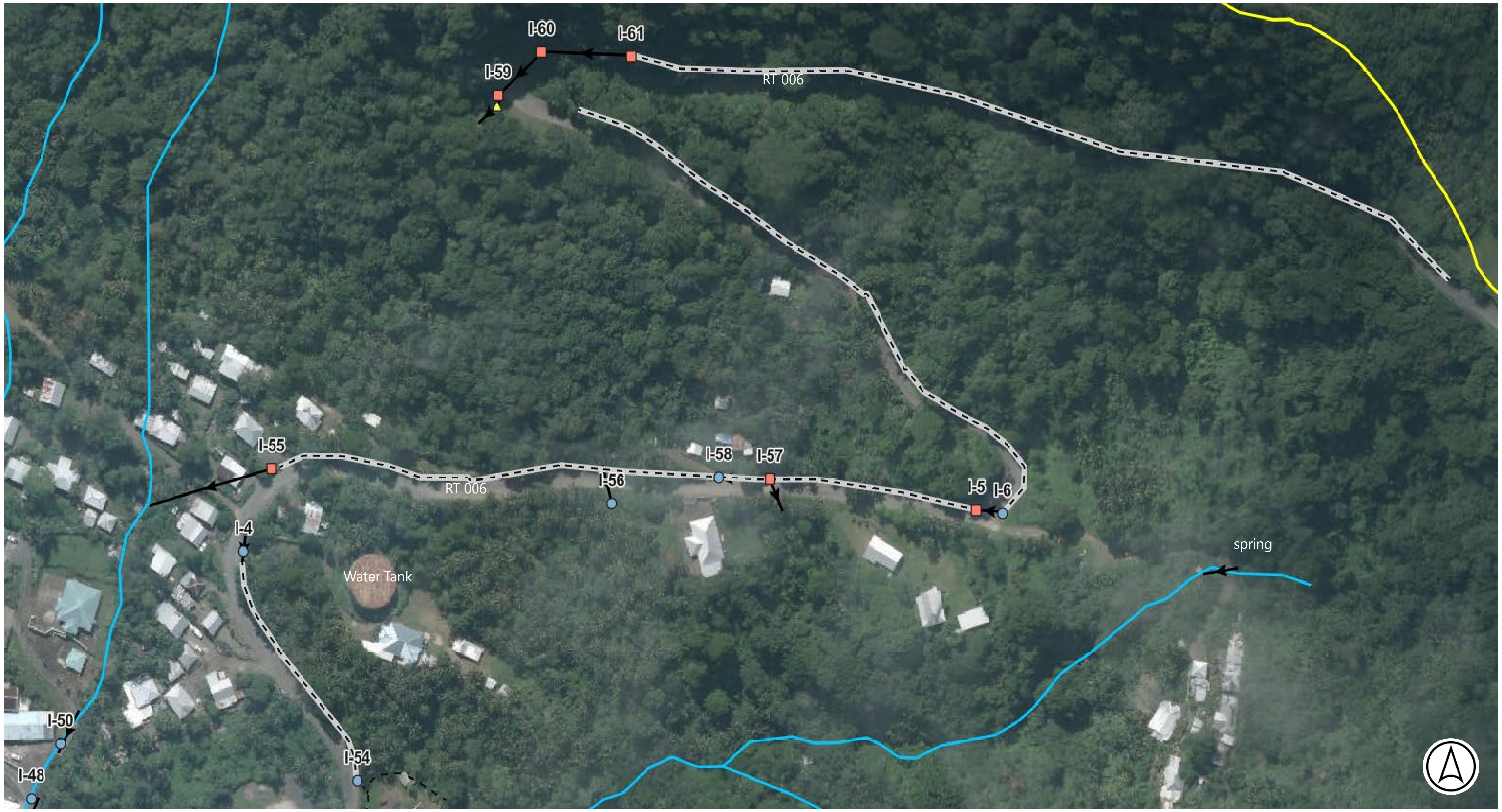
Schematic plan of potential restoration activities, green stormwater infrastructure, and park programming at Onesosopo Park

APPENDIX B.
DRAINAGE INFRASTRUCTURE MAP

Map Key



MAP 1



Legend

- Open concrete ditch
- Naturalized ditch
- Unconfirmed pipe
- Pipe/flow direction arrow
- Inlet/Catch basin
- Culvert
- Outfall
- Other
- NHD Stream (HW corrected 2022)
- Aua Watershed

Site ID	Type	Maintenance Needs	Maintenance Description	Dimensions	Invert	x	y	Notes
I-4	Culvert	Routine Maintenance	Uphill inlet covered in debris.	24 in		-170.661	-14.2675	Clean out inlet
I-5	Inlet	None Needed				-170.658	-14.2674	paved inlet to inside concrete ditch
I-6	Culvert	Routine Maintenance	needs cleaning out, it is clogged			-170.658	-14.2674	
I-48	Culvert	None Needed		4 ft down 6 across	69 in below grade	-170.662	-14.2685	Box culvert water fall ar church entrance; sediment placed on top
I-50	Culvert	None Needed				-170.6621558	-14.26824576	Steep no dog lots of trash
I-54	Culvert	None Needed		4 ft deep by 5 ft wide	56 inches below driveway	-170.6608247	-14.26841637	Concrete gutter starts back up (ended at downhill structure going up hill)
I-55	Inlet Catchbasin	Routine Maintenance	clear debris from inlet grate	2 ft HDPE	80 inches below road	-170.6611889	-14.26718487	Clogged at surface with debris Jonas and Jeff cleared it. Looks good in the structure. Modified design at lip very deep ; this is where concrete gutter switches sides of road
I-56	Culvert	Routine Maintenance	Need to clean out inlet	36 inch		-170.6596645	-14.26734959	Blocked 20 inches sediment
I-57	Inlet	Repair				-170.6589522	-14.26726968	We cleaned: missing cover dangerous: culvert crosses. Road: can't find outfall
I-58	Culvert	Repair	remove blockages, consider replacing			-170.6591803	-14.26725941	Driveway culvert that was clogged
I-59	Inlet	None Needed				-170.6601393	-14.26573969	
I-60	Inlet	Routine Maintenance				-170.6599427	-14.26557596	We cleaned it out looks like keeps going down road
I-61	Inlet	Routine Maintenance		28 by 40 grate pipe is 24	5 ft from rim	-170.66	-14.2656	We cleaned. Keeps flowing down road to next structure

MAP 2

Legend

- Open concrete ditch
- Naturalized ditch
- Unconfirmed pipe
- Pipe/flow direction arrow
- Inlet/Catch basin
- Culvert
- Outfall
- Other
- NHD Stream (HW corrected 2022)
- Aua Watershed

Site ID	Type	2022 Maintenance Needs	Maintenance Description	Dimensions	Invert	x	y	Notes
I-7	Inlet	Routine Maintenance	clean out			-170.667	-14.2699	
I-8	Inlet	None Needed		(2) 18" out and (1) 18" in HDPE	3.5 to top of rim	-170.668	-14.2699	Connected to ocean
I-9	Inlet	Routine Maintenance	Clean out and remove grate?	12?	2.3 to rim, 5 ft to top of wall	-170.667	-14.2699	Interesting design small grate covering out pipe. Couldn't see outfall. 1 ft or more of sediment
I-10	Inlet	Routine Maintenance	Clean out		2.3 ft to rim; 5.4ft top of wall	-170.667	-14.27	No grate on this one
I-11	Culvert	Repair	Upstream scour hole, headwall damage	(3) 24" RCP		-170.664	-14.2688	
I-12	Culvert	Routine Maintenance	clean out trash	Two 18" HDPE		-170.663	-14.2688	
I-13	Inlet	None Needed				-170.663	-14.2689	
I-14	Culvert	None Needed		36" RCP		-170.664	-14.2693	Channel width 4.5 ft, variable depth 3.5 ft deep average
I-15	Culvert	None Needed		4 x 8" RCP		-170.662	-14.2697	Eel, prawns, minnows
I-17	Inlet	None Needed		18" pvc, 27" below the rim outfall; 8 pvc 27" invert from trench drain		-170.663	-14.2699	
I-18	Inlet	None Needed	probably need to clean out/clogged	Out is 8 pvc with 28 below rim, in under grass 8 in pvc 26 below rim, connects to other trench in front of interior gate		-170.663	-14.2699	This one is in Green area
I-19	Inlet	Routine Maintenance	clean out			-170.663	-14.2696	Trench drain
I-20	Inlet	None Needed				-170.663	-14.2701	Trench
I-24	Outfall	None Needed		6 or 8 in		-170.664	-14.2701	6 or 8 inch pvc

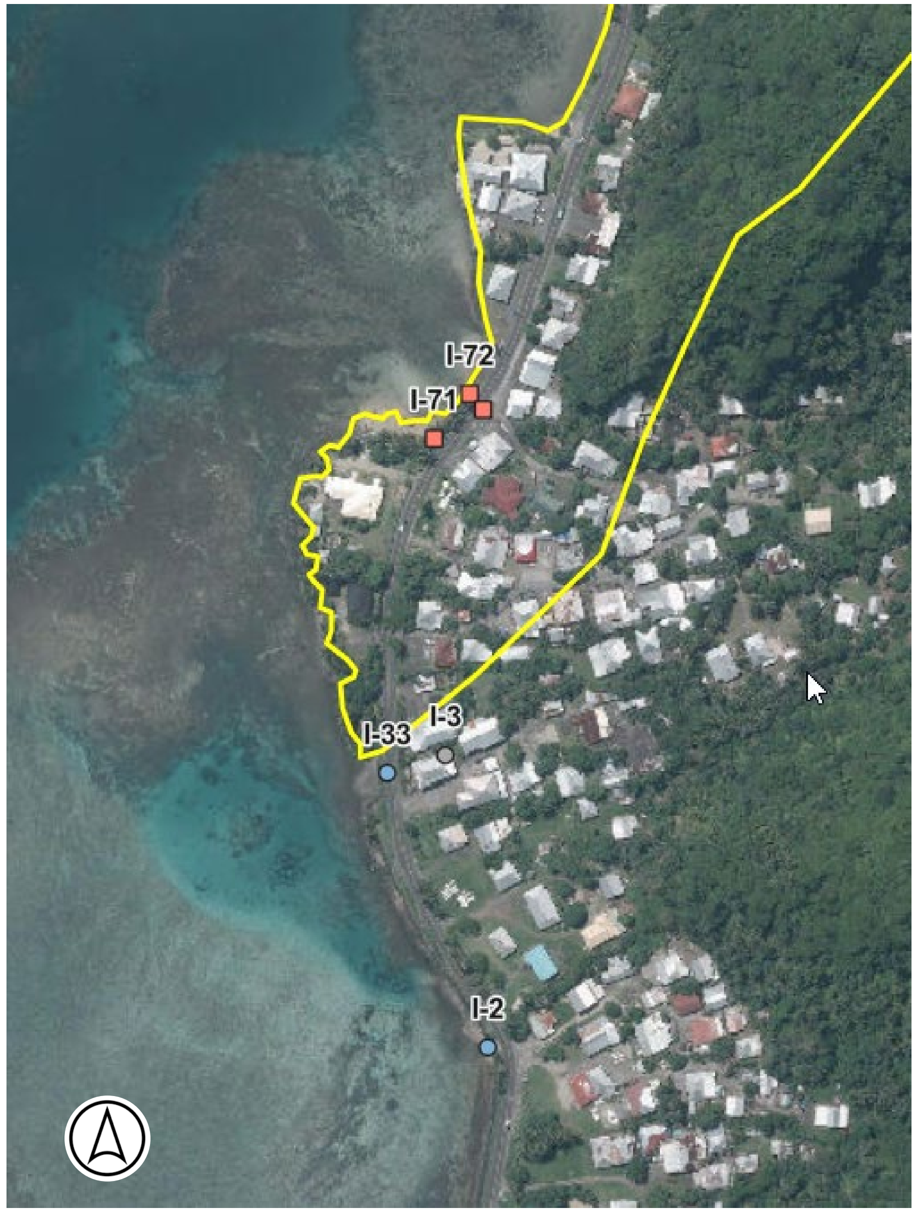
Site ID	Type	2022 Maintenance Needs	Maintenance Description	Dimensions	Invert	x	y	Notes
I-25	Inlet	None Needed				-170.664	-14.27	
I-26	Outfall					-170.663	-14.2693	Couldn't see.
I-27	Inlet	None Needed	Clean out, full			-170.663	-14.2692	
I-28	Culvert	Repair	Eroding under sidewalk	8 X 3 ft concrete box	51 inches	-170.663	-14.2691	
I-29	Bridge	Routine Maintenance		30x37		-170.666	-14.27	
I-31	Culvert	None Needed		6 x 6 RCP	8'	-170.665	-14.2676	2' of cover
I-32	Inlet	Routine Maintenance		18" PVC	36	-170.665	-14.2709	Picking up some drainage from road. Possible limitation with private property to west.
I-40	Culvert	Routine Maintenance	remove sediment	36" CMP	50 inches from top of headwall; which is a foot below road level	-170.663	-14.2712	16 inches sediment
I-44	Culvert	Routine Maintenance	debris removal	36 " CMP	80 to road	-170.662	-14.27	Stream, not on map; good condition; lt bank low wall rt is natural. Looking downstream. Boc 4 ft, toc 7. Ft, ltb ht 4 armored 60 degrees, rtb 2 30 degree vegetated
I-45	Culvert	None Needed		4 ft x 8ft concrete box	5 ft below road	-170.662	-14.2698	Eel fish passage
I-46	Inlet	None Needed		8" PVC	16 below sidewalk	-170.663	-14.2698	
I-47	Inlet	None Needed		4" PVC coming in from stone trench invert 2 ft; out is 12" pvc invert 3		-170.664	-14.27	Soggy grass
I-49	Bridge	None Needed		concrete		-170.664	-14.2707	bridge connecting to Mormon Church
I-51	Inlet	Repair	blockages causing road surface washout, carrying material downstream and clogging inlets downstream			-170.662	-14.2687	Heavy erosion on road bc inlet is blocked. Probably goes into ditch other side of road, 1 ft of cut into road surfacing
I-52	Inlet	None Needed		20" wide concrete		-170.661	-14.2688	
I-53	Culvert	Repair	cover to be replaced on bridge/culvert?			-170.661	-14.2688	Could not get dimensions because of dogs
I-62	Outfall	None Needed		24 inch RCP	43 from flume	-170.66	-14.2658	10 inches of sediment
I-63	Outfall	Routine Maintenance	clean out inlet structure	24" CMP	36	-170.663	-14.2691	Inlet blocked. Comes from upper inlet at intersection
I-64	Inlet	Routine Maintenance	clean out			-170.663	-14.2693	totally clogged, covered over causing flooding on road
I-65	Culvert	None Needed				-170.663	-14.2686	Patrick fuau says stream splits behind both sides of building
I-66	Inlet	Routine Maintenance	Needs to be cleaned out	2 ft by 30 ft		-170.665	-14.2688	Trench drain at sky view
I-67	Inlet	Replace		8 inch Ductile iron pipe where we walked with group	31	-170.665	-14.2694	
I-68	Culvert	Replace	Broken inlet grate, feel when cars go over	2 by 5 ft hard to know	2.5 to top of wall	-170.666	-14.2693	
I-69	Culvert	Repair		2' x 3' box	42	-170.666	-14.2695	
I-73	Inlet	Routine Maintenance	clean out	18 inch HDPE	44 inches from invert to road	-170.665	-14.2755	10 inches of sediment
I-74	Inlet	None Needed				-170.664	-14.2702	

MAP 3

Legend

- Open concrete ditch
- Naturalized ditch
- Unconfirmed pipe
- Pipe/flow direction arrow
- Inlet/Catch basin
- Culvert
- Outfall
- Other
- NHD Stream (HW corrected 2022)
- Aua Watershed

Site ID	Type	2022 Maintenance Needs	Maintenance Description	Dimensions	Invert	x	y	Notes
I-16	Culvert	Routine Maintenance	Clean out, replace paved flume inlet	36" RCP	54"	-170.664	-14.2731	Culvert and outlet with wall and silt socks sediment in channel; it's a mess; it floods. Sometimes oil smell, sewer install issues, floods house
I-21	Inlet	Routine Maintenance	Clean out			-170.664	-14.2703	trench drain
I-22	Inlet	None Needed	Clean out			-170.664	-14.2705	
I-23	Outfall	None Needed				-170.664	-14.2706	
I-30	Bridge	None Needed		28 ft x 30 ft		-170.665183	-14.27095561	And outfall hibiscus, barrontonia
I-34	Inlet	Routine Maintenance		Grate is 40x40		-170.6634222	-14.2719596	Can't see in.flooding in front of Fatima church
I-35	Inlet	Routine Maintenance		Grate is 48x48		-170.6633594	-14.27186072	Cant see pipe
I-36	Outfall	None Needed			48" below headwall to invert; 4"of sediment	-170.6634655	-14.27178369	Can't see% maybe an 8 inch pipe.?
I-37	Inlet	Routine Maintenance	Clean out	Maybe 18 in RCP going out maybe 12 in coming in		-170.6632611	-14.27173926	Full of gravel from road
I-38	Inlet	None Needed		12 in CMP	32 below rim	-170.6631847	-14.2716136	Only pipe we could see. Water may not really be getting here%
I-39	Culvert	Routine Maintenance		36 in CMP	50 inches from top of headwall; which is a foot below road level	-170.662936	-14.27127852	16 inches sediment , stream crossing
I-41	Culvert	Routine Maintenance	Sediment removal veg removal	36 in CMP	60 inches below top of headwall	-170.6626295	-14.2709272	16 in of sediment in bottom
I-42	Culvert	Repair	Maintenance needed around structure erosion happening at edge of road	18 in HDPE	34 in below grade	-170.6625169	-14.27065486	
I-43	Culvert	None Needed				-170.6623437	-14.27040453	
I-70	Outfall		broken	-170.665	-14.2715		I-70	concrete swale /open flume to ocean



MAP 4 & 5

Legend

- Open concrete ditch
- Naturalized ditch
- Unconfirmed pipe
- Pipe/flow direction arrow
- Inlet/Catch basin
- Culvert
- Outfall
- Other
- NHD Stream (HW corrected 2022)
- Aua Watershed

Site ID	Type	2022 Maintenance Needs	Maintenance Description	Severity	Dimensions	Invert	x	y	Notes
I-1	Culvert	Routine Maintenance	Just clean out periodically		Two 24 inch RCP	6" sediment; 41" to top of headwall; 12" headwall to road	-170.664	-14.2833	Mayor digs out stream; stream full of sediment from construction; road was crowned 10 yrs ago and messed up drainage; construction of sewer line messed up downstream side
I-2	Culvert	Repair			RCP is 24; box is 1-2 ft deep and 4.5 ft wide		-170.665	-14.2785	Temp block of stream for sewer pump install
I-3	Sewer Lateral						-170.665	-14.2772	Sewer lateral, stream mangolua
I-33	Culvert	Replace	replace trench grate cover		128 x 24" concrete	37" from road surface	-170.665	-14.2772	24" paved inlet upstream 15" trench drain upstream
I-71	Inlet	Routine Maintenance			18" HDPE and paved flume	32" to rim	-170.665	-14.2757	
I-72	Inlet	Routine Maintenance	clean out		18" HDPE	45" inch	-170.665	-14.2755	Submerged, wave action

APPENDIX C.

FIELD SUMMARY MEMORANDUM

Horsley Witten Group
Sustainable Environmental Solutions
90 Route 6A • Unit 1 • Sandwich, MA 02563
508-833-6600 • horsleywitten.com

MEMORANDUM

To: Harriet Nash, Rob Ferguson, Jewel Tuiasosopo, and Fatima Sauafea-Leau (NOAA)

From: Geoff Glover, Jonas Procton, and Anne Kitchell (HW)

Date: December 21, 2022

Re: Aua Watershed Field Findings

cc: Mayor Muaiavaona Fofoga Pila, Taotasi Archie Soliai (DMWR), Fuamai Tago (CRAG)

The purpose of this memorandum is to document field findings from a restoration assessment of the Aua Watershed conducted by the Horsley Witten Group (HW) on October 17-25, 2022. The assessment was conducted to better understand watershed conditions, identify land-based sources of pollution and other environmental issues, and to evaluate restoration opportunities to help improve water quality conditions for the adjacent coral reef. This memo also summarizes key discussions with agencies and residents and includes a list of data gaps and follow up items from field work. **Attachment A** includes our field itinerary and a flyer describing the planning project.

Shoreline marker indicating the location of the world's oldest coral reef assessment transect is in the Aua Village.

The potential restoration opportunities and watershed observations provided here will be used to inform future stakeholder meetings and, ultimately, the watershed management plan.

Watershed Inventory

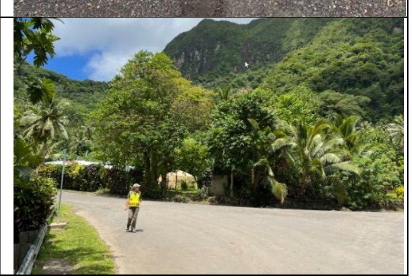
Three HW staff spent five days assessing conditions in the Aua Village and meeting with local stakeholders. Assessments focused on confirming drainage boundaries and flow paths, mapping and inspection of drainage infrastructure (inlets, outfalls, and manholes), and identifying locations and concepts for potential implementation projects. One field day was dedicated to an agency training on field assessment techniques. **Attachment B** includes a summary of what restoration opportunities were looking for in the field and a copy of the training agenda. Hard copy maps and the ArcGIS online ESRI Field Map App were both used to create a drainage system and potential projects map at **https://arcg.is/1nr8qO0.**

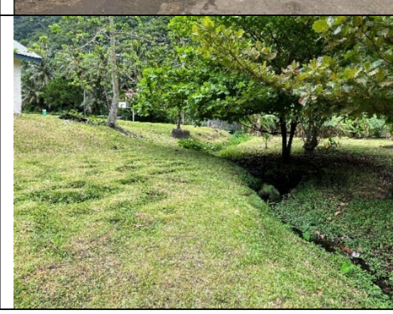
The Village Mayor escorted the field crew through the Village, taking us to known problem areas and providing insight into property ownership, maintenance capacity, and Village management priorities. We did not conduct a thorough stream assessment or collect water quality samples. The assessment focus area extended beyond the predefined watershed boundary westward to the boat ramp and southeast along the coastal road down to Onesosopo Park.

Potential Restoration Projects

We identified 17 potential restoration project sites (**Map 1**). **Table 1** summarizes the site conditions and proposed projects, in no particular order. An initial ranking was determined by the project team based on relative impact and feasibility; however, stakeholder input and a more formal ranking process will be used to identify priorities. **Attachment C** includes field sketches at most of the sites.

Table 1. *Summary of Candidate Restoration Projects*

Site ID	Type	Initial Rank	Description	Photo
1. Paved Courtyard	Other	M	Paved interior courtyard sees flooding, high runoff volumes with small, constricted outlet. Businesses and outdoor material storage could contribute pollutants via runoff. Replace/improve drainage path and outlet to stream (increase pipe size), pollution prevention (covering, education).	
2. Aua Consolidated School K-8. Home of the Rainmakers	Retrofit/ Urban Tree Canopy	M	Paved school parking lot (recently paved July 2022) with no stormwater management other than paved drainage channels that discharge to stream. Principal says it doesn't flood anymore but is really hot. Parking in internal area is unsafe for kids. Gym still floods at NW corner. Retrofit with tree filters/trenches, permeable pavers, small rain gardens. Allow parking in rear and front lots only.	
3. Unnamed Store	Stormwater Retrofit	M	Depression in front of mini-mart store, collapsed culvert under driveway has led to isolated area with overflow connection to stream. Lots of trash. Convert to bioretention and overflow to stream using existing structures. Add shade tree if possible.	
4. Road Inlet	Unpaved Road	H	Clogged catch basin causing severe road surface erosion, eroding material leading to additional blockage downstream. Clean inlet (perhaps redesign to reduce blockage potential) and resurface road with non-erosive materials.	
5. Intersection	Stormwater Retrofit	H	Two inlets clogged and wide paved intersection. The bus stops here. Clean out inlets in order to confirm drainage path. Revegetate or widen channel to church if it receives drainage from catch basin. Confirm stream channel above inlet exists. Evaluate pavement reduction/retrofit options	

Site ID	Type	Initial Rank	Description	Photo
6. Water Tank	Upland Revegetation	H	Excavation behind water tank, dumping soil downslope, no ESC, near land grant reforestation site. Cut just below guardrail of upper road. Stabilize and revegetate. Need retaining walls/gabions and better terracing for replanting. Seems like landslide potential	
7. Unpaved Access Road	Unpaved Road	M	Steep road to uppermost house on hill where spring is, highly eroded, got messed up during sewer extension. False ditch blocking ditch and gullying down surface and clogging inlet on main road. Repave or grade to insloped pitch to ditch. This should be fixed by Fletcher.	
8. Unpaved Driveway and I-73	Unpaved Road	L	Eroding driveway (another site located across from culvert with Eel). Contributes sediment to main road and clogged drain. Good demonstration project. Two track design with berm at entrance	
9. Mormon Church Parking	Stormwater Retrofit	L	Large amount of impervious cover, grass, and network of inlets, manholes, trench drains, outfalls. Runoff is piped to stream(s). Landscaping is raised curb. Few trees. Parking in back also serves as basketball court. Clean trench drains. Use grassed areas to create bio/add trees and tap into existing drainage system. Solar panel cover in rear for shade.	
10. Wetland Restoration at Mormon Church	Stream Wetland Restoration	H	Open grassed area in back of church; some stream bank erosion observed. Mowed turf. Upstream of red mangroves. Re-establish/expand floodplain and restore mangrove wetlands. Maybe the site of new residential construction. Eel in stream. Just downstream the water turned color, looked like laundry discharge. Look for illicit discharges.	

Site ID	Type	Initial Rank	Description	Photo
11. Main Stream Outlet (Lalolamauta)	Stormwater Retrofit	M	Grass roadside near beach with existing infrastructure. Shoreline to the east has minor erosion. Install a bioswale with sand filter to improve treatment. Install living shoreline/low revetment (half wall) with coir and veg above along eastern edge and protect remaining trees.	
12. Auto Yard	Hotspot Pollution Prevention	H	Auto yard, organized but backs up to stream, car washing observed, staining on gravel, excessive trash and junk in stream and buffer. Develop pollution prevention plan. Proper outdoor material storage. Target area for stream cleanup. Remove junk cars	
13. Main Road	Stormwater Retrofit	H	Ponding on road, road needs repaving by ASPA, infrastructure needs cleaning. Repave with road crown, add swale or turnouts in one section, enhance vegetation in ditches. Utility poles in ROW south of Catholic Church.	
14. Shoreline at Coral Transect	Shoreline Stabilization	L	Small area of green shoreline with large undercut (40 inches of under cut 28 inches into slope). Needs stone toe protection, beach nourishment, coir logs, and appropriate coastal plantings. This is a small area, but high visibility and is location of coral transect marker. Replant coconut trees.	
15. Stream Restoration	Stream/ Wetland Restoration	H	Stream channel impacted by sewer construction full of sediment. Buffer used for bananas, stone berm at mouth, excavation at new lift station. Stabilize banks with veg, stone protection at culvert, buffer plantings	
16. Onesosopo Park	Construction Site ESC & Park Masterplan	H	Terrible ESC on display--little effort except for dust control; major stockpiling for sewer project; construction entrance needs replacement. Conduct inspection and implement proper ESC practices. Remaining park includes grass field, fales, and a bathroom. Masterplan for park to avoid what happened at Lyons. Design for tree planting, formalized fields, rain garden, and permeable parking. Other park uses mentioned (a health clinic, fast food restaurant, and a splash pad).	

Site ID	Type	Initial Rank	Description	Photo
17. Origin Gas	Other	L	Gas tanks/storage in residential area. Ensure compliance with all required safety provisions for being located in residential area; work with Mayor on stream and shoreline buffer enhancement	
18. PT Mart and Laundry Mat	Other	L	Remove accumulated sediment and debris from upstream side of culvert. Consider replacing culvert with bridge to reduce capacity issues and sedimentation. Remove wall downstream of road and install backflow preventer (if bridge is not installed). Road may need to be raised if a bridge is constructed.	
Village-wide	Wastewater & graywater management	H	Connect laundry and outdoor toilets to sewer system, Currently, only the house toilet (or what was connected to septic system) is now connected to sewer. Need an inventory of greywater and illicit discharge pipes and a subsidy program for hookups.	
Village wide	Trash cleanup	L	Trash cleanup locations for community volunteer program run by mayor's office: Suaia stream and Rt 6 intersection, channel by auto shop down to wetland, Matagimalie stream (behind chief's new home)	

Map 1. *Potential Restoration Project Sites*

Drainage Infrastructure

We mapped over 70 drainage structures in the watershed including culverts, catch basins and drain inlets, and outfalls. **Tables 2-5** summarizes the type, dimensions, and condition of these structures. **Map 2** shows the locations of drainage structures. Almost 60% of the structures needed maintenance, repair, or replacement due to clogging or physical damage (**Figure 1**, see **Map 3**).

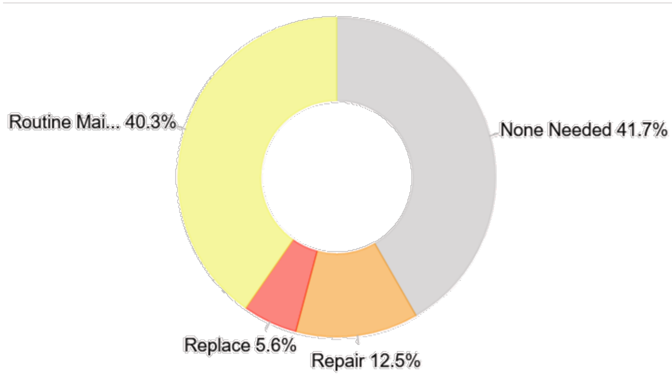


Figure 1. *Drainage Infrastructure Maintenance Needs*

HW removed debris from several inlet structures. Blockage of drain inlets with leaves, trash, and organic debris contributes to cascading erosion and flooding issues further down the road and localized flooding.

We are in the process of creating a drainage network map to show how structures are connected, where discharge points are located, revised stream flow paths, and subwatershed boundaries.

Streams

Based on field observations, we have revised the location of channels and subwatershed boundaries and are in the process of updating GIS features (**Map 4**).

Table 2. *Culverts (pipes crossing under roads and driveways)*

ID	Material	Sediment	Damage	Flow	Erosion	Maintenance Needs	Maintenance Description	Severity	Dimensions	Invert	Notes
I-1	RCP	Full	No	Stream	Low	Routine	Just clean out periodically		Two 24 inch	6 in sediment; 41 in to top of headwall; 12 in headwall to road	Mayor digs out stream; stream full of sediment from construction; road was crowned 10 yrs ago and messed up drainage; construction of sewer line messed up downstream side
I-11	RCP		Yes	Constant Stream	Moderate	Repair	Upstream scour hole, headwall damage	3	3 24 in		
I-12	HDPE					Routine	clean out trash		Two 18 in		
I-14	RCP					None Needed			36		Channel width 4.5 ft, variable depth 3.5 ft deep average
I-15	RCP	None	No	Stream	Low	None Needed			4 x 8		Eel, prawns, minnows. Check runoff bypass from road that is coming down side of headwall
I-16	RCP	Full				Routine	Clean out, replace paved flume inlet protection		36” dia	54”	Call Vert and outfall with crazy wall and silt socks sediment in channel it’s a mess it floods no SIM cards. Sometimes oil smell, sewer install issues, floods house
I-2	RCP	Full		None	Severe	Repair	Temp block of stream for sewer pump install	5	Round is 24; box is maybe 1-2 ft deep and 4.5 ft		
I-28	RCP			Stream	Severe	Repair	Eroding under sidewalk	5	8by 3 ft	51 inches	
I-31	RCP			Stream		None Needed			6 x 6	8'	2’ of cover
I-33	RCP					Replace	replace trench grate cover	2	128 x ….	37 inch from road surface	24” paved inlet upstream 15” trench drain upstream
I-39	Metal	Some		No		Routine			36 in	50 inches from top of headwall; which is a foot below road level	16 inches sediment , stream crossing
I-4	Metal	None		No	None	Routine	Uphill inlet covered in debris. Clean out	24			
I-40	Metal	Some		No		Routine	remove sediment		36in	50 inches from top of headwall; which is a foot below road level	16 inches sediment
I-41	Metal	Some				Routine	Sediment removal veg removal		36 in	60 inches below top of headwall	16 in of sediment in bottom
I-42	HDPE	Some	Yes	No	Moderate	Repair	Maintenance needed around structure erosion happening at edge of road	4	18	34 in below grade	
I-43						None Needed					

ID	Material	Sediment	Damage	Flow	Erosion	Maintenance Needs	Maintenance Description	Severity	Dimensions	Invert	Notes
I-44	Metal			Stream	None	Routine	debris removal		36 in	80 to road	Stream, not on map; good condition; lt bank low wall rt is natural. Looking downstream. BOC 4 ft, toc 7. Ft, LTB ht 4 armored 60 degrees, RTB 2 ft w 30 degree vegetated
I-45	RCP	None	No	Stream	Low	None Needed	check diversion to the left of hte headwall		4 ft x 8	5 ft below road	Eel fish passage
I-48	RCP	None	No	Stream	None	None Needed			4 ft down 6 across	69 in below grade	Box culvert water fall ar church entrance; sediment placed on top
I-50				Stream		None Needed					Steep no dog lots of trash
I-53	RCP			Stream		Repair	cover to be replaced on bridge/culvert?	3			Could not get dimensions because of dogs
I-54						None Needed			4 ft deep by 5 ft wide	56 inches below driveway	Concrete gutter starts back up
I-56		Full	Yes	Wet Weather		Routine	Need to clean out inlet		36 inch		Blocked 20 inches sediment
I-58	PVC					Repair	remove blockages, consider replacing	2			Driveway culvert that was clogged
I-6		Unknown				Routine	needs cleaning out, it is clogged				
I-65						None Needed					Patrick fuau says stream splits behind both sides of building
I-68	RCP	Full	Yes	Stream		Replace	Broken inlet grate, feel when cars go over	5	2 by 5 ft ?	2.5 to top of wall	
I-69	RCP	Some	Yes	Stream		Repair		2	2' x 3' box	42	

Table 3. *Outfalls (discharge pipe or flume to stream or ocean)*

ID	Material	Sediment	Damage	Flow	Erosion	Maintenance Needs	Maintenance Description	Severity	Dimensions	Invert	Notes
I-23						None Needed					
I-24	PVC		No	No	None	None Needed			6 or 8 in		
I-26											Couldn't see.
I-36		Some		Wet Weather		None Needed				48 inches below headwall to invert; 4 inches of sediment	Can't see, maybe an 8 inch pipe?
I-62	Concrete	Some				None Needed			24 inch	43 from flume	10 inches of sediment
I-63	Metal			No		Routine	clean out inlet structure		24	36	Inlet blocked. Comes from upper inlet at intersection
I-70	Concrete	Some	Yes	Wet Weather		Replace		2	4 ft		Broken flume to ocean

Table 4. *Catchbasins, Trench Drains, and Inlets (grated inlets taking surface runoff into a pipe)*

ID	Material	Sediment	Damage	Flow	Erosion	Maintenance Needs	Maintenance Description	Severity	Dimensions	Invert	Notes
I-10						Routine	Clean out			2.3 ft to rim; 5.4ft top of wall	No grate on this one
I-13				Constant Stream		None Needed					
I-17		None	No			None Needed			18 in pvc, 27 in below the rim outfall; 8 pvc 27 in invert from trench drain		
I-18						None Needed	probably need to clean out/clogged		Out is 8 pvc with 28 below rim, in under grass 8 in pvc 26 below rim, connects to other trench in front of interior gate		This one is in Green area
I-19						Routine	clean out				Trench drain
I-20						None Needed					Trench
I-21						Routine	Clean out				trench drain
I-22		Full				None Needed	Clean out				
I-25						None Needed					
I-27		Full				None Needed	Clean out				
I-32	PVC	Some	No	None	None	Routine			18”	36	Picking up some drainage from road. Possible limitation with private property to west.
I-34		Full	Yes			Routine			Grate is 40x40		Can’t see in.flooding in front of Fatima church
I-35						Routine			Grate is 48x48		Cant see pipe
I-37		Full		Wet Weather		Routine	Clean out		Maybe 18 in RCP going out, maybe 12-inch in		Full of gravel from road
I-38	Metal	None	No	No		None Needed			12 in CMP	32 below rim	Only pipe we could see. Water may not really be getting here%
I-46	PVC					None Needed			8	16 below sidewalk	
I-47	PVC	None	No	Wet Weather	None	None Needed			4 in coming in from stone trench invert 2 ft; out is 12 pvc invert 3		Soggy grass
I-5	Concrete					None Needed					paved inlet to inside concrete ditch
I-51					Severe	Repair	blockages causing road surface washout, carrying material downstream and clogging inlets downstream	5			Heavy erosion on road bc inlet is blocked. Probably goes into ditch other side of road, 1 ft of cut into road surfacing
I-52	Concrete	Some		No		None Needed			20” wide		
I-55						Routine	clear debris from inlet grate		2 ft HDPE	80 inches below road	Clogged at surface with debris Jonas and Jeff cleared it. Looks good in the structure. Modified

ID	Material	Sediment	Damage	Flow	Erosion	Maintenance Needs	Maintenance Description	Severity	Dimensions	Invert	Notes
											design at lip very deep ; this is where concrete gutter switches sides of road
I-57			Yes	Wet Weather		Repair		5			We cleaned: missing cover dangerous: culvert crosses. Road: can't find outfall
I-59						None Needed					
I-60						Routine					We cleaned it out looks like keeps going down road
I-61		None	No	Wet Weather	None	Routine			28 by 40 grate pipe is 24	5 ft from rim	We cleaned. Keeps flowing down road to next structure
I-64		Full		Wet Weather		Routine	clean out				totally clogged, covered over causing flooding on road
I-66			No	Wet Weather		Routine	Needs to be cleaned out		2 ft by 30		Trench drain at sky view
I-67	Ductile iron	Some		No		Replace		4	8 inch pipe walked with group	31	
I-7						Routine	clean out				
I-71	HDPE and paved flume	Some	No	No		Routine			18 inch	32 to rim	
I-72	HDPE					Routine	clean out		18 in	45 inch	Submerged, wave action
I-73	HDPE	Some				Routine	clean out		18 inch	44 inches from invert to road	10 inches of sediment
I-74						None Needed					
I-8						None Needed			(2) 18in out and (1) 18" in	3.5 to top of rim	Connected to ocean
I-9						Routine	Clean out and remove grate?	5	12 in?	2.3 ft to rim, 5 ft to top of wall	Interesting design small grate covering out pipe. Couldn't see outfall. 1 ft or more of sediment

Table 5. *Other*

ID	Material	Sediment	Damage	Flow	Erosion	Maintenance Needs	Maintenance Description	Severity	Dimensions	Invert	Notes
I-29	Bridge						Routine		30x37		
I-3	Sewer Lateral										Sewer lateral, stream mangolua
I-30	Bridge						None Needed		28 x		And outfall hibiscus, barrontonia
I-49	Bridge	Concrete			Stream		None Needed				bridge connecting to Mormon Church

Map 2. *Drainage Structures*

Map 3. Drainage Infrastructure Maintenance Needs

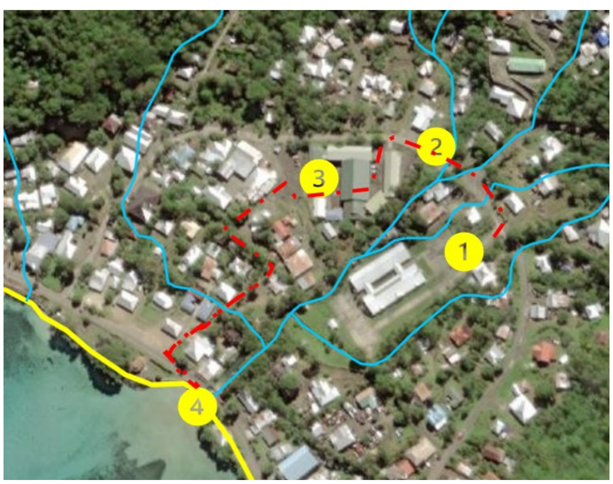
Map 4. *Revised Stream Channels (to be finalized as part of drainage map)*

Stakeholder Engagement

Jewel Tiasosopo, Fatima Sauafea-Leau, and Fuamai Tago were instrumental in establishing contact with stakeholder agencies in Aua and across American Samoa. HW was accompanied by NOAA and CRAG staff at meetings with the following agencies:

- American Samoa Community College (ASCC) – Land Grant Forestry Extension. *The Land Grant program promotes native plantings, operates a nursery, and has at least one residential stewardship site in the watershed.*
- American Samoa Environmental Protection Agency (ASEPA). *The ASEPA has program funding to support community solid waste removal and disposal efforts and improved piggery management. They are agengy lead on activities related to cleanup of oil tank farm.*
- American Samoa Power Authority (ASPA). *Have extensive information on sewer upgrades, remaining disconnections, and pending drinking water distribution line changes. Construction efforts have impacted roads, drainage infrastructure, and streams.*
- Department of Commerce (DOC) Coastal Zone Management (CZM). *Confirmed PNRS process and lack of management for residential development or wetland protection.*
- Department of Marine and Wildlife Resources (DMWR) and the Coral Reef Advisory Group (CRAG). *Confirmed declining quality of adjacent reef and marine habitat, bat roosts in urban center, and current update of forest service plots in the watershed. Interested in potential for improving mangrove wetland to support waterfowl and use of vegetation as component of shoreline stabilization. Acknowledgment that further investment in marine habitat restoration would not make sense without efforts to improve watershed conditions.*
- Department of Public Works (DPW). *Responsible for roads and drainage maintenance; strong support for hard stabilization of shorelines.*

Notes from these meetings can be found in **Attachment D**. In addition to these agency meetings, our team conducted a ½ day workshop with agency staff from Department of Fish and Wildlife and from AS EPA on watershed assessment. We also met with the Village Council, with representation by Fatima (meaning she translated and explained to us what we were supposed to do) and attended a Sunday church service with the Mayor and Fatima to meet Aua residents. We were unable to meet on-site with Bernardo Vargas-Angel and the NOAA monitoring team due to a COVID related delay in our field schedule.



The watershed assessment workshop included four field stations where participants were tasked with identifying drainage patterns, problems, and potential solutions.

General Findings

Some of the key land-based pollution issues that we observed and discussed with stakeholders are summarized below. There are several active requests for additional information to help clarify some of these issues prior to drafting preliminary watershed recommendations.

1. LAND DEVELOPMENT HAS IMPACTED WATERSHED HEALTH.

Although the Village population is not growing significantly – and may in fact be decreasing – there has been increasing development over the past few decades. Increasing impervious cover have led to increased surface runoff, flooding, water quality degradation, urban heating, and aquatic habitat loss. Development projects are required to undergo permitting through the Project Notification and Review System (PNRS), in which several agencies including ASEPA, DMWR, and DOC review proposed development. A lack of zoning, floodplain restrictions, and development standards, make it difficult to manage urban growth and maintain important watershed services, especially with no requirements for onsite stormwater management. Property boundaries and setbacks are not visibly demarcated, and stream/wetland buffer protections are not enforced. Residential construction frequently includes alterations to the stream corridor including clearing, filling in the floodplain, channelization, and dumping. Development patterns in the Village include new home construction or renovations adding an additional story. Some new construction appears to be elevated and some includes the conversion of former foundations to a family fale. Erosion and sediment control is not required for small residential construction and dis not appear to be enforced for larger capital projects (i.e., sewer line upgrades). Due to limitations on available space in the Village, development moving forward will be either redevelopment and infill, or new construction moving up into the hillside.

(TOP LEFT) No erosion controls or stream protection next to residential infill construction site. (TOP RIGHT). New construction in the floodplain. (BOTTOM LEFT) Elevated first floor. (BOTTOM RIGHT) Development on the steep slopes.

2. STREAM & WETLAND RESTORATION WILL BE CHALLENGING.

Streams throughout the Village are narrow (wider in the headwaters and narrower as you get into the Village), highly channelized (vertical walls or piped), and rerouted around buildings. Stormwater is discharged directly to streams with no pretreatment. Channels are frequently filled with trash and debris, and development encroaches all the way to the top of bank. Lack of vegetation along the banks of most streams and loss of floodplain connectivity results in reduced stream shading, habitat loss, and flood storage. Villagers tend to perform maintenance on streams by removing vegetation from within the banks. In a few instances, culverts with elevated drops created barriers to fish, eel, and other aquatic species passage. The Leasi and Lalolamauta streams have baseflow; other streams are reported to flow intermittently. Most streams were flowing during our assessment and eel, shrimp, tadpoles, and small fish were observed in lower reaches. There is little space for stream/floodplain restoration without impacting homes or roads. Historic accounts of a 9-acre central wetland in the Aua Village are hard to envision. Most of this wetland has been filled for development. A small red mangrove system remains extending from the beach up to Mormon Church.

Most streams in the Village converge with Lalolamauta Stream in the center of the Village near the mangrove wetland, which outlets to Pago Pago Harbor under a bridge. The remaining streams (Leasi to the west and 3 other unnamed streams to the southeast) are culverted under Route 001 before discharging to the Harbor. Residents frequently stated that culvert outlets are submerged or otherwise that culverts are low gradient, resulting in sediment accumulation and flooding upstream of outfalls. Submerged outfalls, blocked coastal inlets, and storm surge are contributing to system backups and will continue to worsen as sea levels rise.

(LEFT) Matamigalie Stream near its confluence with Lalolamauta Stream. Water in Matamigalie is turbid, and stream banks are confined by vertical stone walls. (RIGHT) Remaining mangrove system looking downstream.

3. EXTENT OF WWII FUEL TANK FARM SOIL AND GROUNDWATER CONTAMINATION IS UNKNOWN.

In 1938 and 1939, the United States Navy constructed twelve 10,000-barrel above ground steel fuel storage tanks, 13 pump houses, and a 12-inch pipeline delivery system throughout Aua (to canneries). The Farm was for bulk fuel oil storage and distribution to support Naval Station Tutuila during World War II. By 1945, the tanks were dismantled/drained (<5,000 barrels remaining). The fuel farm area was re-graded and flat areas were overlain with 5 to 10 feet of volcanic cobble and boulder of various sizes used as rock fill. As such, any tank remnants are expected to be buried under the rock fill (USACE, https://govtribe.com/file/government-file/w9128a20r0008-petroleum-contaminated-soil-removal-aua-island-of-tutuila-american-samoa-dot-pdf). Between 1989-1991, it was confirmed that petroleum hydrocarbons were present in several areas of the village including along the transmission pipe along the coast (Samoa News, 2/25/19 https://www.samoanews.com/local-news/metal-remnants-third-ww-ii-fuel-storage-tank-found-aua-village?qt-quicktabs=1&qt-photos_videos=0). During the course of those investigations, 9 of the 12 tanks were located (Tanks nos. 4–12); Tank No. 7 could not be found, and Tanks nos. 1–3 were not part of the request for investigation. Large volumes of petroleum impacted soil were encountered during investigations at the various tank sites. Subsequently, bioremediation by oxygen pellets and thermal treatment were used at different stages to treat the contamination. All active remediation efforts ceased in 1999 with the shutdown of the bioremediation system. Subsequently, on three separate occasions between 2018-2021 construction activities exposed contaminated soils—most recently with the sewer line extension. Remediation efforts led by ERRG included thermal treatment (ex situ), reuse petroleum-contaminated soil, as well as in situ bioremediation and extensive (and ongoing) monitoring. ERRG has installed monitoring wells in the Village to better understand potential plume movement, and the Mayor collects groundwater data regularly. More information is needed to better understand the overall impact of hydrocarbon contamination in the watershed and marine ecosystem.

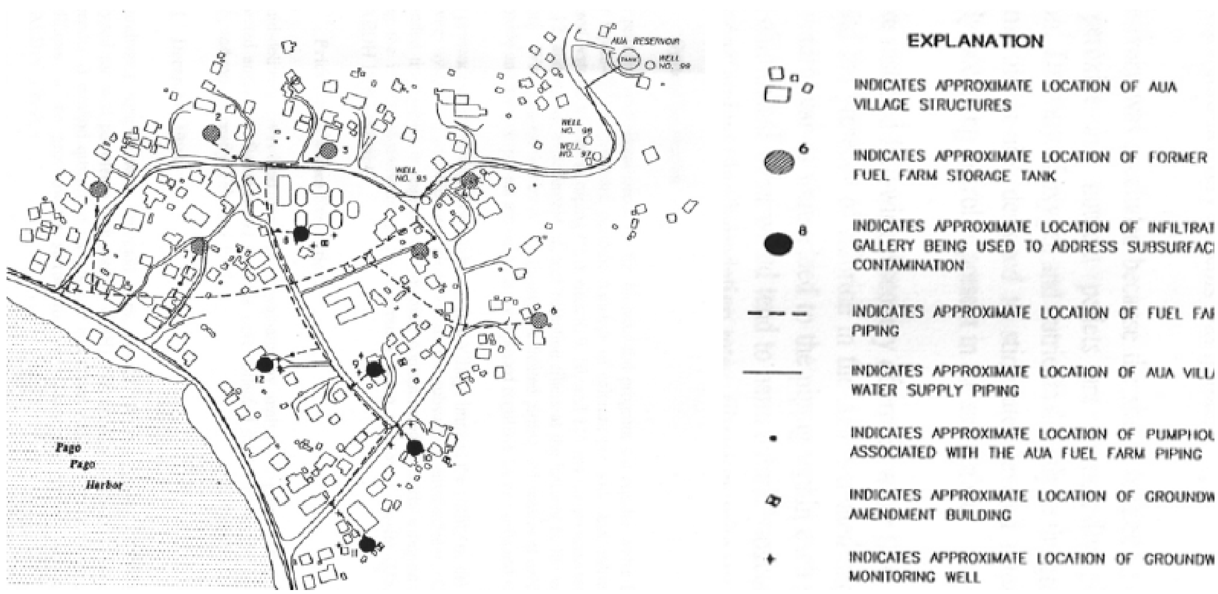


Figure taken from US EPA, 2011 fact sheet showing locations of tansk and distribution lines (http://www.epa.as.gov/sites/default/files/documents/brownfields/aua_fuel_farmoct2011.pdf)

4. THE AUA SEWER EXTENSION IS BOTH A BLESSING AND A CURSE.

ASPA has completed Phase 1 of a sewer expansion project along the east side villages of the Pago Pago Harbor (Package 5), connecting 100% of the Aua Village (ultimately ~ 300 homes) to the Utulei Wastewater Treatment Plant. The second and final phase of Package 5 is and nearing completion. This is a significant, long-term watershed restoration activity for reducing nutrient and bacteria loading. In addition, ASPA reports that only pipes directly connected to former septic systems are now connected to the sewer line (toilets, sinks, and showers). Remaining pipes that discharged directly to streams (e.g., laundry, outdoor toilets) are still not connected. Connecting these remaining discharges to the sewer system would likely be the most impactful action for reducing pollutant loading of Aua to the Pago Pago Harbor. ASPA informed HW that funds for sewer extension will be depleted with the conclusion of

Package 5 Phase 2, and additional funding would be required to connect remaining discharges. In addition, construction activities have had a major impact on road conditions and the drainage network. Very few erosion and sediment control practices were being used during our assessment (except for dust control), although it was reported that earlier phases of the project did a better job. Every steam, culvert, catch basin and inlet located near active construction was full of sediment. Construction staging area had no functioning perimeter controls (construction entrance, silt fences, etc.). Roads heading up into the Village and hillside residences were in rough condition where pipe extensions were installed. Repaving of the road network should be done in a way to better manage stormwater (provide treatment and minimize flooding).

(TOP LEFT) ASPA East Side Villages Wastewater Collection System project map. (TOP RIGHT) Lift station installation in stream. (MIDDLE LEFT) Direct pipe to stream. (MIDDLE RIGHT) New lateral hookup to sewer at a residence. (BOTTOM LEFT) Sediment laden runoff on main road. (BOTTOM LEFT) Sedimentation from construction in channel discharging to ocean.

5. REGULAR DRAINAGE INFRASTRUCTURE MAINTENANCE WOULD HELP A LOT.

Aua is not alone in its poor maintenance practices. Most of the inlets and culverts we saw were clogged and could use regular cleaning. There were several locations where clogged pipes were causing flooding or leading to additional infrastructure damage.

6. THE AUA WATERSHED IS NOT A PRIORITY FOR UPLAND HABITAT CONSERVATION, YET.

The heavily forested upland of the Aua Watershed is not designated as a high priority habitat for conservation per the ASCC Land Grant Forestry Extension, but they do have an active residential forest stewardship project in the watershed (near the ASPA water tank). The steepness of the terrain has limited past inventory efforts; however, the U.S. Forest Service has a single Forest Inventory Analysis (FIA) plot in the forested upland, which was actively being updated while we were on island. DMWR operates a bird acoustic monitoring station at the top of Mount Pioa (“Rainmaker Mountain”) to detect nesting seabirds. Few invasive plants have been identified in the forested area of the watershed relative to other Villages. Several trees serve as roosting habitat for the bats that are indigenous to Tutuila. The Forestry Extension has been monitoring the condition of mangroves in the watershed with support from DOC staff for at least 6 months and supports restoration projects by recommending or providing appropriate tree species. The *taloa* species of duck is endemic to Aua and is monitored by DMWR.

(LEFT) Mt. Pioa and heavily forested upper region of Aua Watershed. (RIGHT) Bat rookery right on the main road.

7. THE APPROACH TO SHORELINE STABILIZATION SHOULD INCLUDE NATURE-BASED SOLUTIONS.

Much of the shoreline in Aua is hardened and coastal erosion was observed in only a few locations. Policies and attitudes towards shoreline stabilization practices vary among agencies. DPW maintains and repairs shorelines that present significant erosion concerns. DPW repairs are typically hard armor solutions such as rip rap boulders, stone or concrete piles, or interlocking concrete blocks. This is true even in setting with low wave energy or tidal variation. DPW also noted that a standard practice during shoreline repairs is to remove coastal trees due to concerns of hard armor solutions being undermined by roots. Forestry Extension, DMWR, and DOC expressed a preference or interest in either avoiding coastal tree removal or attempting living shoreline restoration techniques (i.e., beach nourishment and coastal plantings) where feasible (in areas protected by fringing reef or low energy shorelines). Hybrid solutions with low boulder walls/toe protection and a combination coir log backfilled and planted could be tested at some key locations. Loss of shoreline trees also contributes to reduced shade/heat protection, habitat and species diversity, and aesthetics.

Shoreline erosion in the vicinity of the Aua Coral Transect marker

8. SOLID WASTE MANAGEMENT COULD BE IMPROVED.

Proper solid waste disposal was identified as a challenge among community members. The Mayor has organized past solid waste cleanup activities in the Village. ASEPA offers waste collection supplies for community groups to utilize, although it does not appear that the Village has acquired waste removal supplies through ASEPA in the recent past. ASEPA also enforces regulations for removal and disposal of non-operating vehicles. Disposal of residential non-operating vehicles and other scrap metal is coordinated between ASEPA and Villages at no cost; commercial disposal is performed at cost. ASPA waste receptacles are located throughout the Village, and waste collection occurs three times per week. We have seen worse on Tutuila than what we observed in the Aua watershed, however, there are several locations where volunteer trash collection events could focus, especially along the stream corridor behind individual residences.

9. POLLUTION PREVENTION OPPORTUNTIES EXIST IN THE WATERSHED.

Some land uses have the potential to generate higher pollutant loads than typical urban areas, such as the construction sites (sewer project staging area, current and pending drinking water system upgrades); the auto yard in northeast section of the Village; and the Laundromat adjacent to Skyview Store and Tent Rental. According to ASEPA, there is currently no system for tracking or specifically regulating land uses with higher potential pollutant loads. ASPA has multiple large scale projects in the watershed that need to inspect/enforce approved pollution prevention plans (sewer expansion and Water Tank and pending 8" distribution line Village bypass). In fact, the excavation behind the Water Tank should be inspected to ensure the cut will not impact the stability of the upper road and to develop a plan for stabilizing cut material that was cast downslope. Animal operations are also considered high pollution generators. Waste from piggeries can have an impact on water quality. ASEPA is tracking three piggeries in the Village. This signifies a reduction in piggeries over the past few decades. We did not see any active piggeries and were unable to evaluate management condition or opportunities for improvement.

(LEFT) *Automobile shop and lot. (RIGHT) Excavated material cast downslope at Water Tank construction site.*

10. ENGAGE AGENCIES AND STAKEHOLDERS IN WATERSHED EDUCATION.

Little environmental education programming is reported to have occurred in the Village over recent years, according to representatives at the Forestry Extension, DMWR, and the Aua Consolidated School (a public school serving students between Kindergarten and 8th Grade). The Forestry Extension offers environmental education programming on a general basis, which one individual in the Village has engaged in.

Next Steps

This memo is intended to document initial impressions and findings from our assessment of the watershed and what we learned from agencies and residents. Next steps in the watershed planning process include:

1. Adjust watershed boundary, drainage, and stream map to reflect field observations.
2. Coordinate with local partners to fill remaining data gaps:
    a. Mayor's report on Navy fuel tanks from ERRG
    b. ASPA- GIS mapping for water and sewer lines, estimate on number of homes/% remaining discharges to stream
    c. ASEPA – water quality data from stream and beach monitoring program
    d. DOC—Sandra has a 6-month progress report on Mangroves and Talimoni Farm (supported by Forestry Extension)
    e. ASEPA- reef flat survey data
    f. NOAA--Bernardo survey data
    g. ASEPA/DOC--Confirm wetland setbacks, for pesticide, structural setbacks, etc
    h. DPW-details of curbs and drainage structures, unit costs for typical materials
    i. DMWR – names of engendered snails and other animals in the watershed
3. Model watershed pollutant load and reduction potential to evaluate the benefit of potential project implementation;
4. Conduct public and agency meetings to get guidance on watershed management priorities and identify projects for further design development;
5. For priority projects, develop concepts and planning-level cost estimates;
6. Develop a watershed plan that summarizing conditions, recommendations, priority actions, and best management practices for Aua; and
7. Identify one priority project and return to Aua to implement it as a demonstration project as a reference for future green stormwater projects.

ATTACHMENT A

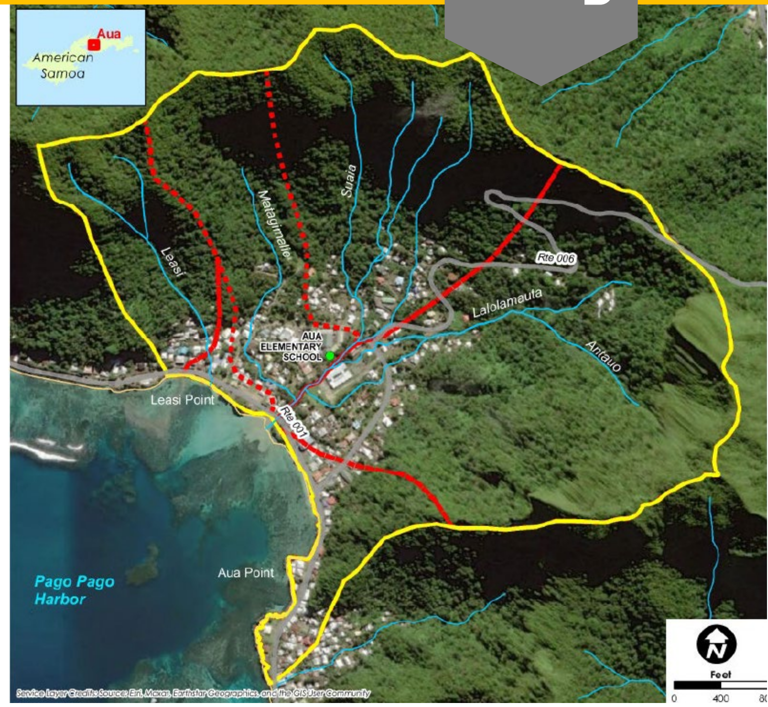
ITINERARY
PROJECT HANDOUT

Watershed Assessment Itinerary—Aua
10/30/2022

Date	**Activity**
Monday, Oct 17	Travel
Tuesday, Oct 18	**Preparation Meeting at NOAA office with Fatima and Jewel.** **AM Watershed recon & mapping** • Make sure subwatershed boundaries are correct • Map drainage infrastructure **Meet Mayor**
Wednesday, Oct 19	**Council meeting with village chiefs.** **Prep for Training:** (e.g., school or church, road/culvert, stream, shoreline, revegetation, providing lunch) **Watershed Assessment—**anywhere folks direct us or want to show us
Thursday, Oct 20	**Meetings with:** • ASPA • AS EPA • CRAG • College- Land Grant • DFW • DPW More prep for training, if needed.
Friday, Oct 21	**Watershed restoration training** -1 hour indoors, purpose and GI intro -2-3 hours outdoors—go to sites, be drainage detectives, come up with solutions
Saturday, Oct 22	**Public Meeting in the AM** • What are agency programs or utility priorities relevant to Aua • What can we integrate/support with watershed recommendations? • What plants are they growing/planting • Any other information
Sunday Oct 23	**Church service** • Use day to go back to sites or fill gaps in our assessment • Computer time to draft up watershed recommendations **Tour other GI projects around island**
Monday, Oct 24	**Debrief with Mayor and NOAA** **Travel**

NOAA CORAL REEF CONSERVATION PROGRAM

AUA WATERSHED MANAGEMENT PLAN 2023



PROTECTING THE WORLD'S OLDEST REEF SURVEY SITE...

flood mitigation • erosion control • replanting native forests • shoreline stabilization • stream habitat restoration • dry compost piggeries • trash cleanup • invasives management • stormwater retrofits • Community projects • wastewater upgrades • watershed education • Lotonu'u

Photos: www.kaust.edu.sa

WHAT WOULD YOU FIX?

If you could change or improve ONE THING in the Aua watershed, what would it be? Where would it be? Drop a pin on a map & tell us about it!

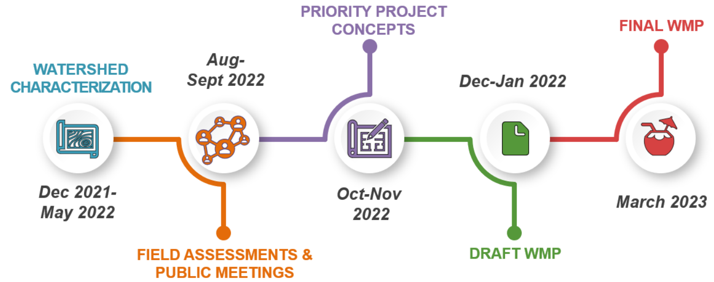
SHARE YOUR OPINION

What are the biggest watershed issues and most important restoration actions we should focus on? 5 minute survey = 5 years of action!

CONTACT US

Jewel Tuiasosopo, NOAA AS CRCP & CZM liaison
jewel.tuiasosopo@noaa.gov
Fatima Sauafea-Le'au, NOAA
fatima.sauafea-leau@noaa.gov
Anne Kitchell, HW (off island)
akitchell@horsleywitten.com

SCAN ME



HTTPS://AUA-HORSLEYWITTEN.HUB.ARCGIS.COM/

ATTACHMENT B

FIELD ASSESSMENT SUMMARY
TRAINING FLYER

WATERSHED ASSESSMENT CHEAT SHEET

Table 1. Drainage Infrastructure Form Information

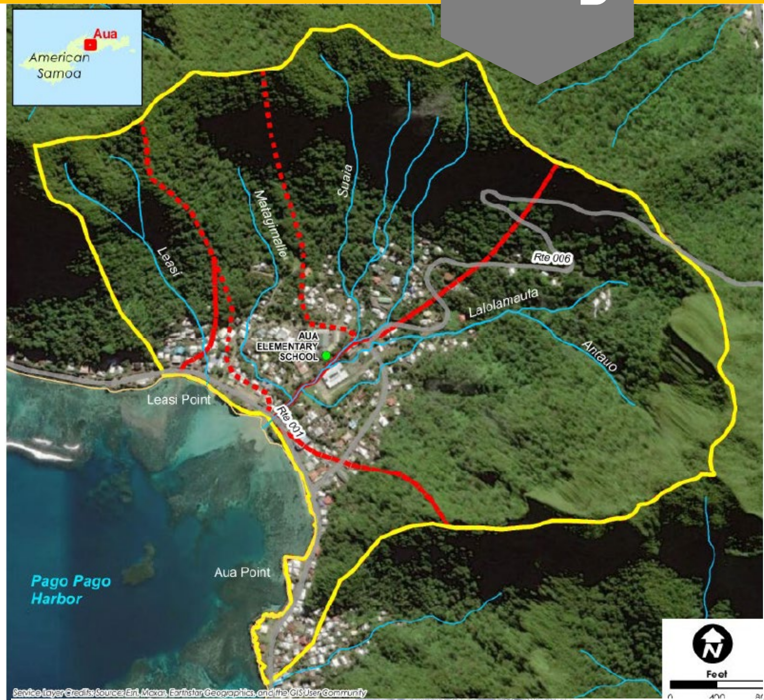
Type	Info Needed	Opportunities
Culvert **Outfall** (not stream mouth or outlet) **Inlet/Catch basin (CB)** **Manhole** **BMP** **Other**	• Location name or ID (if helpful) • Your name (if needed) • Date (should auto-populate) • Type of structure (choose from drop down) • Material structure made of (select primary from drop down) • Dimensions (typically of pipe width or grate, but this is open text. • Pipe invert or other critical elevations (top of road) and if there is a sump in a CB • Observations- is it full of sediment, damaged, is there flow, erosion? • Maintenance needs- routine, repair, or replacement (pls describe) • Severity of damage (1 to 5 scale, 5 being severe due to safety or vulnerability) • Notes and photos	• Routine maintenance, repair, or replacement • Reduced flooding • Public health & safety • Infrastructure protection • Part of bigger project • Improved resiliency • Reduced erosion or impacts on resources • Water quality improvement • Fish/aquatic insect passage

Table 2. Restoration Opportunities Form Information

Project type	Info Needed	Opportunities
Stormwater Retrofits Projects to better manage stormwater from existing impervious cover using green stormwater infrastructure (bios, infiltration, permeable pavers, etc)	• Describe existing condition and what proposed restoration might entail • Contributing drainage area • Source of problem, pollutants of concern and description of land use activities • Type of practice • Conveyance mechanism and pretreatment • Constraints: soils, groundwater issues, utilities, etc • Space available/footprint of practice • Public vs. private—who will do O&M? • Access and visibility	• Upgrade existing BMP • Improve water quality, reuse, or flood control using new BMP • Encourage GI • Add trees or provide other co-benefits • Education opportunity
Unpaved Road Improvement Projects to regrade or install drainage practices like dips, check dams, cross drains, strategic paving) on existing unpaved roads or parking lots	• Length of segment • Type and location of erosion (surface, ditch) • Is there offsite drainage • Shoulder and road dimensions • Slope (flat-steep) and pitch (crowned, inside, outside) of segment • Are there places to discharge? • Traffic volume • Public or private road	• Diversions, • cross drains, water bars, • dips, • turnouts • traps • slope stabilization • resurfacing
Coastal Shoreline Stabilization Projects to address eroding shorelines or restore mangroves/ coastal vegetation	• Length/height of eroded area • High or low energy area • Substrate and surrounding vegetation • Access • Upland land use	• Living shoreline • Replanting/vegetate upland • Infrastructure protection • Hard structure or combo • Repair existing feature • Retreat?
Stream/Wetland Restoration Projects to stabilize stream channels, improve buffers, expand floodplains, and/or restore freshwater wetlands	• Cross section dimensions and length of impacted area • Rate bank erosion/bed scour • Channelization • Trash/debris • Invasives • Buffer impacts • Access and other constraints • Cause of problem?	• Habitat restoration • Infrastructure protection • Reduced erosion, bank stabilization • Link to upland volume controls • Improve buffer • Invasives removal • Replant vs natural revegetation • Reconnect to floodplain
Upland Revegetation or	• Description of area & Cause of problem	• Invasives removal

Project type	Info Needed	Opportunities
Invasive Management For projects mostly outside of the stream or shoreline buffer; landslide prevention; hydroseeding	• Ownership info • Estimated size • Access limitations	• Replant vs natural revegetation • education
Wastewater Improvement System improvements (pump stations, service extensions, package systems) or onsite septic upgrades, illicit discharges	• Specific location • Residential vs other use • Dry or Wet weather, Smell, Color, Suds • Discharge point • Source, if known • Public vs. private • Type: Violation (intentional dumping) or accident (unintended spill)	• WQ improvement • Health and safety • SSO or pump repair • Upgrade or repair OSDS • IDDE and monitoring • Behavior change/education (dumping washwater) • Connect to sewer • WWTP upgrade or package system
Construction Site ESC Issues specific to construction activities or site clearing	• Site name/location • Contractor • Permit # • Describe BMPs in use/failures • downstream/offsite impacts	• Propose BMP installation or maintenance recommendations • Report problems
Hotspot Pollution Prevention/site remediation Mostly non-structural opportunities (non-retrofit) to reduce pollutants at agricultural, commercial and industrial properties	• Land use/description of activities at site • Observed pollutants • Violations? • Contact info • Storm drains on-site • Nearby wetlands/water resources? • Do they have a SWPP or NPDES permit? • Piggeries • Water useage	• Structural and non-structural • Monitoring • Trash cleanups/Dumpster cover • Spill prevention • Outdoor material storage • Landscaping • Vehicle maintenance/ washwater-dedicated areas • Animal waste management • Buffer encroachment/restoration
Residential Stewardship If able to generalize about a group of homes/neighborhood's potential to collectively reduce pollution (non-retrofits)	• Neighborhood/area delineation • Project contact (HOA)/advocate • Community gathering place? • Confirm sewer/septic • Curb/gutter? SW BMPs?	• Lawn care • Pet waste • Connect to sewer • Downspouts or driveway disconnection • Buffer enhancement • Vehicle maintenance • Trash management • Common space mgmt
Watershed Education/Signage Any spot outside of a specific project site that would be good for signage or to target with messaging?	• Describe location • Who is target audience? • What is the message? • Describe activity or signage?	• Improve watershed awareness • Build community support • Incorporate into E&O plan
Land Conservation This may be hard to see in the field, but maybe during conversations with stakeholders if areas are identified.	• Public vs. Private • Surrounding Land Use • Replanting vs Natural Regen • Use (park vs. natural) • Goal (e.g., education, expand buffer, flood control, habitat) • Contact info	• Habitat protection • Preserving hydrologic functions • Improved resiliency

AUA WATERSHED ASSESSMENT TRAINING



HONE YOUR SKILLS AT DRAINAGE DETECTION AND RESTORATION VISIONING

WHEN: Friday, October 21st

TIME: 8 AM - Noon

WHERE: NOAA PIRO Conference Room

AGENDA

8:00 AM Sign In & Coffee
8:15-8:30 Welcome & Introductions
8:30-9:00 Watershed Assessment & Green Infrastructure
9:00-12:00 Field Trip to Aua Sites
Lunch

WHAT YOU NEED TO BRING

Safety vest, water bottle, and something to write with. We will be measuring pipes, looking at parking lots, and walking the shoreline (no hiking through steep streams). You will have a chance to sketch your ideas for potential restoration projects that can be included in the Aua Watershed Plan.

REGISTRATION

No cost. Lunch will be provided. Please contact **Jewel Tuiasosopo**, AS CRCP and CZM liaison if you or your staff are interested in participating.

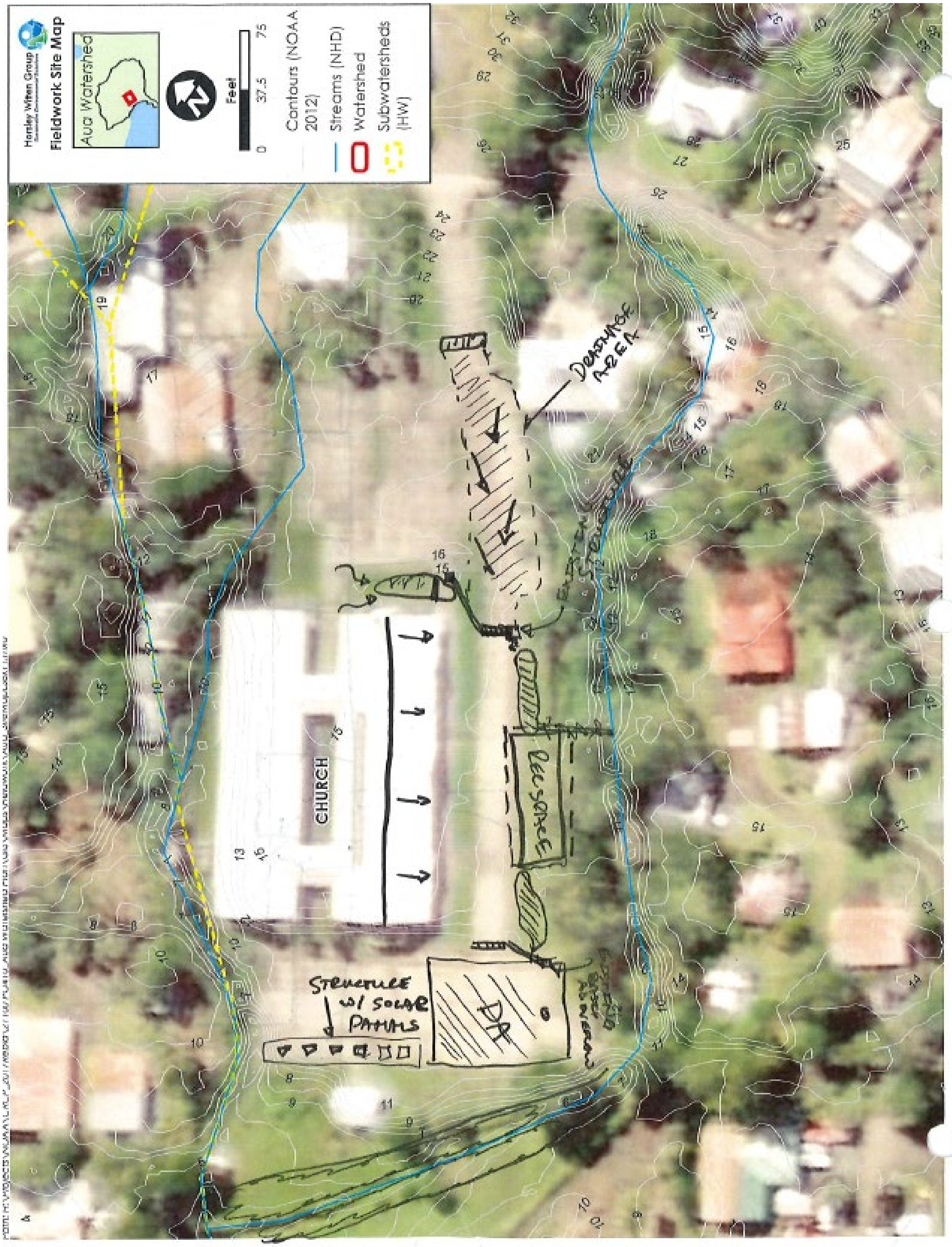
jewel.tuiasosopo@noaa.gov

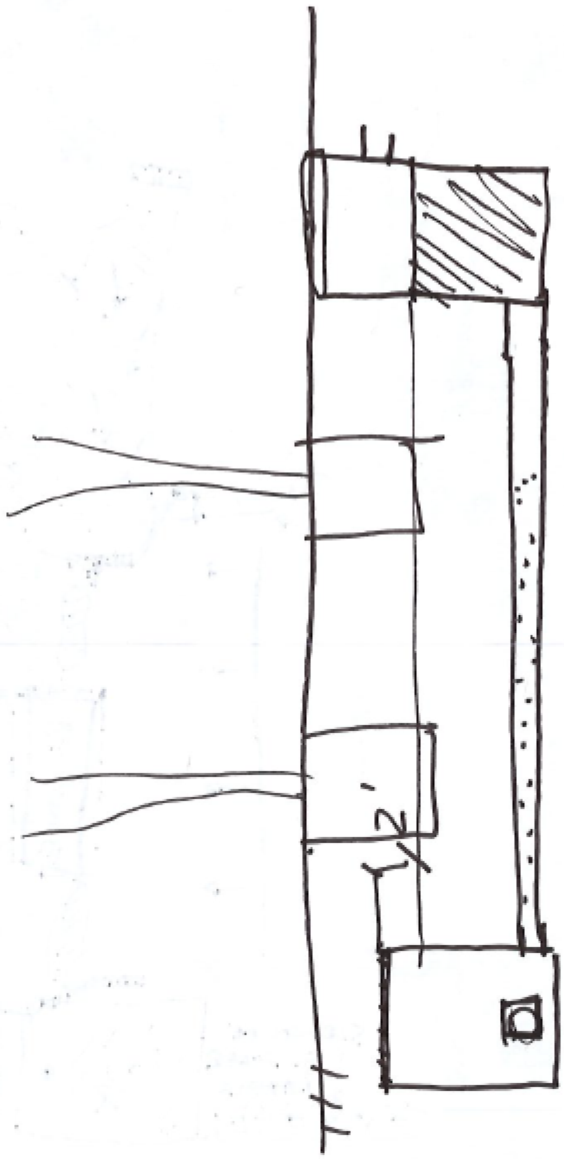
FOR INFORMATION ON THE AUA WATERSHED PLAN 2023 , VISIT HTTPS://AUA-HORSLEYWITTEN.HUB.ARCGIS.COM/

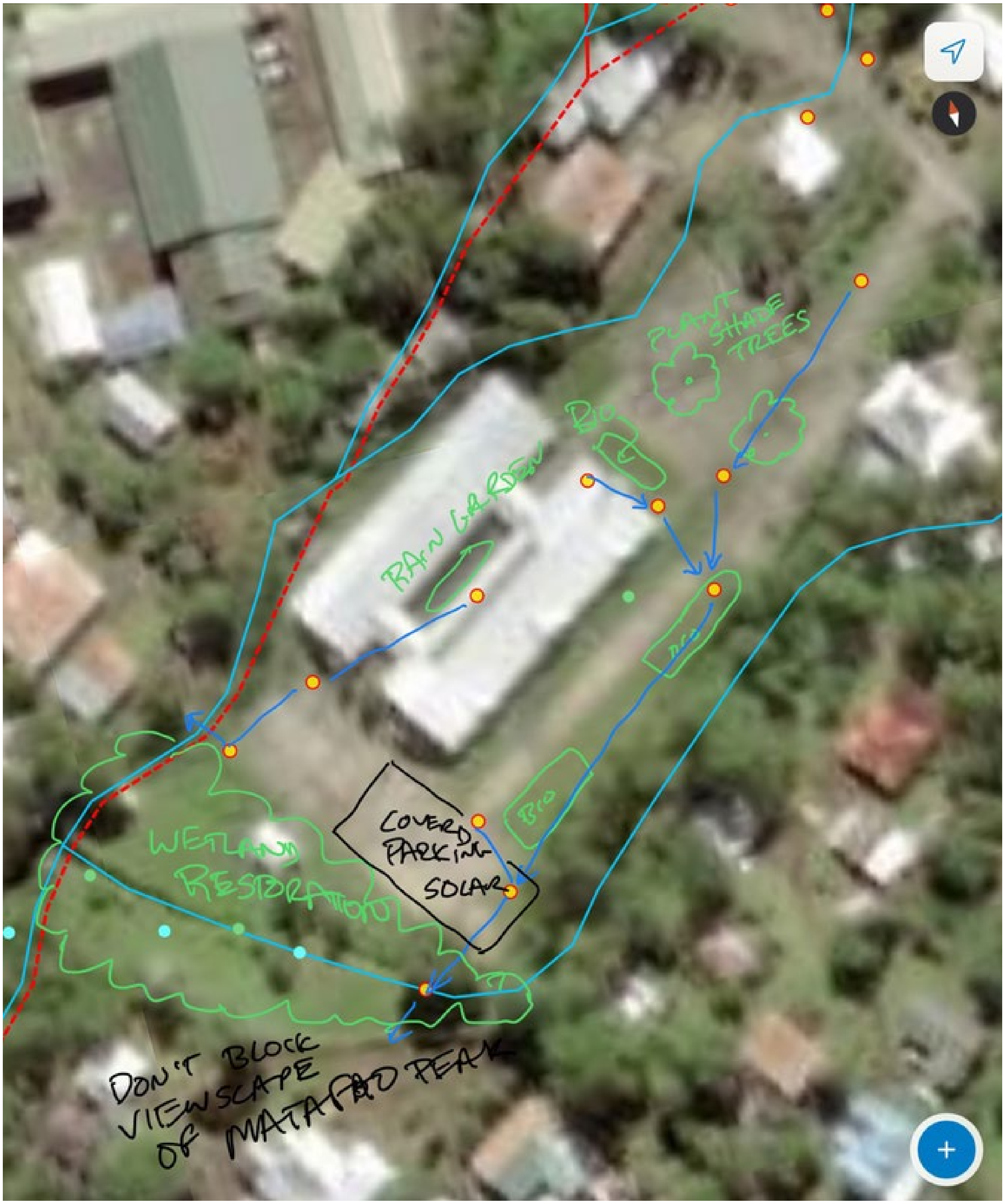
ATTACHMENT C

FIELD SKETCHES

MORMON CHURCH




1/2'


PLANT SHADE TREES
BIO
RAIN GARDEN
BIO
COVERED PARKING SOLAR
WETLAND RESTORATION
DON'T BLOCK VIEWSCAPE OF MATAFAO PEAK

BIO
BIO/ RAIN GARDEN
BIO
Ex. BB Culvt
Divert outfall to SED FOREBAY
SOLAR COVER PARKING
MODIFY EX. OUTFALL SED FOREBAY
EXPAND FLOODPLAIN
CHANNEL RESTORATION
RED MANGROVE / WETLAND RESTORATION

Reverse osmosis.

65% DONE

PVC PIPE - WATER

3 DEEP.

DONE

TO - DO

LIST OF TYPICAL UNIT COST

FROM & DPW → RUBEN.

10/24/22

MORMON CHURCH STREAM X-SECTION #1

STATION	50.5	49.5	48	46	38	33	23	11	2FT	0
	BOTTOM OF BANK 82"	E.O.W 74"	61"	TOP OF BANK 55"	54"	41"	33"	30"	28"	BANANAS

STATION	DEPTH	NOTE
51.5	89"	~~Thalweg~~
55.5	80"	BOTTOM OF BANK
56.5	77"	Edge of water
58	58"	

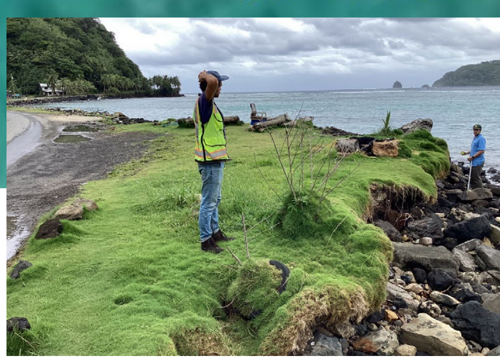
59.5	53 inch	top of bank
64	53 inch	
68.5	35 inch	
73.	25 inch	
79	17 inch	
84.5	0 inches	

2

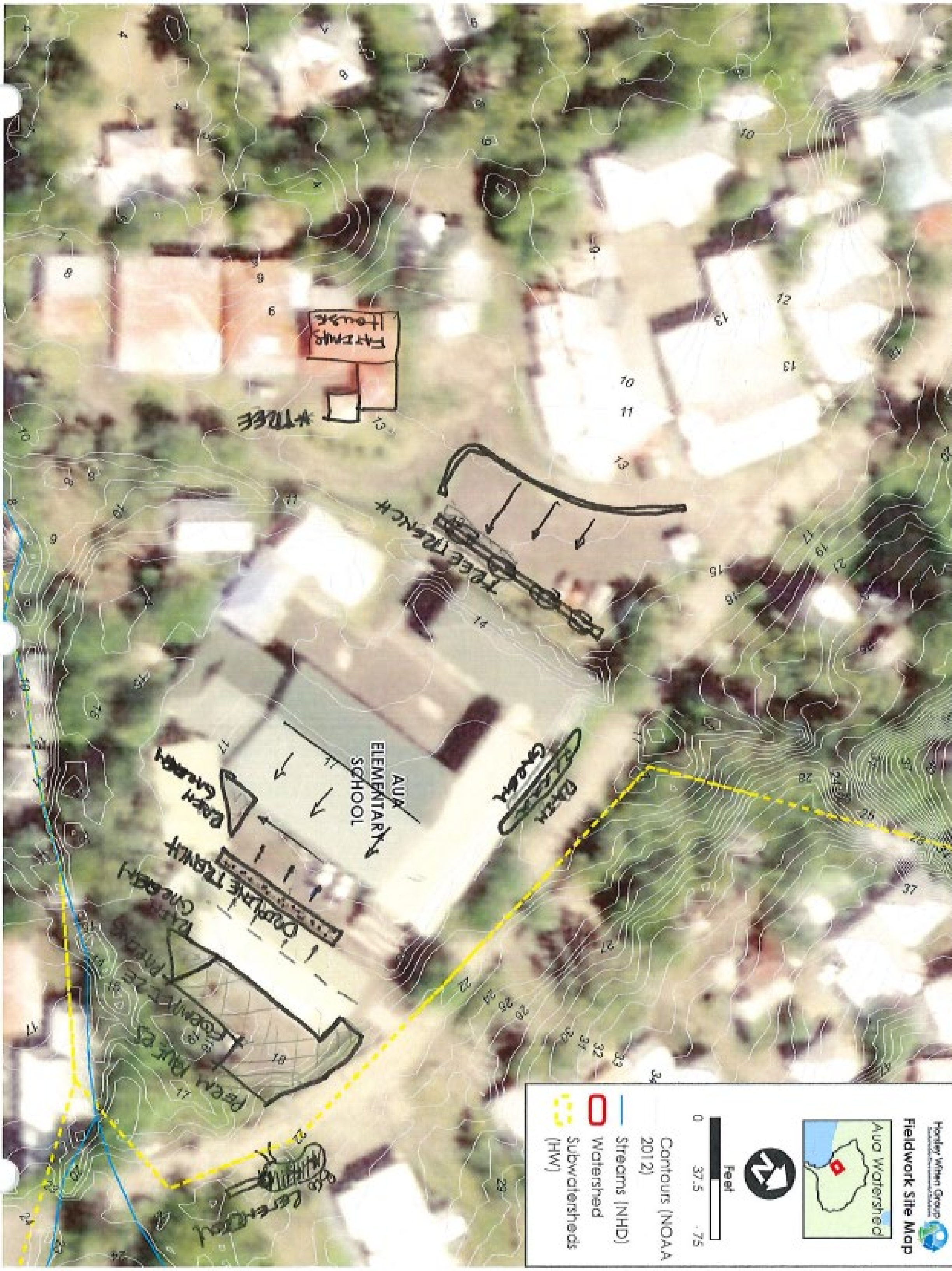
Max undercut 4 FT in line = edge of building

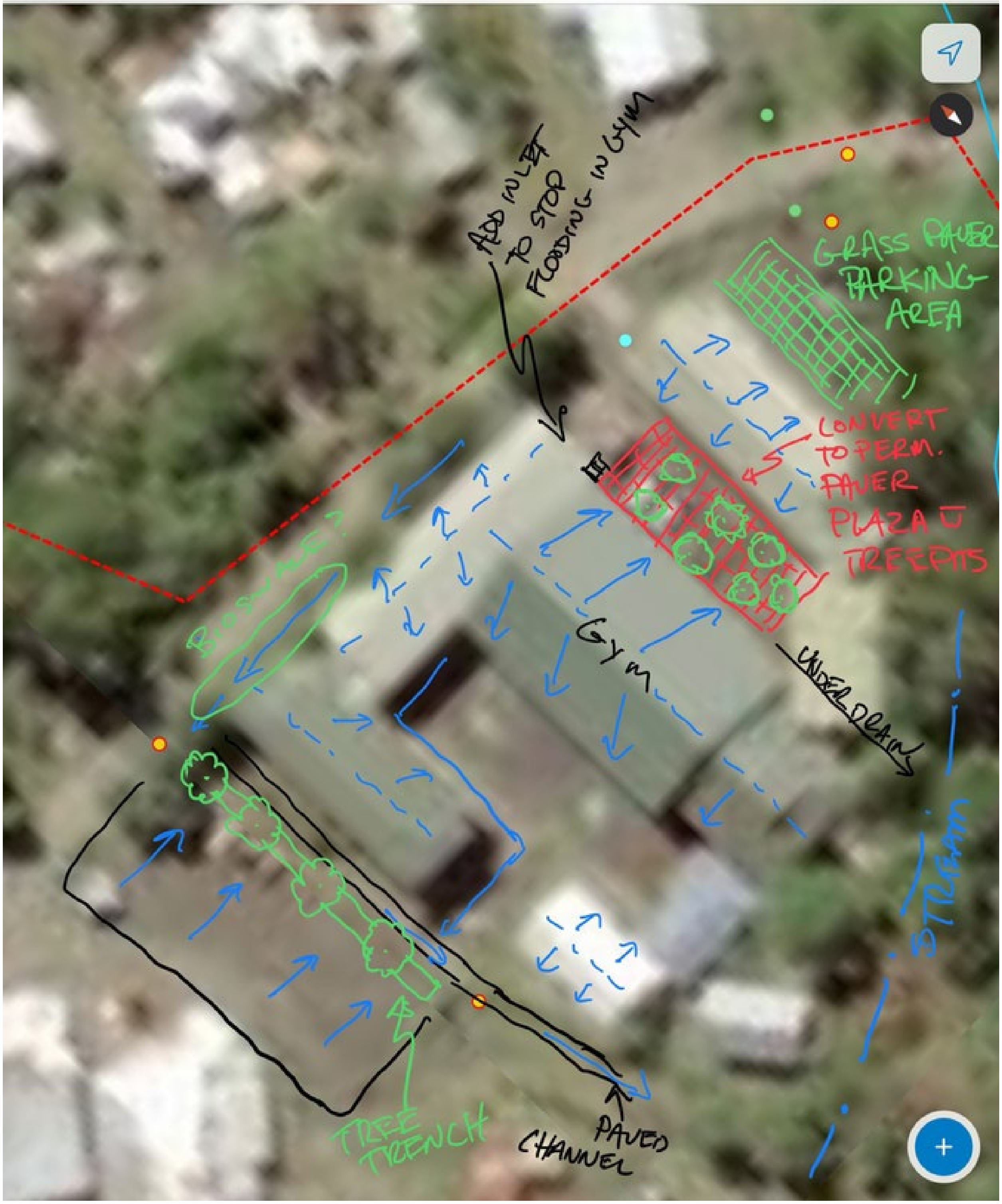
STATION	DEPTH (inches)	NOTE
0	45	Fence
22	45	
25	53	
37	53	
50	46	TOP OF BANK LT
51.5	52	
52	84	BOTTOM OF BANK & CHANNEL
* 55.5	77	TOP OF WATER *
54	86	Thalweg
55	80	Bottom of bank RT
59	73	Bank full
60.5	59	Top of bank
72	46	
100	58	

SHORELINE STABILIZATION BY CORAL TRANSECT

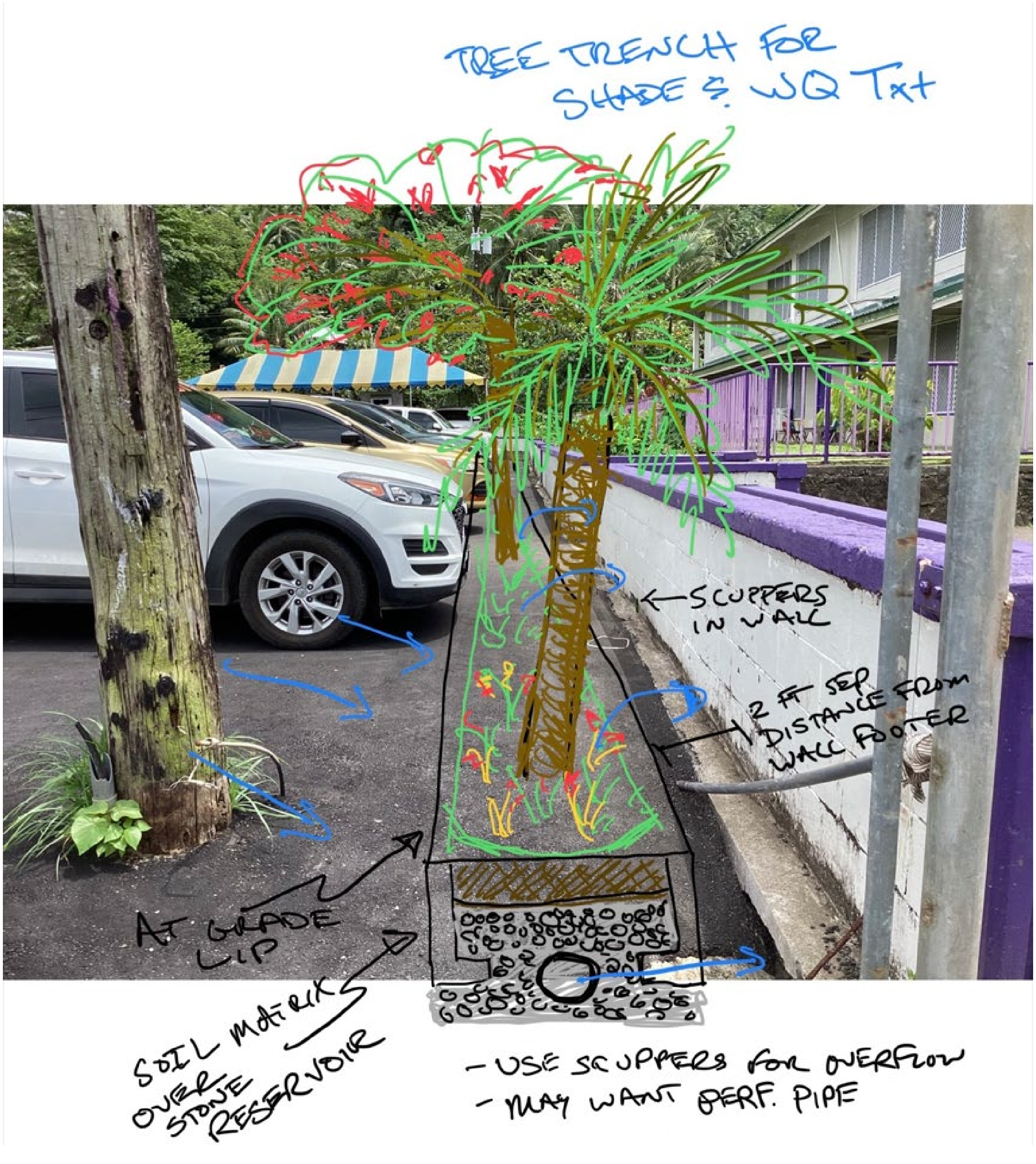


AUA CONSOLIDATED SCHOOL





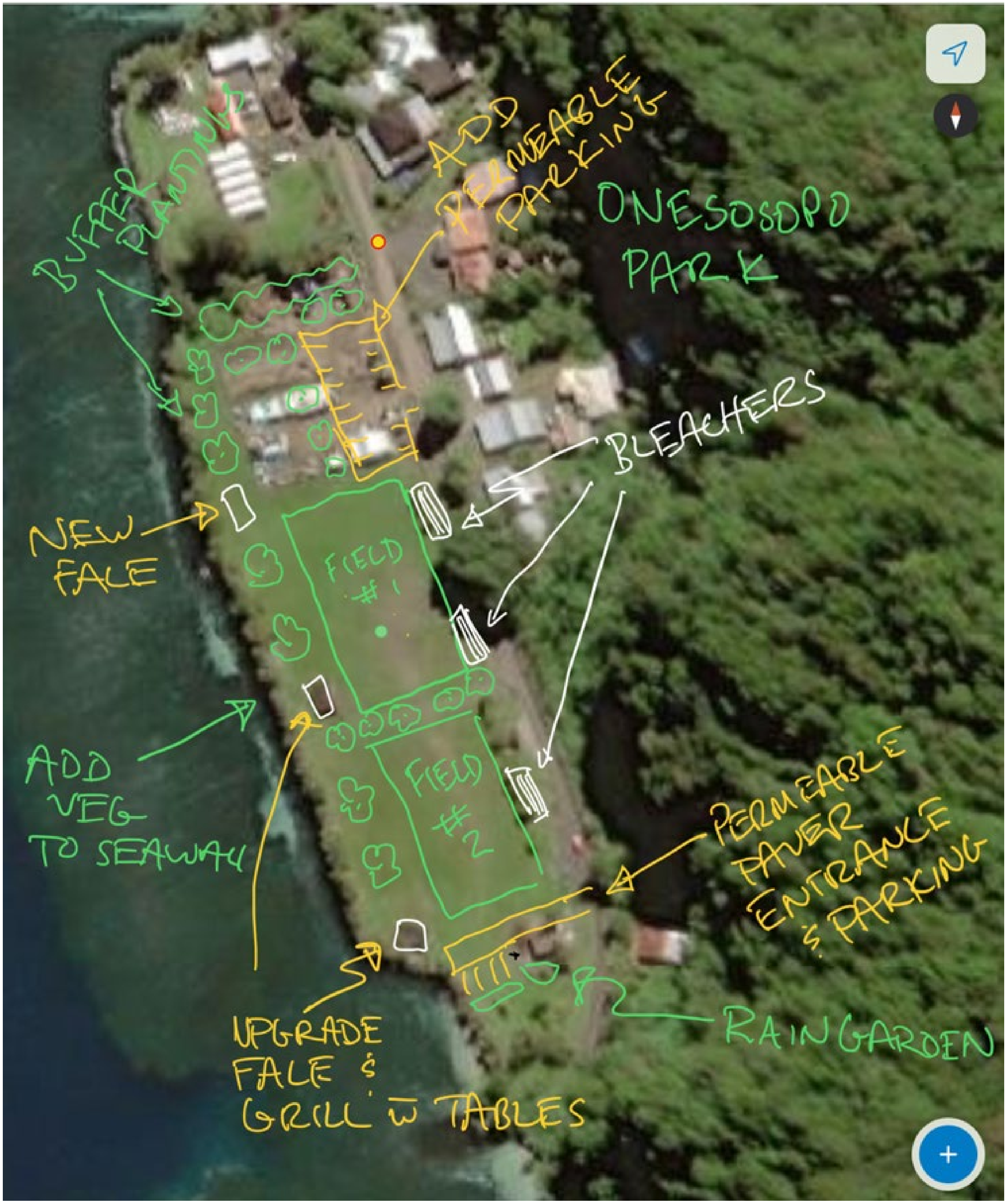
ADD INLET TO STOP FLOODING IN GYM
GRASS PAVER PARKING AREA
CONVERT TO PERM. PAVER PLAZA W/ TREEPITS
BIOSWALE?
GYM
UNDERDRAIN
STREAM
TREE TRENCH
PAVED CHANNEL


TREE TRENCH FOR
SHADE & WQ Txt
SCUPPERS
IN WALL
2 FT SEP.
DISTANCE FROM
WALL FOOTER
AT GRADE
LIP
SOIL MATRIX
OVER
STONE
RESERVOIR
- USE SCUPPERS FOR OVERFLOW
- MAY WANT PERF. PIPE

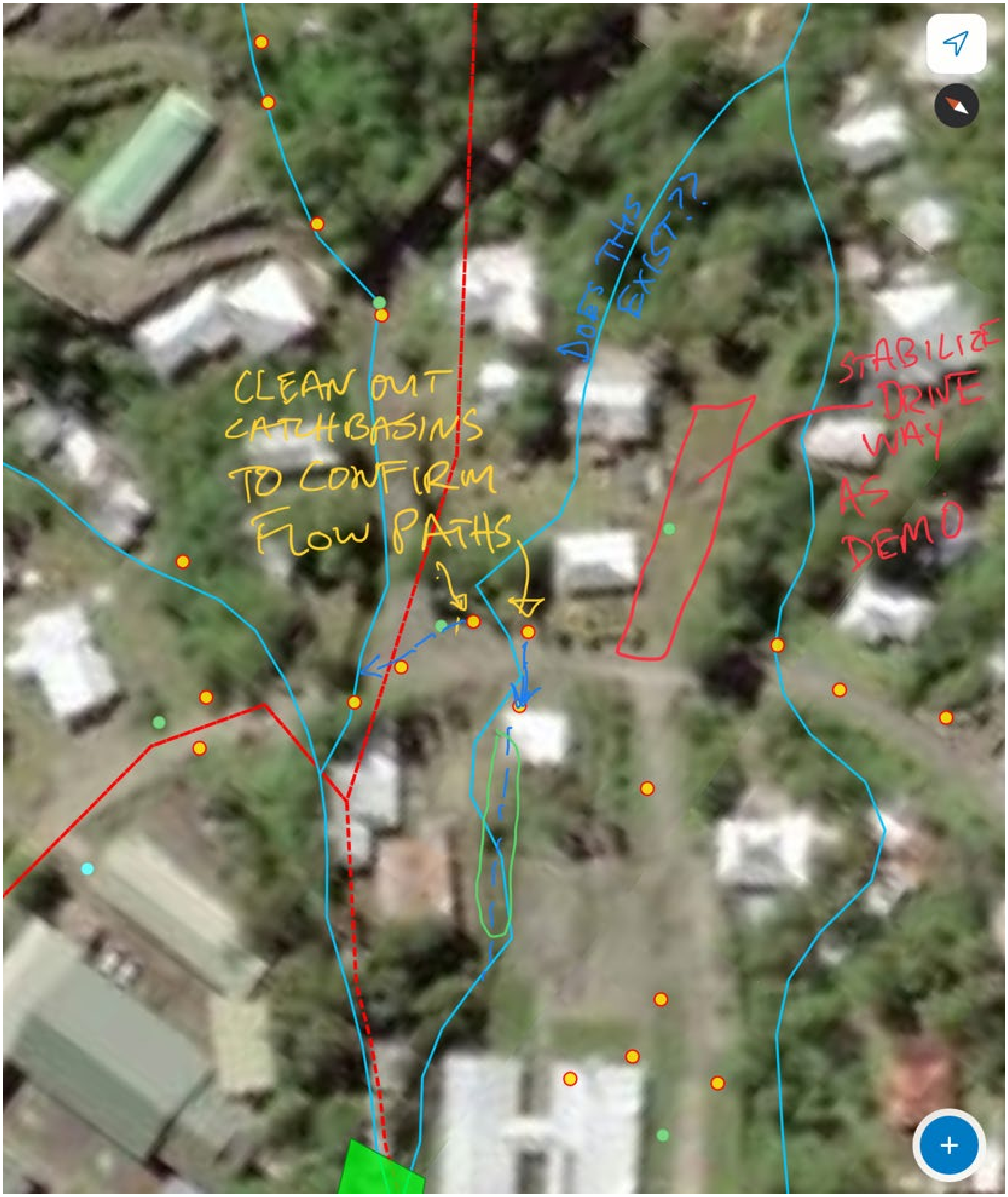
ROAD IMPROVEMENTS

UNNAMED MINI-MART

ONESOSOPO PARK



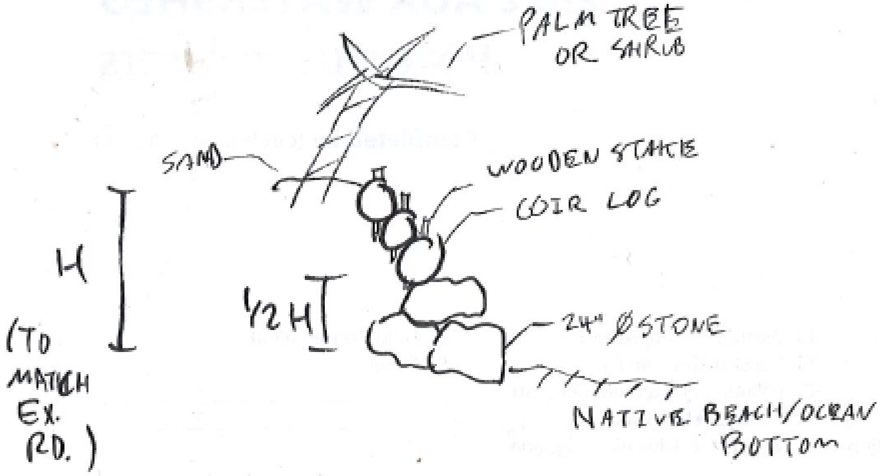
MAIN INTERSECTION



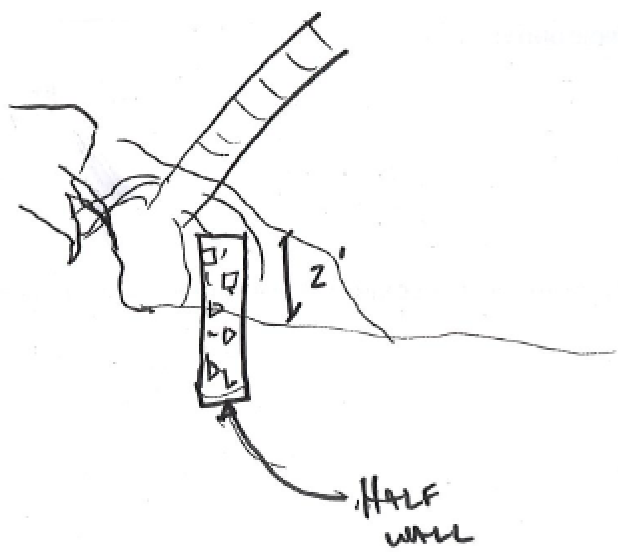
MAIN STREAM OUTLET

SHORELINE AT CORAL TRANSECT

SKETCH:



PALM TREE OR SHRUB
SAND
WOODEN STAKE
COIR LOG
H
(TO MATCH EX. RD.)
1/2 H
24" Ø STONE
NATIVE BEACH/OCEAN BOTTOM



2'
HALF WALL

ORIGIN GAS & STREAM

= NOAA Kingtide data.
July 13, 2022

= sand mining ??

= SKY VIEW ROAD FLOODING

AMERIKA SAMOA

Tisa Faamuli 29@gmail.com

AUA
ELEMENTARY
SCHOOL
CHURCH
atagimalie

DIRT ROAD
DRINKING WATER
Antauo
Leolamoula
Matagimalie
AUA ELEMENTARY SCHOOL
CHURCH
Leasi
36" CULVERT
LEASI POINT
AUA POINT
90' SEDIMENT

ATTACHMENT D

Meeting Notes

HW/Agency Meeting Notes- Aua Watershed Planning

Forestry Extension

10/19/22, 1-1:45 PM

Personnel: Denis Sene

1) Forestry personnel also visiting from the US
    - Looking at 72 plots. Each plot is made of (4) 16’x16’ subplots
2) 1 Forestry Extension site in Aua
    - Talimoni family
    - Near water tank
    - Includes Lalolamauta stream
    - Extension is providing forestry assistant (“plant X tree, remove Y tree”
3) Forest quality in Aua
    - Some invasives, but less intense/dense than other villages
    - Aua is very steep, not well surveyed
    - Some invasives upgradient of houses where Leasi Stream enters village
4) Mangroves
    - Sandra Talimoni (DOC) is involved in a mangrove project through the extension
    - DJ has a 6 month progress report
5) Soil stabilization work
    - Extension only helps with soil stabilization as requested by villages/individuals
    - Species
        - Vetaba grass
        - Lemon grass
6) Coastal trees
    - Ext. plants coastal trees as requested
    - Species vary depending on what seeds are ready
        - Fetaau
        - Tali
7) Ext. very busy now through December
8) Ext. recently did a watershed project
    - 4 watersheds
        - Leone
        - Pago Pago
        - Nuuli
        - Lauli
    - Went to churches to get volunteers
    - Walked streams to remove trash
    - Good cleanup, little to no maintenance of streams
9) Ext. does not cut down vegetation in streams
    - No protection exist on stream buffers or mangroves
    - Only buffers are in place on buildings (25 ft residential, 50 ft commercial)
        - Not well enforced

    - Also pesticide restrictions exist
        - Not well enforced

10) Any education outreach on invasives?
    - None w/ Aua Elementary (or very little)
    - Only educational outreach in Aua is through the Talimoni family
11) Any initiatives related to parks/open space?
    - Difficult to get trees in parks
    - Any that are planted get removed within 1 week
12) Any species that are threatened in Aua?
    - No hardwoods are threatened
    - DMWR would be better to ask about fauna
    - Fire ants (invasive) not found in Aua
    - Butterfly preservation project ongoing
        - Talafalu plant is helpful for butterflies
    - Ironwoods are a good tree species
    - Pines also good
13) Mangrove propagation is supported by Ext.
    - Mostly red mangroves
14) Entire island of Tutuila is a “priority area”
    - Ext. tries to assist with all projects because of that

ASEPA

10/20/22, 9-10 AM

Personnel: Tualagi Gaoteote (Pesticides Branch), Ioakimo Makiasi (Water Quality Branch)

15) Locations of WQ monitoring stations? Stream collection stations?
    - 3 sample locations (near shore) in Aua
        - Out of 41 weekly beach sample locations in Tutuila
        - Sampled every Tuesday
        - Only measure bacteria (E coli, enterococci)
    - 2 stream sample locations
        - Sampled monthly
        - Leasi
            - 2 samples: 1 near mouth, 1 as high upstream as possible)
        - Lalolamauta
            - 3 samples: 1 near mangroves, 1 DS of eels, 1 off of Route 006)
        - Sample for:
            - DO
            - Turbidity
            - pH
            - Nitrate
            - Nitrite
            - TN
            - TP

        - Also record weather conditions
        - **Lab manager can send us results**
16) Every year, 3 pristine, 3 intermediate, and 3 extensive streams are added to the sample list
17) Lalolamauta is heavily monitored as a remnant of the piggery compliance program
    - **There are currently 3 active piggeries in Aua**
        - 1 is dry litter, 1 is washdown
18) Other initiatives in Aua?
    - Reef flat survey project
        - Conducted every 5 years
        - 2 locations sampled around Aua
        - **Final version of report just approved, 2020-21**
        - Done in house, supported by a consultant
19) Regulations/enforcements
    - Litter enforcements
        - Solid Wastes (Keep Am Sam Beautiful) program will provide materials for cleanups if villages do the trash collection
            - No disposal included in this service
            - ASPA does this disposal (by weight)
    - Solid waste accumulations
    - Pesticide setbacks
        - 20 feet from streams
        - 50 feet in WQ standards
        - Aiming to increase to 100 feet
    - Burning of litter
        - No burning of plastics or rubbers allowed
    - Trash/rubbish removal in ocean
    - Inspections
        - Routine inspections of known sites
        - For-cause/complaint inspections
        - Construction inspections
            - By Kimo
            - Random, occasional
            - Review of ESC/plans
    - Wetland protections
        - Illegal to use pesticides
        - No enforcement against filling
            - Although it is prohibited
            - Landowners are supposed to seek permission/use BMPs if disturbing wetlands
20) Oil contamination in Aua
    - Ongoing remediation efforts
        - Tank locations not known by ASEPA
        - Mayor has that data
        - GW monitoring by ASPA

    - 12 tanks all around perimeter road
        - Last tank still buried under Catholic Church
    - No monitoring from ASEPA, only from EERG (sp?)
    - The tanks have been subsiding
        - Onesosopo was the Navy Cafeteria Area (history)
    - Tanks have a Brownfield
    - About 1 liter of oil left in each tank

21) Commercial farming
    - No known commercial farming in Aua
    - Only pesticide use is from non-Ag growth (common weed killers only)
    - Fairly new to use chemicals as weed killers
22) Any school programming/outreach?
    - Outreach program exists
    - May not have visited Aua Elem.
    - Morning talks on radio
23) Tracking of locations with higher potential pollutant loads?
    - Unlikely
    - Car yards may be in the solid wastes plan
        - There are regulations on non-operating cars – must be covered with a tarp or removed and set to a scrap yard
    - Scrap metal disposal
        - 1 scrap yard on Tutuila
        - ASPA picks up scraps when enough has accumulated in a village
        - Commercial/autoshops are required to pay for disposal
        - Mayors of villages are supposed to document household scraps

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DOC – CZM

10/20/22, 10-11:15 AM

Personnel: Georgina Faiga, Grace Felise, Lava Grohse

24) Most of autoshop in Aua built on wetland
    - Floods when it rains
    - Last 2 years, streams have been dry
    - Water is going onto the road instead of the stream, then entering through catch basins
25) Landslide prone area on east side of the village
    - Also flooding occurs in that area
26) CZM Projects
    - Wetland delineation
        - Mangroves are undelineated
        - Occasionally the bridge by the mangroves gets blocked by sand
27) One of the CZM staff in this meeting lives in Aua
    - Aunt hopes to build in the open space behind the Mormon Church
28) Land use permitting system (PNRS)
    - 8 agencies involved to review development

29) CZM regulates entire island
    - 25 ft residential setback from streams/wetlands
    - 50 ft commercial setback
30) Shoreline work/sea level rise
    - Goal for past year has been living shoreline projects
    - Mostly focused on critical areas (special management areas)
    - Aua is not one of the priority areas
    - Sunny day flooding during high tides does occur
31) Development patterns
    - Expect more new structures in Aua
    - Population is not growing
    - Old buildings are not removed/decommissioned, typically turned into fales
32) Maintenance of infrastructure is handled by family zones
33) Onesosopo Park
    - CZM supports park upgrades
    - Ideas:
        - Water park/splash zone
        - Mix of gray and green infrastructure
        - More access to water front and open space
        - Could be a good space for rain gardens

DMWR & CRAG

10/20/22, 11:15 AM – 12:15 PM

Personnel: Taotasi Archie Soliai, Selaina Tuimavave, Trevor Kaitu'u, Kim McGuire, Fuamai Tago, Warren Seva'aetasi, Tina Mataafa

34) Wildlife
    - Can send us info on animals
        - Endangered land snail found in trees
        - Bats and birds
35) Lots of development on island
    - Looking for federal support to create protections
    - Survey for snail in order to protect spaces
36) Protection for mangroves?
    - Toma w/ Governor’s Office focuses on wetlands
        - DOC’s jurisdiction
    - Duck that uses wetlands for habitat
        - Taloa
        - Mainly in Aua
37) DMWR installs bird acoustic readings in upland to try to detect seabirds that are nesting
    - On Rainmaker
    - Collaboration with Dr. Rain in HI
38) Aua is trying to build seawall on east side of the village
    - Past efforts unsuccessful

39) WQ problem in reef
    - Sewage (septic)
    - Elem. Used to pipe sewage directly into harbor
40) Goals
    - Coral is ok, resilient, tolerating disturbances
    - There are coral trial sites
        - Aua Point
    - DMWR's main goal is coral restoration
41) Living shorelines
    - DMWR disappointed with the ones that have been built so far
        - Funding is frequently received and not used
    - Unrelated to the root problem: pollution in watersheds
42) Outreach
    - Aua Elem. Is part of DMWR's outreach, although no specific programming in Aua
    - DMWR would like to set up an MPA…but there would be a point currently
        - WQ isn't good enough

DPW

10/20/22, 1:15-2:30 PM

Personnel: Dympna Pangilinan (Design Engineer), Reuben Siatu'u (Chief Engineer)

43) DPW's role
    - Roads and bridges
    - Permit needed to excavate in roads
44) ASPA supposed to manage ESC on their own
45) Roads are 1 year overdue for rebuilding in Aua
46) SLR concerns
    - Many outlets are submerged
    - Would have to raise the road
47) A+E
    - Develops classrooms
    - No new classrooms are likely in Aua any time soon
        - But they may knock down the school and rebuild it at any point
    - Interest exists to put rain gardens in new school designs, but no $ in the past when there was interest
        - Political pressure against green islands, etc.
48) ROW
    - Roads are supposed to be maintained within 50 ft corridor
    - ROW exists 35 ft from centerline of road
49) ASPA supposed to repave every 750 ft
    - They typically go farther
    - Blame is put on the contractor by ASPA
    - DPW hopes to require ASPA to have a representative on site for the next phase
50) Septic *removal* is not required within ASPA's contract

51) Catch basins
  - Usually have 1 ft sumps
  - Sometimes frogs get stuck inside, die
52) O+M
  - Only 1 vacuum truck
    - Vacuumed material is dumped at a designated spot
  - No set program for O+M, mostly reactive
  - Limited inventory of drain infrastructure
53) Shoreline
  - DPW looking for "investment protection"
    - No desire to green shorelines
    - Take out trees next to shoreline because the roots may damage seawalls
  - No inventory of shoreline loss
54) Licensing
  - No licensing board for engineers, so any US PE can work in Am Sam
  - Surveys need to be by certified Am Sam surveyor
55) SW regulation
  - Only regulation is to "manage" the appropriate volume of SW
  - Doesn't have to be GSI
  - DPW prefers that it isn't GSI
56) DPW wants…
  - Asset management maintenance schedule
    - Maint. Is not run by Hwy Dept.
    - Hwy Dept. only does official Routes
  - Map of structures
57) DPW offers details for driveways
  - DPW will plan pavement projects for unpaved roads/houses
58) DPW gets Geotech consultant when cutting into mountain
  - Installs nets as directed
59) DPW to send catalogue of details
60) DPW to send route map

APSA

11/20/22, 3-4 PM

Personnel: Fidel Aguila, Andre Milford

61) Septic is eliminated in Aua, but other graywater pipes go to stream
  - ASPA not helping connect other pipes/plumbing
62) 100% of houses in Aua will be connected
  - Some side houses drain sewage directly to streams, which won't be connected
63) New houses will have to apply to ASPA for help to connect to water/sewer
  - Edmund will know how many houses this includes
64) Filling old septic systems
  - This is done in Phase I

65) 280-300 houses have been connected

   - ESV Package 5 Phase 1: 230 customers (already connected), Status: 100% complete, 3-Lift stations installed with design capacity of flow of 600GPM at 104 TDH, 5.2 miles of sewer pipe installed
   - ESV Package 5 phase 2: 300 customers (target to be connected) , Construction on-going 67% complete(target date of completion: January 2023)
   - ASPA WW treatment Design capacity are as follows: Tafuna WWTP: 3MGD; Utulei WWTP: 2MGD

66) All of Phase I is on sewer now
67) Onesosopo is the end of the current project
68) Repaving is up to contractor
   - Not adding any drainage infrastructure
   - Repaving is coordinated with DPW
69) Water tank supplies Aua all thew ay down to Tula (east)
   - Depth is down to ~MSL
   - Filtration system – RO
     - Desalinating -> soak pit
   - Second well downgradient of main well is high salinity
   - There will be a new gabion wall next to the filter to stabilize the slope
70) Soil from Onesosopo will go to EPA-approved disposal site
71) Solid waste disposal?
   - 3 times per week
   - No fees
   - Recycling in the works
72) Utility pole disposal?
   - Telephone poles are up to Blue Sky or ASTCA
73) **ASPA will send us plan/fact sheet**
74) WWTP capacity
   - ASPA will do a new master plan after this Package
75) Water distribution system
   - PVC pipe
   - No private wells in Aua
   - New well to be built for uppermost houses
   - Water supply is old and lines leak
76) New projects next year
   - From Samoa Tuna to Aua water tank, new water line (10" PVC)
   - On mountain side of the road
77) **DOC has all GIS maps of water/sewer line**
78) When ASPA encountered the oil tanks, they coordinated with ASEPA
   - Don't expect to encounter tanks again with water line project (less deep)
79) No inventory of pipe layout inside each ouse
80) Grant for sewer project was from USEPA
   - Sewer laterals were 4" pipe
81) Over 300 houses to be added in Phase II

- Capacity for at least 100 more houses to be built

82) ASPA wants…
    - $ to do the installation
        - They have capacity, if the funds are there

83) Car wastes not allowed to connect to sewer

84) TMDL guys in Aua were here 6-8 weeks prior
    - USEPA
    - TetraTech

Appendix D: Pollutant Load Modeling Report

One element used in the development of the Aua Watershed Plan is an estimate of existing and future watershed pollutant loads to help prioritize management actions. To this end, we used the Watershed Treatment Model (WTM), Version 3.0 (Caraco, 2013) – a public-domain, Microsoft Excel-based spreadsheet model used to estimate annual watershed pollutant loads for total nitrogen (TN), total phosphorus (TP) total suspended solids (TSS), fecal coliform bacteria (FC), and runoff volume.

The WTM was applied to three major stream catchments within the Aua Watershed (Leasi, Lalolamauta, and Aua Point) as illustrated in **Figure 1**. It is worth noting that the overall watershed boundary is limited to the area identified by the Pacific Islands Ocean Observing System (PacIOOS) as the Aua Watershed (Wright, 2016), which does not include portions of the political boundaries of Aua south of Aua point or west of Leasi Point. Watershed recommendations located outside of the watershed boundary are still included in the WTM for the purpose of evaluating their relative impact on pollutant load reduction. Recommendations outside of the watershed boundary are included in the next closest subwatershed modeled in the WTM.

The model relies principally on primary inputs (e.g., annual rainfall, land use, and soil types) to apply standard event mean concentrations and runoff coefficients to generate pollutant load and runoff volume estimates. The model allows the user to incorporate secondary pollutant sources such as wastewater systems, marinas, channel erosion, and livestock, if known. In addition, the WTM allows the user to predict future loads based on land use changes, new development, and treatment measures (stormwater management practices, stream buffers, regulatory and educational programs, wastewater improvements, street sweeping, etc.), making it an ideal tool for watershed planning. Depending on the quality of input data, the WTM can be used to quickly generate relative comparisons across watersheds or implementation scenarios. Readily available GIS data from sources such as USGS, NOAA, NRCS, and others are used to generate much of the input data. Field observations on pollutant sources, stream characteristics, and other watershed conditions can be used to adjust model input variables. Unless the user inputs watershed-specific data, the WTM uses default values derived from US national averages for primary and secondary sources.

Inputs and Assumptions

Tables 1-2 and **Tables 3-5** summarize key data input assumptions used to generate existing and future loads, respectively. These can (and should) be adjusted as more information is collected, particularly if numerical loads are considered important. The model inputs are based on a combination of available mapping information and our observations of watershed conditions, existing management measures, and potential opportunities for restoration. It should be noted that:

- Not all input parameters were fully vetted during field investigations (e.g., livestock, street sweeping). Some of the GIS data used may not accurately reflect conditions (e.g., impervious cover, agricultural land uses). No model calibration or validation was conducted using water quality data.
- The model does not account for routing, attenuation, or subsurface flows in the watershed. The smaller the watershed area modeled, the better.
- Stream erosion and shoreline stabilization is not well accounted for in the model, although the user can provide a broad estimate of the contribution of stream erosion to TSS loading.

- The model estimates load to groundwater from infiltration practices but does not include those loads in the total surface loads to receiving waters. Groundwater loads are reported separately.
- Surface loads to receiving waters includes both coastal waters and the freshwater mangrove wetland in Aua. Separate loads to the existing wetland, and the amount of treatment offered by those wetlands, could be estimated by modeling contributing drainage areas to the wetlands first and then treating the wetlands as BMPs prior to coastal discharge.
- No existing management practices are included the estimate of existing pollutant loads. Exclusion of existing practices is based on field observation and discussion with stakeholder agencies in Aua.
- Pollutant loading due to livestock is accounted for in the model, but estimates of livestock quantities are not based on observed counts of pigs. Pollutant loading from dogs may partially be accounted for by residential pollutant loading rates. To further account for pollutant loading from dogs, residential pollutant loading rates could be increased, or additional "livestock" could be added to represent unmanaged dog waste. Because we didn't make adjustments based on dogs or determine the actual population of pigs in the watershed, actual bacteria and nutrient loading may be higher than the model predicts.
- The area of active construction was not modeled to decrease in future conditions, although the area of Onesosopo Park that was being used for construction staging and storage will at some point return to a public recreation land use. This assumption allowed for modeling the impact of erosion controls across the areas of active construction that were observed during the field assessment. As a result, TSS load reductions are probably greater than the model shows under future conditions, since there will be less area of active construction. TSS load estimates are also affected by a lack of data on stream erosion rates, which may under- or over-account for the impact of channel stabilization on TSS removal under future conditions.

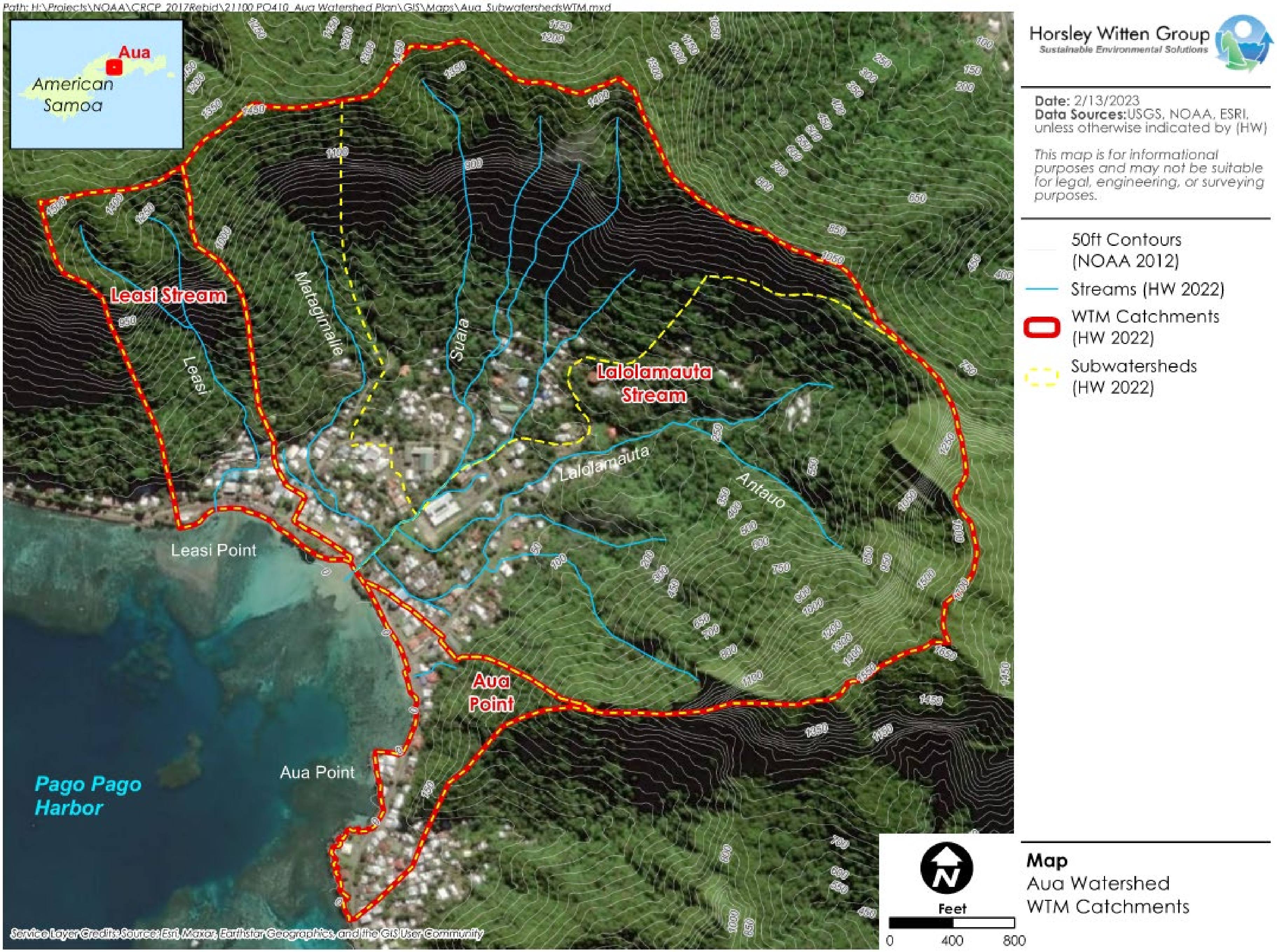

Figure 1. Aua Watershed Treatment Model Catchments

Table 1. Input Data Used to Estimate Existing Loads

Input Parameter	Value			Description
	Leasi	Lalolamauta	Aua Point	
PRIMARY SOURCES				
Avg annual rainfall	150 inches			USDA, 1995
Watershed Area (acres)	42	336	23	Overall watershed area based on delineation by USDA, 1995. Subwatershed delineation identified by HW based on field observation and topography from NOAA, 2012.
Land Use	**See Table 2.** NOAA, 2010 provided the most current landcover GIS layer. HW estimated land use areas from comparable landcovers (add table?). Approximate areas of the Aua Consolidated School and the Mormon Church were identified using Google Earth and designated as Municipal/Institutional. Approximate areas of the stores and laundromat adjacent to the Consolidated School as well as the automobile yard were identified using Google Earth and designated as Commercial. Areas of paved roadway were estimated based on length of roadway from USGS, 2023 multiplied by an assumed average width of 24 feet. Length of unpaved road was not measured or publicly available; paved road that has been under Active Construction during the sewer main expansion project was assumed to be 1/5 of the total paved road length, and the total paved road was scaled by 4/5. The total area of high-density residential equals the area of developed, high intensity land identified through GIS minus the sum of the Roadway, Institutional, Commercial, and Active Construction areas.			
Impervious Cover (acres/% watershed using GIS layer or by acres/% using coefficients in WTM)	NOAA: 2.9 acres (6.9%) or WTM: 2.6 acres (6.2%)	NOAA: 20.9 acres (6.3%) or WTM: 19.7 acres (5.9%)	NOAA: 5.1 acres (23%) or WTM: 4.6 acres (20.4%)	IC is used in model to estimate runoff volume. There are two options for deriving IC: 1) use NOAA IC layer; or 2) use default impervious coefficients for land use categories. We used option 2 in the model.
Pollutant Event Mean Concentrations (EMCs)	See **Table 2.** EMCs and loading rates from various land uses are typically based on values from the National Stormwater Quality Database (NSQD), which is a summary of stormwater data from over 200 jurisdictions across the US (Pitt et. al., 2003). Land uses with impervious cover are assigned an EMC. Land uses without impervious cover use an assigned loading rate. We have adjusted the default values for sediment using data from the USVI/PR, but they should be adjusted for AS as data becomes available. TSS runoff rates for Forest were lowered from USVI/PR rates to reduce the effects of the high proportion of upland forest on TSS loading estimates. EMCs for Active Construction were changed to match those of Unpaved Roadway, since the majority of ongoing construction observed in the watershed was roadwork following the sewer main expansion.			

Input Parameter	Value			Description
	Leasi	Lalolamauta	Aua Point	
Hydrologic Soil Groups (% of watershed)	15% HSG A; 68% HSG B; 17% HSG D	30% HSG A; 58% HSG B; 12% HSG D	9% HSG A; 58% HSG B; 33% HSG D	Based on NRCS mapping. The HSGs are used to estimate surface conditions for infiltration potential, with A soils generally having a high permeability rate (e.g., sandy soils) and D soils generally having a low permeability rate (e.g., clay soils). Impervious cover and "urban fill" are assumed to by HSG D.
Depth to Groundwater (% of watershed)	5% <3 ft; 10% 3-5f; 85% >5 ft	10% <3 ft; 5% 3-5ft; 85% >5 ft	5% <3 ft; 10% 3-5f; 85% >5 ft	NRCS soil mapping (depth to groundwater estimates) reports a depth to groundwater of 6.6 feet throughout the watershed, which is unlikely for areas near wetlands or waterbodies. HW assumed that 15% of the watershed is within 5 feet of groundwater. Given historic record of a large (approximately 9 acre) wetland in the Lalolamauta subwatershed that has been mostly filled in, a higher proportion of that watershed is assumed to have a smaller depth to groundwater. Shallow depths to groundwater (e.g., <24") can signify a higher potential for nutrients to enter groundwater, while deeper depths (e.g., > 48") can provide better pollutant removal.
Stream length (miles)	0.64	4.39	0.06	USGS, 2020 hydrography shapefile, modified by HW based on field observation.
SECONDARY SOURCES				
Sanitary Sewer Overflows (SSO) (pipe network miles/#overflows)	0.3 miles # SSOs:0.003	3.2 miles # SSOs:0.032	0.6 # SSOs:0.006	As of 2023, the entire watershed is sewered, although graywater systems and outdoor toilets are not connected to the sewer system. These systems are assumed to represent half of all wastewater generated in the sewershed, so a 50% rate is applied to the fraction of load as storm flow (greater than the default 30% value). Length of sewer lines are assumed to equal the length of paved roads from the USGS 2023 dataset. We assumed 0.14 overflows per mile (this could be low).
Onsite Disposal Systems (OSDS) (#dwellings total/# with OSDS/%OSDS within 100' of stream)	50/0/25% within 100' of stream 80% failure rate of OSDS	304/0/25% within 100' of stream 80% failure rate of OSDS	76/0/25% within 100' of waterway 80% OSDS failure rate	Sewage impacts are estimated from # dwellings, standard nutrient and bacteria concentrations of raw sewage, and default assumptions of volume generated per dwelling. Failure rate estimated based on previously modeled nutrient loading prior to installation of sewage system (Kennedy et al., 1986) # of dwellings is estimated from the total number of dwellings recorded in the watershed per OpenStreetMap, 2023. 100% of buildings are assumed to be on the ASPA sewer system as of the East Side Villages Wastewater Collection System project (Package 5), with graywater and outdoor toilet discharges accounted for as illicit discharges rather than OSDS.

Input Parameter	Value			Description
	Leasi	Lalolamauta	Aua Point	
Illicit discharge into the storm drain or stream (fraction illicitly connected)	25% of residents and businesses (of 3 total businesses)	25% of residents and businesses (of 9 total businesses)	25% of residents and businesses (of 3 total businesses)	This is non-stormwater runoff discharge into storm drain or stream. Based on conversations with ASPA, no graywater or outdoor toilets are connected to the sewer main expansion throughout Aua. Proportion of wastewater flow that is illicitly discharged is assumed to be 2.5 times typical illicit discharge rates for a typical sewershed. Model default values used for concentrations in sewage and wastewater. # of businesses estimated based on field assessment as well as aerial data available through Google.
Livestock	None	10 pigs	None	Not based on any data. There are 3 known piggeries in the watershed according to AS-EPA, although the number of pigs in each is unknown. This may be low by an order of magnitude. It doesn't account for dogs…
Stream Channel Erosion	Low. 25% of total sediment load			Stream channels are typically armored and channelized based on field observation. Default method 1 selected in the model, which back calculates a % for channel erosion based on sediment load and miles of stream. Stream visual assessments did not indicate level of erosion in armored areas, however some areas of coastline and a few natural streambanks showed signs of erosion. Coastal banks were included in this category in order to assess the impact of proposed shoreline stabilization projects in subsequent stages of the WTM.
EXISTING MANAGEMENT PRACTICES				
Structural stormwater BMPs (post-construction)	No BMPs were observed in the watershed during the field assessment.			
Erosion and Sediment Control	20% program efficiency; 0% of building permits regulated			Based on field observation, ESC practices are minimal if at all present at areas of active construction. Enforcement of construction permits as they relate to ESC is rare.
Catch basin cleaning	none	none	none	Several catch basins were observed to be clogged or buried during the field assessment. This could be refined based on DPW guidance.
Riparian Buffers (% impacted/OK miles)	0%; 0 miles OK			Riparian buffers are established for construction and pesticide usage, however buffers are rarely enforced. Construction adjacent to streams was frequently observed during the field assessment, as was construction debris accumulation in streams.

Table 2. Area, % cover, and EMCs for each land use category

LU Category	Area (Acres)			% Cover		Event Mean Concentrations			
	Leasi	Lalolamauta	Aua Point	Imper.	Turf	TN* (mg/l)	TP (mg/l)	TSS (mg/l)	FC (MPN/ 100 ml)
LDR > 1 ac	0.9	9.3	2.6	20%	16%	1	0.2	102	20300
HDR <0.25 ac	2.5	9.2	4.0	65%	7%	1	0.2	102	20300
Municipal/Inst.	0	4.0	0	72%	6%	1.2	0.22	49	20000
Commercial	0	1.5	0	72%	6%	1.2	0.39	56	20000
Roadway -Paved	0.2	1.8	0.4	100%	0%	1.2	0.16	36	13700
Roadway -Unpaved	0	0	0	90%	2%	1.2	0.24	2895	13700
Active Construction	0.7	7.4	1.4	--	--	1.2	0.24	2895	13700
	Area (Acres)			**% Cover**		**Annual Loading Rate**			
	Leasi	**Lalolamauta**	**Aua Point**	**Imper.**	**Turf**	TN (lb/ac)	TP (lb/ac)	TSS (lb/ac)	FC (# billion/ac)
Forest/Park or Undeveloped	37.1	298.4	13.9	0%	0%	1.8	.25	100	12
Ag	0	2.3	0	0%	0%	1.8	.25	100	39
Open Water/wetland	0.3	0.02	0.2	--	--	12.8	0.5	155	--
Total Acres	**42**	**334**	**23**			--			

*TN values used here are considerably lower than standard concentrations for urban runoff which are generally 2 mg/L or higher for mainland US. Lower values were based on assumption of lack of fertilizer usage in AS.

Table 3. Future management measures applied in the model

Input Parameter	Proposed Project #	Leasi	Lalolamauta	Aua Point
Illicit Connection Removal	19	• 100% of system surveyed • 100% of repairs made		
SSO repair and abatement	19	• Goal of 100% reduction • 100% complete		
Stormwater retrofits (See **Table 4**)	(See **Table 4**)	None	5.9 additional acres managed (88% impervious)	None
		• assumed 100% capture rate for target volume (1.0 inch) • No design standards • No maintenance guidance		
Erosion and Sediment Control	16	80% program efficient, 100% of building permits regulated, 0.6 installation/maintenance discount		
"Urban Downsizing"	10	None	0.33 acres of LDR converted to Forest	None
Channel Protection	14	--	--	0.025 miles of unstable channel/ 100% stabilized; 2% flow control for smaller streams

Input Parameter	Proposed Project #	Leasi	Lalolamauta	Aua Point
	15	--	--	0.20 miles of unstable channel/ 100% stabilized; 2% flow control for smaller streams
	18	--	0.67 miles of unstable channel/ 100% stabilized; 2% flow control for smaller streams	--

Table 4. Future stormwater management practices (retrofits) modeled

Stormwater BMP	Proposed Project #	**Drainage Area Managed** (Total acres/Impervious acres)		
		Leasi	**Lalolamauta**	**Aua Point**
Infiltration Practices	1		0.82/0.82	
	2		1.61/1.61	
Bioretention	3		0.57/0.46	
	9		0.90/0.90	
	11		0.24/0.24	
Road Stabilization	4		0.39/0.39	
	5		0.17/0.17	
	7		0.14/0.14	
	8		0.37/0.22	
Grassed Filter Strips	6		0.61/0	
Grass Channel	13	None	0.35/0.35	None
Total		**--**	**6.2/5.3**	**--**

Table 5. Future land use changes and new development assumptions

Leasi	Lalolamauta	Aua Point
None	• 0.81 acres of remaining mangrove wetland and 0.33 acres of floodplain by Mormon Church converted to HDR • 0% of stormwater regulation on new development; channel protection not required • 0.1 miles of sewer constructed • No illicit discharges	None

RESULTS

While the WTM can be used to generate quantitative nutrient, TSS, and bacteria loads, it is better for comparing relative contributions between subwatersheds and management scenarios. At this time, we have only run a preliminary model to estimate existing and predict future load reductions based on an initial assessment of conditions and restoration opportunities.

Table 6 summarizes model results for existing conditions, future management options/watershed treatment, and with future development. Implementation of future BMPs is modeled to reduce nutrient loading by 68-77%, TSS loading by 22-32%, and FC loading by 77-98%. The actual reduction for TSS loading may be higher than modeled, since future watershed conditions are likely to have less areas of active construction than the conditions of the watershed during the assessment (i.e., Onesosopo Park in use as a construction staging area). Quantification of the numeric annual load, while useful, is highly dependent on specific data inputs, such as runoff concentrations, illicit connection rates, area of active construction, etc. We don't recommend putting much stock in these numbers until more refined input data can be obtained and the model compared with findings from the water quality monitoring program.

Table 6. Loads to Surface Waters

Subwatershed Scenario	TN (lb/year)	TP (lb/year)	TSS (lb/year)	Fecal Coliform (billion/year)	Runoff Volume (acre feet/year)
Leasi					
existing	451	76	23,276	240,594	40
w future BMPs	134	22	18,232	4,826	40
% reduction	**70%**	**71%**	**22%**	**98%**	**0%**
Lalolamauta					
existing	2,998	503	403,215	2,556,792	289
w future BMPs	998	163	272,755	592,736	278
% reduction	**67%**	**68%**	**32%**	**77%**	**4%**
w future development	1,022	168	275,198	594,863	286
Aua Point					
existing	628	108	37,143	367,328	55
w future BMPs	142	26	27,444	7,737	55
% reduction	**77%**	**76%**	**26%**	**98%**	**0%**

Table 7 separates load reduction by each watershed recommendation. Like the estimates of pollutant loading shown above, estimates of pollutant load reductions should be interpreted only for relative comparison among proposed projects. The actual pollutant load reduction that a given project may offer is highly dependent on inputs such as pollutant loading and the accuracy of assumptions such as BMP maintenance rates, illicit discharge survey completeness, etc.

Table 7. Net Effects of Watershed Recommendations

Proposed Project	Subwatershed	TN	TP	TSS	Fecal Coliform	Runoff Volume
		(lb/year)	(lb/year)	(lb/year)	(billion/year)	(acre feet/year)
1. Infiltration Practice	Lalolamauta	9.2	1.9	908	953	2.1
2. Infiltration Practice	Lalolamauta	18.1	3.8	1784	1871	4.2
3. Bioretention	Lalolamauta	6.0	1.1	543	620	1.1
4. Road Stabilization	Lalolamauta	0	0.7	355	245	0
5. Road Stabilization	Lalolamauta	0	0.3	155	107	0
6. Grassed Filter Strip	Lalolamauta	2.4	0.5	234	140	0.6
7. Road Stabilization	Lalolamauta	0	0.2	127	88	0
8. Road Stabilization	Lalolamauta	0	0.5	284	196	0
9. Bioretention	Lalolamauta	10.3	1.9	931	1063	1.9
10. "Urban Downsizing" (Wetland Restoration)	Lalolamauta	2.0	0.4	257	256	0.9
11. Bioretention	Lalolamauta	2.3	0.4	207	236	0.4
12. Hotspot Pollution Prevention	Lalolamauta	Not modeled				
13. Grass Channel	Lalolamauta	1.6	0.3	212	37	0.2
14. Shoreline Protection	Aua Point	0	0	19	0	0
15. Stream Restoration	Aua Point	0	0	150	0	0
16. Erosion and Sediment Control	All	59.2	11.8	119,130	519,753	0
17. Gas Tank Storage Compliance	Aua Point	Not modeled				
18. Stream Restoration	Lalolamauta	0	0	1936	0	0
19. Wastewater & Graywater Management	All	2,678	449	17,866	2,022,410	0
20. Trash Cleanup	All	Not modeled				

Figures 2-5 illustrate which of the catchments and sources are identified by the model as the biggest contributors of annual pollutant loads to the Aua embayment of the Pago Pago Harbor from the Aua watershed.

For the purposes of the Aua WMP, it is the relative change in value between existing and future conditions, all data input assumptions being equal, that is the most relevant. Determining the full, optimal extent of management actions required to meet a reduction target is an iterative process. We, however, only ran the WTM one time with one set of potential future management activities. Several takeaways include:

1. The model identifies Lalolamauta as the largest total contributor of annual pollutants of the three catchments. This is explained by the fact that the Lalolamauta subwatershed is the largest of the

three catchments analyzed in the WTM. The Lalolamauta subwatershed is notable in that all discharges to surface waters within the subcatchment pass through the mangrove wetland just upstream of the stream outlet. Restoration of (or further development within) the mangrove wetland has broad impacts for all pollutant loads that discharge to the Aua embayment from the Lalolamauta subcatchment.

2. The single largest source of pollutant loading to the watershed is illicit connections. This is consistent for TN, TP, and fecal coliform loading, with illicit connections appearing as one of the five largest contributors to TSS loading as well. Another major source of pollutant loading is active construction areas, which accounts for over half of all TSS loading in the water shed and a third of fecal coliform loading. Pollutant loading from urban land, which represents just over 10% of the total forested area in the watershed (43 urban acres to 352 forested acres), is roughly equal to that of forested land.

   Figures 6-9 illustrate the relative pollutant load contributions of the various pollutants sources in the watershed.

3. Under treatment scenarios modeled, the most effective treatment options to reduce nutrients and bacteria in the watershed are wastewater improvements and illicit discharge removal. Accurate and thorough surveying and elimination of remaining illicit discharges should be a priority.

   Additional treatment scenarios that show the highest potential for pollutant load reduction are erosion and sediment control programming and stream channel/shoreline stabilization. Both of these scenarios are modeled as having outsized impacts on TSS load reduction relative to other scenarios. It should be cautioned that the load reductions associated with stream channel stabilization have not been calibrated relative to actual stream channel sediment loading, so TSS load removal estimates may be greater than would actually be expected.

   Figures 10-13 illustrate the relative impact of each of the treatment scenarios modeled.

4. Of the stormwater retrofits proposed, Projects 2 (Aua Consolidated School) and 9 (Mormon Church) are modeled as having the largest impact on pollutant loading rates. In addition to benefits to water quality, these highly visible stormwater benefits could offer co-benefits such as increased shade, biodiversity, and environmental education.

5. Future development in the little remaining area of mangrove wetland and floodplain along Lalolamauta is expected to contribute an additional 1% of TN, TP, and TSS loading annually, as well as an additional 2.5% annual runoff volume. Though these percentages may seem small, they are based only on changes to land use, and do not account for the pollutant uptake services provided by the mangrove wetland. It is likely that further removal of wetland habitat and species would be detrimental to the water quality of Lalolamauta as it enters the Aua embayment, regardless of changes to land use. Pollutant removal services provided by the wetland are not currently incorporated into the model.

It is important to keep in mind that a model is only as good as the data that goes into it. The purpose of this exercise was to identify the load reduction potential of some identified restoration projects. The WTM offers a lot of flexibility to accommodate better data as it becomes available, but also provides a comprehensive framework that is perfect for big picture watershed planning purposes. To further utilize the model, consider the following:

1. There are a few projects, such as wetland restoration, education, and better maintenance and enforcement, that could be put into the model so their benefits can be quantified.
2. Review water quality data for the watershed to evaluate how representative the model results are at this stage.
3. Refine input variables where assumptions are wrong and data is readily available to add or correct input, such as primary land use revisions (i.e., updated impervious cover, dirt road areas, active construction), and secondary sources that other agencies have better insight on (e.g., # illicit discharges, livestock estimates).

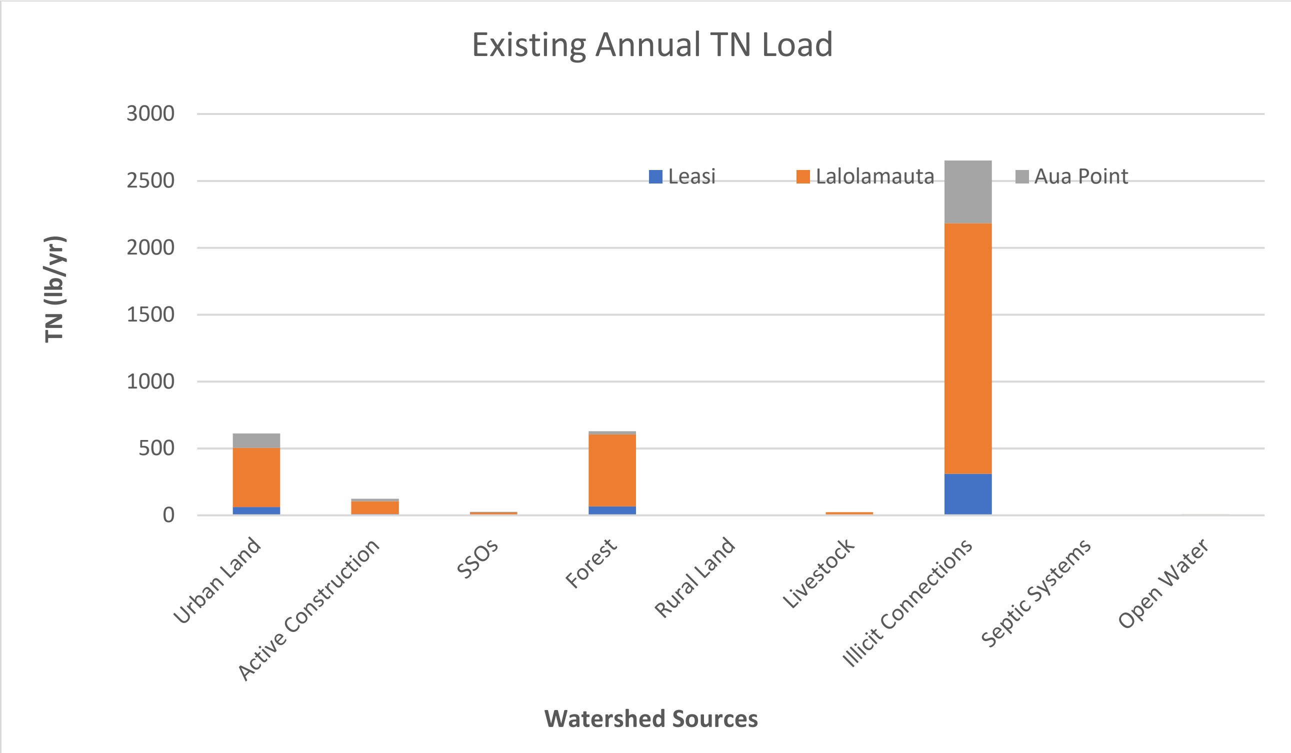

Figure 2. Sources of nutrient loads to surface waters by watershed

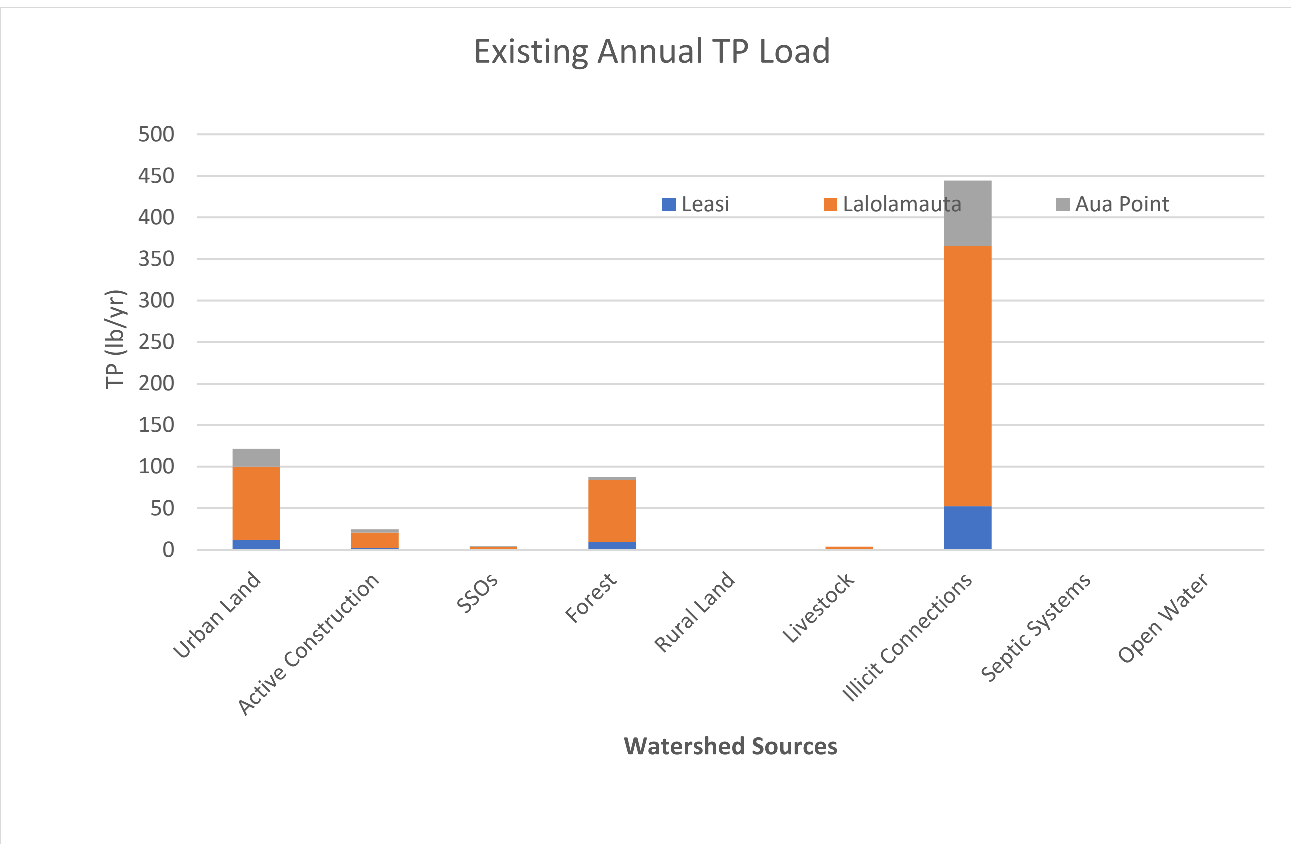

Figure 3. Sources of nutrient loads to surface waters by subwatershed

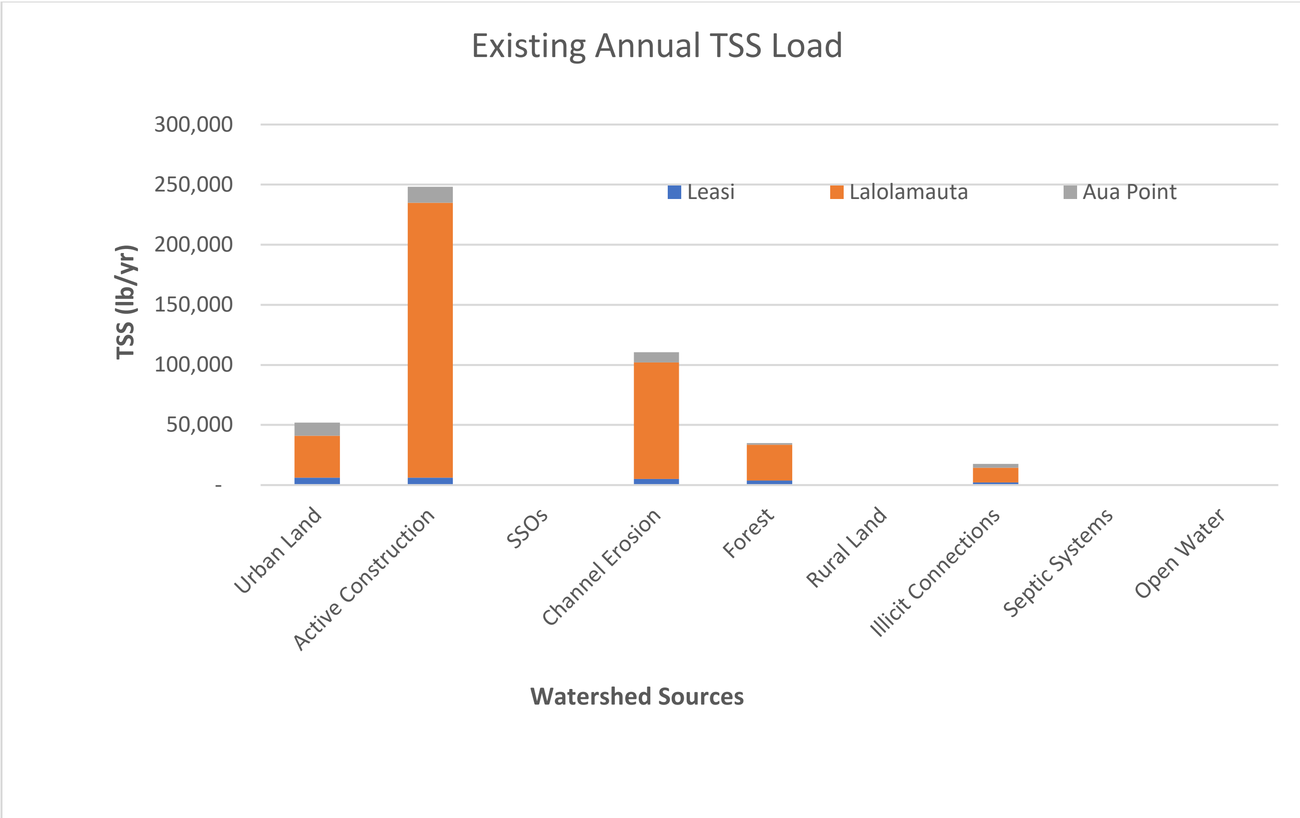

Figure 4. Sources of sediment loading to surface water by subwatershed

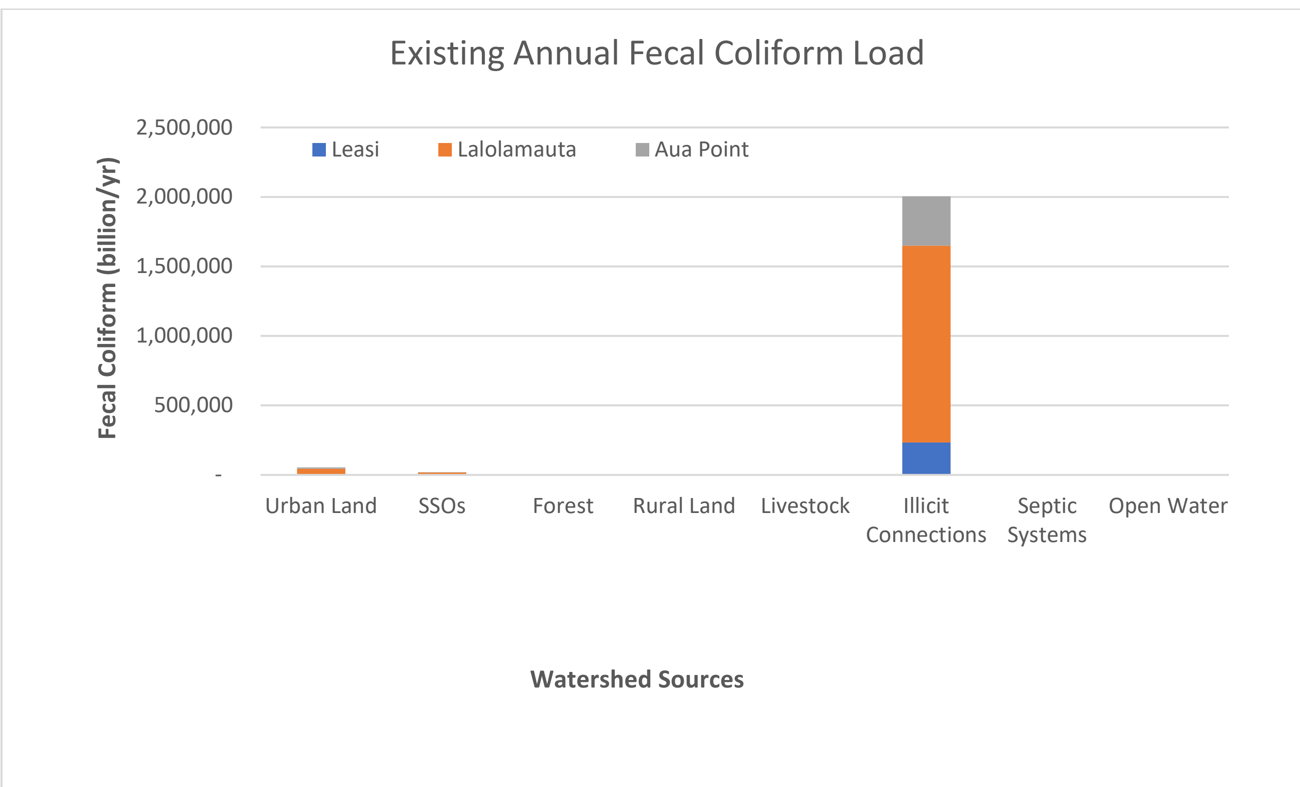

Figure 5. Sources of bacteria loading to surface water by subwatershed

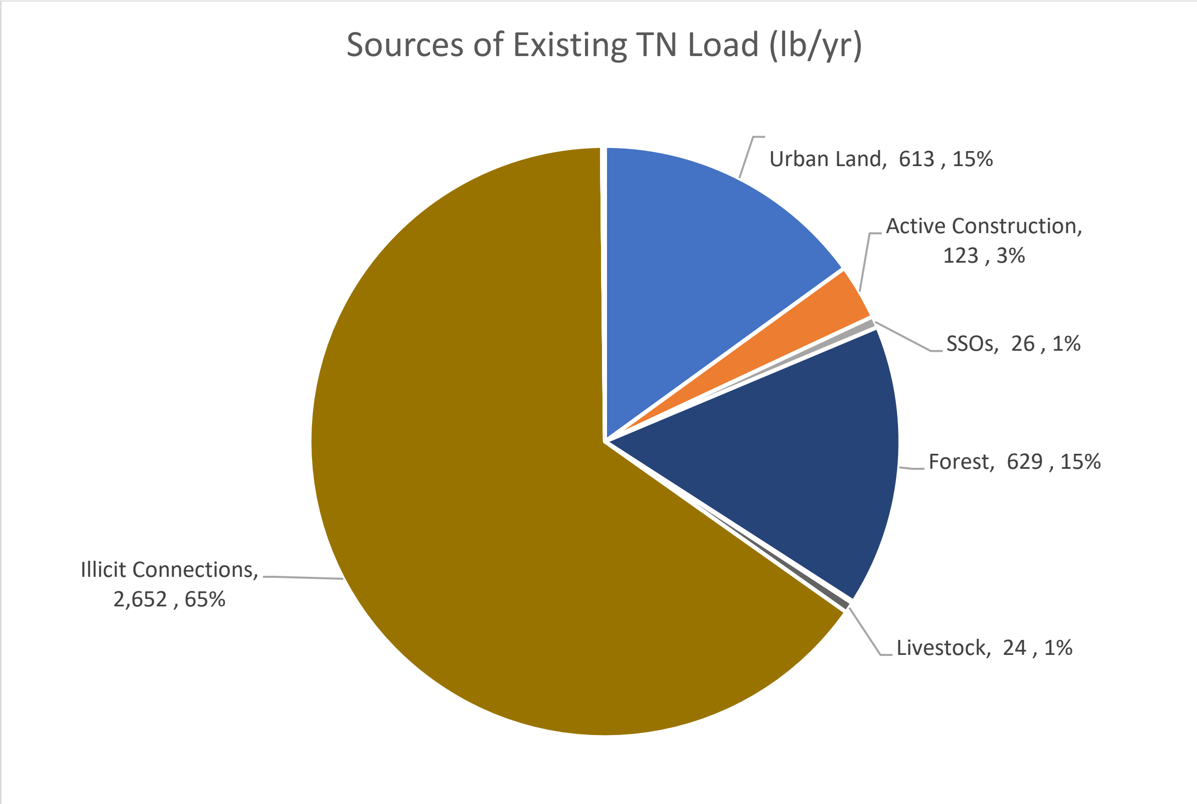

Figure 6. Sources of nutrient loads to surface water by source type

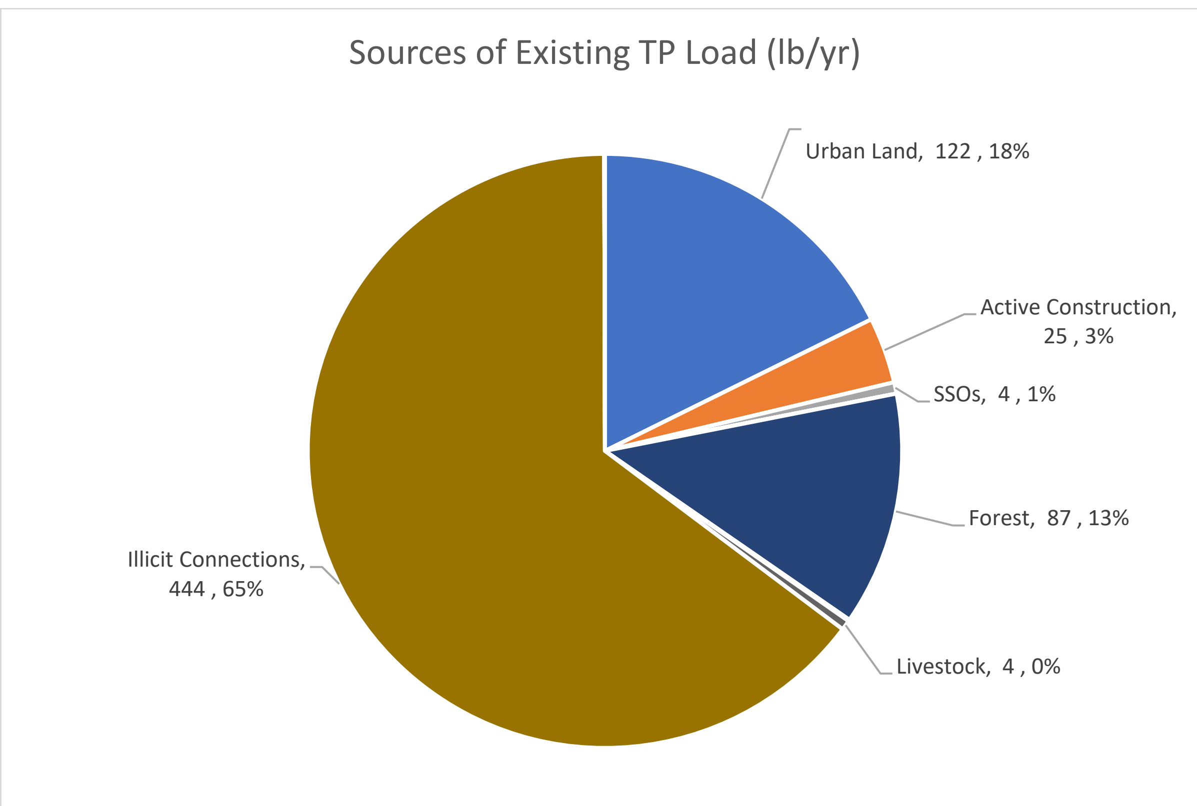

Figure 7. Sources of nutrient loads to surface water by source type

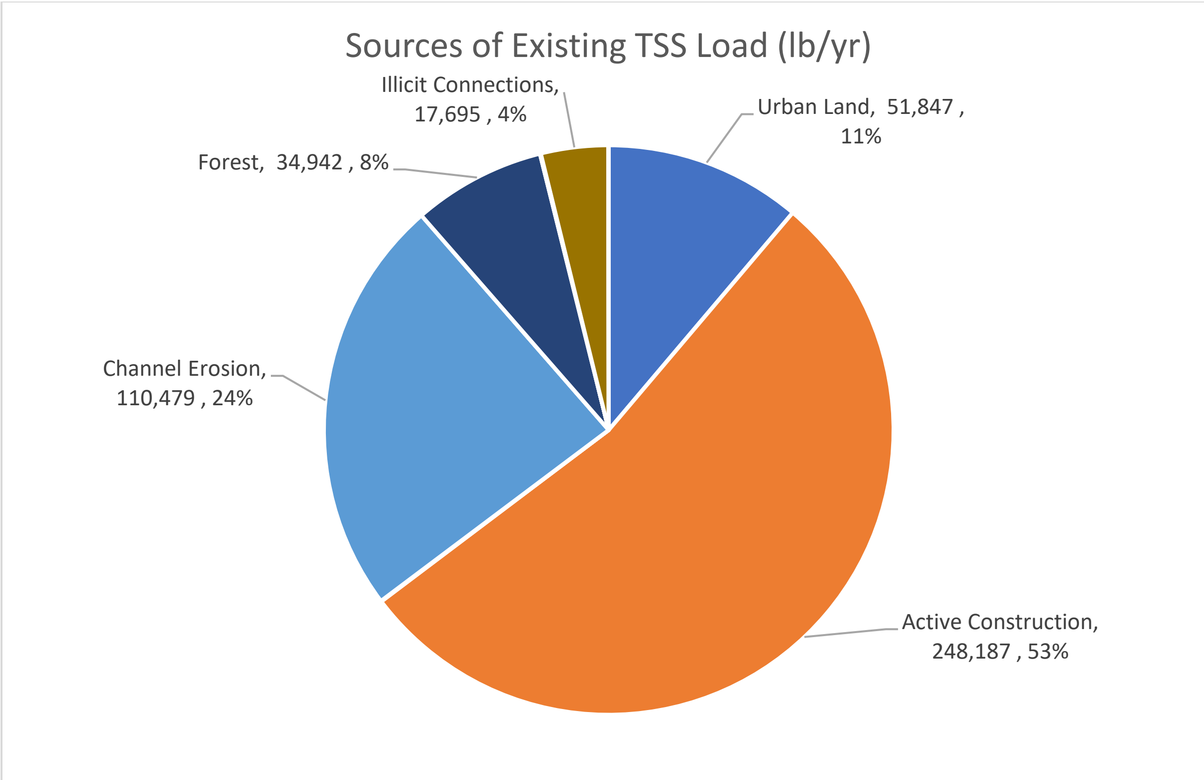

Figure 8. Sources of sediment loading to surface water by source type

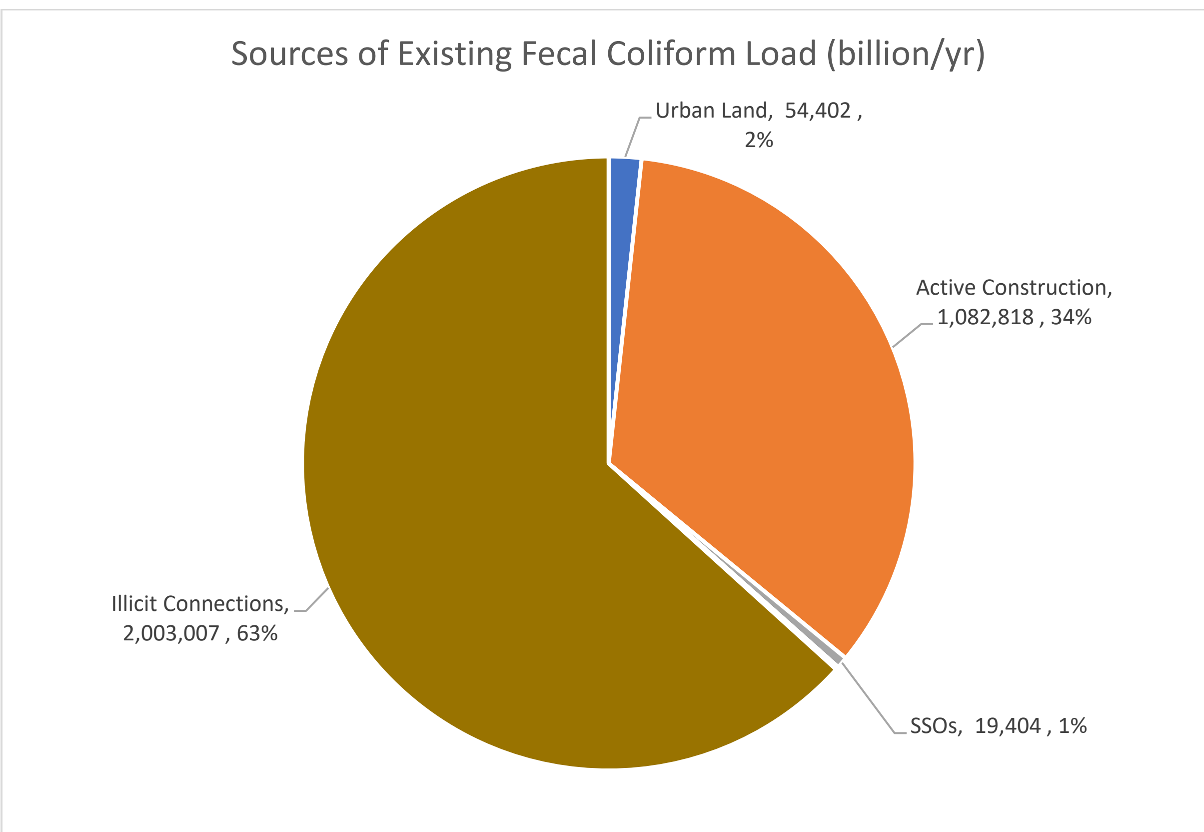

Figure 9. Sources of bacteria loading to surface water by source type

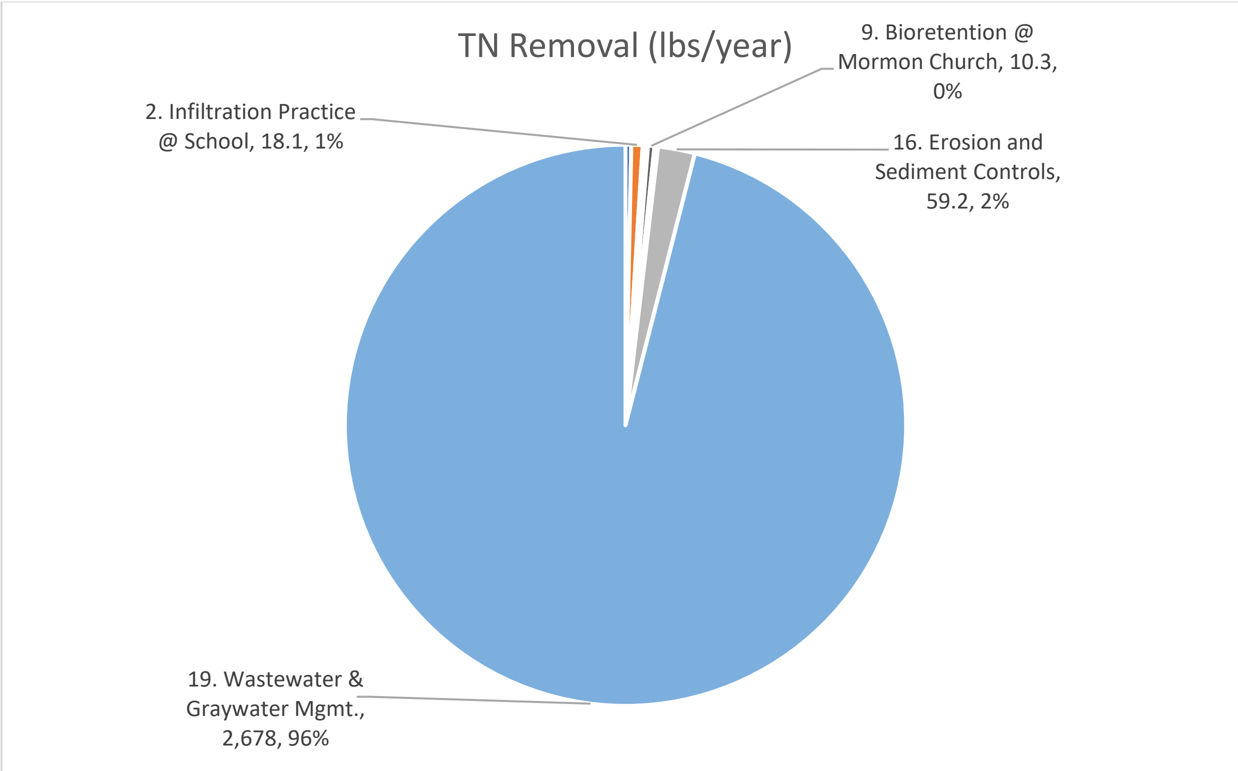

Figure 10. Estimated Total Nitrogen removal

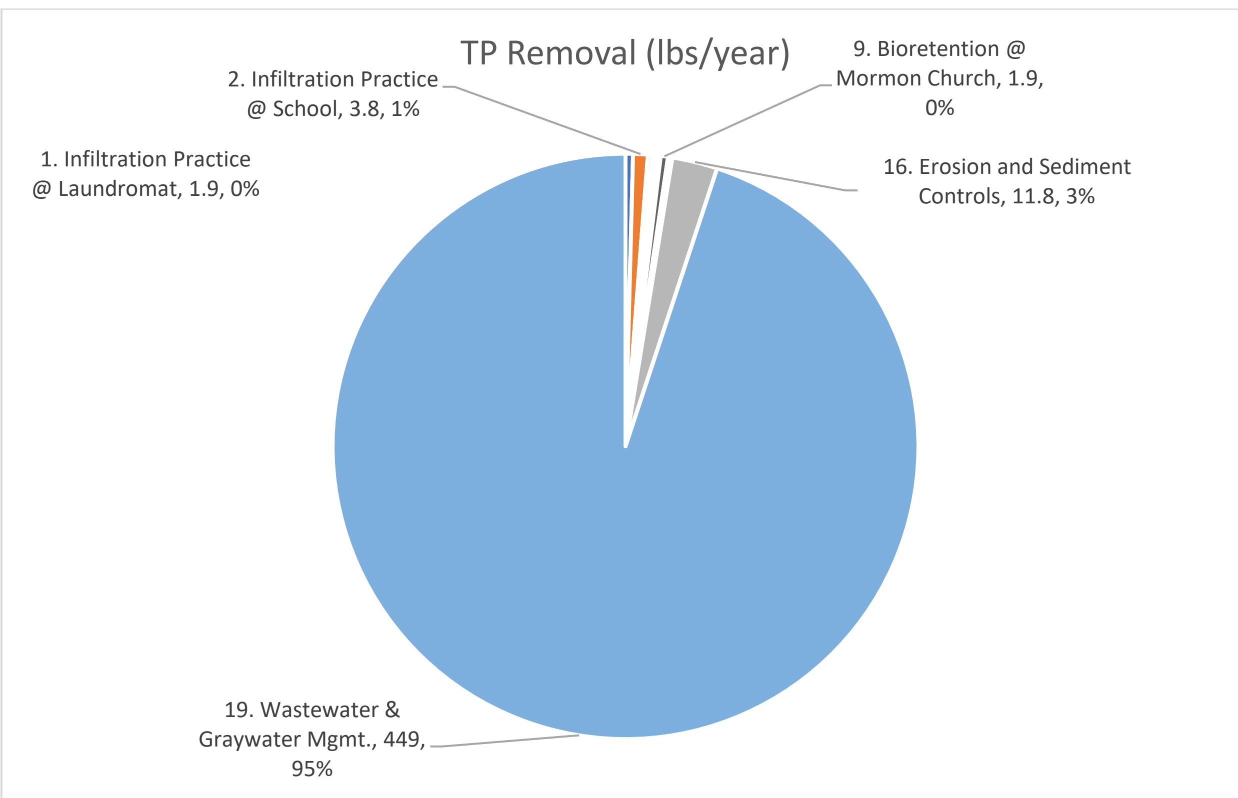

Figure 11. Estimated Total Phosphorus removal

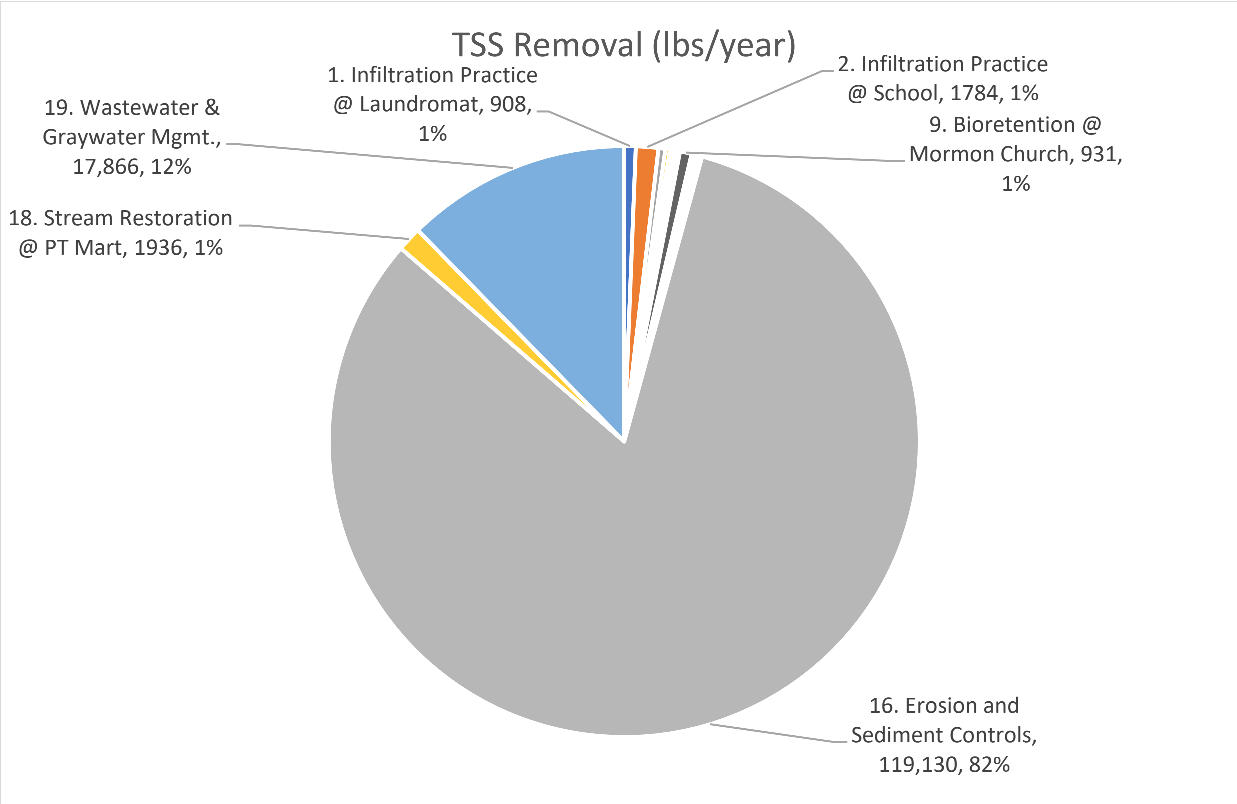

Figure 12. Estimated Total Suspended Solid removal

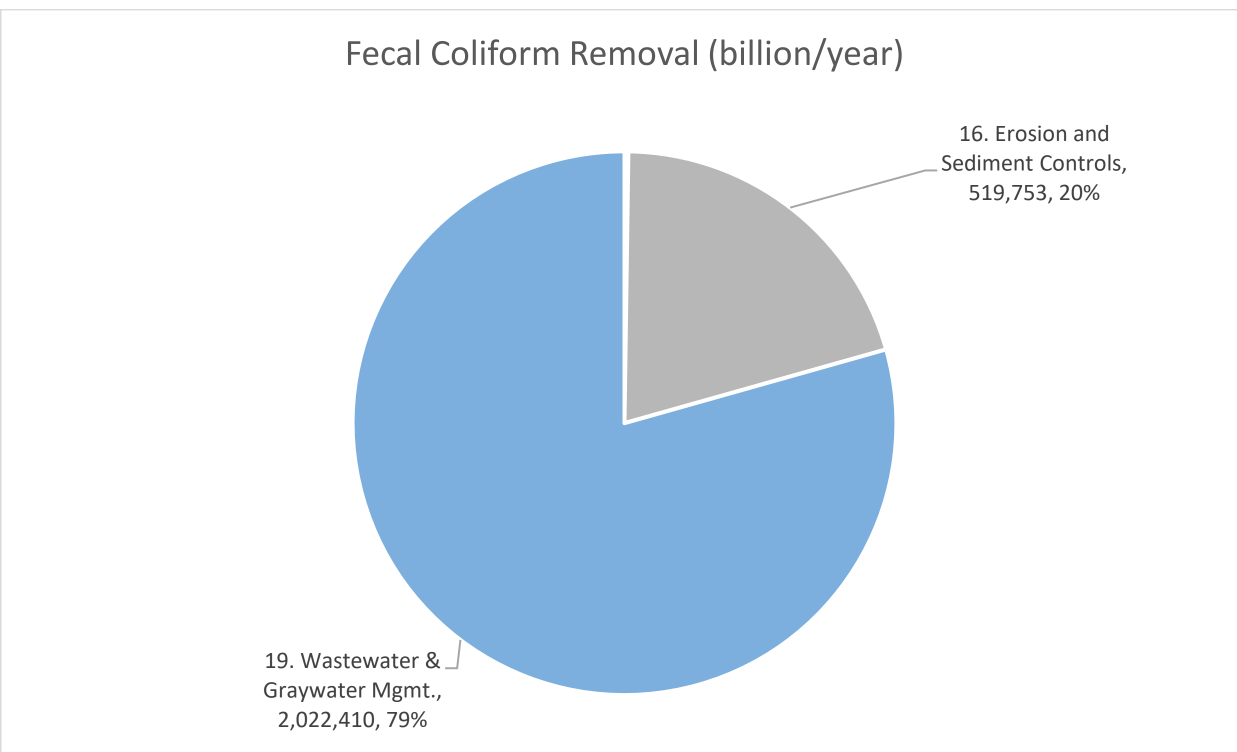

Figure 13. Estimated Fecal Coliform removal

APPENDIX E: AUA WATERSHED CHARACTERIZATION REPORT

Photo: Joy Smith 2022

Interim Report dated August 2022

Revised September 2023

Prepared for:
American Samoa Coral Reef Advisory Group
NOAA Coral Reef Conservation Program

Prepared by:
Horsley Witten Group, Inc.

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1.0 Introduction

The Aua Watershed was identified by CRAG and the NOAA Coral Reef Advisory Program (CRCP) as a priority area for watershed assessment and management (**Figure 1**). As a contributing drainage area to the Pago Pago Harbor on the island of Tutuila, this watershed includes the village of Aua, the southwestern side of the Olo Ridge, Route 001 between Aua Point and Leasi Point, several churches and businesses, and one public school (**Map 1**). This moderately developed watershed is a short distance east of Pago Pago, and is one of several subwatersheds that comprise the Pago Pago Harbor watershed (AS-EPA Watershed 24B). The Pago Pago Harbor is the most industrialized embayment within American Samoa; five of the six NPDES point sources identified in the Territory discharge to Pago Pago Harbor, none of which are within the Aua subwatershed. Recent sanitary sewer infrastructure developments have connected Aua Village to the municipal wastewater treatment facility Utulei Waste Water Treatment Plant (ASPA) on the southwestern embayment of Pago Pago Harbor. The Aua watershed contains freshwater wetland areas associated with the streams that extend from Aua Village into the surrounding uplands. A tidal wetland is also found within the watershed inland of Route 001 at the confluence of the Lalolamauta, Suaia, and Matagimalie streams. Streams within the watershed are impaired for total nitrogen, total phosphorus, turbidity, dissolved oxygen, and pH. Site contamination from residual fuel oil, piggery waste, household trash, unmanaged stormwater runoff, and past septic system failure are some of the known issues in this watershed affecting water quality.

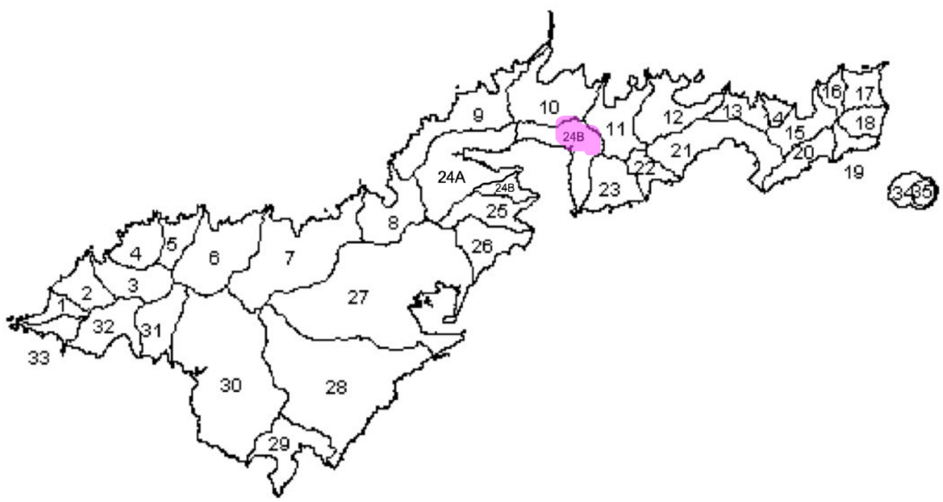
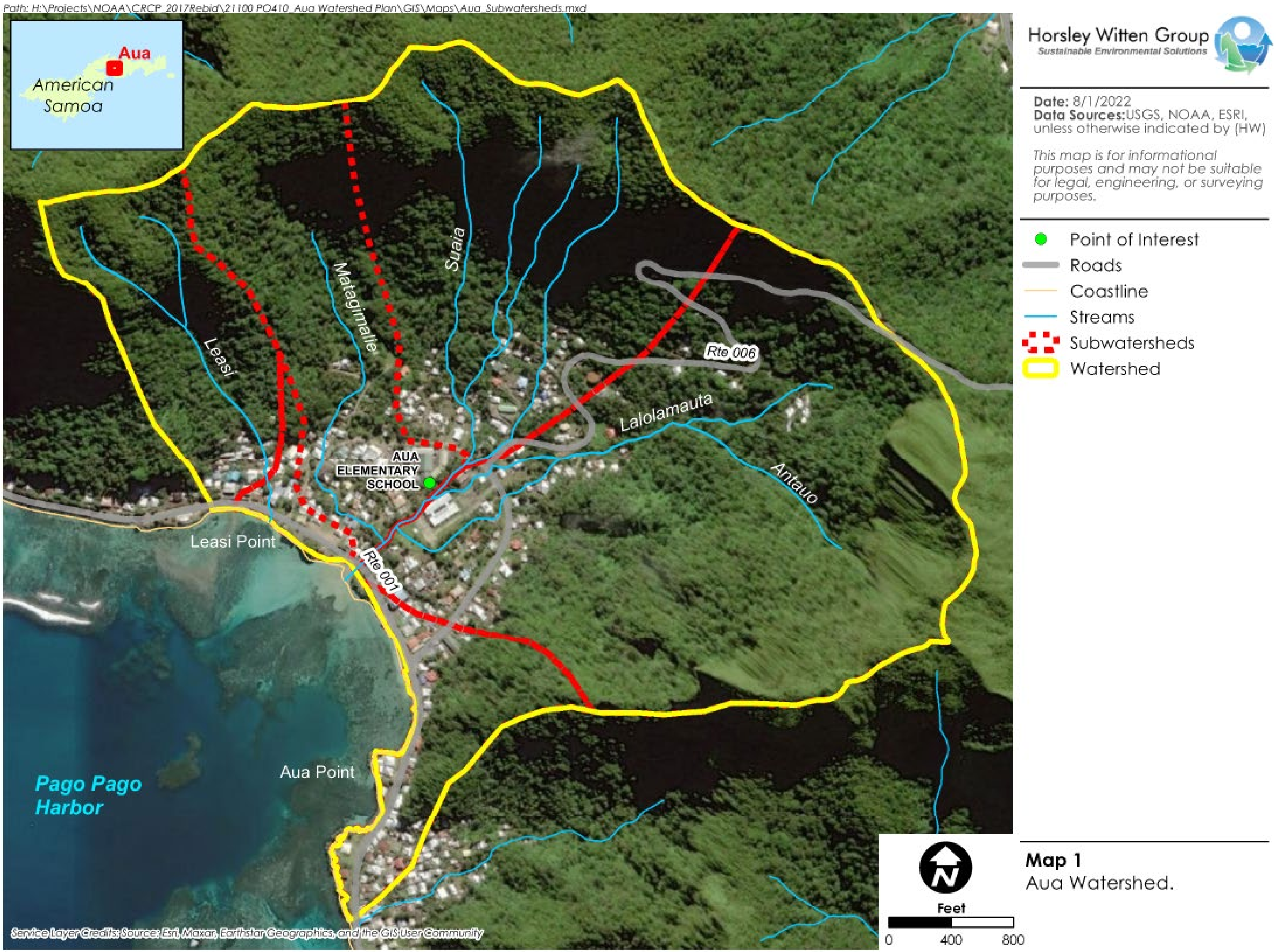


Figure 1. Tutuila Watershed Map and Aua Watershed (integrated Waters Report, 2020)

For the purposes of this report, the Aua Watershed is defined as 395 acres of land (0.62 square miles) that contributes surface drainage from Olo Ridge down to the Pago Pago Harbor via five main streams: Leasi, Matagimalie, Suaia, Lalolamauta, and Antauo (**Map 1**). The watershed is currently divided into six subwatersheds. From northwest to southeast, these are: Leasi Stream (39.6 acres); Leasi Point (6.1 acres) Matagimalie Stream (55.38 acres); Suaia Stream (99.3 acres); Lalolamauta Stream (168.9 acres, including drainage from the tributary Antauo Stream); and Aua Point (26.7 acres, south of Aua Village). Three of these subwatersheds (Matagimalie, Suaia, and Lalolamauta Streams) converge in Aua Village and drain to an estuary at the interface of Aua Village and Pago Pago Harbor.

This report provides a characterization of watershed conditions based on a review of existing information relevant to the watershed. Initial compilation of this information was used to identify data gaps, and provide background material for field assessments and public engagement activities. This report is now , incorporated into the Watershed Management Plan as a reference guide.



Map 1
Aua Watershed.

2.0 Land Use and Land Cover

2.1 Population Demographics

As of the 2020 Census, Aua Village has a recorded population of 1,549 people, making it the tenth largest village in American Samoa (U.S. Census Bureau, 2020). The village contains 388 housing units, with a population density of approximately 1,400 people per square mile (**Figure 2**). The population of Aua has decreased since 2010, at which point the population was recorded at 2,077 people. The majority of the population in Aua Village is Samoan, and 100% of the land within the watershed is owned by Samoan *aiga* (clans). The principal *aiga* in Aua are the Paopao, Liufau, Ponausuia, Tufaga, and Uii (USDA, 1995).

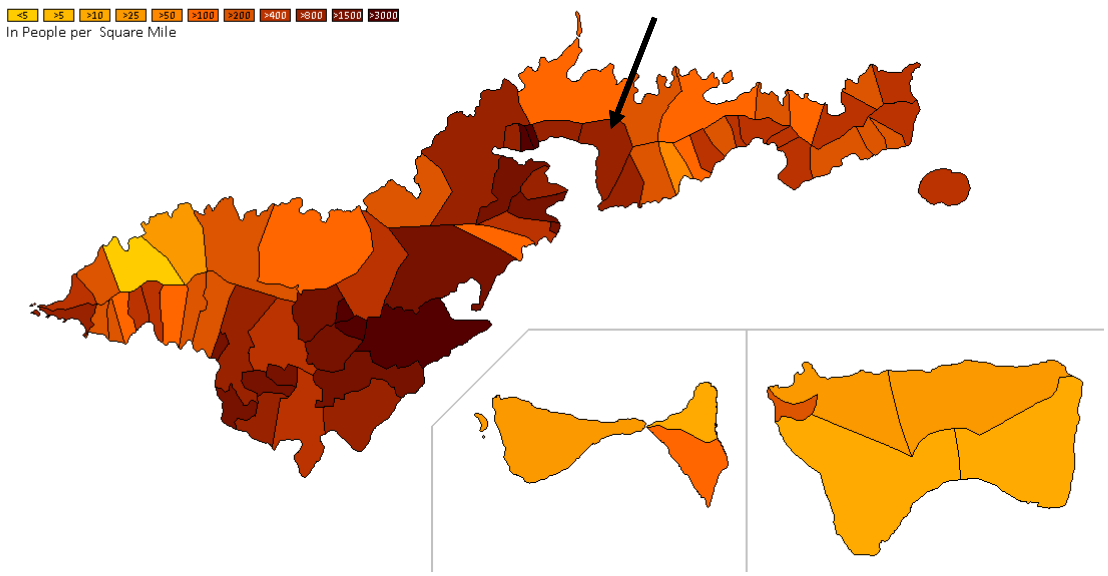


Figure 2. Population Density of American Samoan Villages (U.S. Census Bureau, 2020)

2.2 Land Use

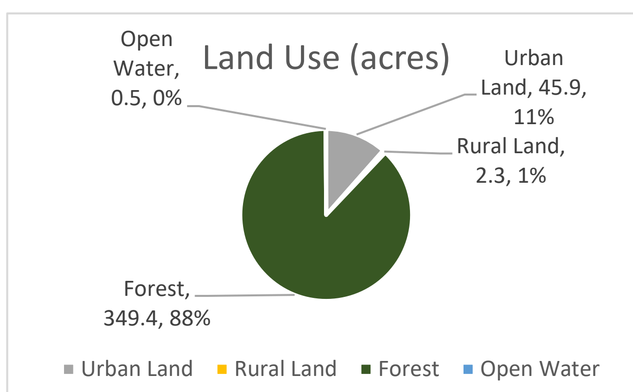


Figure 3. Land Use Distribution in Aua Watershed

The Aua Watershed is characterized by relatively flat, low-lying areas adjacent to Pago Pago Harbor and steep, rocky terrain upland of Aua Village. Aua Village is the location of nearly all development in the watershed. Development is generally limited to residential buildings, a few commercial buildings, and 4-5 churches; municipal facilities such as the Aua Elementary School, and a number of fales, are also found in the watershed (ASEPA, 2000). Agriculture is described as generally limited to upland areas, since little arable land remains undeveloped in the lowland area occupied by Aua Village. Present crop fields are generally 1–4-acre plots, intercropped with plants such as banana, taro, and sweet potato. Agriculture in the watershed today is generally limited to subsistence farming. At one point, an estimated 120 farmers were active within the Aua Watershed, and approximately 100 acres were devoted to farmland. In addition to crops, about 15-25 “backyard” piggeries were operated throughout the village, totaling about 100 total animals (USDA, 1995). Agricultural land has diminished significantly as of 2022 (**Figure 3**), and AS-EPA reported the presence of 3 active piggeries in the watershed. Documented piggery locations are shown below in **Figure 4**.

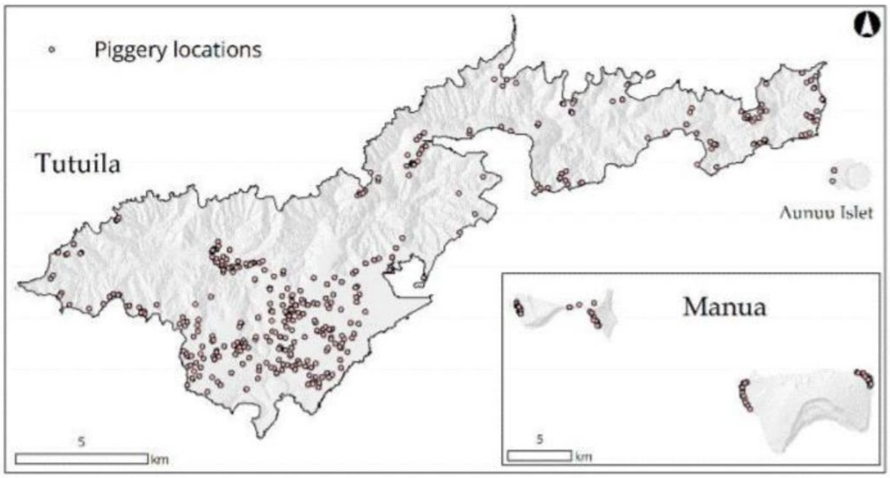


Figure 4. Piggery Locations (ASPA, 2018)

Two major roads, both paved, run through the Aua Watershed. These are Route 001, which runs along the coast of Pago Pago Harbor, and Route 006, which ascends from Aua Village up to Olo Ridge and ultimately to Afona Village on the north side of Tutuila. A number of dirt roads intersperse Aua Village and run as offshoots from Route 006. The majority of the developed areas within the Aua Watershed are distributed between the Leasi, Matagimalie, Suaia, and Lalolamauta subwatersheds. Leasi Point and Aua Point subwatersheds are generally forested, with development mostly limited to areas fronting Route 001. Upland areas of the watershed are forested.

2.3 Landcover

Of the 395 acres in the Aua Watershed, approximately 63 acres are occupied by residential and commercial lots, and an estimated 3 acres are devoted to agricultural land. Paved roads stretch over about 4.1 miles of the watershed, covering a footprint of roughly 10 acres. The remaining 319 acres are naturalized surfaces, including 9 acres of wetland and large swaths of forested land. Approximately 35 acres of the watershed are covered by impervious surfaces, or around 8%. Landcover breakdowns for each watershed are shown below in **Table 1.** Distributions of each landcover across the Aua Watershed is shown below as **Map 2**.

Table 1. Subwatershed Landcover Distribution

	Subwatershed:	**Leasi Stream**	**Leasi Point**	**Matagimalie Stream**	**Suaia Stream**	**Lalolamauta Stream**	**Aua Point**	**Total**
Landcover Type (acres)	Developed, High Intensity	1.8	2.4	5.9	5.9	10.5	6.1	32.6
	Developed, Open Space	0.3	0.9	1.7	1.8	5.1	2.8	12.6
	Cultivated Crops	0.7	0.1	0.9	-	0.7	-	2.4
	Grassland/Herbaceous	< 0.1	< 0.1	< 0.1	< 0.1	0.3	-	0.4
	Evergreen Forest	36.7	2.2	46.1	91.3	140.7	16.9	333.9
	Scrub/Shrub	-	0.3	0.2	0.3	11.4	0.3	12.5
	Barren Land	0.1	0.1	0.4	-	0.2	0.4	1.2

2.4 Regulatory Designations

Designated Areas of Particular Concern in the Aua Watershed include the Aua Village tidal wetland, the Aua Community-based Fisheries Management Program (CFMP) reserve, and FEMA flood zones within the watershed. The Tidal Wetland is shown as **Map 3**. The CFMP reserve is shown below as **Map 4**. FEMA flood zones are shown as **Map 5**. Significant portions of Aua Village fall within the FEMA 100-year floodplain, including many residential properties and the Aua Elementary School.

No other regulatory designations have been identified within the watershed.

2.5 Historic and Cultural Sites

As shown on **Figure 5**, no properties are listed as Historic Properties on the National Register of Historic Properties within the Aua Watershed (ACOE, 2022). Samoans are believed to have reached the island of Tutuila by 600 B.C.E., if not earlier (Stanley, 1986). Aua Village is included in descriptions of the 13th-14th century chief Tuifeai, who held a stronghold in the village. The stronghold or "great house" was bounded by *Malaeopaepaeulupoo*, or the "field of stacked skulls," in which stacks of skulls were used to signify an area of sacred grounds and to ward off enemies (Kramer, 2000).

Figure 5. Listed National Properties on the National Register of Historic Places (ACOE, 2022)

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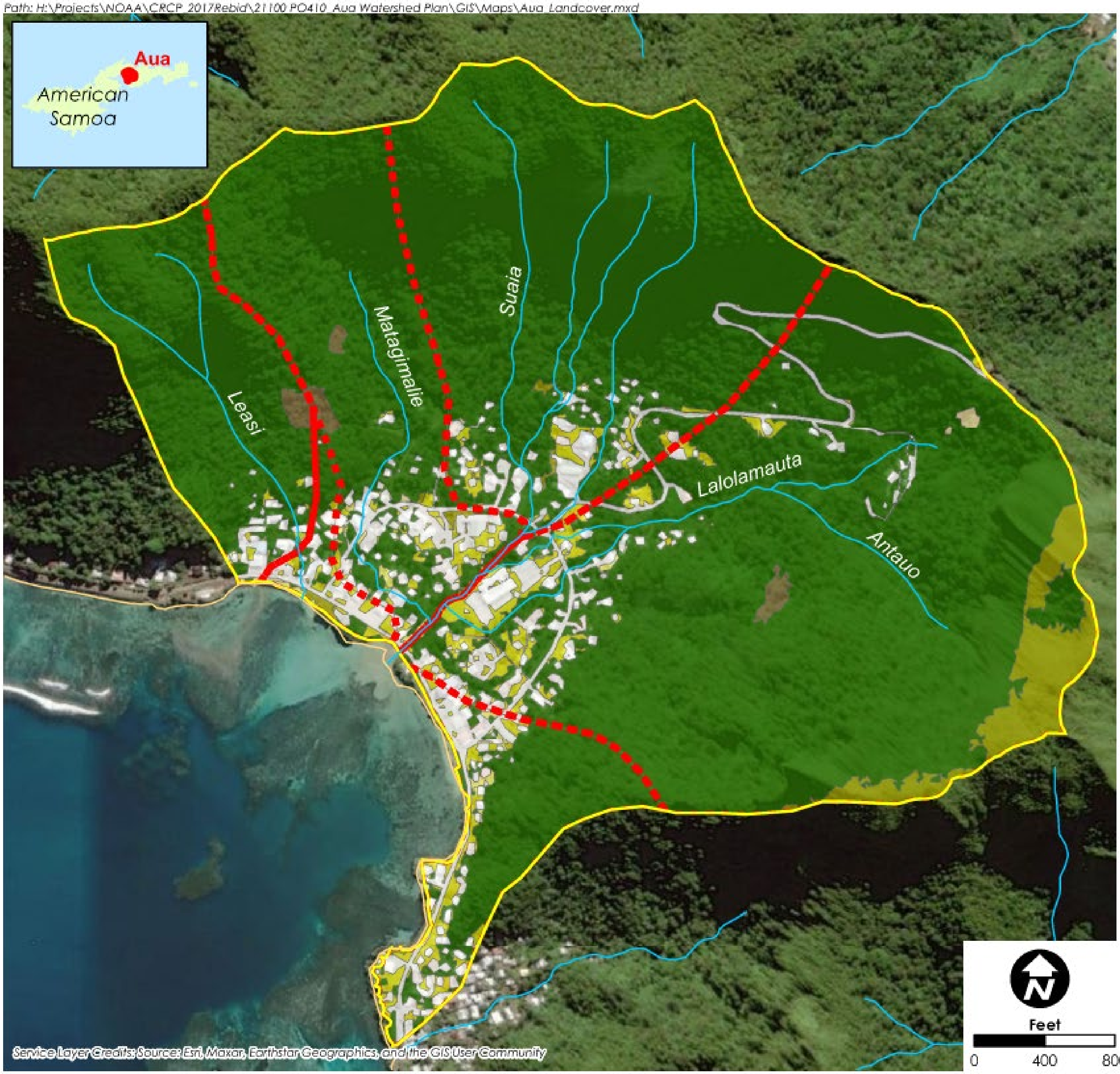

Horsley Witten Group
Sustainable Environmental Solutions

Date: 8/1/2022
Data Sources: USGS, NOAA, ESRI, unless otherwise indicated by (HW)

This map is for informational purposes and may not be suitable for legal, engineering, or surveying purposes.

- Coastline
- Streams
- Watershed
- Subwatersheds

Landcover Classes

- Developed, High Intensity
- Developed, Open Space
- Cultivated Crops
- Grassland/Herbaceous
- Evergreen Forest
- Scrub/Shrub
- Barren Land

Map 2
Aua Landcover.

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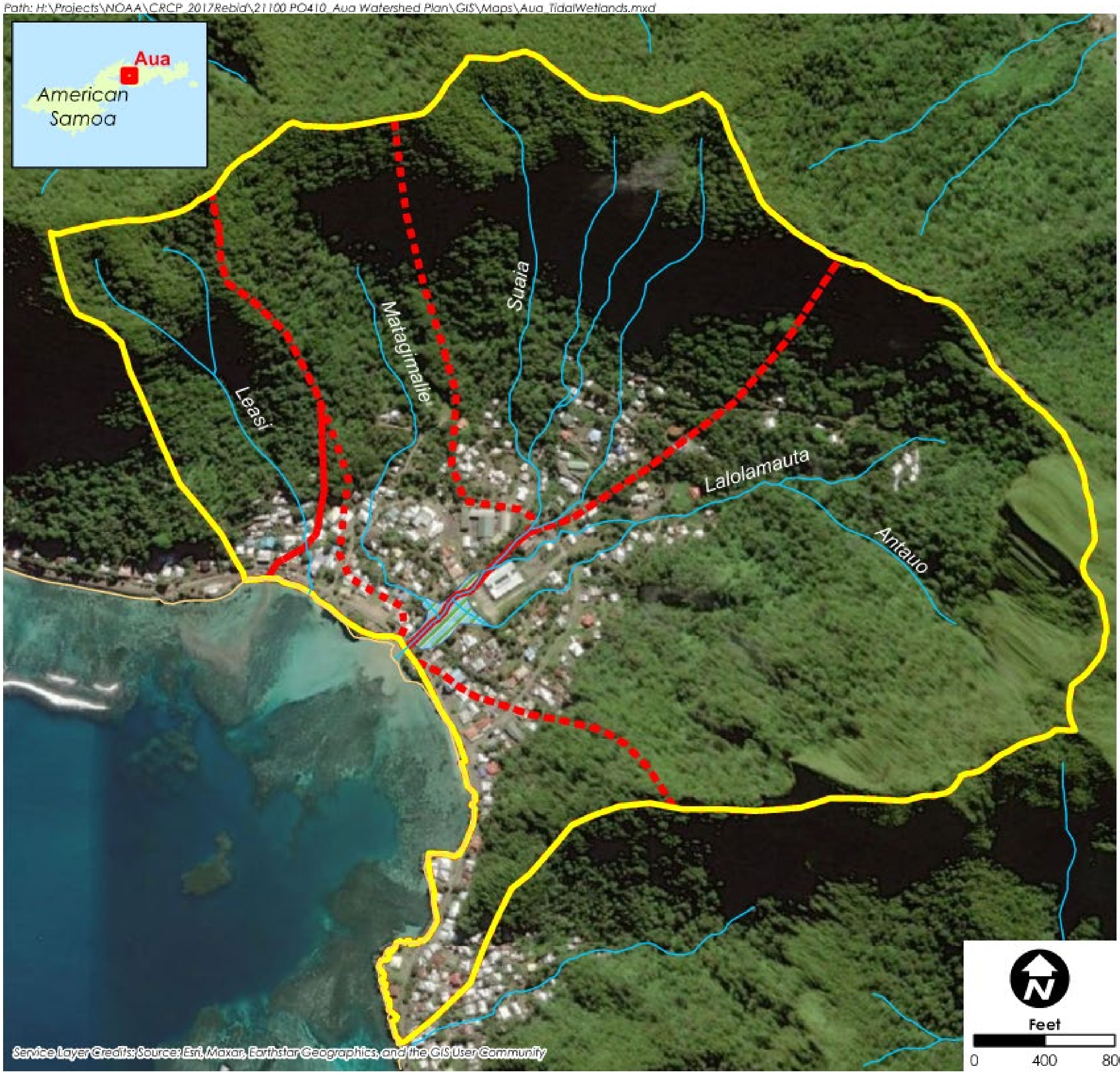

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Date: 8/1/2022
Data Sources: USGS, NOAA, ESRI, unless otherwise indicated by (HW).

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Coastline
Streams
Watershed
Subwatersheds
Estimated Tidal Wetland

Map 3
Tidal Wetlands.

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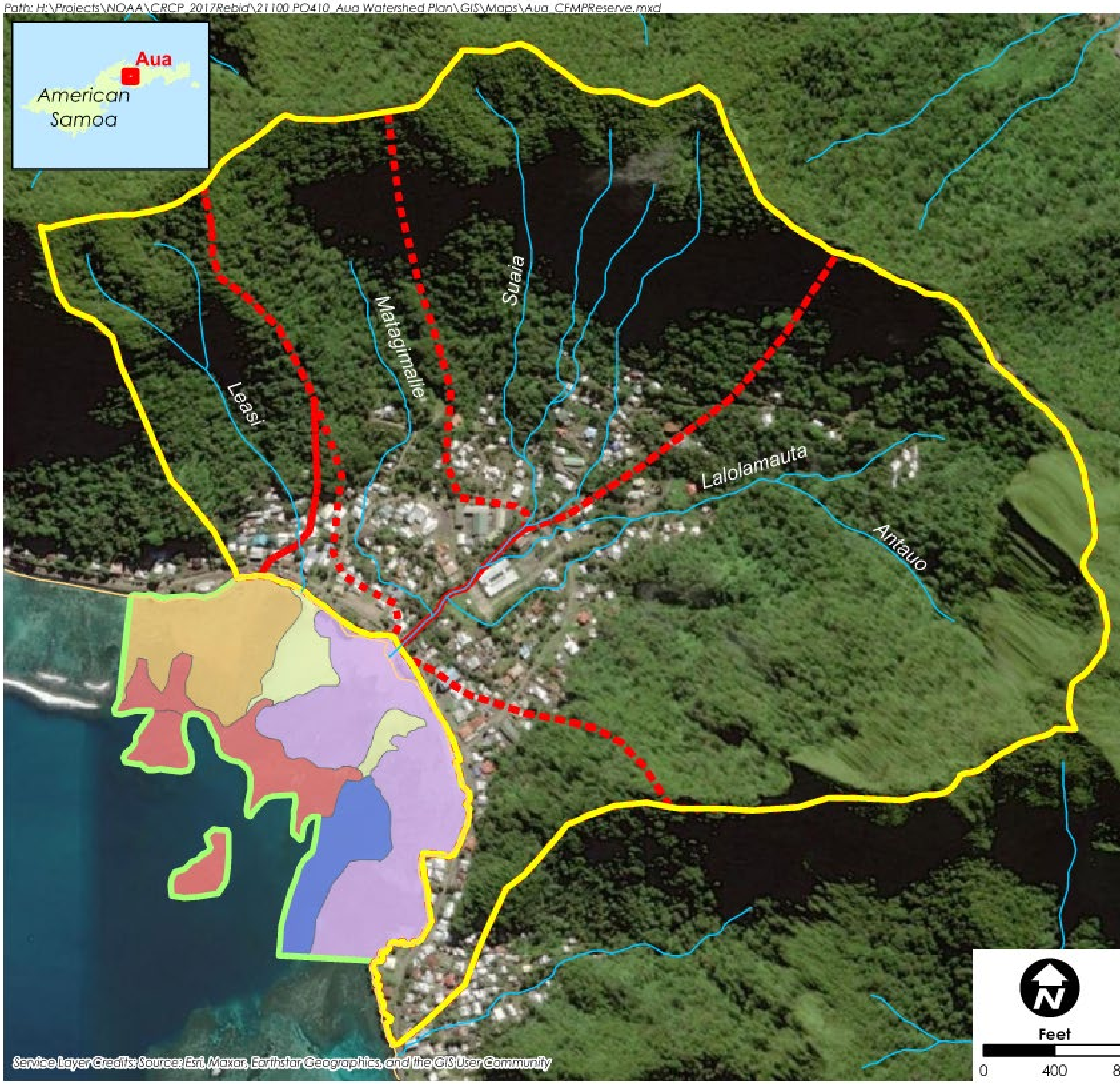

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Date: 8/1/2022
Data Sources: USGS, NOAA, NCCOS, ESRI, unless otherwise indicated by (HW).

This map is for informational purposes and may not be suitable for legal, engineering, or surveying purposes.

Coastline
Streams
Watershed
Subwatersheds
Aua CFMP Reserve

Benthic Cover Type

Coral
Coralline Algae
Turf
Uncolonized
Unknown

Map 4
Aua Community-based Fisheries Management Program (CFMP) Reserve.

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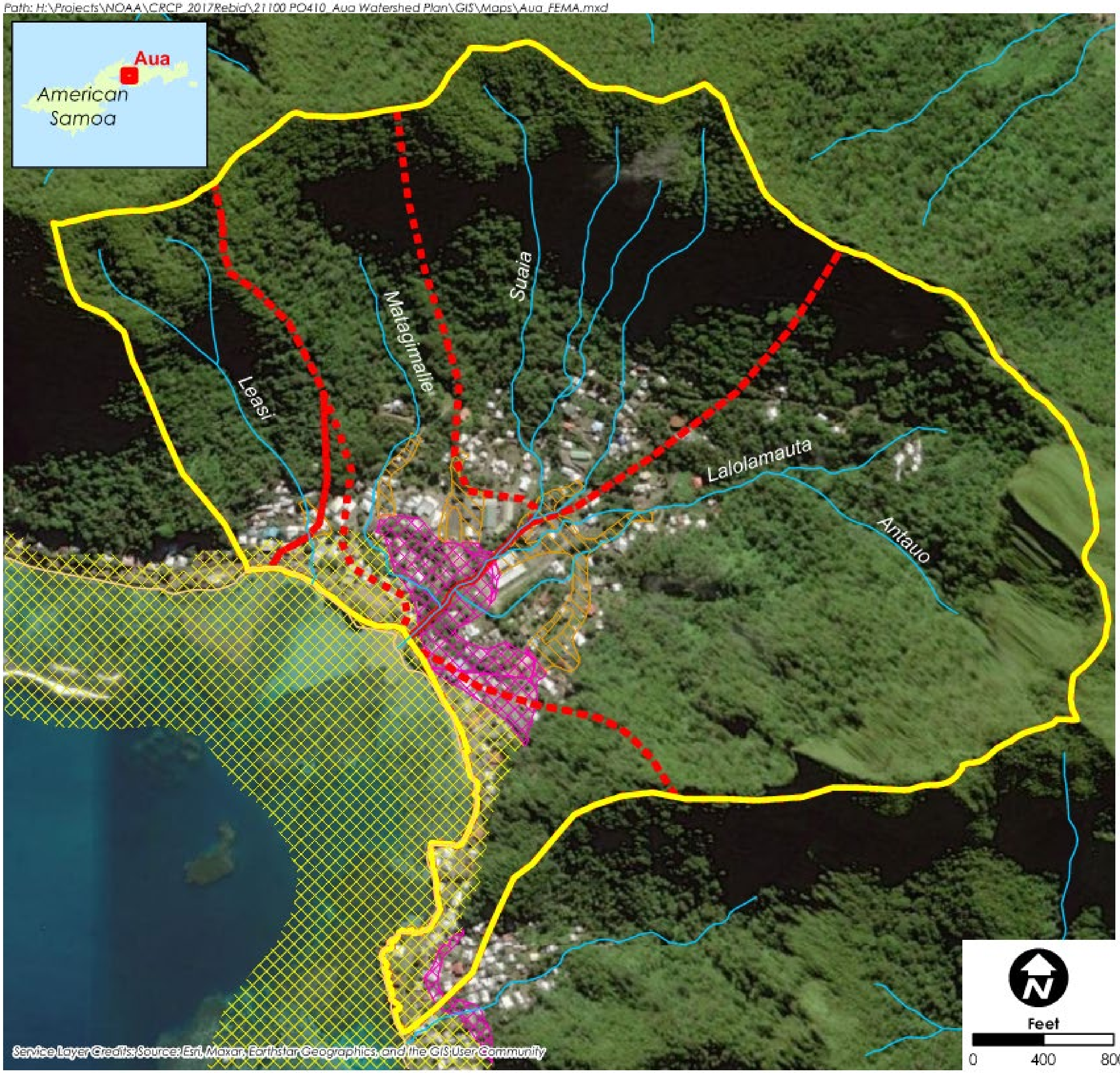


Horsley Witten Group
Sustainable Environmental Solutions

Date: 8/1/2022
Data Sources: FEMA, NOAA, ESRI, unless otherwise indicated by (HW)

This map is for informational purposes and may not be suitable for legal, engineering, or surveying purposes.

Coastline
Streams
Watershed
Subwatersheds

Flood Zones

A
AE
VE

Map 5
Aua Watershed FEMA Flood Zones.

2.6 Historic Contamination

In 1938 and 1939, the United States Navy constructed twelve 10,000-barrel aboveground steel fuel storage tanks, 13 pump houses, and a 12-inch pipeline delivery system throughout Aua to provide fuel to tuna canneries to the west. Fuel tank locations are shown below in **Figure 6**. The farm was established primarily for bulk fuel oil storage and distribution to support Naval Station Tutuila during World War II. By 1945, the tanks were largely dismantled and drained, with only 5,000 barrels remaining. The fuel farm area was re-graded and flat areas were overlain with 5 to 10 feet of volcanic cobble and boulder of various sizes used as rock fill. As such, any tank remnants are expected to be buried under the rock fill (ACOE, 2020).

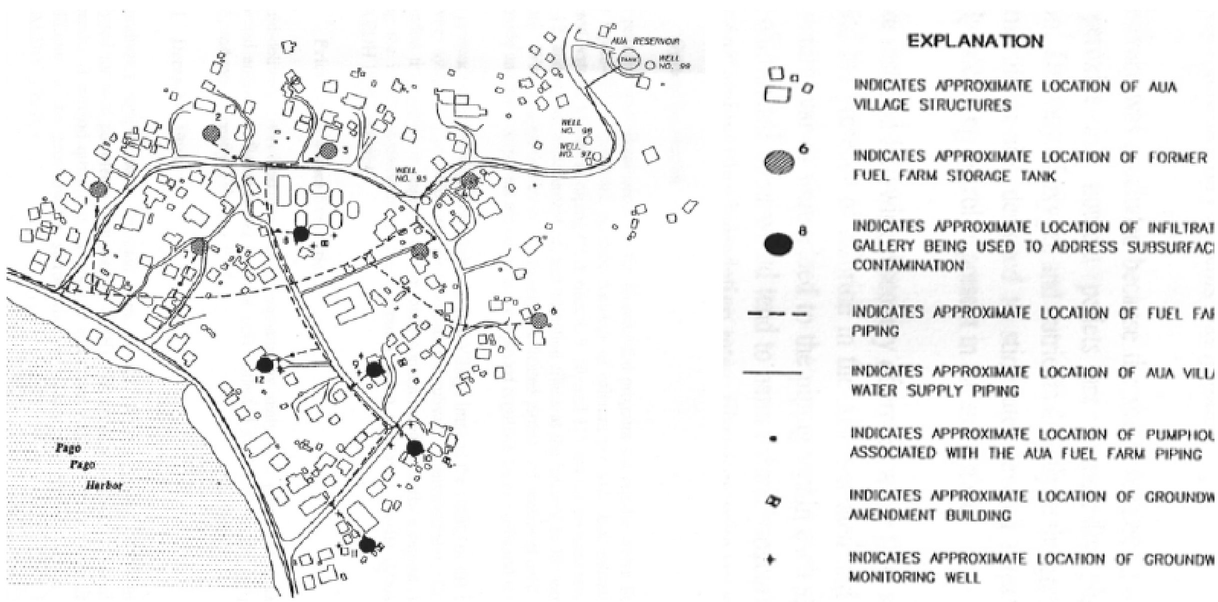


Figure 6. Fuel Tank Locations and Distribution Lines (USEPA, 2011)

Between 1989-1991, it was confirmed that petroleum hydrocarbons were present in several areas of the village including along the transmission pipe along the coast (Chen-Fruean, 2019). During the course of those investigations, 9 of the 12 tanks were located (Tanks nos. 4–12); Tank No. 7 could not be found, and Tanks nos. 1–3 were not part of the request for investigation. Large volumes of petroleum-impacted soil were encountered during investigations at the various tank sites. Subsequently, bioremediation by oxygen pellets and thermal treatment were used at different stages to treat the contamination. All active remediation efforts ceased in 1999 with the shutdown of the bioremediation system.

Subsequently, on three separate occasions between 2018-2021 construction activities exposed contaminated soils—most recently during the sewer line extension project (described below). Remediation efforts led by ERRG, Inc. included thermal treatment (ex situ), reuse petroleum-contaminated soil, as well as in situ bioremediation and extensive (and ongoing) monitoring. ERRG has installed monitoring wells in the Village to better understand potential plume movement. More information is needed to better understand the overall impact of hydrocarbon contamination in the watershed and marine ecosystem.

3.0 Infrastructure

3.1 Wastewater

Wastewater generated in Aua is piped to the Utulei Sewage Treatment Plant, a wastewater treatment plant managed by the American Samoa Power Authority (ASPA) on the western shore of Pago Pago Harbor. A yearslong project extending the sewer line into Aua began in 2019 and was completed in 2022 with funding by the United States Environmental Protection Agency (USEPA) (Samoa News, 2012), as shown in **Figure 7**. The Utulei Sewage Treatment Plant is one of five identified point sources that are permitted to discharge to Pago Pago Harbor through the National Point Discharge Elimination System (NPDES). No NPDES discharge points are located in Aua Watershed itself.

Figure 7. Route 001 Sewer Installation Project (HW, 2019)

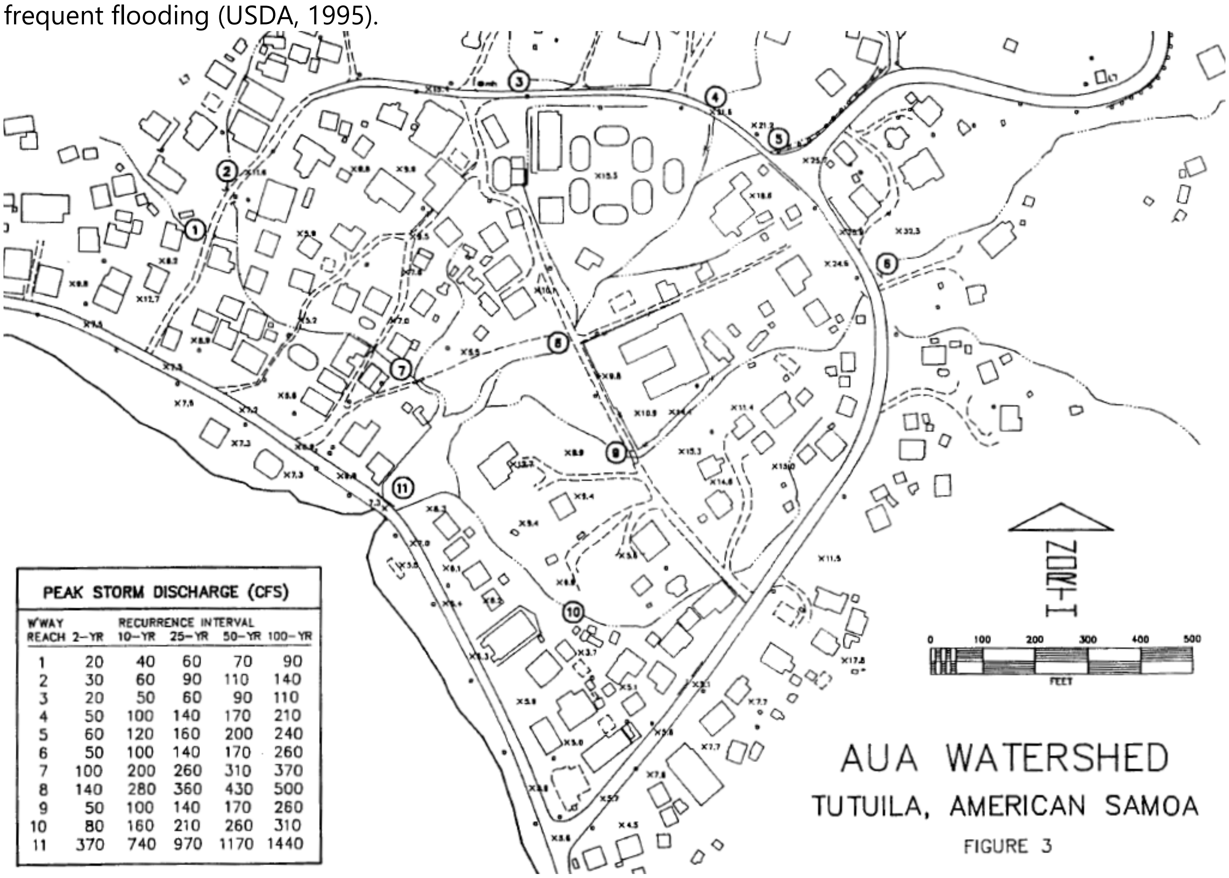
Prior to 2019, the village was entirely served by cesspools and septic systems. High groundwater levels and the prevalence of fill in low lying portions of the village reduced the overall effectiveness of these wastewater treatment practices (USDA, 1995).

3.2 Stormwater

While on-island in October, 2022, HW mapped drainage infrastructure within the Aua Watershed and at locations in the Aua Village outside of the delineated watershed extents. The locations and descriptions of the drainage infrastructure identified are included in the Field Memo (**Attachment B**).

American Samoa is not currently regulated by the USEPA under the NPDES Phase II permit for municipal separate storm and sewer systems (MS4). Therefore, no federal requirement currently exists that requires stormwater management within the Aua Watershed. No stormwater system or outfall mapping is readily available for the Aua Watershed. A system of curbs and gutters is in place throughout Aua Village to convey stormwater away from roadways. Catch basins have been installed in a few locations around the Village (generally near Routes 001 and 006) to collect runoff from the gutters. At points where streams intersect roads in the Village, culverts have been installed to convey streamflow. At the outlet of Lalolamauta Stream from the central wetland to Pago Pago Harbor, a 28-foot-wide bridge is in place – the only bridge in the Watershed.

During riverine flood events, the five major streams of the Aua watershed must cross through eight culverts within Aua Village before discharging into Pago Pago Harbor (**Figure 8**). The culverts are generally undersized for intense storm events, and several of the culvert elevations are too low and experience frequent clogging with sediment (USDA, 1995). The four streams other than Leasi Stream converge in Aua Village before passing under the Route 001 bridge. The Route 001 bridge is sized with a flow capacity of 250 cubic feet per second (cfs), which is less than the estimated 2-year flow of the stream (370 cfs). As a result, the roadway and approximately 18 upstream structures experience relatively frequent flooding (USDA, 1995).



W'WAY REACH	RECURRENCE INTERVAL 2-YR	10-YR	25-YR	50-YR	100-YR
1	20	40	60	70	90
2	30	60	90	110	140
3	20	50	60	90	110
4	50	100	140	170	210
5	60	120	160	200	240
6	50	100	140	170	260
7	100	200	260	310	370
8	140	280	360	430	500
9	50	100	140	170	260
10	80	160	210	260	310
11	370	740	970	1170	1440

Figure 8. Flow Profiles of Streams at Points within the Aua Watershed (USDA, 1995)

3.3 Drinking Water

The American Samoa Power Authority (ASPA) maintains between 2-3 wells within Aua Village (ASEPA, 2000) (ASCC, 2020). During two- to three-month dry periods, shallow groundwater reservoirs are depleted by uptake for water supply. Deeper wells in Aua extend more than 100 feet below sea level in order to reach a freshwater aquifer. Saltwater intrusion is a frequent concern with the deeper wells, and chloride levels in well water are monitored to prevent overextraction of the freshwater aquifer (ASPA, 2014).

A tank along Route 006 is the main piece of water supply storage infrastructure in Aua. Beginning in 2022, installation of a filter for desalination began at the tank. Future water projects planned for the Watershed include replacement of the ASPA water mains throughout the Village; no timeline has been determined for this project.

3.4 Infrastructure Improvements

Recent large-scale projects in the Aua Watershed include the expansion of wastewater services to Aua Village (ongoing through 2022), remediation of plumes of fuel in soil at the former Aua Fuel Farm that was originally developed during World War II (completed in 2021) and upgrading water filtration at the tank along route 006 (ongoing through 2022).

4.0 Hydrology & Coastal Dynamics

4.1 Mean annual/monthly Precipitation

Mean annual precipitation for the watershed is approximately 150 inches per year, most of which occurs between November and April. **Figure 9** shows average monthly rainfall at the Pago Pago Airport based on data from the past 30 years. Rainfall is highly variable on Tutuila due to the island's mountainous topography, and annual rainfall has been known to range from 125 inches to 250 inches at different points on Tutuila over a single year.

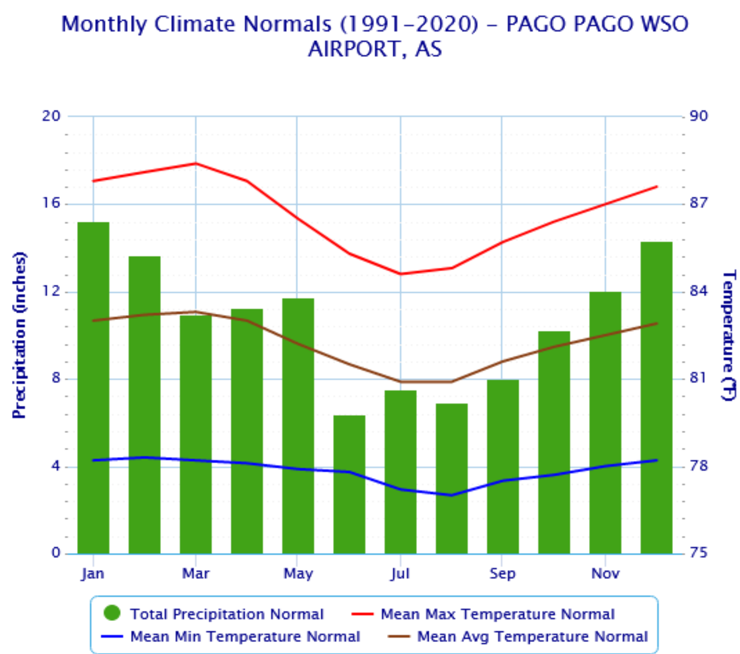


Figure 9. Average Monthly Rainfall and Temperatures at Pago Pago Airport (National Weather Service, 2022)

Annual rainfall amounts have trended upward over the past 50 years of record at the Pago Pago Airport station, as shown below in **Figure 10**. The rolling 10-year average annual rainfall has increased from relative lows around 115 inches per year in the 1970s to highs around 135 per year in the 2020s at Pago Pago, suggesting that annual precipitation in Aua may also be increasing over time. More specific rainfall estimates for Aua are not readily available.

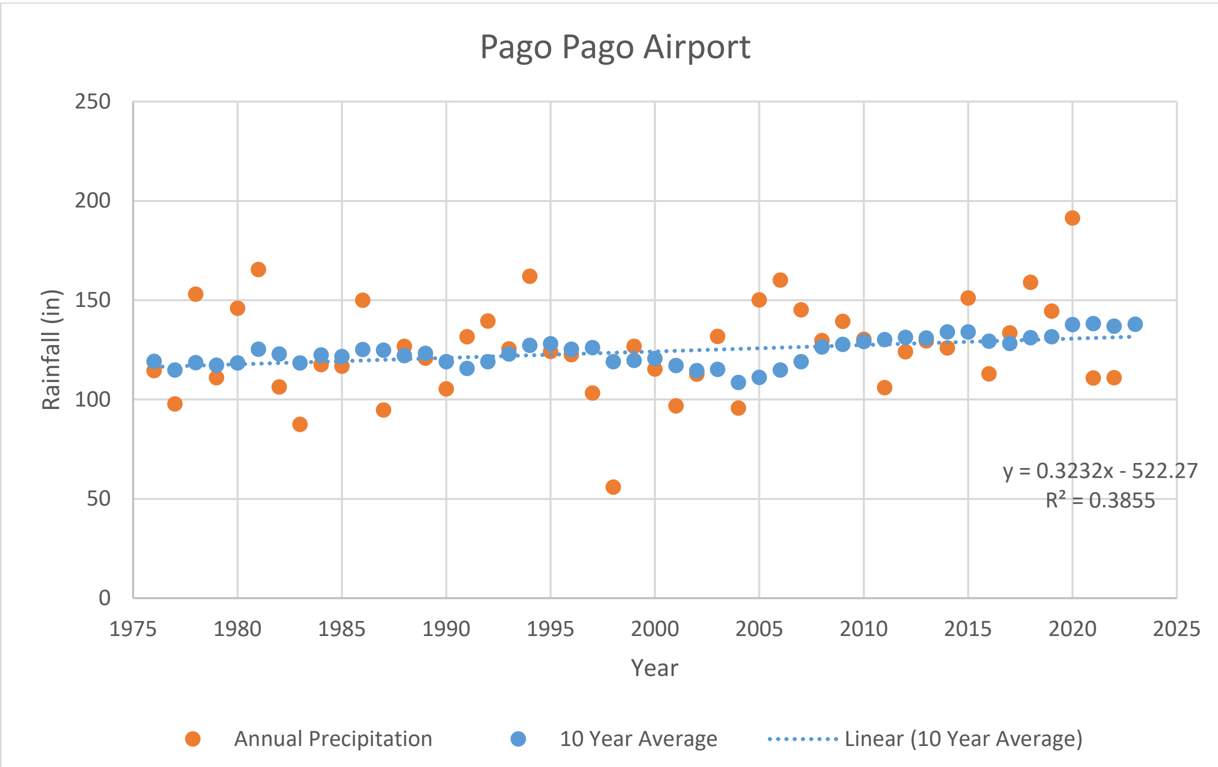


Figure 10. Annual Rainfall Record at Pago Pago Airport

The only other known rainfall gauge in the vicinity of the Aua Watershed is to the east of Aua Village, just over the top of Pioa Mountain in Afono. Operated by the United States Geological Survey (USGS), data from the Afono gauge from 1987-97 indicated a mean annual rainfall of 164 inches. As with Aua and the nearby gauge at Pago Pago, the Afono station observed its heaviest periods of rainfall between November and April (USGS, 1999).

4.2 Stream Flow/Discharge

There are several small upland tributaries and springs that combine to comprise the five major streams within the Aua Watershed (from west to east): Leasi, Matagimalie, Suaia, Lalolamauta, and Antauo. Antauo Stream is a tributary to Lalolamauta Stream and converges with Lalolamauta a short distance upgradient of Aua Village. Stream gaging efforts by USGS between 1960 and 1995 established two continually operated stream gaging stations on Lalolamauta and Matagimalie Streams. Based on stream gaging efforts across Tutuila, an estimated 65.6% of annual peak discharges occur between the wet season (November through April) (USGS, 1996), **Figure 11** shows the distribution of annual peak discharges based on USGS data collected through 1990.

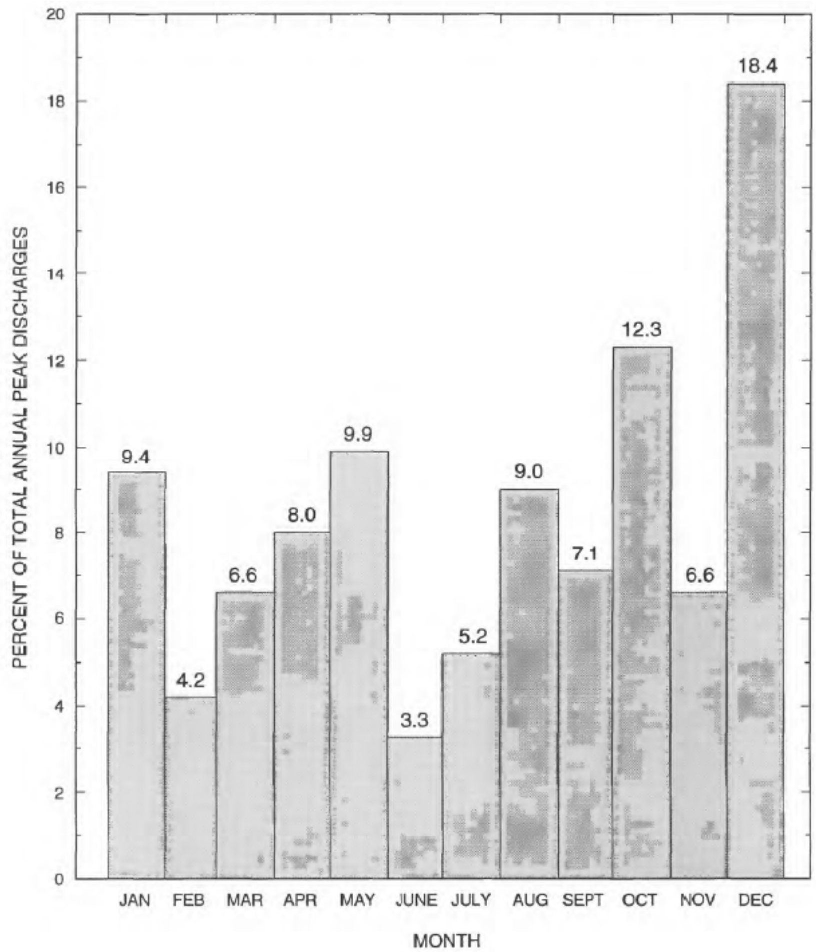


Figure 11. Monthly Occurrence of Annual Peak Discharges from 1960-1990 for 11 Continuous-Record Stream Gaging Station on Tutuila (USGS, 1996)

Regression models to estimate flood flows of ungaged streams on Tutuila have been developed both by the Army Corps of Engineers (ACOE, 1990) and by USGS (USGS, 1996). Regression equations used in both models are reproduced below. **Table 2** shows estimates of peak flood flows for each of the four largest streams within the Aua Watershed. Estimates of median flow in Matagimalie and Lalolamauta Streams were developed by USGS based on measurements taken between 1959 and 1977 (USGS, 1996). Median flow estimates are shown below in **Table 3**.

Table 2. Peak Flood Rate Estimates at Major Streams in Aua Watershed

Recurrence Interval	Leasi		Matagimalie		Suaia		Lalolamauta	
	ACOE	USGS	ACOE	USGS	ACOE	USGS	ACOE	USGS
2-year (cfs)	37	55	46	66	102	127	212	233
10-year (cfs)	82	112	100	134	205	247	402	439
50-year (cfs)	140	180	168	211	322	370	594	628
100-year (cfs)	171	214	204	250	380	429	682	711

Table 3. Median Flow Estimates at Major Streams in Aua Watershed

Stream:	Matagimalie	Lalolamauta
Drainage Area (sq mi)	0.03	0.14
Median Flow (cfs)	0.14	0.21

5.3 Groundwater

Across Tutuila, steep topography and volcanic geology result in high-level groundwater reservoirs and aquifers contained in layers of rock above sea level (ACOE, 2022). The low permeability of the volcanic geology limits the flow of groundwater out to streams as base flow. Records of groundwater pumping between 1987-97 indicate that uptake of groundwater for water supply usage generally results in groundwater levels 12-15 feet below mean sea level (USGS, 1999). Estimates of annual net groundwater infiltration and approximate water table elevations across Tutuila from Shuler (2019) are shown below in **Figure 12** and **Figure 13**.

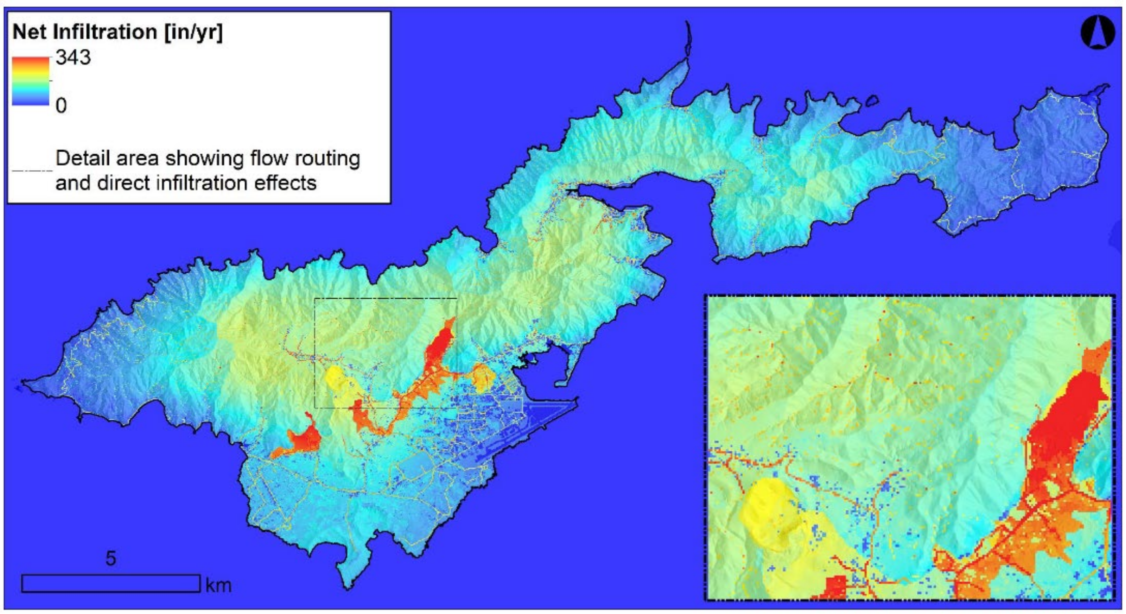


Figure 12. Net Infiltration Across Tutuila (Shuler, 2019)

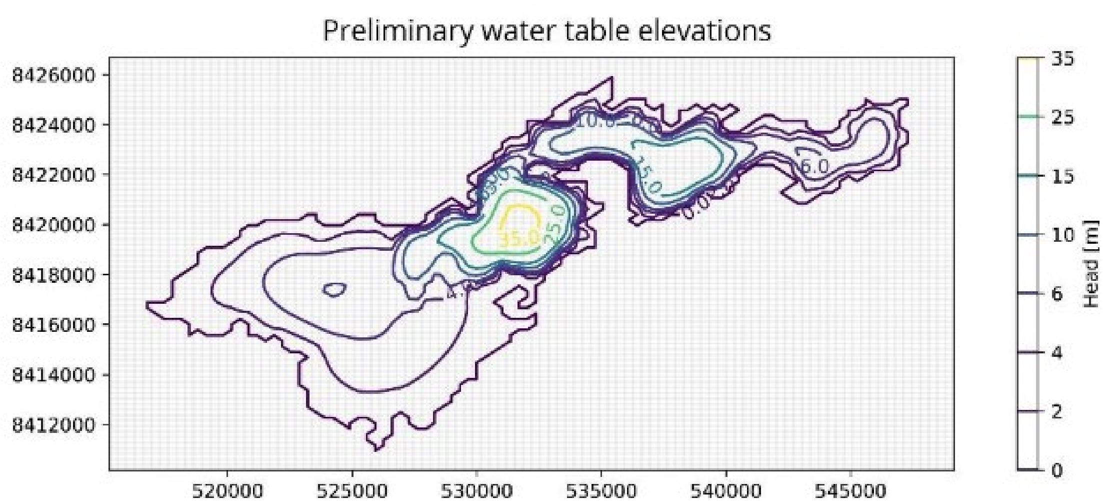


Figure 13. Approximate Water Table Elevation Map for Tutuila (Shuler, 2019)

5.4 Hydrodynamics

Pago Pago Harbor is the largest coastal inlet on Tutuila, located roughly in the center of the island. The embayment at Aua Village is at the northeast corner of the harbor, from Leasi Point to the northwest to Aua Point to the southeast. A reef at the edge of the Aua embayment is 500-800 feet wide and generally follows the shape of the coast along Aua Village. In general, the harbor experiences less wave energy than other areas off the coast of Tutuila (Comeros-Raynal et al., 2019). As a result, pollutants and other inputs into the Aua embayment and its reef are dispersed less quickly than at reefs along the outer coast of the island.

The closest sea level gage to Aua is located in Pago Pago and is operated by NOAA. Tidal statistics for the Pago Pago gage are shown below in **Table 4**.

Table 4. NOAA Tidal Gage 1770000 – Pago Pago, American Samoa, American Samoa (accessed December 2022)

Tidal Statistic	Elevation Relative to Mean Sea Level (ft)
Highest Observed Tide (HOT)	4.01
Mean Higher High Water (MHHW)	1.42
Mean High Water (MHW)	1.29
Mean Low Water (MLW)	-1.30
Mean Lower Low Water (MLLW)	-1.36
Lowest Observed Tide (LOT)	-2.47
Mean Range	2.59

Occasional "king tide" (high spring tide) events occur across Tutuila. The most recent king tide occurred between July 12-15, 2022. The 2022 king tide caused significant damage, affecting a total of 34 residences and destroying four (Samoa News, 2022). A chart of wave height at a station in Aunu'u, east of Tutuila, during the period of the king tide is shown below as **Figure 14**. In Aunu'u, waves were recorded at a height of 15.42 feet. At the NOAA gage in Pago Pago during the same time, sea levels were recorded at a peak of 2.08 feet above mean sea level. Based on the position of Aua, it is likely that sea levels were close to those measured by the Pago Pago gage.

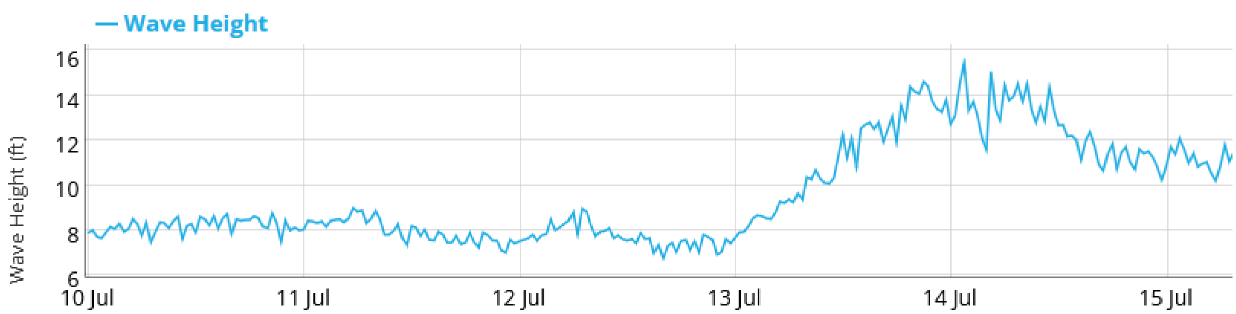


Figure 14. Wave Height in July 2022 at Aunu'u Station (PacIOOS, 2022)

As of year 2000, seven rusted longliner ship hulls lay grounded on the outer margin of the reef between Aua Village and Leloaloa to the west. Analysis by Pederson Planning Consultants in 1996 indicated that the hulls may have an impact on nearshore current patterns (ASEPA, 2000). The remains of the vessels may adversely impact littoral drift, contributing to a net erosion of sand along the coast of Aua Village.

5.5 Climate Vulnerability

Positioned along the coastline of Pago Pago Harbor, Aua Village is susceptible to coastal threats such coastal flooding from high tides and tropical storms. Portions of the village are within FEMA flood zones A and AE, while the shoreline of the Aua watershed is located within FEMA flood zone VE (FEMA, 2022) (**Map 5**). Portions of the Zone A flooding are associated with the streams of the Aua watershed that run through Aua Village, exposing the village to flood risks beyond merely coastal flooding. **Figure 15** shows a cluster of populations at risk to a low level of coastal flooding in Aua Village (ACOE, 2022). As many as 67 buildings in Aua are periodically damaged by both coastal and riverine flooding (USDA, 1995). Flood events typically result in standing water, sedimentation of infrastructure, and accumulation of debris.

Figure 15. Population at Risk (PAR) to Coastal Flooding (ACOE, 2022)

Sea level has gradually increased over the past several decades and is predicted to continue to increase at an accelerating rate. Following a September 2009 earthquake, Tutuila experienced 7-9 inches of subsidence, exacerbating the impacts of sea level rise. Subsidence of the island is expected to continue, although at a decelerating rate, over the next 20-30 years (NOAA, 2021b). As of November, 2021, NOAA installed a new water level sensor in Pago Pago well above the highest observed water level in order to monitor sea level rise.

As shown in **Figure 16**, the amount of time in which Pago Pago experienced water levels above the city's high-water threshold has rapidly increased since 2009. Under a high carbon emissions scenario, American Samoa could experience as much as 8 feet of sea level rise by the end of the century (**Figure 17**) (PIRCA, 2021).

The extents of flooding during mean higher high tidal levels under a range of sea level rise depths is shown in **Map 6**. When factoring in sea level rise, the severity of flood exposure to populations at risk in Aua is expected to increase (**Figure 18**) (ACOE, 2022).

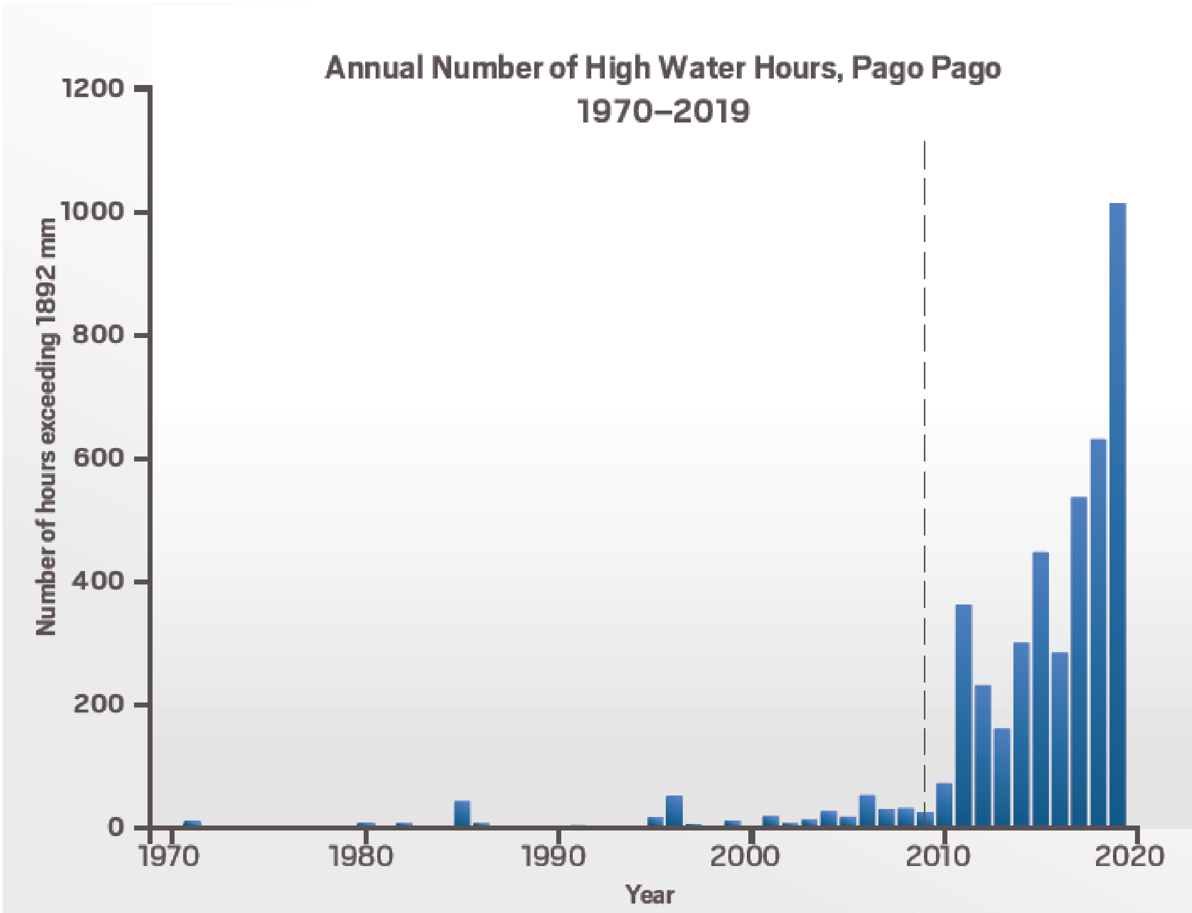


Figure 16. Number of High Water Hours per Year at Pago Pago from 1970-2019
The high water threshold (1892 mm) is defined as the mean higher high water level plus one-third of the difference between that and the mean lower low water level. The dashed line indicates the occurrence of the 2009 earthquake and onset of subsidence. (PIRCA, 2021)

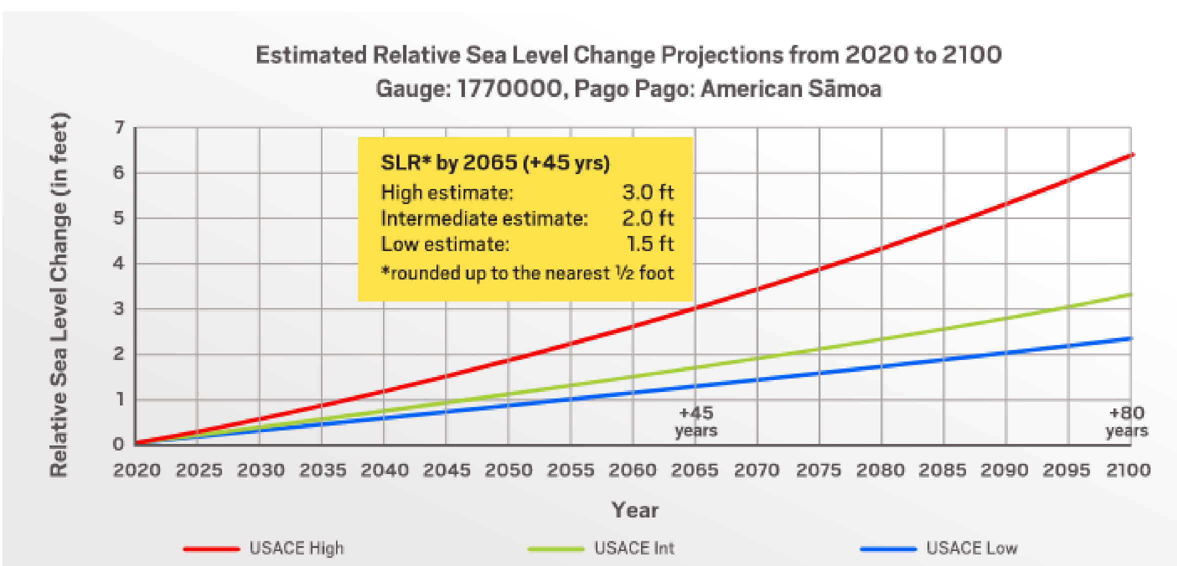


Figure 17. Regional Sea Level Rise Scenarios Considering Subsidence (PIRCA, 2021)

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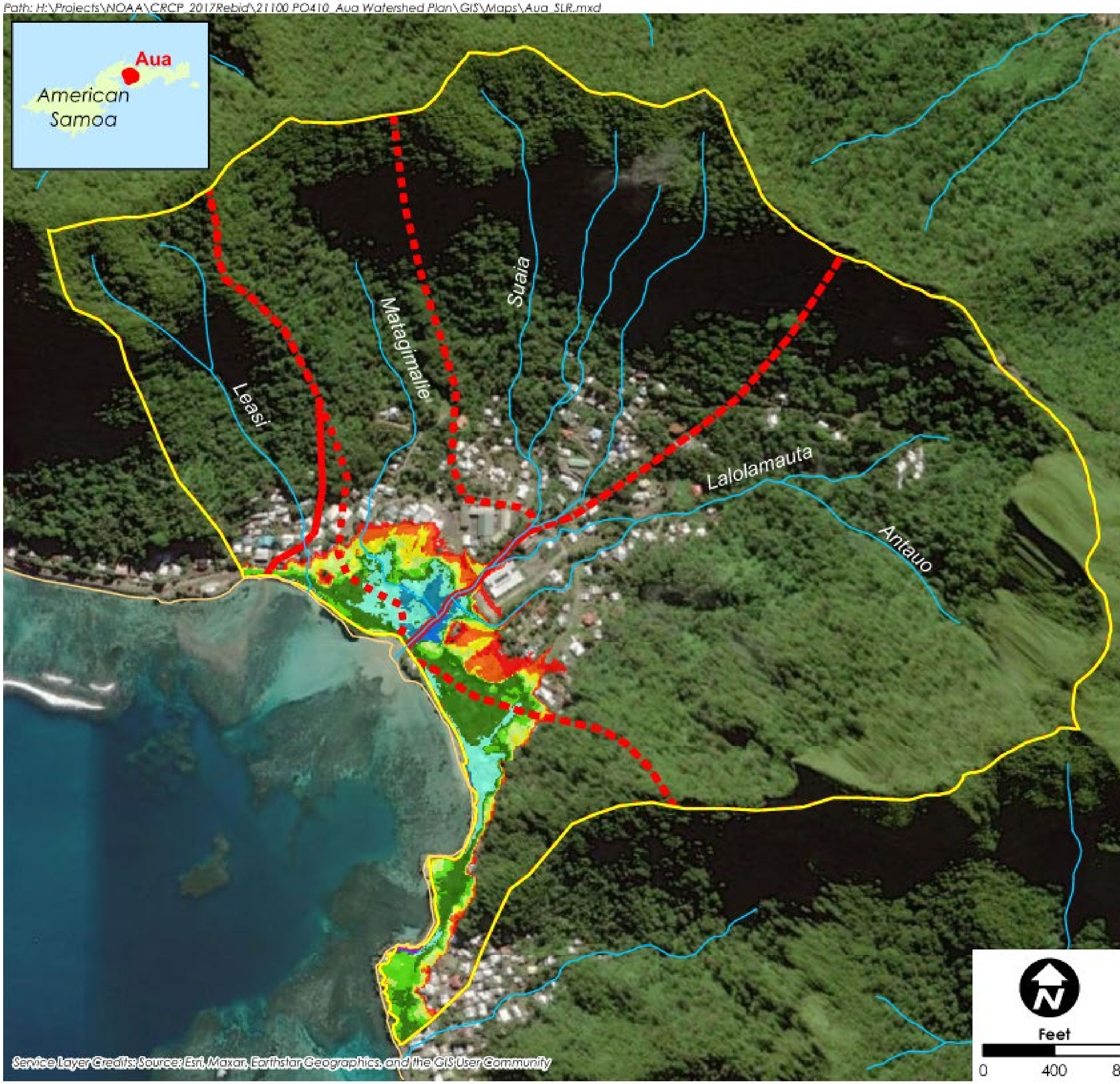

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Date: 8/1/2022
Data Sources: USGS, NOAA, ESRI unless otherwise indicated by (HW).

This map is for informational purposes and may not be suitable for legal, engineering, or surveying purposes.

Coastline
Streams
Subwatersheds
Watershed
1ft
2ft
3ft
4ft
5ft
6ft
7ft
8ft
9ft
10ft

Feet
0 400 800

Map 6
Sea Level Rise in feet above the existing MHHW.

Figure 18. Population at Risk (PAR) to Coastal Flooding, Incorporating Predicted Sea Level Rise (ACOE, 2022)

Coastal flooding currently poses a threat to the roadways in and around Aua. As shown in **Figure 19**, Route 001 is at risk of receiving 0.5-1 foot of flooding due to storm surge where it fronts Aua Village, and up to 3 feet farther to the south. The roadways within Aua Village are at risk of up to 3 feet of inundation during a storm surge event (ACOE, 2022). Despite this, the Aua Watershed is ranked as relatively low in terms of vulnerability to transportation infrastructure (**Figure 20)**. Likewise, the Coastal Resilience Assessment (Dobson et al., 2021) rates Aua Village medium to low in terms of threat to due to coastal flooding (**Figure 21)**. However, the same assessment rates Aua as medium to high in terms of community assets (**Figure 22)**. Critical infrastructure within Aua includes the Aua Elementary School, which serves as a national shelter for the island of Tutuila.

Figure 19. Existing Inundation Hazard on Roads Around Pago Pago Harbor (ACOE, 2022)

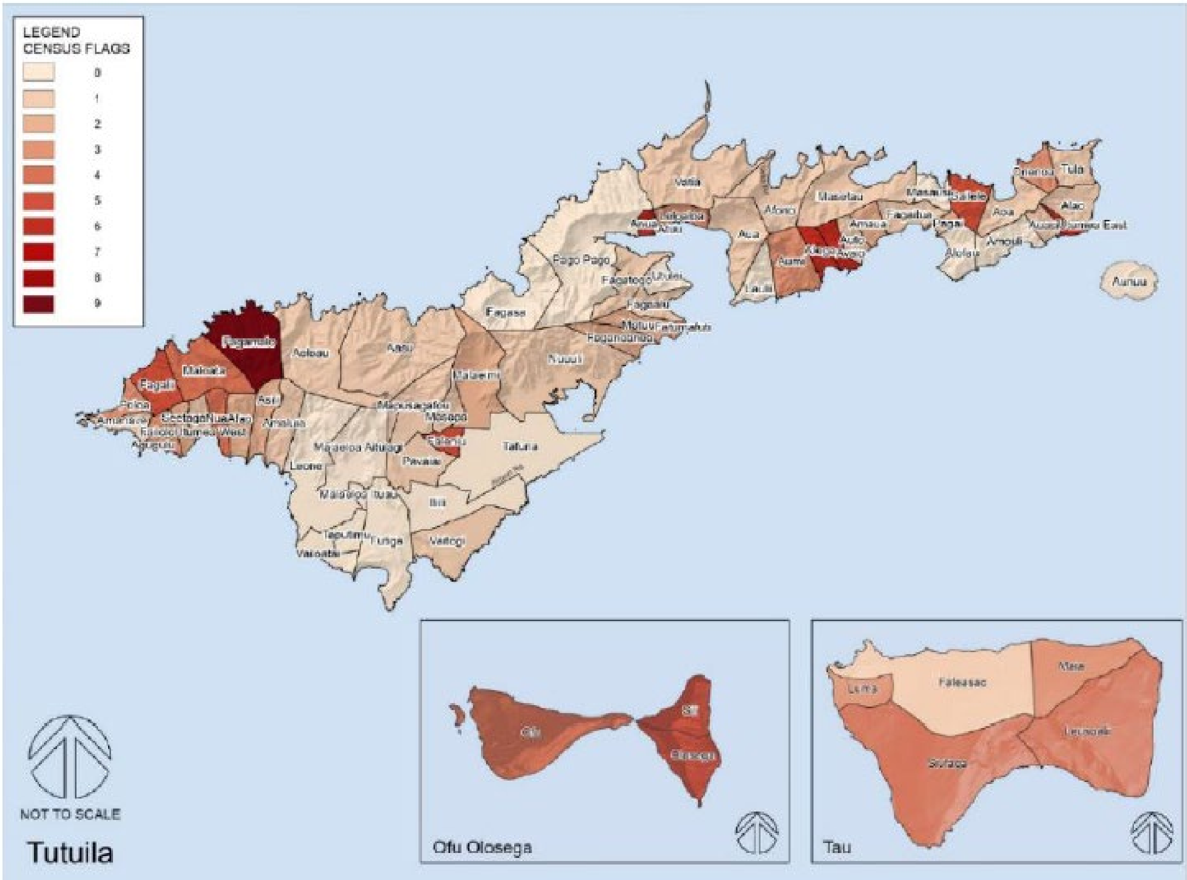

Figure 20. Areas of Vulnerability for Transportation Infrastructure on Tutuila (ACOE, 2022)

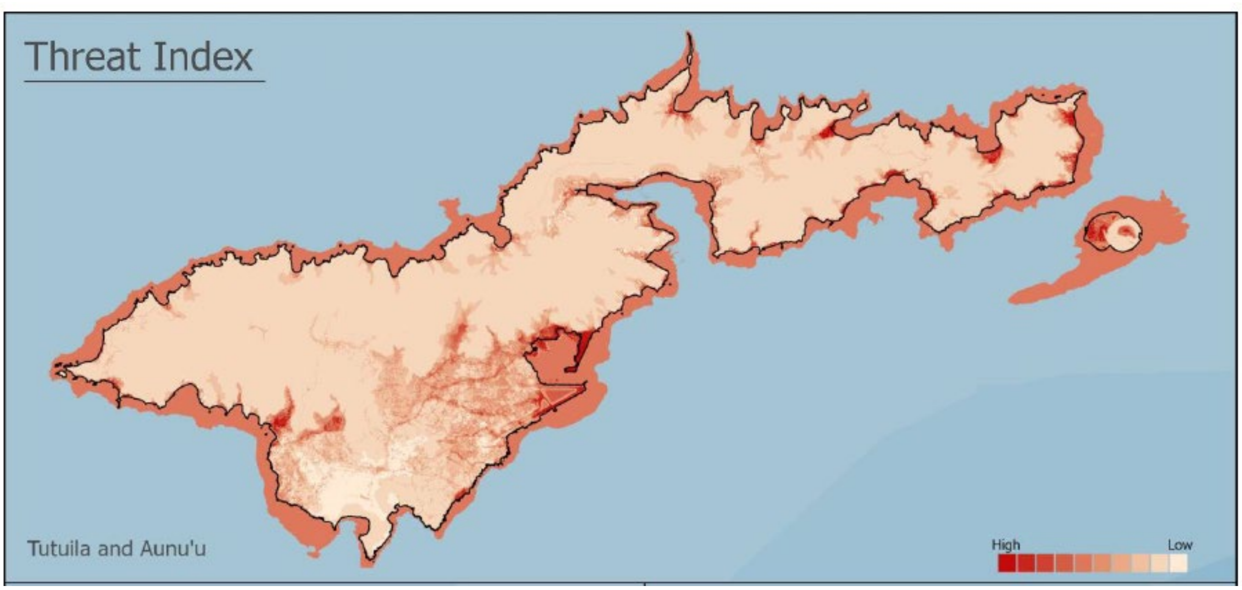

Figure 21. Coastal Resilience Assessment Threat Index (Dobson et al., 2021)

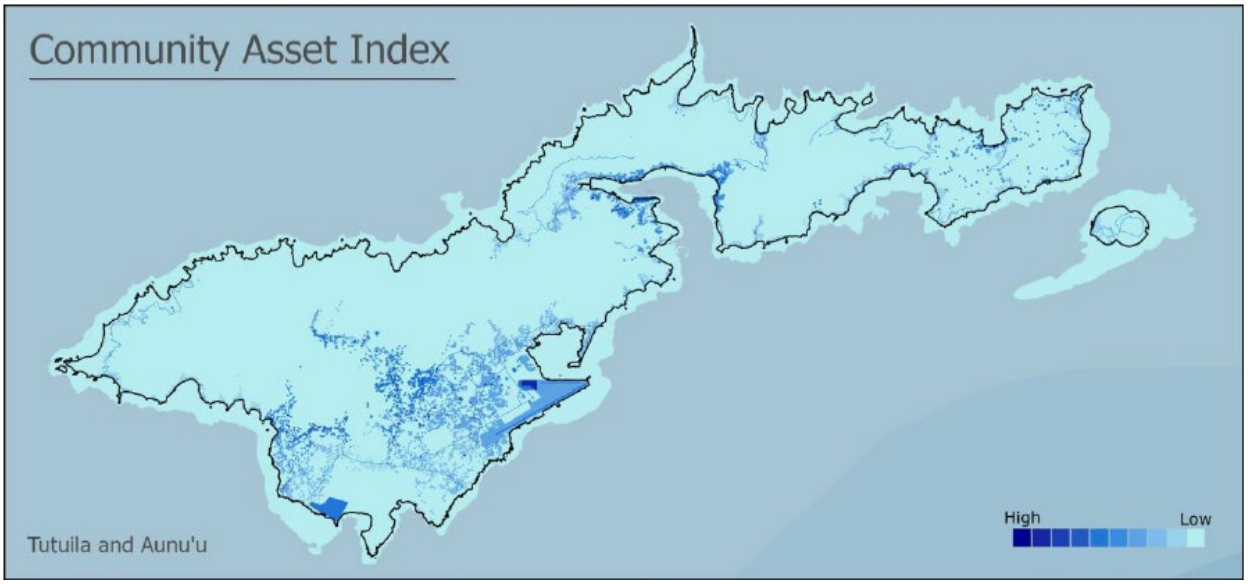

Figure 22. Coastal Resilience Assessment Community Asset Index (Dobson et al., 2021)

5.0 Geology & Soils

5.1 Geology

The geology of Tutuila consists of Pago Volcanic series rock in upland areas and sedimentary rocks along the flat lowlands surrounding the upland. This is consistent with the geology of the Aua Watershed. In the area within the watershed that surrounds Aua Village, dike structures in the mountains create high level springs that serve as primary water sources for the village. Additionally, low permeability lavas have confined the Aua aquifer that exists at the northeast corner of Pago Pago Harbor. A thin layer of soil overlies the geology of the watershed. Geological units within the Aua Watershed are shown in **Map 7**.

5.2 Soils (HSG)

Per the USGS soil classification hydrologic soil groups (HSGs), the Aua Watershed is generally comprised of HSG A and B soils (higher infiltration capacity, lower runoff potential). In steeper, upland areas, soils are generally the rocky Fagasa Family-Lithic Hapludolls-Rock outcrop association, a well-draining soil type with moderate runoff due to the steepness of terrain (70-75%). Closer to the village, upland areas are characterized by Aua very stony silty clay loam, a well-draining soil that is likewise prone to moderate runoff due to the steepness of terrain (30-60%). Aua Village generally occupies an area of urban land-Aua-Leafu complex, a soil class that is a combination of moderately well-draining Aua soils and poorly draining Leafu soils. Unlike the relatively well-draining soils in the upper portions of the watershed, Leafu soils are occasionally prone to flooding (NRCS, 2022). Due to the gentle-to-moderate slope (0-6%) of the area characterized by Aua-Leafu complex, the vast majority of residential areas are built in this latter soil complex. Much of the cropland associated with the village is located on the steeper slopes of the Leafu complex and on the steep Aua very stony silty clay loam.

Table 5 shows the distribution of hydrologic soil groups (HSGs) across the watershed; the location of each HSG is shown in **Map 8.** Subwatersheds are grouped according to their outlet into the Aua embayment.

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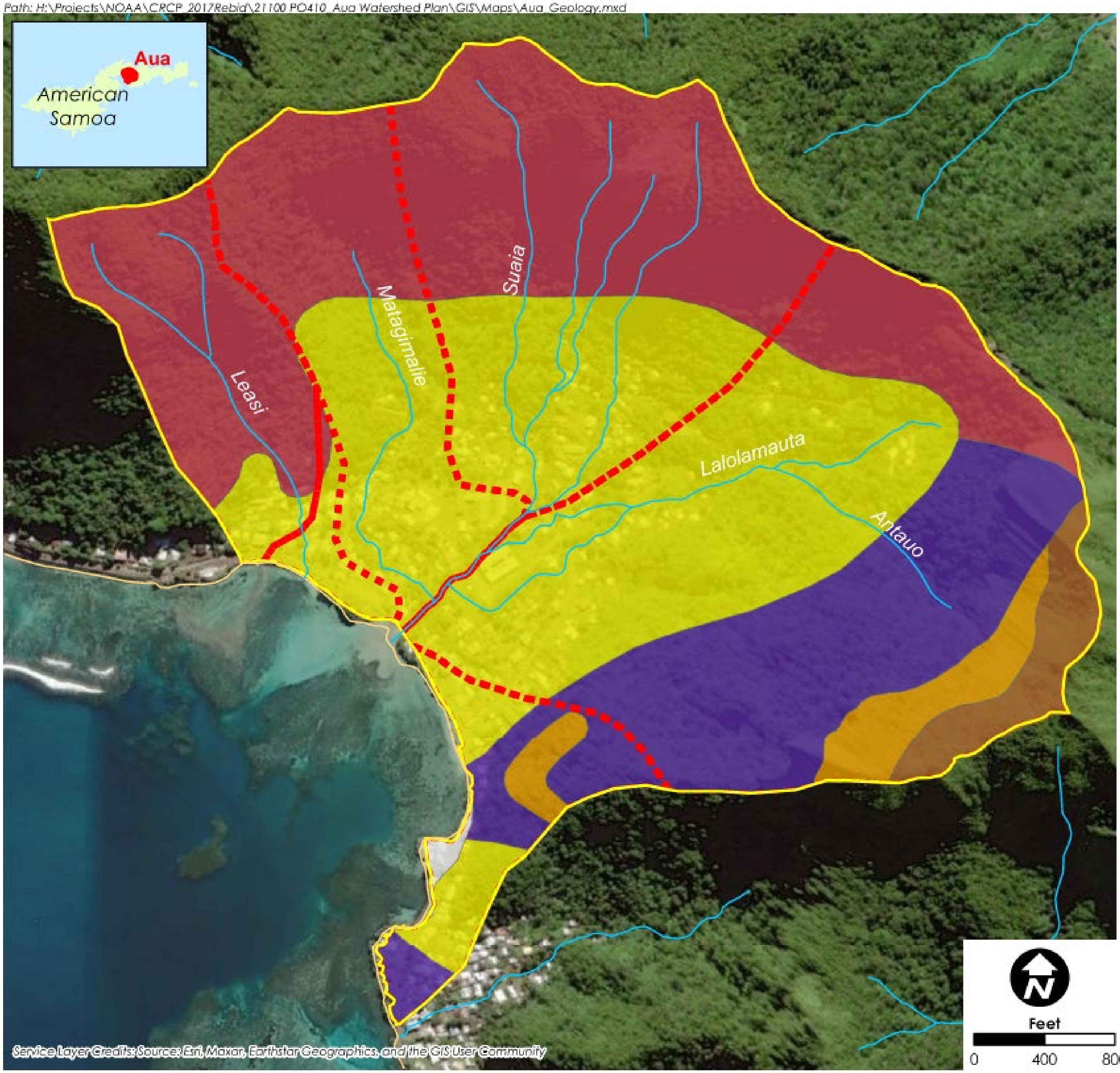

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Date: 8/1/2022
Data Sources: USGS, NRCS, NOAA, ESRI, unless otherwise indicated by (HW).

This map is for informational purposes and may not be suitable for legal, engineering, or surveying purposes.

Coastline
Streams
Subwatersheds
Watershed

Geologic Unit Name

Uncategorized
Calcareous sand, talus and alluvium
Pago Volcanic Series, extra-caldera volcanics
Pago Volcanic Series, intra-caldera volcanics
Pago Volcanic Series, lithic-vitric tuff
Trachyte plugs and dikes

Map 7
Geology.

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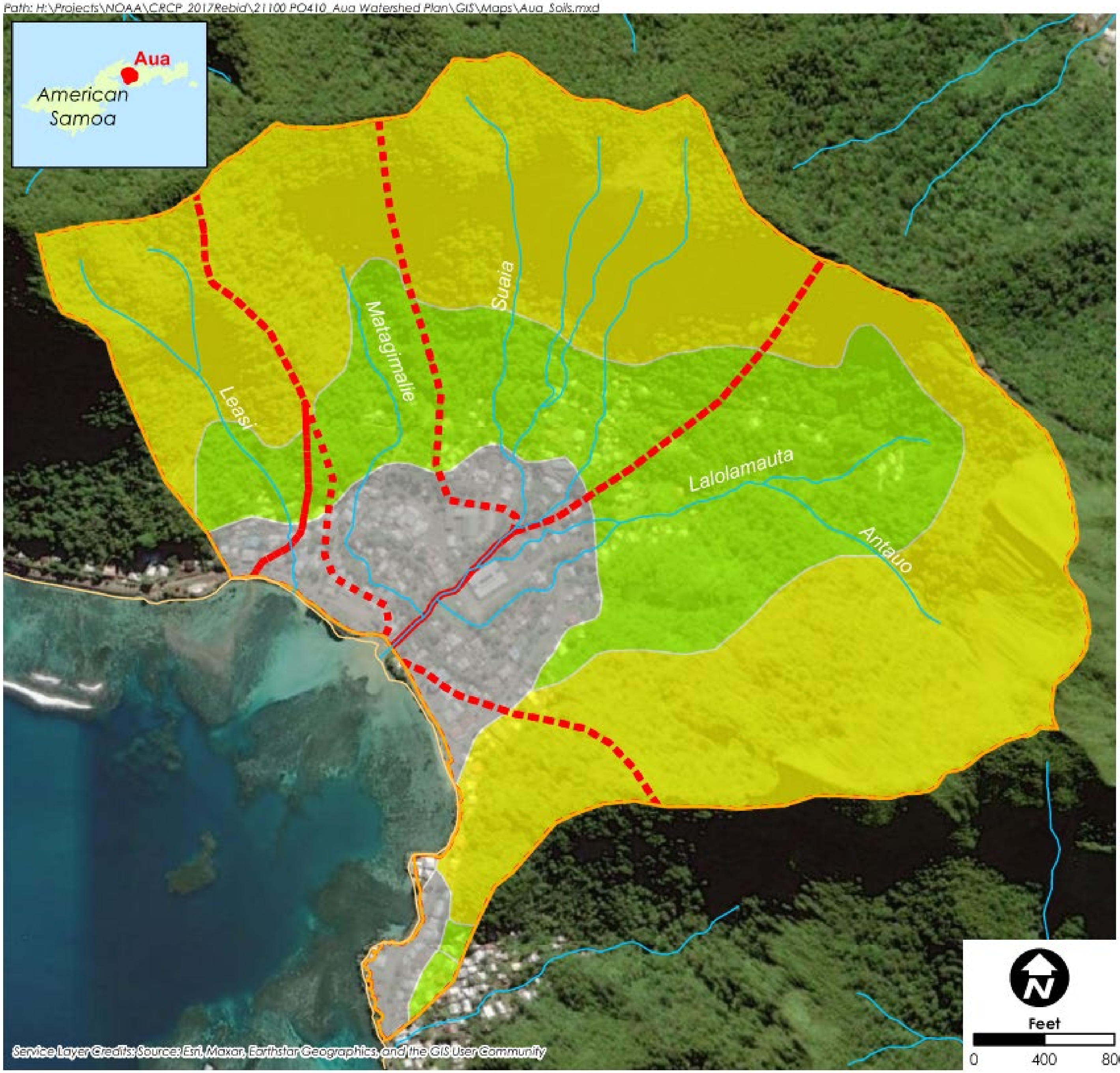

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Date: 8/1/2022
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Coastline
Streams
Subwatersheds
Watershed

Hydrologic Soil Group

HSG Not Rated - Urban land-Aua-Leafu complex, 0 to 30 percent slopes

A - Aua very stony silty clay loam, 30 to 60 percent slopes

B - Fagasa family-Lithic Hapludolls-Rock outcrop association, very steep

Map 8
NRCS SSURGO-Certified Soils.

Table 5. Hydrologic Soil Group (HSG) Information for Aua Watershed

Leasi Point and Leasi Stream		Matamigalie, Suaia, and Lalolamauta Streams		Aua Point	
HSG A	15%	HSG A	30%	HSG A	9%
HSG B	68%	HSG B	58%	HSG B	58%
Not Rated	17%	Not Rated	12%	Not Rated	33%

5.3 Erosion potential

Approximately 136 acres of the Aua Watershed have been identified as having highly erodible land (USDA, 1995), and an estimated 5,492 tons of sediment erode from within the watershed annually (Kennedy et al., 1986). This land is typically located in the steeper portions of the watershed, upland of Aua Village. Due to the prevalence of residential development in flatter, low-lying portions of the watershed, the majority of agricultural land use is found within the steep, highly erodible areas upland of the village.

Erosion potential in the watershed is also exacerbated by the construction of roadways in steep upland areas. The hillside along Route 006 has been identified in the past as a major sediment source dating back to the 1960s, a consequence of the route's construction. Soils from the hillside frequently wash onto Route 006; eroded sediment has also been observed to flow into Lalolamauta Stream.

Erosion from the Olo Ridge slopes is also linked to debris that is loosened or exposed following landslides. After landslides, residual slide material typically sits on talus slopes at the bottom of slide zones. When rainfall occurs in the period following landslides, loose material on the talus is readily eroded and transported downgradient in the Aua Watershed.

5.4 Landslides

The upland soils characterized as Aua very stony silty clay loam are prone to landslide due the steepness of the mountain terrain and a high proportion of non-cohesive component soils in the Aua family. Several large slides occurred along the slopes to the east of Aua Village following Cyclone Ofa in February 1990. During the construction of Route 006 from Aua to Alfona in 2000, at least eight separate landslides occurred; landslides were attributed to construction activity (Territory of American Samoa, 2020). Landslide risk across the island is shown below in **Figure 23**.

In addition to the natural instability of the soils upgradient of Aua Village, the proliferation of invasive plant species is believed to be a contributing factor in exacerbating landslide potential. The species *Falcataria moluccana* is a common invasive tree on the island (**Figure 24**), and has been observed on the slopes and ridge upgradient of Aua Village. The shallow root system of *F. moluccana* offers little stability to soils. When native trees with deeper root systems are outcompeted by *F. moluccana*, landslide potential increases.

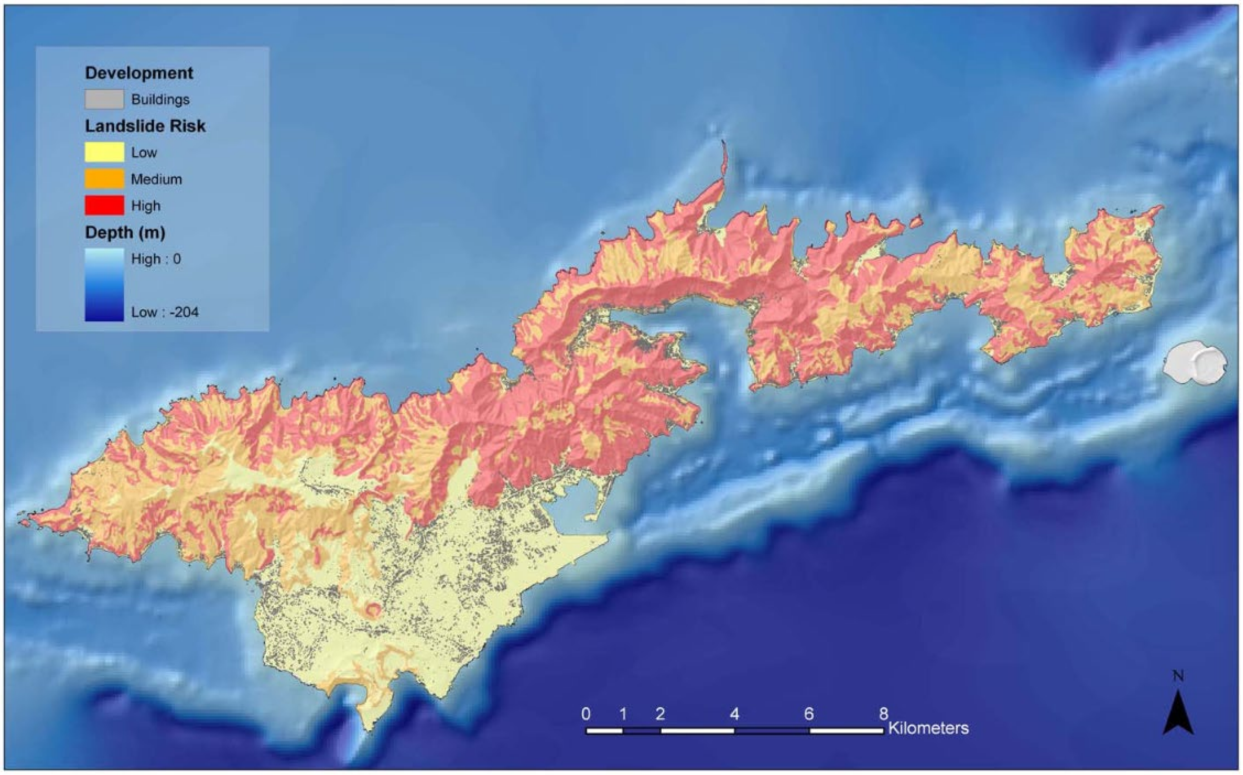


Figure 23. Landslide Risk Across Tutuila (USGS, 2006)

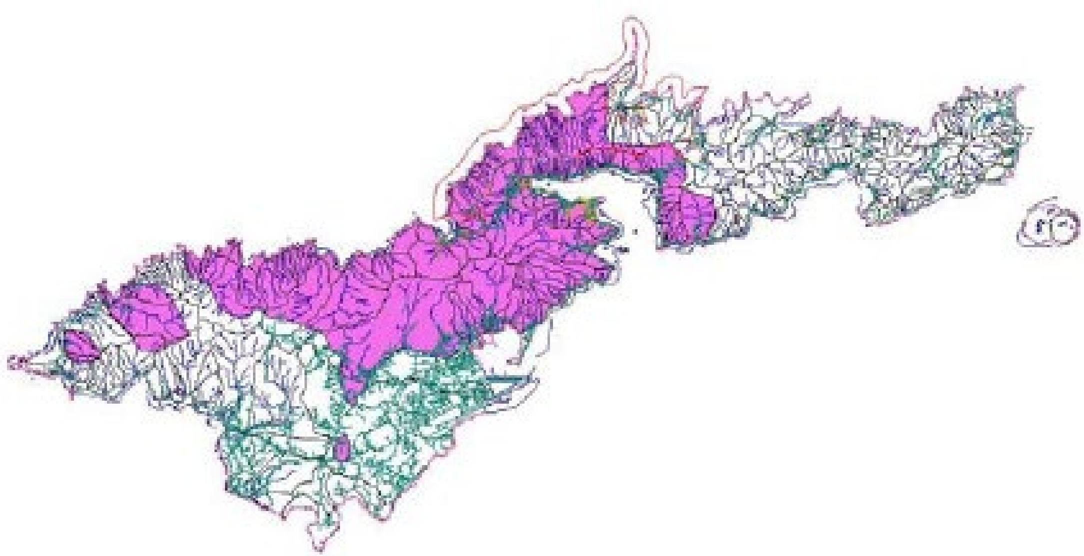


Figure 24. Distribution of Falcataria moluccana on Tutuila (USGS, 2006)

5.5 Earthquakes

Several local geologic fault lines have been identified under Tutuila, including immediately under Aua Village (**Figure 25**). Despite this positioning, little data suggests that recent earthquakes impacting Tutuila originated from these faults (Territory of American Samoa, 2020). Earthquakes affecting American Samoa generally originate from the Tonga Trench, approximately 100 miles to the southwest of Tutuila. **Figure 26** shows the epicenters of earthquakes since 1900 that are within 500 kilometers of American Samoa. That includes 242 earthquakes with a magnitude greater than or equal to 7 (an average rate of more than two large earthquakes each year) (Petersen et al., 2012).

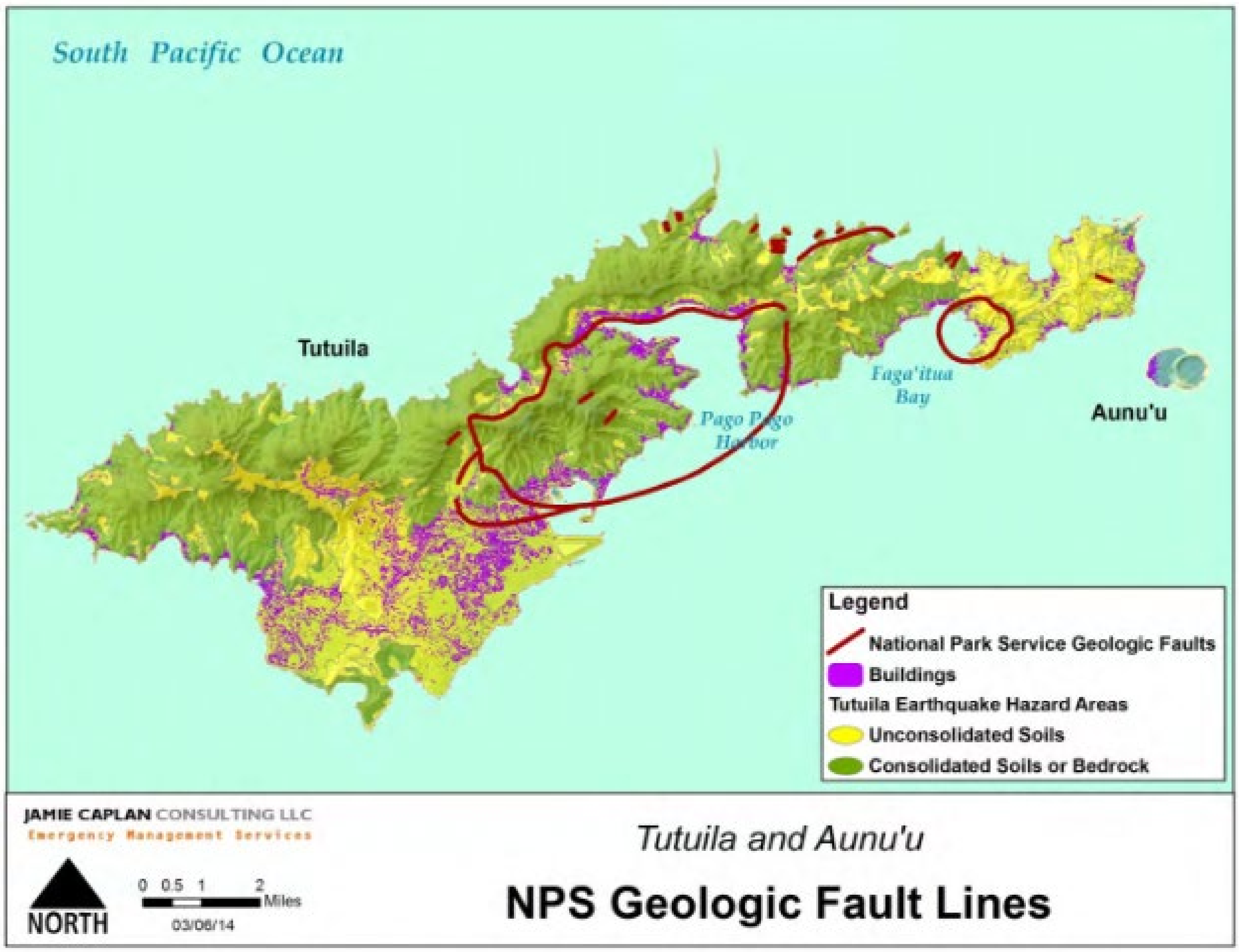


Figure 25. Tutuila Island and Aunu'u Island Earthquake Fault Lines and Hazard Areas (Territory of American Samoa, 2020)

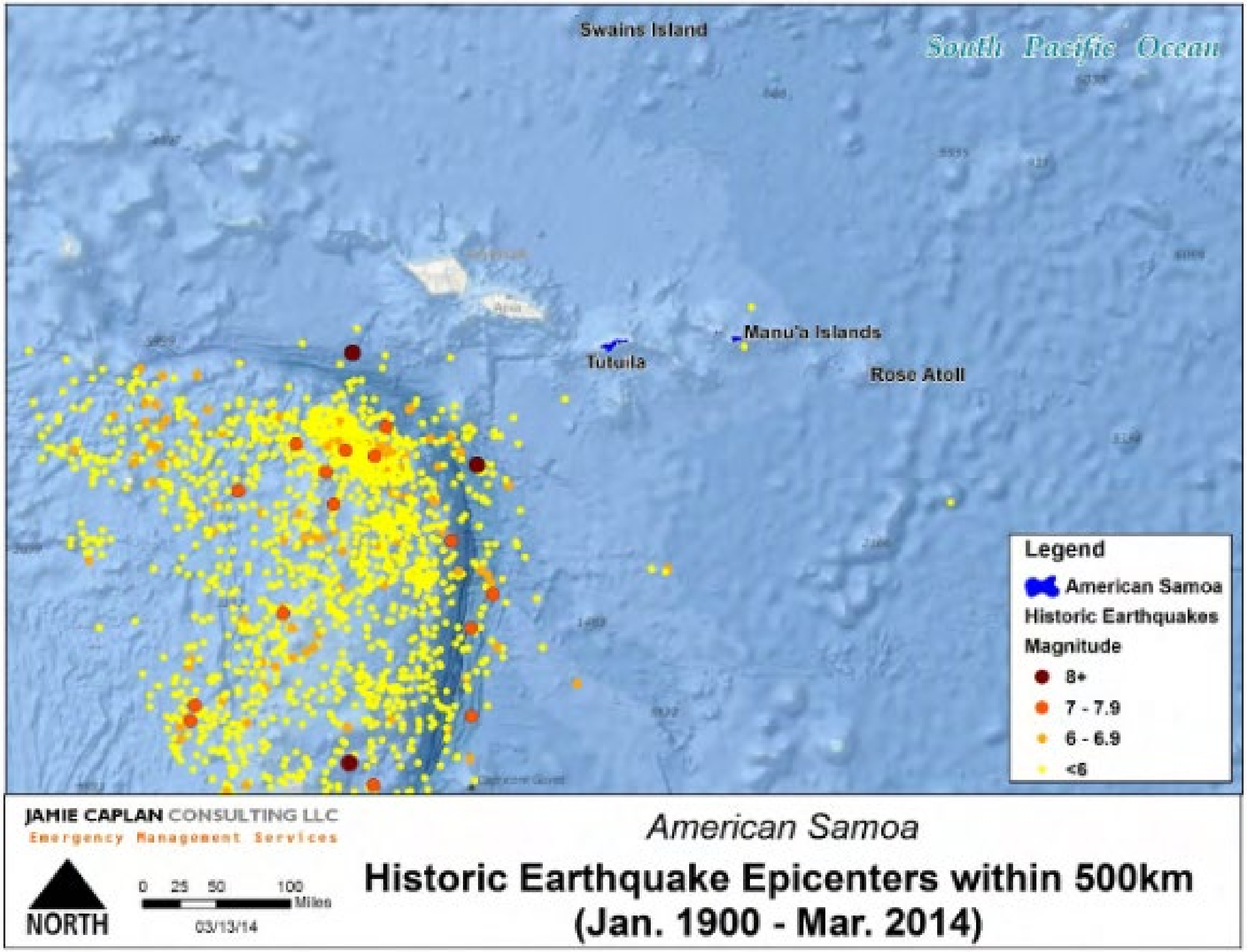


Figure 26. Historic Earthquakes near American Samoa (Territory of American Samoa, 2020)

Buildings and other infrastructure on Tutuila most at risk of earthquakes are generally those built on or near unconsolidated soil. Most buildable land on Tutuila is within areas of less steep, unconsolidated soils, resulting in a high proportion of buildings which are vulnerable to seismic activity. Across the island, 235 out of 239 buildings identified as critical facilities are considered vulnerable to earthquakes (Territory of American Samoa, 2020). In Aua Village, the only critical facility identified in the 2020 American Samoa Hazard Mitigation Plan is Aua Elementary School; the school, along with the majority of the village, is built on unconsolidated soil and is therefore at risk in the event of an earthquake (**Figure 27**).

The most recent major earthquake that impacted American Samoa occurred in the Pacific Ocean near the island chain on September 29, 2009. Following the earthquake, a period of rapid subsidence ensued. The land elevation of Tutuila began to subside at a rate of approximately 13.5 millimeters (0.5 inches) per year (NOAA, 2021b), as shown in **Figure 28**. Subsidence is expected to continue for the next 20-30 years, although at a decelerating rate.

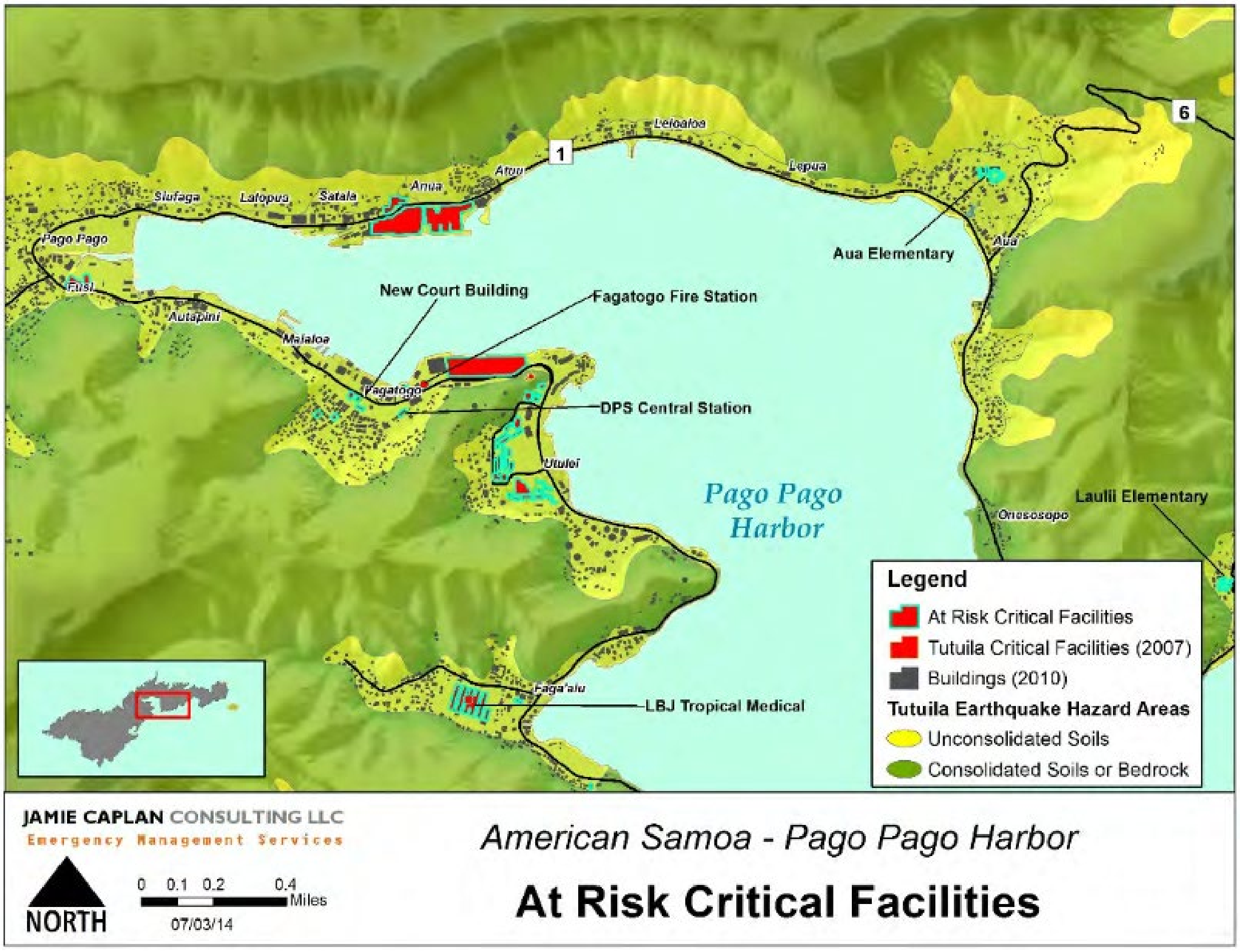


Figure 27. Critical Facilities Potentially at Risk to Earthquake along Pago Pago Harbor (Territory of American Samoa, 2020)

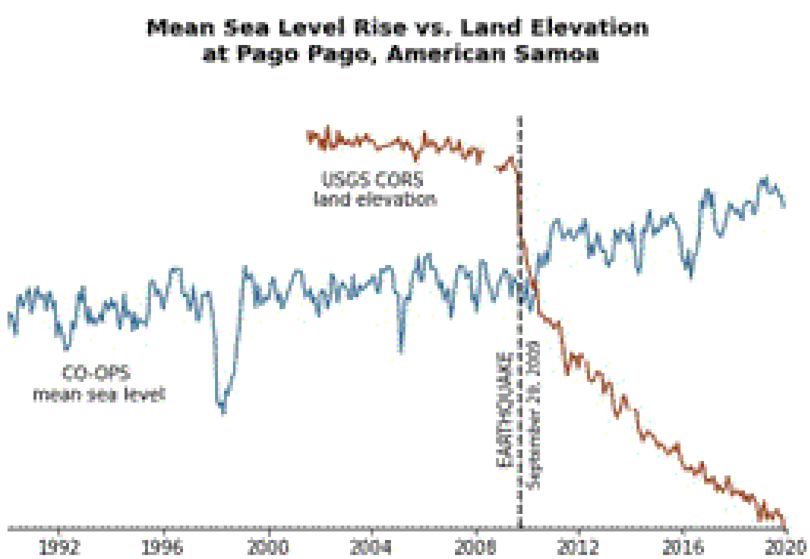


Figure 28. Mean Sea Level Rise and Land Elevation Before and After the 2009 Earthquake Near American Samoa (NOAA, 2021b)

5.6 Tsunamis

Due to seismic activity in the South Pacific, tsunamis present an additional natural hazard to American Samoa. Among the most recent significant events, at least two earthquakes occurred in the Pacific Ocean between Samoa and American Samoa on September 29, 2009. The quakes resulted in tsunami waves up to 72 feet in height, killing 34 people in American Samoa and 192 people in total across Samoa and Tonga (NOAA, 2021a). The estimated maximum wave height along American Samoa is shown below in **Figure 29**. Additional damage included the disabling of a local power plant, destruction of 241 homes and 1 school, major damage to 308 homes and 4 schools, and more moderate damage to another 2,750 dwellings (Territory of American Samoa, 2020). **Figure 30** shows that a portion of Aua was inundated during the 2009 tsunami; damage was largely incurred on residences within Aua Village, and no loss of life was documented (Wood et al., 2019).

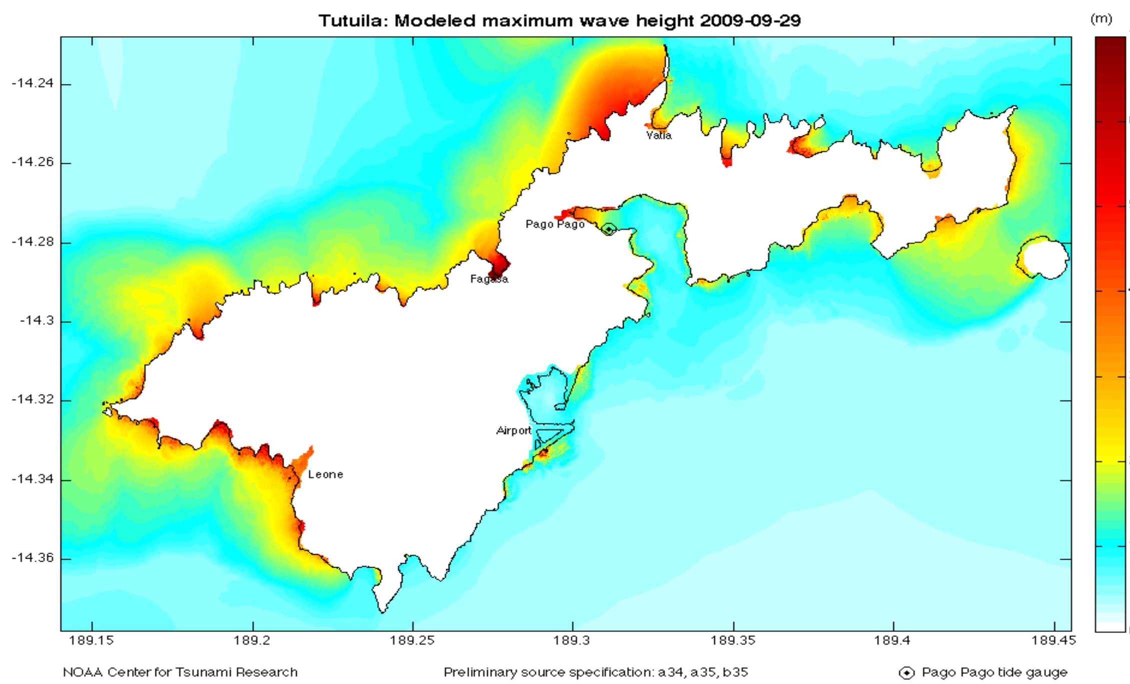


Figure 29. Estimated Maximum Wave Height During 2009 Tsunami (NOAA and PMEL, 2009)

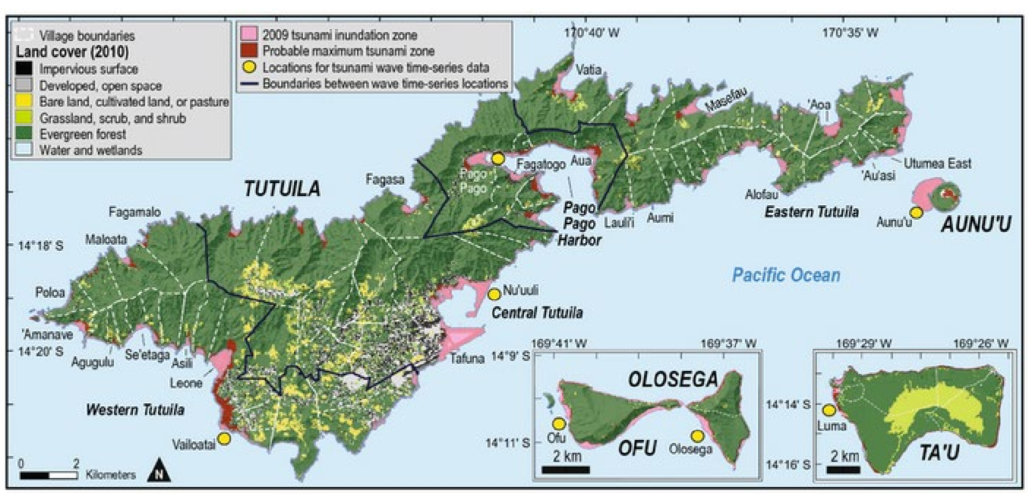


Figure 30. 2009 Tsunami Inundation Zones (Wood et al., 2019)

Between 1837 and 2020, a total of 78 tsunami events were recorded. Of these, a majority did not result in significant damage. The record suggests that roughly 2 to 3 destructive tsunamis occur every 50 years, yielding an annual probability of occurrence around 4-6% (Territory of American Samoa, 2020). Since 2009, a number of tsunami sirens have been installed throughout the Territory. The sirens reduce the risk of loss of life, but low-lying properties remain vulnerable. During tsunamis, wave action is most concentrated in coastal inlets, as the water column is essentially funneled toward a narrow point. Thus, the Aua Village is predicted to be less exposed to tsunami damage than the Inner Harbor-located city of Pago Pago. Still, **Figure 30** shows that much of Aua Village is within the probably maximum tsunami zone (Wood et al.). Based on the 2020 Hazard Mitigation Plan, nearly the entire village falls within the "Tsunami Buffer Zone," the 0.25-mile buffer from the shoreline that is a conservative estimate for potentially inundated areas (Territory of American Samoa, 2020). Below, **Figure 31** shows the extents of the Tsunami Buffer Zone in the vicinity of Pago Pago Harbor and identifies critical infrastructure at risk to flooding. The Aua Elementary School lies within the Tsunami Buffer Zone and is therefore at risk of inundation during large tsunami events.

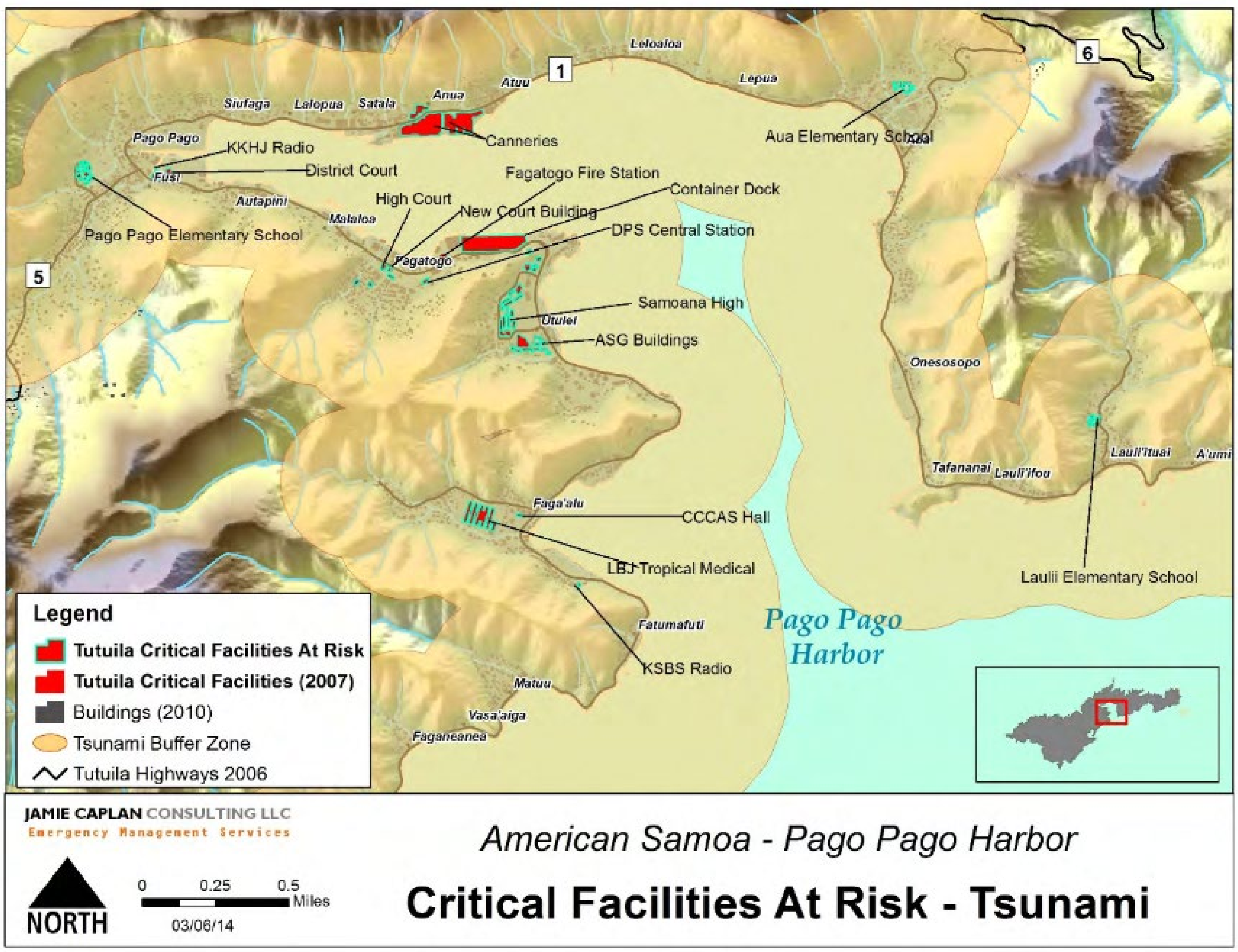


Figure 31. Critical Facilities Potentially Impacted by Tsunamis along Pago Pago Harbor (Territory of American Samoa, 2020)

5.7 Beach Erosion

Shoreline erosion along Aua Village is documented as non-critical (i.e., having low susceptibility to erosion) for the majority of the embayment. The outlet of Lalolamauta Stream into Pago Pago Harbor has potentially critical shoreline erosion (i.e., is moderately susceptible to erosion). From Leasi Stream to Leasi Point, critical (highly susceptible) erosion is documented. The shoreline of Aua Village has marginal, if any, engineered shoreline protection against wave action (Territory of American Samoa, 2020). Shoreline erosion concern and protection status is shown below as **Figure 32**. A shoreline protection inventory, updated as part of the HW 2022 Field Assessment, is included below as **Map 9**.

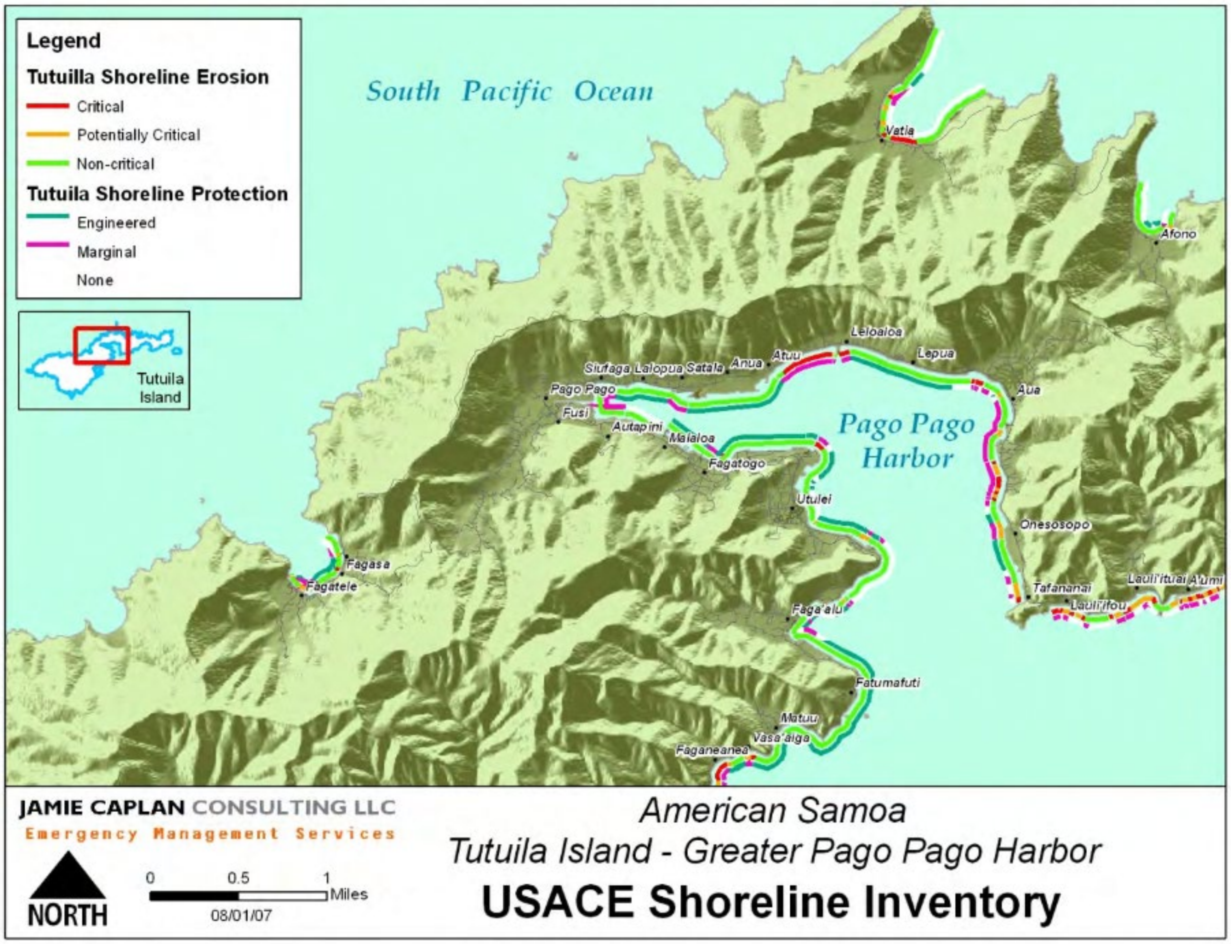
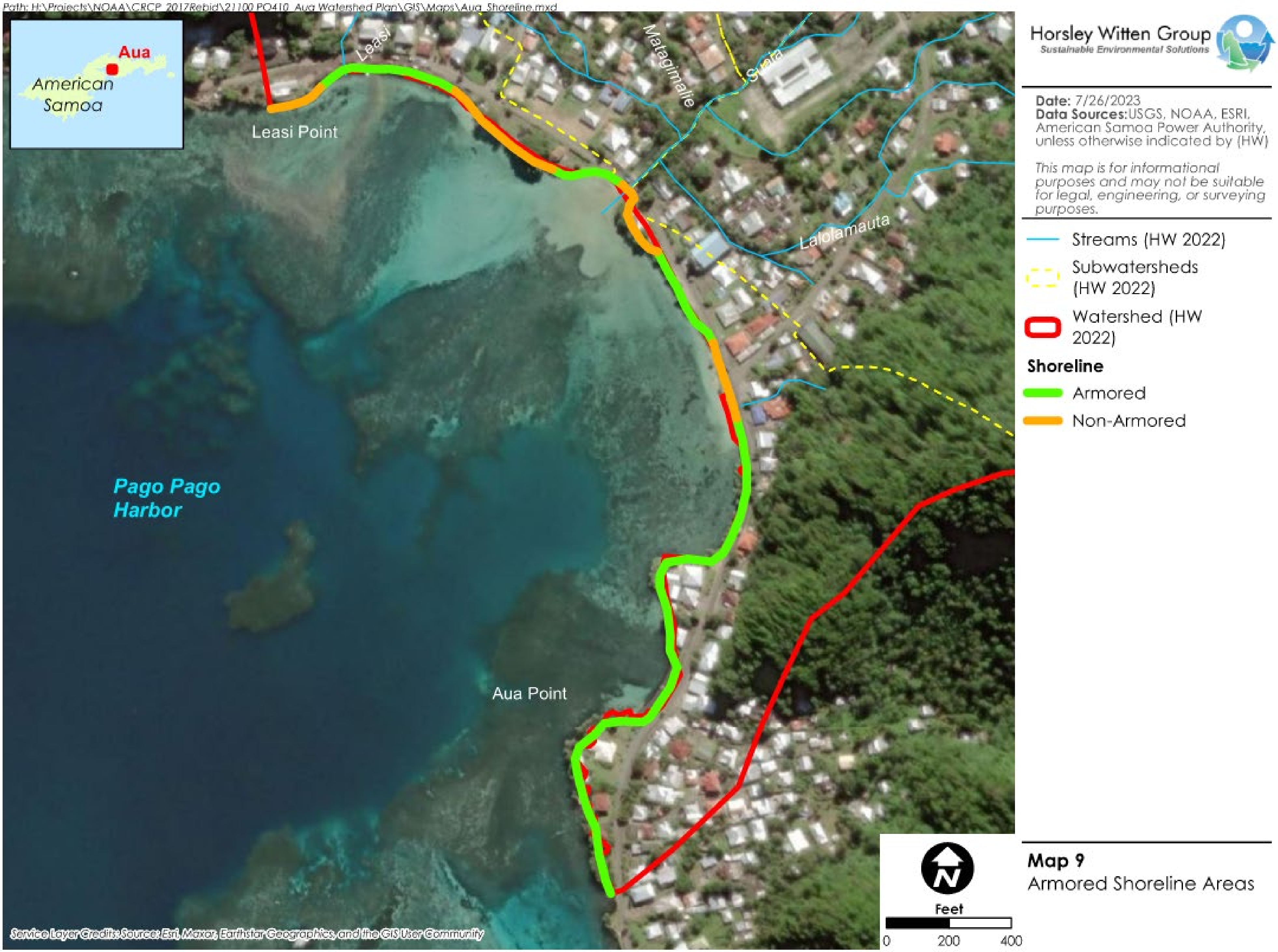


Figure 32. Greater Pago Pago Harbor Shoreline Inventory (Territory of American Samoa, 2020)

In anticipation of increased exposure to high sea levels and storm activity due to climate change, beachfront erosion is expected to increase along the shore of Aua Village. Though not well documented within the village itself, a series of recommendations to protect against coastal flooding and erosion were generated by the Army Corps of Engineers (ACOE, 2022). These recommendations include conducting a wave exposure analysis as well as a coastal erosion analysis in order to understand historic rates of beach erosion and identify shorelines at high risk as sea level rise and island subsidence progress. Shoreline protection strategies such as green infrastructure installation, ecosystem enhancement, wetland restoration, and artificial reef replication have all been proposed as solutions to reduce the impacts of erosion.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Aua
American Samoa
Leasi Point
Leasi
Matagimalie
Sufia
Lalolamauta
Pago Pago Harbor
Aua Point
Service Layer Credits: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
Horsley Witten Group
Sustainable Environmental Solutions
Date: 7/26/2023
Data Sources: USGS, NOAA, ESRI, American Samoa Power Authority, unless otherwise indicated by (HW)
This map is for informational purposes and may not be suitable for legal, engineering, or surveying purposes.
Streams (HW 2022)
Subwatersheds (HW 2022)
Watershed (HW 2022)
Shoreline
Armored
Non-Armored
N
Feet
0
200
400
Map 9
Armored Shoreline Areas

6.0 Ecology

6.1 Terrestrial

The Aua watershed contains high value terrestrial habitat, generally in the form of forest area. Aua Village is ranked as a high priority landscape for urban forests (ASCC, 2020) (**Figure 33**), and the entire Aua watershed has a high index rating for terrestrial habitat (Dobson et al., 2021) (**Figure 34**).

Vegetation within the terrestrial portion of the watershed includes *Thespesia populnea*, banana (*Musa spp.*), coconut (*Cocos nucifera*), and banyan (*Ficus prolixa*). Migratory shorebirds are frequently found within the watershed, generally at the delta of the stream mouth at its estuary with Pago Pago harbor. The Samoan flying fox or fruit bat is found throughout Tutuila, but is most prevalent outside of the Aua watershed at Fagatele Point.

According to the American Samoa Community College Forestry Extension, the forested areas in the upland portion of the Aua Watershed have not been well surveyed. Some invasive plant species have been identified in the watershed, but at a lower density than most other villages on Tutuila.

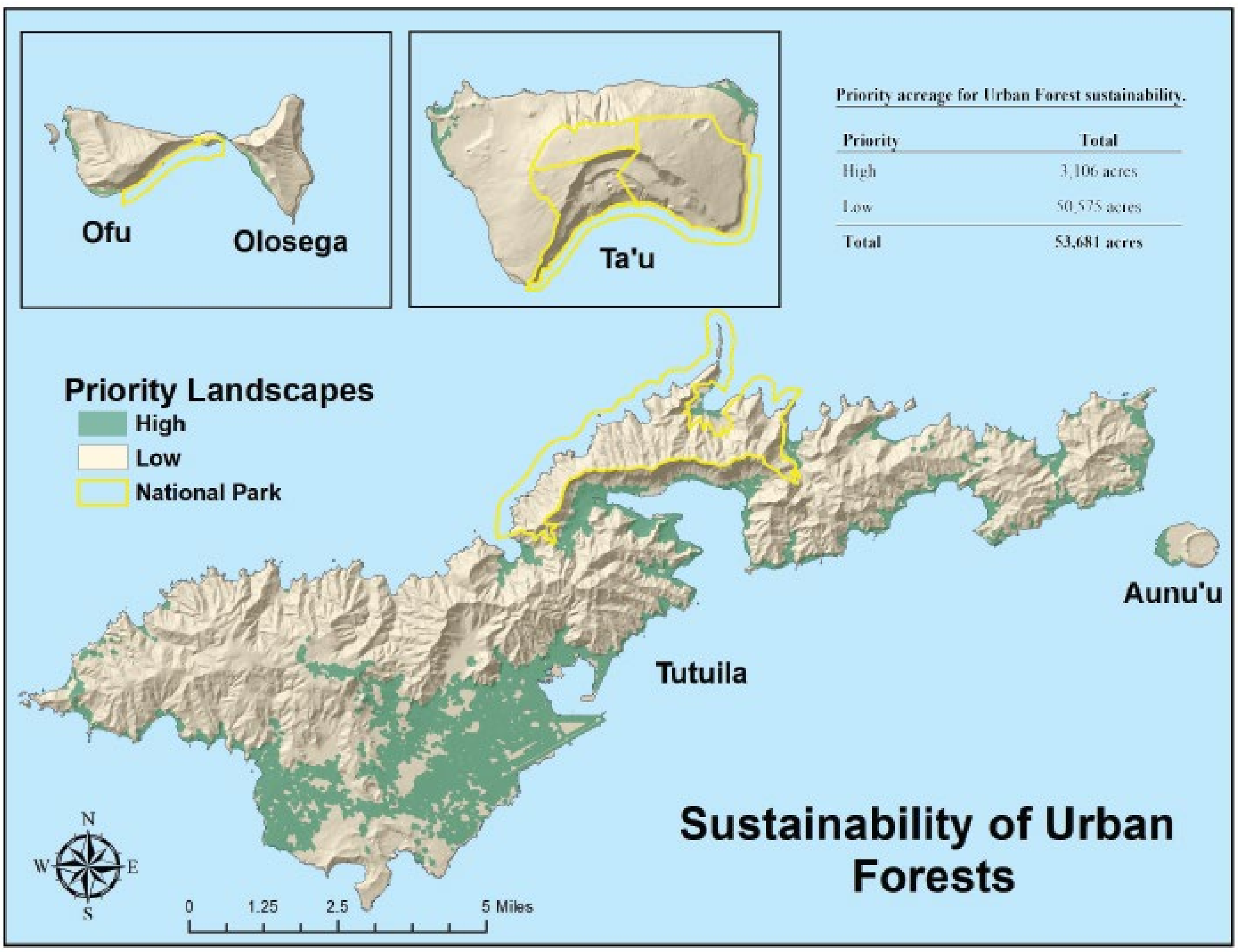

Figure 33. Urban Forest Priority Landscapes (ASCC, 2020)

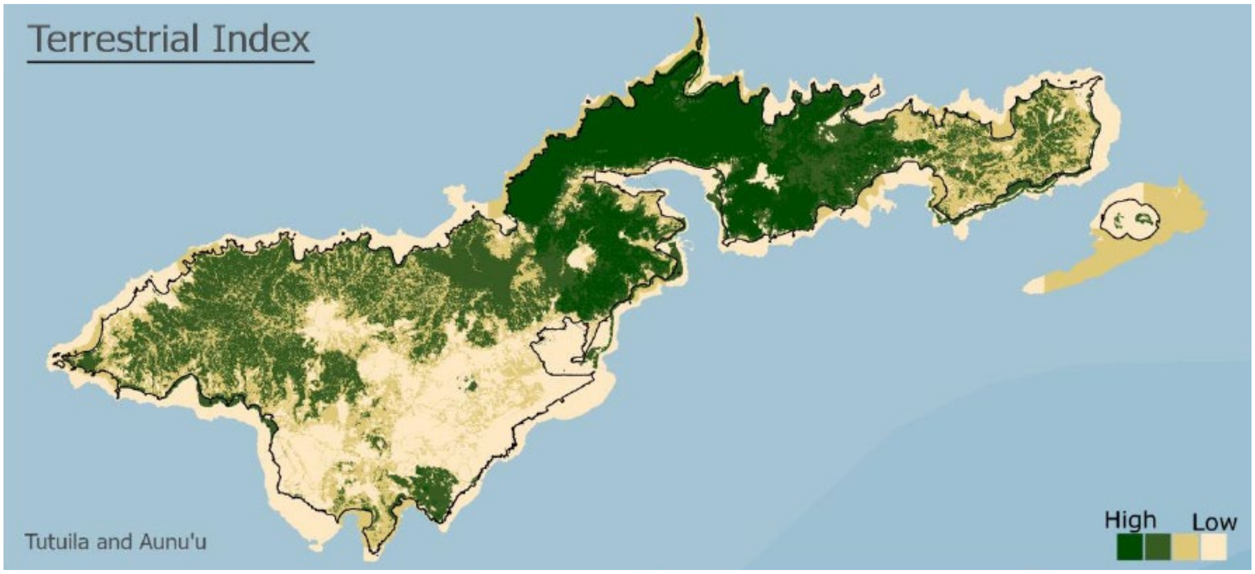

Figure 34. Coastal Resilience Assessment Terrestrial Index (Dobson et al., 2021)

6.2 Wetland and Streams

The Aua watershed contains approximately 9.2 acres of wetland, of which 7.4 acres are freshwater and 1.8 acres are saltwater (USDA, 1995). Most freshwater wetland areas are associated with the streams that extend from Aua Village into the uplands. As shown in **Figure 35**, the wetland areas with the Aua watershed are a considered high priority for conservation (ASCC, 2020).

In the freshwater streams of the Aua watershed, a variety of fish and invertebrates have been observed. At lower elevations (downstream and up to the village), mountain bass (*Kuhlia rupestris*) and mullet (*Mugil troscheli*) have been observed. Upstream of the village, gobies (*Eleotris fusca*), eels (*Anguilla mauritiana*), *Pocilia mexicana*, several shrimp species, and limpets (*Septaria porcellana*) have been found. Streams in the watershed have been severely altered by human activity; less than one quarter of stream reaches within Aua Village have unhardened banks (USDA, 1995). According to the Coastal Resilience Assessment (Dobson et al., 2021), Aua is rated low to medium for fish and wildlife as well as for marine biota (**Figure 36** and **Figure 37**).

The saltwater wetland found at the confluence of the Lalolamauta, Suaia, and Matagimalie Streams is dominated by red mangrove (*Rhizophora mangle*) and beach hibiscus (*Hibiscus tiliaceus*). The saltwater wetland is heavily impacted by sediment and fill, which erode into the wetland from nearly all upland portions of the watershed. The wetland has been characterized as having low functional value in terms of flood control and storm prevention; fish, shellfish, or wildlife habitat; sediment trapping and pollution abatement; groundwater recharge or discharge; water supply; or recreation and education (USDA, 1995).

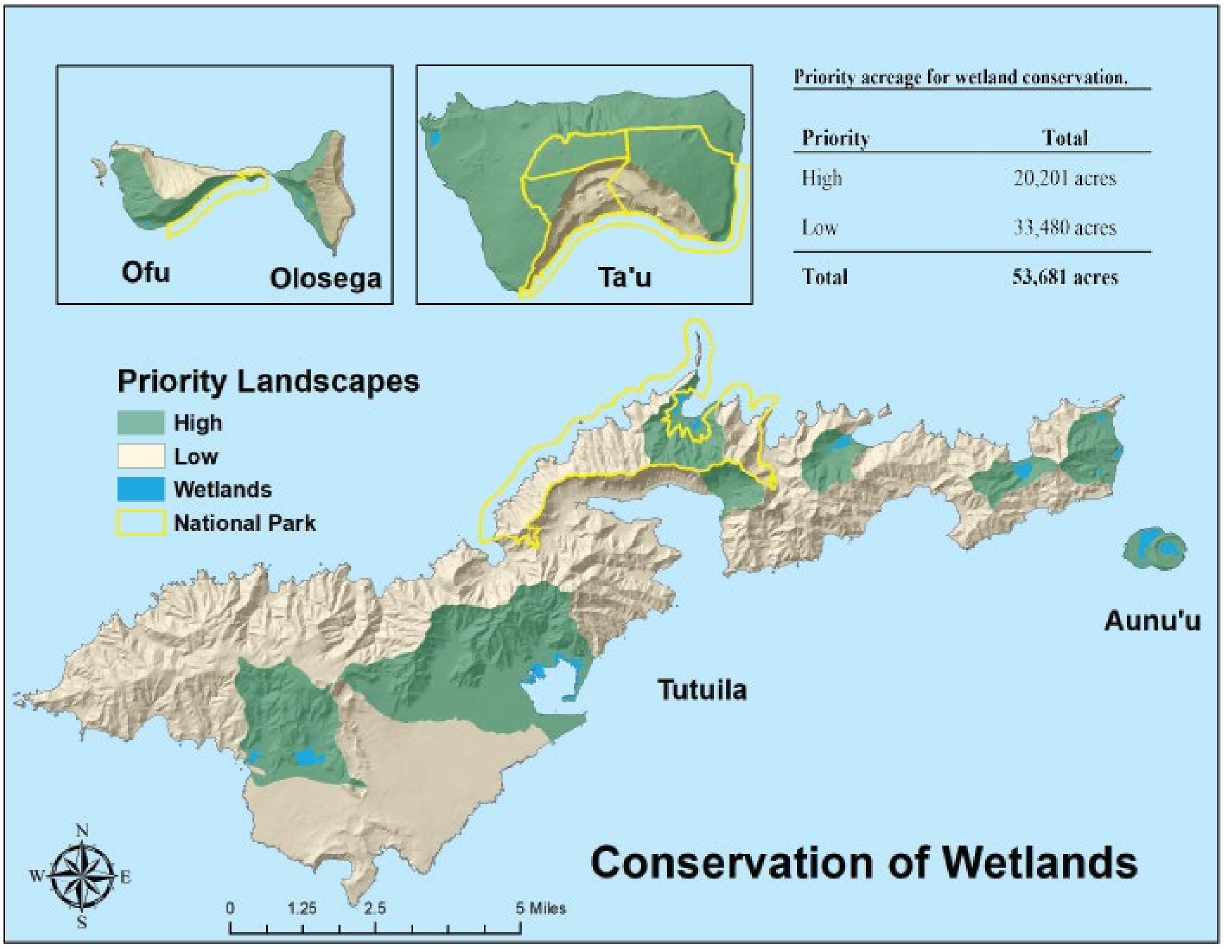

Figure 35. Wetland Priority Landscapes (ASCC, 2020)

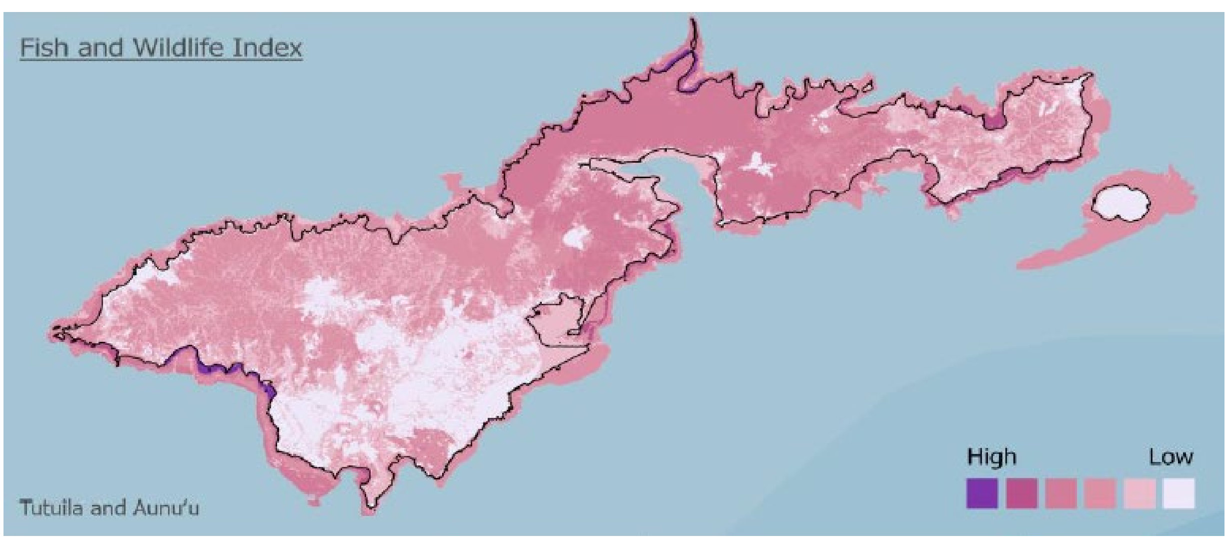

Figure 36. Coastal Resilience Assessment Fish and Wildlife Index

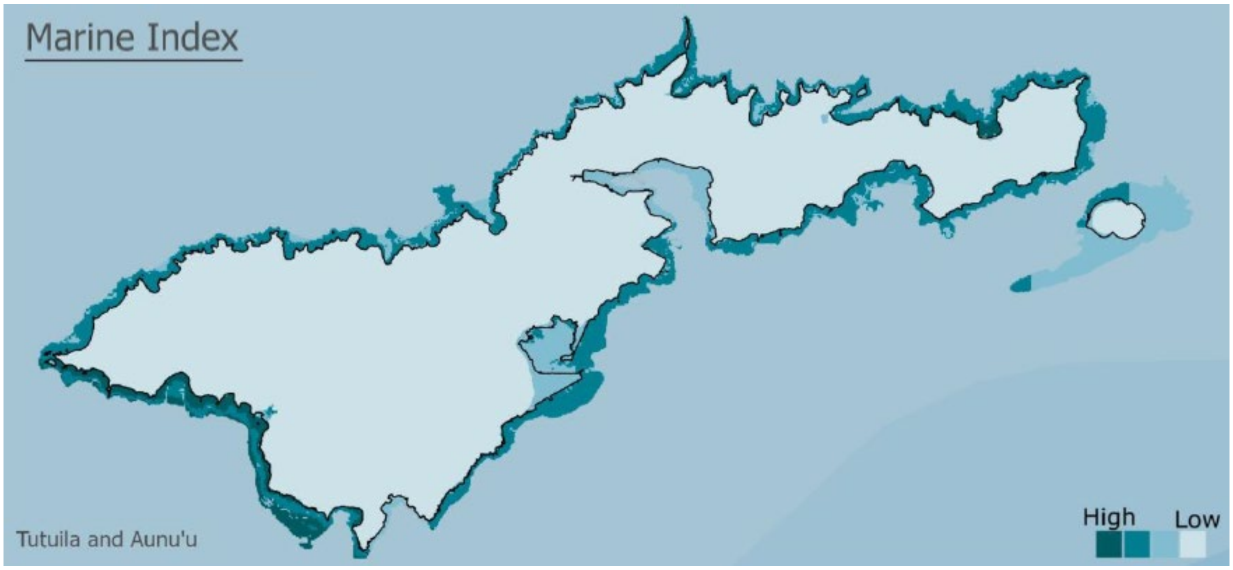

Figure 37. Coastal Resilience Assessment Marine Index

6.3 Marine Benthic

The ecology of the Aua embayment includes a coral reef area designated as a high priority protection by the 2020 Forest Action Plan (**Figure 38**) (ASCC, 2020). The reef margin is broken by a number of *ava*, or channels (ASEPA, 2000).

The coral reef along the Aua embayment is the longest continuously studied reef on the planet, ever since the establishment of a survey transect in 1917 by marine biologist Alfred Mayor. When the coral transect was first studied in 1917, it was in pristine condition. However, use of parts of the reef as a borrow pit for sand in the 1930s and 40s along with other environmental stressors have led the inner (closest to the shore) and middle sections of the reef to become significantly degraded. Only the outer (farthest from the shore) section of the reef appears to be healthy – surprisingly, with a greater abundance of corals than were recorded in 1917 (Kaust, 2021).

Significant coral bleaching was observed in 1994 (USDA, 1995). Assessments between 1995 and 2006 have shown varying levels of reef health. In 1995, live coral coverage averaged 17% in the embayment that fronts Aua Village. Coverage was generally greatest in the shallow flats near Aua (coverage approaching 20%) and declined toward the deeper portions of the harbor (5% or less) (USDA, 1955). This is consistent with the 2006 assessment, which found that between 10-50% of the reef provided habitat to macroalgae and coraline algae (USGS, 2006).

Between 2010 and 2015, the reef was observed to contain hard bottom reef flat with coral, crustose coralline, and turf algae as well as soft bottom reef with sparse massive corals (**Figure 39**) (USDA, 1995).

In 2022, water samples collected from the Aua embayment in the vicinity of the reef indicated that coral is less concentrated at the outlet of Lalolamauta than farther away from the outlet (Smith et al., 2023). This observation was found in tandem with a higher presence of sediment, turf algae, and macro fleshy algae near the Lalolamauta outlet.

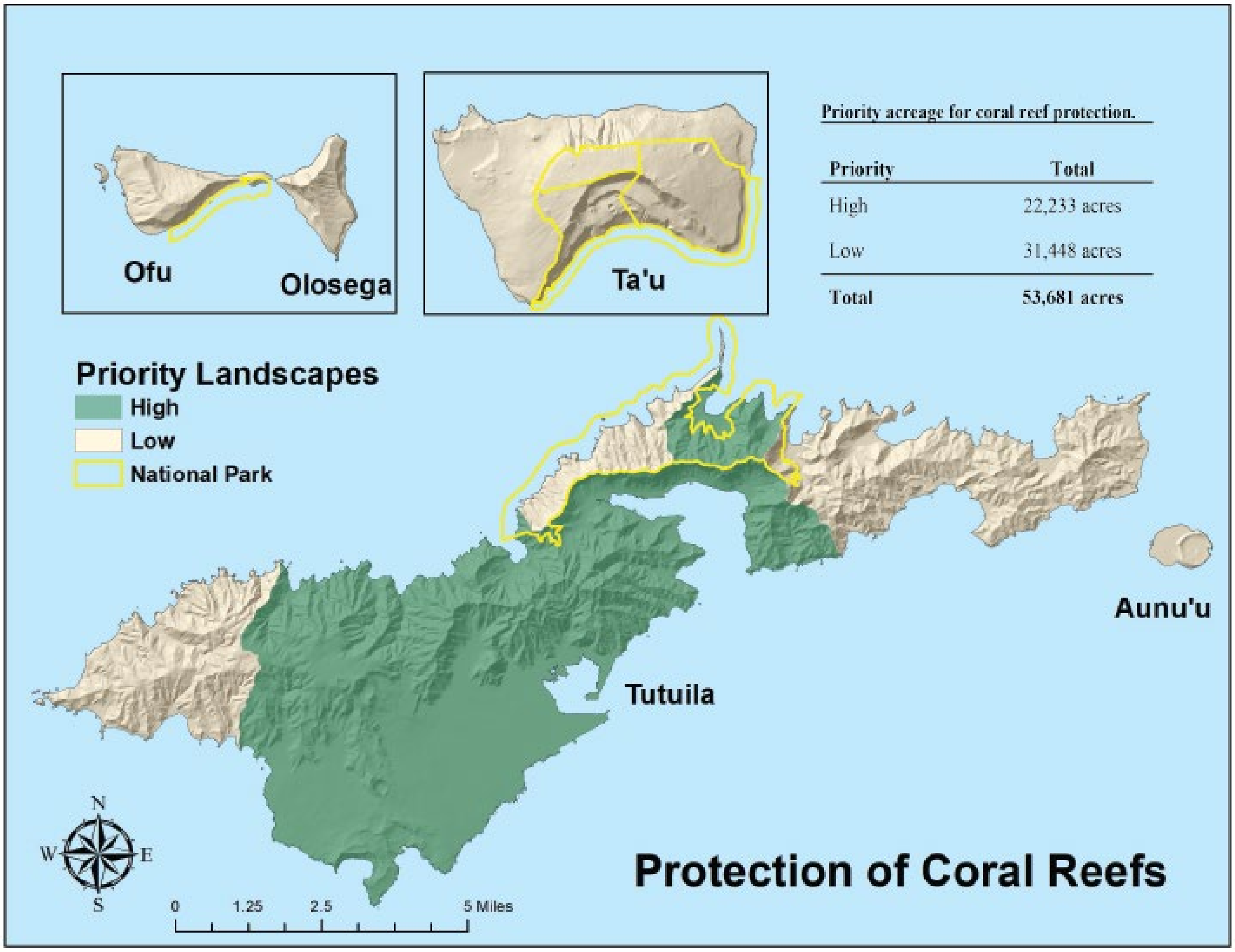

Figure 38. Coral Reef Priority Landscapes (ASCC, 2020)

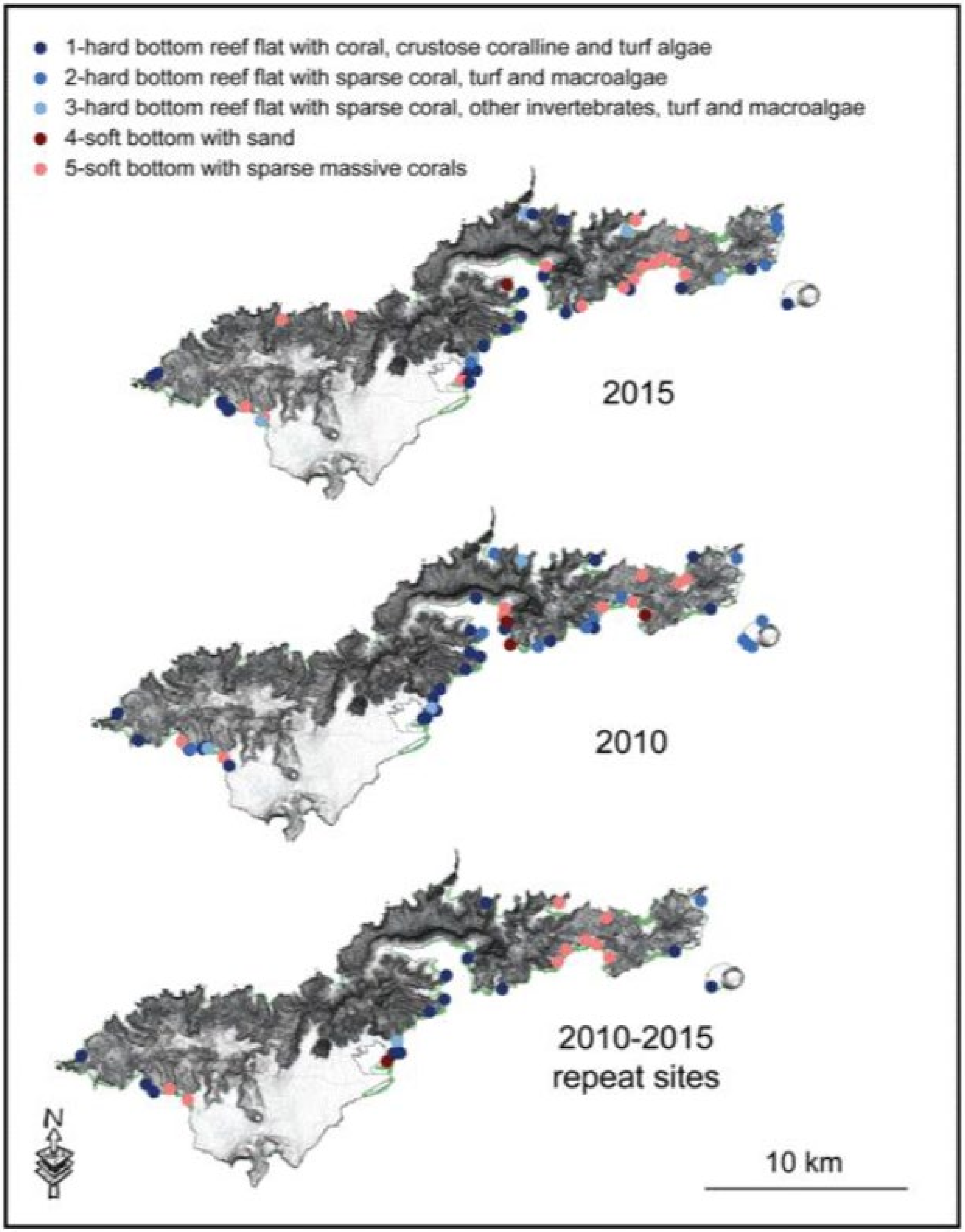

Figure 39. Benthic Survey Characterizations (Houk et al., 2015a)

7.0 Water Quality

7.1 Standards for Surface and Groundwater

Water quality standards for waterbodies in the Aua Watershed as described in the American Samoa Environmental Protection Agency (ASEPA) 2020 Integrated Watershed Monitoring and Assessment Report are summarized below in **Table 6**.

Table 6. Summary of American Samoa Water Quality Standards (ASEPA, 2020)

Parameter	Fresh Surface Waters	Pago Harbor Embayment
Temperature	Does not deviate more than 1.5° F from ambient and not to fluctuate more than 1° F on an hourly basis or exceed 85° F (except when due to natural causes	
Light Penetration Depth	Not <65.0 feet (to exceed given value 50% of the time)	
pH	6.5-8.6 range (+/- 0.2 pH units of that which would naturally occur)	
Dissolved Oxygen	Not < 75% saturation or not <6.0 mg/L	Not < 70% saturation or not <5.0 mg/L
Turbidity	Not > 5.0 NTU	Not > 0.75 NTU
Chlorophyll-a	N/A	Not > 1.0 ug/L
Total Nitrogen	Not > 300 ug/L	Not > 200 ug/L
Total Phosphorus	Not > 175 ug/L	Not > 30 ug/L
E. coli / Enterococcus	E coli: Statistical threshold value not > 410/100 ml Enterococci: Statistical threshold value not > 130/100 ml Geometric mean not > 35/100 ml	Enterococci: Statistical threshold value not > 130/100 ml Geometric mean not > 35/100 ml

Water quality standards for groundwater in the Aua Watershed are also set by the ASEPA, although no standards are set for light pollution depth, pH, dissolved oxygen, turbidity, chlorophyll-a, TN, TP, or bacteria. Standards for temperature are the same as those for fresh surface waters (**Table 6**). Toxic substances are required to be less than those defined by the 2002 National Recommended Water Quality Criteria, EPA-822-R-02-047 (EPA, 2002).

7.2 Monitoring Stations

Stream monitoring at the outlet of Lalolamauta Stream into Pago Pago Harbor was conducted between 1984 and 1991. The results of the monitoring, compiled from 31 sampling occasions, are shown below as **Table 7** (ASEPA,1991). Stream monitoring is presently conducted at three stations along Lalolamauta Stream and two stations along Leasi Stream. Monitoring at these locations has been ongoing since 2016.

Table 7. Median Water Quality Values in Lalolamauta Stream, 1984-91

	Parameter		
	NO2 + NO3	Total Nitrogen	Total Phosphorus
Median Concentration (ug/l)	168	368	98

The ASEPA maintains three monitoring stations along the shore of Aua Village (ASEPA, 2011). These stations are identified as Aua Pouesi Beach, Aua Stream Beach, and Aua Diosa Beach (also referred to as A&M Video). All three stations are monitored on a weekly basis.

Groundwater monitoring is managed jointly by the ASEPA and by the ASPA. The ASPA operates two wells within the Aua Watershed (ASCC, 2020). Chloride concentration monitoring has been an ongoing effort since at least 1994, when the chloride concentration in ASPA Well #97 (located in Aua) exceeded the Secondary Regulation maximum contaminant level of 250 milligrams per liter (ASEPA, 2000). Results of ASPA's 1994 Water Operations Report are shown below in **Table 8**, revealing heightened chloride levels in two of ASPA's Aua-based wells (ASPA, 1994).

Table 8. High Chloride Well Statistics for ASPA Wells Located in Aua

Well Number	Chlorides (ppm)	Elevation of well bottom below sea level (feet)	Average daily withdrawal (mgd)
97	720	161	0.32
99	560	153	0.34

The locations of all beach, stream, and well monitoring locations are shown below as **Map 10**.

Based on available monitoring data, both Lalolamauta and Leasi Streams were found to exceed water quality standards for total coliform bacteria on nearly every date in which samples were collected. Leasi Stream was also found to exceed standards for turbidity on every sample date; turbidity was not measured in Lalolamauta. Leasi also frequently exceeded standards for TP, and occasionally exceeded standards for TN, pH, and DO. Lalolamauta generally did not exceed fresh surface water quality standards other than bacteria, although TP measurements in Lalolamauta frequently exceeded Pago Harbor Embayment water quality standards. A summary of exceedance rates at the various monitoring stations is shown below in **Table 9**.

Table 9. Stream Water Quality Sample Summary – 2016 to present. Data provided by ASEPA

	% of Samples in Excess of Fresh Surface Water Quality Standards				
Parameter	**Lalo - US**	**Lalo - Mid**	**Lalo - DS**	**Leasi - US**	**Leasi DS**
Temperature	0	0	0	0	6
pH	0	0	0	23	14
Dissolved Oxygen	0	0	0	13	44
Turbidity	N/S	N/S	N/S	100	100
Total Nitrogen	0	0	0	20	18
Total Phosphorus	0	0	0	80	72
E. coli / Enterococcus	90	97	100	100	100

All three beach sampling locations have exceeded water quality standards for bacteria in the past 11 years of record, with especially high bacteria levels observed at the Aua Stream station (**Figure 40**). This is consistent with water quality monitoring data collected by NOAA in 2023, which found higher total suspended sediment concentrations closer to the outlet of the Lalolamauta Stream than at other beaches along the Aua Shore (Smith et al., 2023), shown below in **Figure 41**.

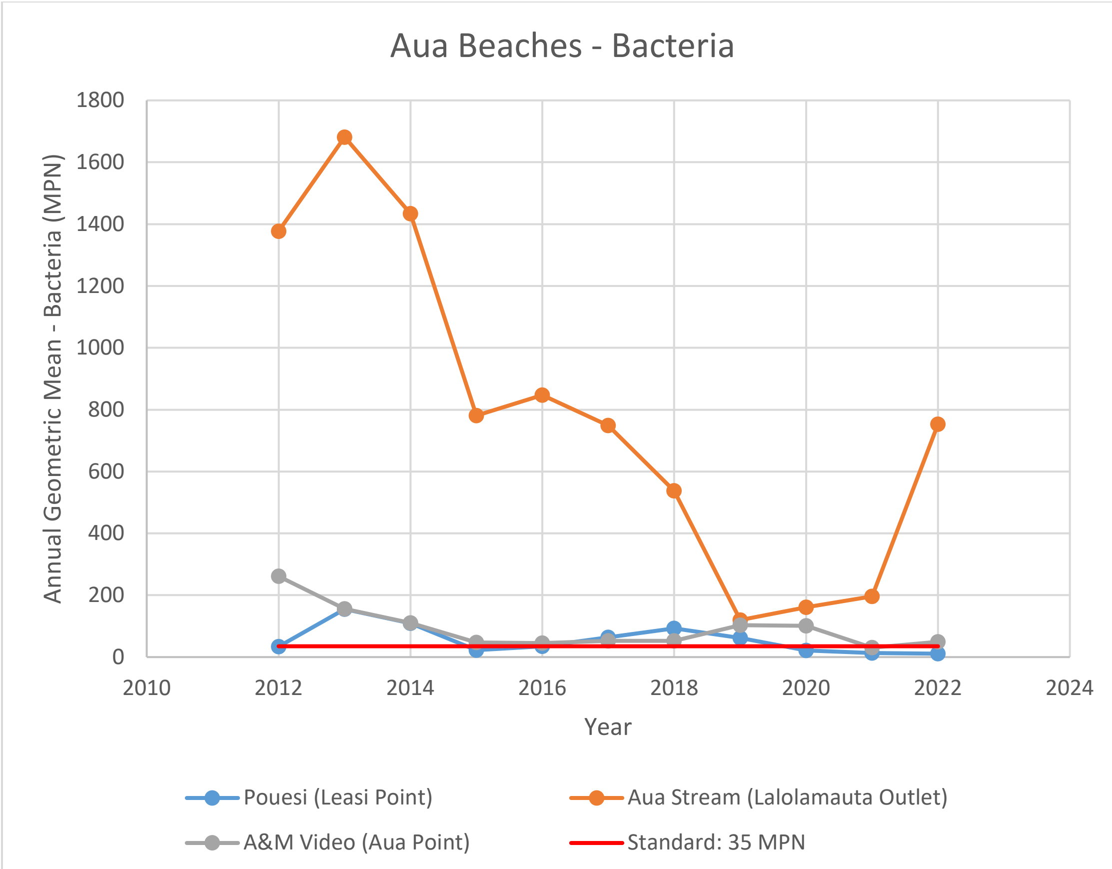

Figure 40. Annual Bacteria Water Quality Monitoring at Aua Beaches. Data provided by ASEPA

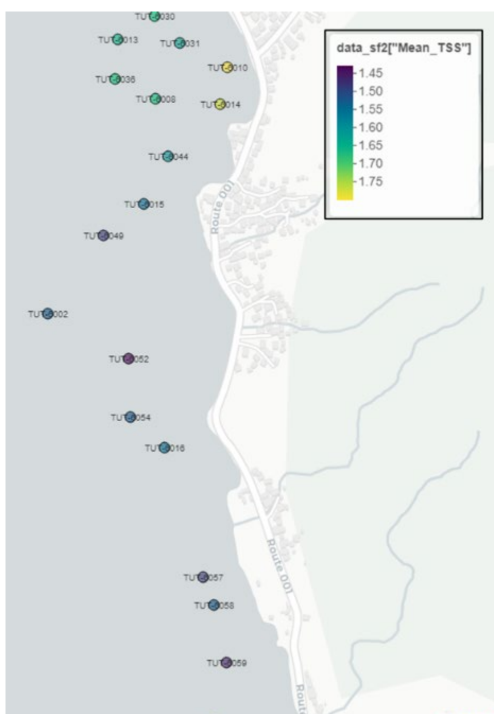

Figure 41. Total Suspended Sediment Concentrations along Aua Shore (Smith et al., 2023)

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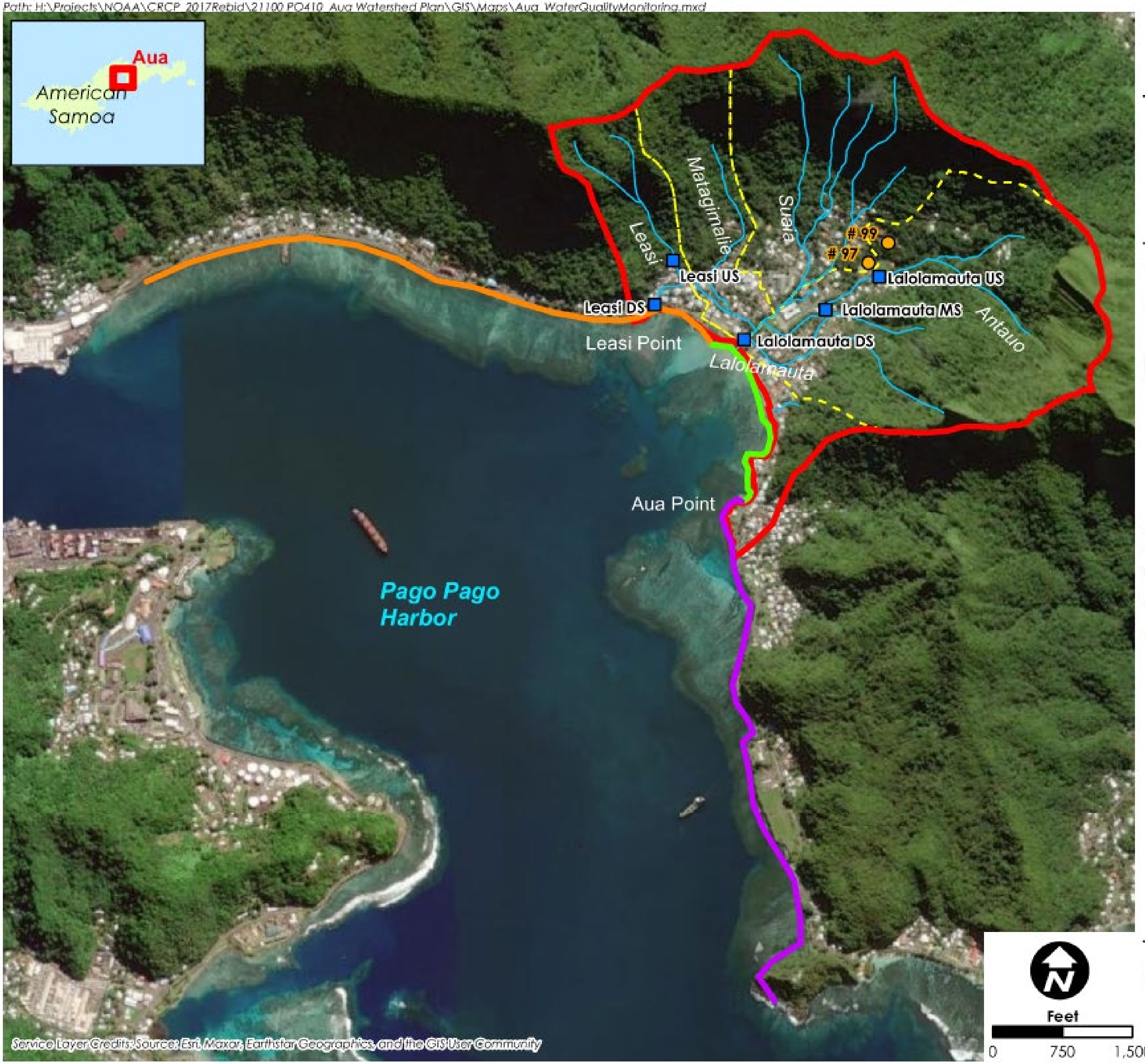

Horsley Witten Group
Sustainable Environmental Solutions

Date: 7/21/2023
Data Sources: USGS, NOAA, ESRI, American Samoa Power Authority, unless otherwise indicated by (HW)

This map is for informational purposes and may not be suitable for legal, engineering, or surveying purposes.

- Streams (HW 2022)
- Subwatersheds (HW 2022)
- Watershed (HW 2022)
- ASPA Wells
- ASPA Stream Monitoring Stations (Approximate)

ASEPA Beach Monitoring Locations

- A&M Video Beach
- Aua Stream Beach
- Pouesi Beach

Map 10
Water Quality Monitoring Locations

7.3 Impairments and TMDLs

For regulatory purposes, the Aua Watershed is grouped as part of the Pago Pago (Outer Harbor) watershed (Watershed #24B), one of 42 watersheds identified by the ASEPA in the territory (ASEPA, 2020). According to the ASEPA's 2020 Integrated Water Quality Monitoring and Assessment Report, streams in the Pago Pago Outer Harbor are impaired; a total maximum daily load (TMDL) is needed but has not been completed for the watershed. The ocean shoreline along the Pago Pago Outer Harbor is likewise impaired, although a TMDL has been completed for the waterbody. Neither swimming nor aquatic life are supported by the current water quality conditions of streams and the ocean shoreline in the watershed. Impairments include total nitrogen, total phosphorus, turbidity, dissolved oxygen, and pH.

7.4 Pollutant Load Modeling

In 1986, a pollutant loading model was developed for several major watersheds within Tutuila by the Coastal Zone Management Office and Environmental Quality Commission of the American Samoan Government. The model combined a surface runoff method with the Universal Soil Loss Equation to estimate land surface erosion from each watershed in Pago Pago Harbor, including the Aua Watershed. Nonpoint source pollutant loading from the Aua Watershed was modeled to result in 1,756 tons of sediment, 1.5 tons of phosphate, 17.3 tons of total nitrogen, and 36.1 tons of biological oxygen demand. Pollutant loading was not projected to change significantly based on land used changes projected at the time the model was developed (Kennedy et al., 1986). Similar to the land use conditions of the Aua Watershed when the model was created, little undeveloped space remains in the watershed, so it is likely that the land use assumptions of the model remain valid.

More recent modelling indicates that submarine groundwater discharges may represent a greater source of pollutant loading than riverine-based sediment and nutrient transport (Shuler et al., 2019). Submarine groundwater discharges are expected to play a smaller role in the Aua Watershed as a result of the expansion of wastewater infrastructure to Aua Village, as the quantity and usage of cesspools and septic tanks has likely been reduced. However, sources of groundwater pollution such as piggeries and other unmanaged waste may still play a significant role in nutrient transport to Pago Pago Harbor via groundwater.

Other recent modelling efforts have evaluated the relationship between watershed/embayment position on Tutuila and dissolved inorganic nitrogen (DIN) concentrations in adjacent reefs (Comeros-Raynal et al., 2019). The Comeros-Raynal model found the Aua Watershed to have the highest DIN concentration of the 26 watersheds evaluated (**Figure 42**). Regression models showed the variables of total human population and human population per square kilometer as the best predictors of DIN in stream mouths. Disturbed land cover and disturbed land cover per square kilometer were also significant variables in predicting DIN concentrations, particularly in wave-sheltered reefs like the one associated with the Aua Watershed. Additional findings from regression modelling show that "fish condition" (determined using a framework for biological condition scores developed by Houk et. al, 2015b) in wave-sheltered reefs are primarily influenced by the distance of a reef to Pago Pago Harbor and secondarily by total human population in the adjacent watershed. As a densely populated watershed situated directly on Pago Pago Harbor, the Aua reef is modelled to be poor in fish condition. Using a similar criteria, "benthic condition" in reefs was found to be primarily associated with the distance of a reef to the nearest harbor and secondarily by the population density of the adjacent watershed.

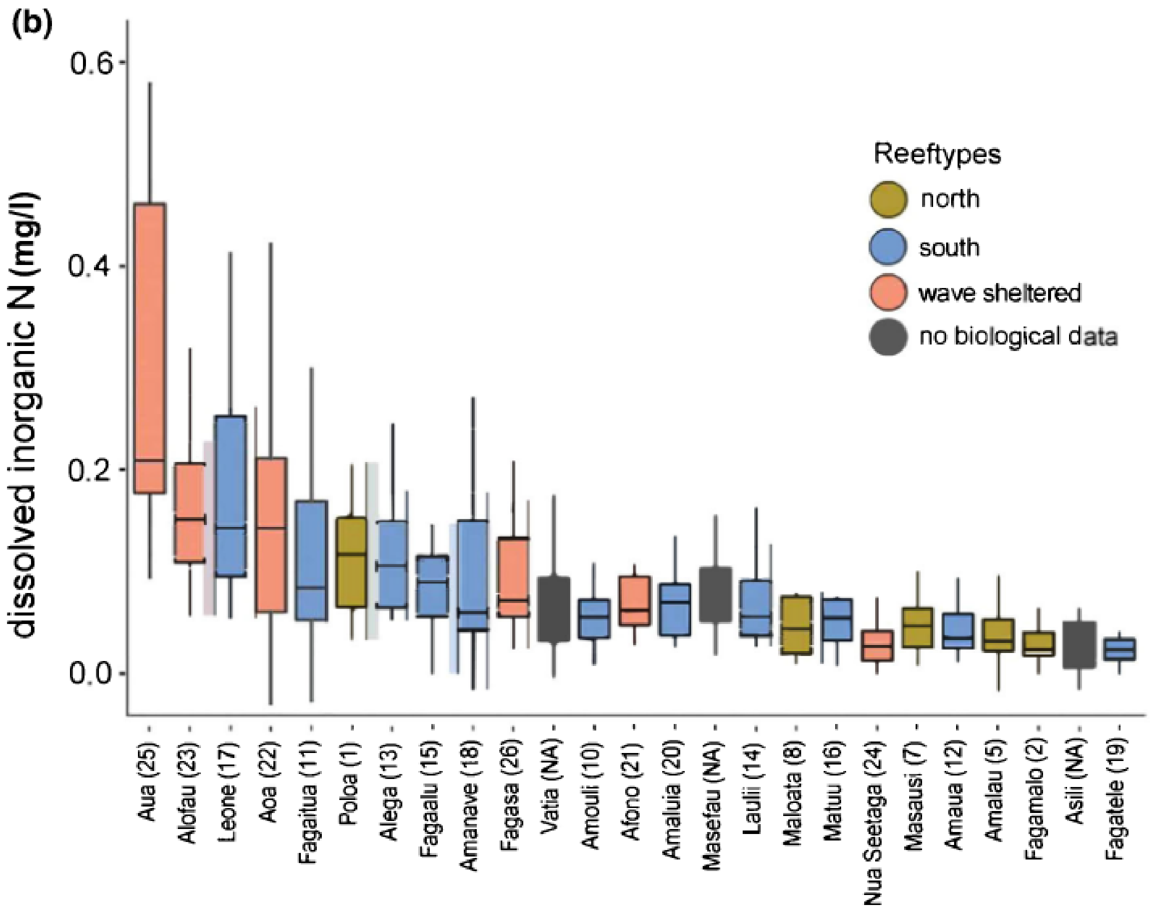

Figure 42. Distribution of monthly DIN concentrations from September 2016-17

8.0 Previous Watershed Recommendations

A summary of previous recommendations to support the resiliency of infrastructure and natural resources in Aua is shown below in **Table 10**. The recommendations shown below are from a variety of previously developed studies and plans, the most recent and comprehensive of which was developed by the Army Corps of Engineers for the entire island of Tutuila (ACOE, 2022). Although recommendations shown below were developed with reference to Tutuila, they are relevant and applicable to Aua based on the characterization of the watershed.

Table 10. Past Recommendations (general)

Recommendation	Description	Source
Shoreline & Reef		
Submerged or Detached Breakwaters	Breakwaters are used to protect a harbor or shoreline from waves by dissipating wave energy.	ACOE, 2022
Rock Seawalls	Seawalls deflect waves to prevent erosion.	ACOE, 2022
Revetments	Similar to seawalls, revetments are sloping erosion-resistant structures built along a shore to deflect wave energy. Typically made out of stone.	ACOE, 2022
Beach Nourishment	The practice of adding large quantities of sand or sediment to beaches in order to replace lost sand.	ACOE, 2022

Recommendation	Description	Source
Vegetation Enhancements	Native vegetation to improve aesthetics and environmental benefits. Vegetation can be incorporated into levees, floodwalls, embankment dams, and appurtenant structures without compromising their performance. Roots from plantings also reduce erosion.	ACOE, 2022 Sene, 2022
Reef Balls	Artificial reef modules designed to mimic native reefs. Reef balls are made from concrete and placed near shorelines to dissipate wave energy and provide aquatic habitat.	ACOE, 2022
Shoreline Protection	Restoration of natural systems (e.g., cliffs, dunes, wetlands, and beaches) to protect infrastructure landward of the shoreline. Shoreline protection contributes to storm damage reduction and coastal erosion mitigation.	ACOE, 2022 Sene, 2022
Native Invertebrate Recruitment	Restoration of native invertebrates. Invertebrates filter pollutants from water, dissipate wave energy, and provide critical ecosystem services.	ACOE, 2022
Water Quality Monitoring	Sampling and analysis of water constituents to determine physical, chemical, and biological characteristics. Characteristics may include: temperature, pH, dissolved oxygen, conductivity, salinity, oxygen reduction potential, turbidity, and transparency.	ACOE, 2022 ASEPA, 2000
Increased Shoreline Monitoring and Data Collection	The use of traditional and innovative methods to monitor and collect data. (E.g., unmanned aerial system imagery)	ACOE, 2022
Wave Exposure Analysis	Identification of areas where ecosystem enhancement/green infrastructure solutions are feasible and/or where more durable structures are required.	ACOE, 2022
Coastal Erosion Analysis	Analysis of historical rate of coastal erosion and updating the shoreline condition inventory to highlight high risk areas with rising sea levels and rapid subsidence rates.	ACOE, 2022
Subsidence Study	Identification of areas affected by subsidence hotspots and use of LiDAR to monitor subsidence zones.	ACOE, 2022
Coral Reef Mapping	Ongoing database of current status and spatial/temporal trends of coral reef ecosystem health.	ASEPA, 2000 CRAG, 2020
Stormwater & Drainage Infrastructure		
Resizing Hydraulic Structures	Replacement of a structure submerged or partially submerged in water that disrupts the natural flow of water. Examples include artificial canals/channels, detention basins, levees, and dams.	ACOE, 2022 USDA, 1995
Culvert Maintenance	Maintenance of stormwater culverts at shoreline discharge points.	ASEPA, 2000 USDA, 1995
Slope Drains	Installation of a pipe or lined channel extending from the top to the bottom of a slope. Meant to protect slopes from erosion caused by runoff.	ACOE, 2022
Detention Basins	Detention basins detain stormwater runoff, reducing downstream erosion and capturing pollutants by allowing them to settle.	ACOE, 2022
Rain Gardens	Vegetated depressions designed to capture and filter runoff.	ACOE, 2022
Improved Construction Best Management Practices (BMPs)	Practice of managing stormwater runoff and associated pollutants during construction. BMPs include policies, practices, or products to mitigate the environmental impacts of development.	ACOE, 2022
Stormwater Management BMPs	Techniques to manage stormwater quantity and quality on a site.	ACOE, 2022 CRAG, 2022
Slope Stabilization		
Terraced Hillsides	Levelling of a hillsides ground in sections to create a series of flat	ACOE, 2022

Recommendation	Description	Source
Wattles	Installation of straw wattles on steep slopes to breakup runoff before it accumulates speed.	ACOE, 2022
Sloped Plantings	Planting native vegetation on slopes greater than 25% (4:1 H:V). On slopes greater than 50% (2:1 H:V), plants should be selected that do not require mowing.	ACOE, 2022 Sene, 2022
Detailed Landslide Mapping	Creation of a database of past landslide information including location, cause, runout length, volume, weather, and potential hazard. Identification of areas with slopes over 60% and/or new construction in these hazard areas.	ACOE, 2022
Water Supply		
Water Wells & Boosters Backup Power Supply	Installation of generators, batteries, and solar panels to provide backup power in case an electrical grid is disrupted.	ACOE, 2022
Water Tank Reinforcements	Support stability of water tanks and prevent loss of water inside.	ACOE, 2022
Desalination	Conversion of saline water into freshwater by removing mineral components	ACOE, 2022
Rainwater Harvesting/Capture	Storage of clean precipitation from rooftops, to be used for graywater systems or irrigation. Rainwater harvesting reduces peak runoff velocities and volumes.	ACOE, 2022
Gravity Fed Water Catchment Systems	Harvesting water for irrigation from stormwater runoff. Similar to Rainwater Harvesting/Capture (above).	ACOE, 2022
Wastewater		
Wastewater System/Septic System Improvements	Includes two techniques: (1) conversion of basic septic systems to centralized sewer systems or advanced septic systems, and (2) repairing existing sewage system components.	ACOE, 2022 ASEPA, 2000
Roadway		
Road Compaction	Compaction of the soil in dirt roads to reduce the volume of air in the soil. Compaction stabilizes roadways, reducing rates of erosion.	ACOE, 2022
Plantings on Dirt Roads/Cesspools	Planting native vegetation to reduce runoff and improve water quality. Shallow root plants should be selected for plantings above cesspools.	ACOE, 2022
Permeable Roads, Parking Lots, and Sidewalks	Installation of porous surfaces which allow stormwater to naturally drain through to the subsurface.	ACOE, 2022
Wetlands & Forestry		
Mangrove Plantings	Mangroves can offer shoreline protection from erosion and even help sand and sediment accumulate in low-energy coastal settings. Mangroves also improve water quality and offer marine habitat.	ACOE, 2022 ASEPA, 2000 Sene, 2022 USDA, 1995
Invasive Species Removal	Elimination or reduction of populations of plants, animals, or other living organisms that are not native to a particular area. Invasive species may displace native species, often without providing comparable environmental services such as pollutant uptake.	ACOE, 2022 Sene, 2022
Wetland Delineation	Identification of areas which are inundated or saturated by surface or groundwater at a frequency and duration to support vegetation which is adapted to saturated soil conditions.	ACOE, 2022 Sene, 2022
Agricultural BMPs	Conservation practices which can be used to reduce soil and fertilizer runoff, manage animal waste, and protect water and air quality on farmland.	ACOE, 2022
Agroforestry BMPs	Identification and promotion of BMPs to conserve soil and reduce runoff in agroforestry areas, steep slopes, riparian zones, and coastal shorelines.	Sene, 2022

Recommendation	Description	Source
Collaborative Database	A virtual platform designed to support interagency information sharing, particularly for water quality monitoring.	ACOE, 2022
Waterway Debris Prevention	Improvement of trash/bulky item pickup services in order to reduce debris in streams, shorelines, and reefs. Removal of debris found in and near streams.	ACOE, 2022 ASEPA, 2000 Sene, 2022 USDA, 1995
Stabilize Stream Corridors	Identification of riparian areas and streams that need trees and vetiver grasses to maintain and stabilize stream corridors.	Sene, 2022
Fell Wood Collection	Collection of fell wood to create wood chipper. Wood chipper is used to address piggery runoff.	Sene, 2022
Flooding & Tsunamis		
Gauge Installation/Early Warning Systems	Automated water gauges monitor water levels in real time to detect if a flood, high tide, or large wave is imminent. Warning systems can then alert areas that will be affected.	ACOE, 2022
Elevate Structures Above Estimated Flood Heights	The use of stilts or other structure raising techniques reduces susceptibility to damage caused by future floods or elevated sea levels.	ACOE, 2022
Replacement Housing Design Guides	Development of recommendations for materials, structures, site issues, and planning to support the design of adaptive, resilient buildings.	ACOE, 2022
Disaster Recovery Plans	A plan that has a primary goal of enabling survival of a disaster and to assure critical functions can resume in order to continue normal operations.	ACOE, 2022
Structure Relocation	The process of moving a structure from one location to another. This involves disassembling and then reassembling at the required destination or raising and transporting whole.	ACOE, 2022
Weatherproof Key Infrastructure/Utilities	Flood barriers to protect critical infrastructure include levees, dikes, and seawalls. Alternative methods include elevating equipment or placing it within waterproof containers or on foundation systems.	ACOE, 2022 USDA, 1995
Expand Critical Infrastructure Database	Development and maintenance of a database documenting the location and conditions of critical infrastructure for hazard analysis.	ACOE, 2022
Tsunami BMPs	Mitigation strategies designed to reduce the likelihood that coastal populations will be impacted by tsunamis, typically through engineering structures or removing communities from known tsunami inundation zones.	ACOE, 2022
Emergency Action Plan Development	Plan to reduce or avoid losses from hazards, assure prompt assistance to victims, and achieve rapid and effective recovery. Steps include prevention, mitigation, preparedness, response, and recovery.	ACOE, 2022
Emergency Response Exercises	Enhanced knowledge of plans through exercises allows key personnel to improve their performance during emergencies and identify opportunities to improve emergency responses in case of future events.	ACOE, 2022
Tsunami Warning System	A network of sensors to detect tsunamis and a communication infrastructure to issue timely alarms to permit evacuation of coastal areas.	ACOE, 2022
General		
Enforcement and Regulations	Development and enforcement of written regulations to increase resiliency.	ACOE, 2022 CRAG, 2022
Education and Outreach	Efforts to provide informative knowledge in a manner that excites public interest.	ACOE, 2022 Sene, 2022 CRAG, 2020

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