

MANELL-GEUS WATERSHED MANAGEMENT PLAN 2025-2030

Prepared by Horsley Witten Group, Inc.
for the Guam Coastal Management Program, Village of Merizo/Målesso',
and NOAA Coral Reef Conservation Program

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Merizo Bell Tower

EXECUTIVE SUMMARY

The Manell-Geus watershed was identified by the Government of Guam as a priority area for management and is one of the NOAA Habitat Focus Areas. Located on the southern tip of Guam, the watershed encompasses the majority of the Village of Merizo/Målesso', the critical Route 4 connector, and the Achang Reef Flat Preserve—the largest of Guam's marine preserves. 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 many streams are impaired for turbidity, nutrients, dissolved oxygen, and bacteria; and the lagoon, reef, and community have been impacted by these pollutants. In addition, 303 structures (71% of the total in the watershed) 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 of existing drainage infrastructure. Conditions will continue to worsen with ~3 feet of relative sea level rise predicted over the next 50 years.

Past and on-going efforts to improve and expand sewer service, revegetate badlands, remove invasive bamboo, expand mangroves, and study river re-alignment alternatives are important steps in restoring watershed health. Additional management options have been identified in collaboration with NOAA, local agencies, and Village leaders. The Manell-Geus Watershed Management Plan (WMP) was developed to address the US Environmental Protection Agency's (EPA's) nine minimum elements of a watershed plan to offer a roadmap for achieving four watershed goals:



1. Minimizing flooding now and in the future. Priority actions include river realignment, wetland and floodplain restoration and protection, restoring natural hydrology and flow paths, drainage infrastructure improvements at problem sites, and hazard planning for vulnerable segments of coastal roads.



2. Reduce watershed-based pollutant loads to nearshore waters. Focus on badland restoration and wildfire prevention, green stormwater infrastructure for managing urban runoff, wastewater system and non-service area upgrades, and feral pig best management practices.



3. Restore habitat and improve biodiversity. Key projects include the restoration of badlands and wetlands, feral pig best management practices, invasive bamboo removal, shoreline stabilization/mangrove restoration, and a dam removal study.



4. Support community engagement. Priority actions include designating a watershed coordinator, annual progress reporting, K-5 lesson plans, watershed signage, encourage participation in the Sustainability Plan and Forest Health Plan, public involvement/training with badland restoration, and resident education/training on neighborhood drainage, wildfires, off-roading & septic systems, etc.

This WMP was developed as part of NOAA's Habitat Focus Area program, which has already been conducting monitoring studies and improvements in the Cocos Lagoon and the Achang Reef Flat Preserve. Six areas in the watershed are identified in the WMP as priorities to focus on for implementation. Key wastewater and drainage infrastructure improvements are in progress by Guam Waterworks Authority and the Department of Public Works, and the Army Corps of Engineers is advancing plans for restoring the Manell River. Guam's current zoning and forest/habitat planning initiatives targeting the southern portion of the island offers a unique opportunity to advance watershed scale land use policies. An additional investment of approximately \$11.5M in the Manell-Geus watershed for implementation is projected over the next 5 years to address watershed goals.

Management goals and priorities should be reassessed by the Watershed Planning Committee in 2030 and updated based on progress and to adapt to changing priorities. Success will require enthusiastic participation from key implementation champions including Village leaders, Guam BSP-GCMP, Guam DOAG-Coral Reef Initiative, Guam DPW, Guam DOAG-FSRD, Guam-EPA GWA, NOAA-CRCP, TNC, and US ACOE.



Village marker at the Ajayan River crossing on Route 4.

1 INTRODUCTION

Purpose

The Manell-Geus watershed has been designated as a NOAA Habitat Focus Area and as a priority watershed by the Government of Guam. The watershed drains to the island's only shallow water lagoon, the Cocos Lagoon, characterized by fringing reefs, mangroves, and extensive seagrass beds that extend eastward into the Achang Reef Flat Marine Preserve. This area supports a strong fishing tradition in the Village of Merizo/Målesso' and is an important habitat for green and hawksbill sea turtles, as well as many other important species of marine wildlife and seabirds.

While the marine resources are substantial, they have been impacted by decades of poor water quality from streambank and hillside erosion exacerbated by fires, feral animals, and off-roading vehicles. The streams and residents of Merizo are impacted by extreme flooding in many areas, threatening lives, homes, and infrastructure. This Watershed Management Plan (WMP) takes a comprehensive look at watershed conditions and identifies specific restoration opportunities to improve watershed health.

The purpose of this WMP is to complement ongoing marine and terrestrial habitat protection efforts, build on previous and ongoing efforts, address community priorities, and guide land-based implementation activities over the next 5 years. It identifies key sources of, and solutions to, land-based sources of pollution (LBSP) impacting the nearshore ecosystems. This plan summarizes existing conditions and management priorities for improving watershed health. The WMP is intended to provide implementable actions for agencies and for residents. 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 Merizo Mayor's Office. This plan recognizes the integral role of local leaders and residents for effective management of watershed resources.

Context with Other Efforts

This WMP is intended to support ongoing efforts in the watershed. Various agencies, universities, and community members have been collaborating to better understand the causes of impacts to these valuable marine resources and, more importantly, to find solutions. In fact, much has been learned about Manell-Geus over the past 5-10 years, and there have been some significant accomplishments, including but not limited to: biological and water quality monitoring, stream studies, badland revegetation, bamboo removal, shoreline cleanups, socioeconomic monitoring, etc. The key efforts considered during the WMP development include some of the following:

Guam Coastal Zone Management/Coral Reef Initiative/NOAA Habitat Focus Area (HFA)

This WMP builds on the 2017 HFA Implementation Plan, which identified the following objectives:

1. Improve reef ecosystem health by reducing coral predation and nuisance algae
2. Improve community safety and health by reducing impacts from fires and floods
3. Maintain or improve local food production and marine tourism opportunities for Merizo
4. Improve community engagement in watershed and marine resource management



Focus Area Objectives At a Glance

3-5 years

Coral Reefs – Decrease sedimentation impacts

Seagrass Beds – Maintain or increase extent and density

Mangroves – Establish monitoring plan to detect changes in the health of the mangrove forests

Stream Beds – Improve stream habitat and increase presence of native fauna in at least 3 streams

Community – Increase community engagement in conservation programs

Longterm

Resilient reefs and terrestrial habitats that will be able to sustain the people of Merizo well into the future.

A safer, more resilient and engaged human community

Figure 1. Excerpt from NOAA's Habitat Blueprint Manell-Geus watershed HFA fact sheet.

Guam Bureau of Statistics and Plans (BSP)

BSP is actively coordinating the development of the Guåhan 2050 Sustainability Plan. This plan is effectively an updated comprehensive land use plan for the entire island that centers on building a sustainable future for Guam. The focus of the plan is on economic growth, affordable housing, clean water, reliable infrastructure, environmental preservation, and public health and safety. Specifically relevant to the Manell-Geus watershed, this planning process will, for the first time, provide zoning and other land management guidance for southern Guam.



US Army Corps of Engineers (ACOE)

A 2020 U.S. Army Corps of Engineers Flood Hazard Study of the Manell subwatershed developed recommendations to address flooding from the Manell River. These recommendations were further developed in a 2022 Federal Interest Determination Report (Continuing Authorities Program Section 205-Flood Risk Management) for Manell River.

Guam Department of Public Works (DPW)

In 2010, the DPW published a Stormwater Drainage Master Plan, via Parsons Public Transportation Group, Inc., which identified 30 infrastructure improvement projects in the watershed for a total project cost of \$13.2 million. These projects include stabilizing headwalls, replacing culverts, and upgrading bridges. These were assessed in the field as a part of this WMP development and are cross referenced in the drainage infrastructure map (**Appendix B**). In addition, some of these improvement projects were prioritized for implementation between 2024-2027 (Guam Transportation Improvement Plan Fiscal Years 2024-2027). These include the Merizo Inland Culvert Rehabilitation (culvert along Geus Road for the Geus River – Focus Area 3) and the Ajayan Bridge Replacement (Focus Area 6 – Ajayan River). Guam DPW also has a municipal separate storm sewer system (MS4) permit from US EPA for discharges from the stormwater infrastructure they operate on Guam, including in the Manell-Geus watershed.

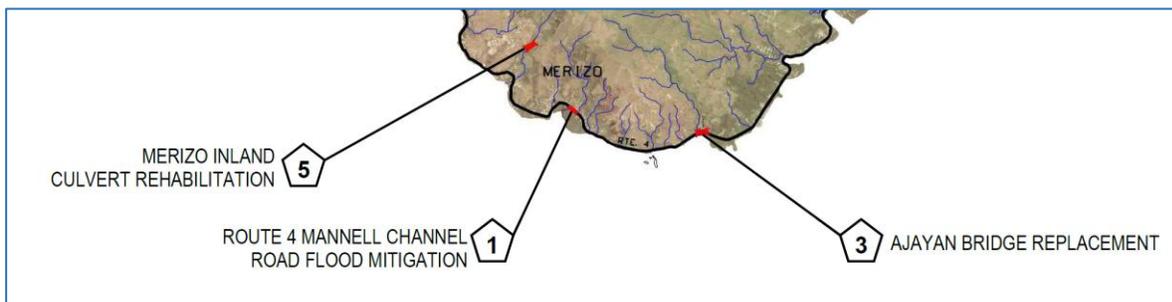


Figure 2. Excerpt from a Guam Transportation Improvement Plan (2020-2023) map of projects. Note that the Route 4 Mannell Channel Road Flood Mitigation project is now being designed by the ACOE.

Guam Waterworks Authority (GWA)

GWA manages all wastewater and water infrastructure in the watershed. In the *2018 Water Management Master Plan Update*, GWA has identified specific upgrades and repairs for wastewater and water infrastructure in the watershed. These include the Pigua Water Tank Upgrade and the Umatac-Merizo Sewer Replacement.

Guam DOAG – Division of Aquatic and Wildlife Resources (DAWR)

DAWR is working with University of Guam (UOG) Center for Island Sustainability (CIS) to develop the *Guam Habitat Conservation Plan* (HCP) to request an “Incidental Take Permit” under the federal Endangered Species Act (ESA) for activities on non-federally controlled lands in Guam. The HCP will function as a long-term planning tool that supports the conservation of threatened and endangered species, or those species that are likely to become listed as such, while allowing for continued sustainable development in Guam consistent with the HCP. The HCP includes lands identified in the Guam Forest System Plan. HCP will go out for public review shortly.

Guam DOAG – Forestry and Soil Resources Division (FSRD)

In March 2022, the Department of Agriculture (DOAG) issued their Guam Forest System Plan “to implement provisions of the Forest Legacy Act by proposing and creating management strategies for Guam’s resources.” The Plan aims to address the necessary balance between public interest and sustainable long-term protection and management of multiuse open spaces and conservation areas for the benefits they provide (see goals and objectives listed below). In addition, FSRD has been leading the badland restoration efforts in the Manell-Geus watershed supported by partners from the BSP, USDA Forest Service State and Private Forestry and State Fire Assistance, and NOAA - under Guam's Coral Program and NOAA's Habitat Blueprint initiative.

Guam Habitat Conservation Initiative (REPI, Joint Region Marianas, and NFWF)

Established in 2020, this program is a partnership between the Department of Defense (DoD) Readiness and Environmental Protection Integration (REPI) Program, Joint Region Marianas, and the National Fish and Wildlife Foundation (NFWF). The program’s goal is to protect, restore, and enhance targeted native limestone forest, ravine forest, and savanna habitats in Guam specifically to support conservation and recovery of federally listed and at-risk species (NFWF 2022). The program aims to complement ongoing conservation work, providing funds and support where gaps may exist. An implementation plan was developed in 2022 to guide efforts in targeted areas on Guam, hoping to expand in future years based on outcomes.

Goals and Associated Objectives from the 2022 Forest System Plan

Goal 1. Manage watersheds to protect and improve water quality of surface water, groundwater, and nearshore marine habitats.

- Reforest watersheds and expand existing ravine forest remnants;
- Create riparian buffers to protect stream systems and reduce flooding impacts;
- Address wildfires through education, prevention, and augmented suppression efforts;
- Control feral ungulates that pose threats to watersheds; and
- Participate in collaborative initiatives with local and federal government agencies, non-profit organizations, and private landowners to enhance watershed management.

Goal 2. Maintain and enhance biological integrity of native ecosystems.

- Identify and protect rare plant individuals and populations;
- Protect, enhance, and manage native habitats;
- Propagate and outplant native and threatened or endangered species;
- Manage habitats to create viable spaces or habitat for potential reintroduction of extirpated species; and
- Monitor forest and associated habitat to inform adaptive management strategies.

Goal 3. Support public access to the Forest System.

- Create, restore, and maintain trails, viewpoints, and public recreation areas with 3 appropriate signage and safety considerations;
- Provide public recreation, education, and hunting opportunities;
- Improve forest habitats to ensure availability of culturally important plant species; and
- Work with recreational and hobby groups to facilitate access and uses compatible with protection of water quality, habitats, and populations of threatened or endangered species.

Goal 4. Strengthen the economy by sustainable use of forest products, and protection of key forest ecosystem services, such as flood abatement, erosion control, carbon fixation, and ecotourism.

- Use wood from hazardous trees and invasive tree removal efforts;
- Provide opportunities for timber harvest when compatible with habitat protection, water quality protection and public recreational uses;
- Prioritize forest and forest fragment protection to maximize water retention, carbon fixation, and erosion control potential;
- Operate orchards and conservation areas for use as seed banks to provide high quality plant material to increase populations of native species and restore forests around Guam; and
- Work with private sector, non-profit organizations, and village leadership to develop ecotourism opportunities.

The Manell-Geus Watershed

A watershed is the contributing area of land that drains to a given body of water when it rains. The Manell-Geus watershed is located along the southern tip of Guam (**Figure 3**) and contributes runoff to the Cocos Lagoon. The 4,075-acre (6.4-square mile) watershed encompasses the Village of Merizo/Målesso' (*referred to as Merizo throughout this plan*). The population of Merizo has been declining over recent years. As of 2020, the population of the village stood at 1,604 people, as compared to 1,850 people just 10 years prior. It remains to be seen if the population decline trend will reverse in upcoming years.

Annual rainfall amounts range from 80 inches along the coast to 110 inches or more in the uplands (hydroguam.net). The hydrologic network consists of seven named surface rivers/streams, listed here from west to east: Geus River, Manell River, Suyafe River, Sumay River, Liyog River, Asgadao Creek, and Ajayan River (**Figure 4**). In addition, there are unnamed streams identified in the Pigua, Suyafe, Quinene, and Tainatongo areas, as well as areas with direct runoff to the lagoon but no streams. Based on these drainage features and recent LiDAR topography data, the Manell Geus watershed was divided into subwatersheds to better understand both issues and restoration opportunities.

The watershed is mostly vegetated (grassland, 39.7%; forest, 35.9%), particularly in the upper regions, with (4.7%) residential and commercial urban land mainly in the Pigua area, along Geus and Quinene Roads, and along the coastal road (**Table 1**). Over 6% of the watershed is a type of wetland (252 acres), mostly freshwater (palustrine) wetlands associated with streams, particularly in the coastal plain. More than one-third of the watershed is forested and almost 40% is grassland. Barren land accounts for 6% of the watershed, with the largest acreage mapped in the Quinene subwatershed.



Figure 3. Location of the Manell-Geus watershed (in red).

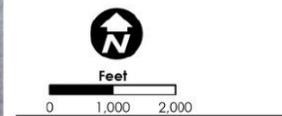


Figure Watersheds and Hydrology.

Figure 4. Manell-Geus Watershed

Table 1. Land Use/Land Cover in the Manell-Geus Watershed

Watershed/ Subwatershed	Land Use/Land Cover, Acres						
	Developed Areas*	Agriculture	Forest	Scrub/Shrub	Grassland	Barren Land	Wetlands**
Geus							
Pigua	51.4	-	42.7	9.6	63.1	3.9	1.5
Geus	47.5	0.3	465.6	84.4	241.4	33.5	57.0
Subtotals	98.9	0.3	508.3	94.0	304.5	37.4	58.5
Manell							
Direct Drainage	9.4	-	51.0	8.0	29.0	9.7	2.5
Quinene	29.0	-	73.2	14.5	38.7	93.6	20.1
Manell	15.7	1.0	333.0	39.1	177.8	5.2	55.2
Suyafe	11.3	-	93.1	13.9	169.2	7.2	39.9
Sumay	4.8	-	39.4	18.2	39.3	51.9	20.9
Direct Drainage	2.8	-	15.5	0.4	13.2	2.6	0.8
Liyog	0.7	-	37.5	13.9	185.1	29.0	11.3
Asgadao	0.9	-	4.9	9.1	40.1	0.8	6.9
Direct Drainage	1.0	-	2.6	0.1	4.6	0.1	0.1
Tainatongo	1.3	-	7.8	3.1	36.4	1.9	0.1
Direct Drainage	2.0	2.4	9.7	2.1	14.5	-	0.9
Ajayan	14.3	15.5	285.8	63.0	563.3	14.6	35.1
Subtotals	93.2	18.9	953.5	185.5	1,311.3	216.7	193.5
Watershed Total	192.1	19.2	1,461.8	279.5	1,615.8	254.1	252.0

*Combination of "Developed, High Intensity and Developed, Open Space" (NOAA CCAP 2016 data)

**Combination of Estuarine and Palustrine Emergent, Scrub/Shrub, and Forested Wetlands and Shoreline (NOAA CCAP 2016 data)

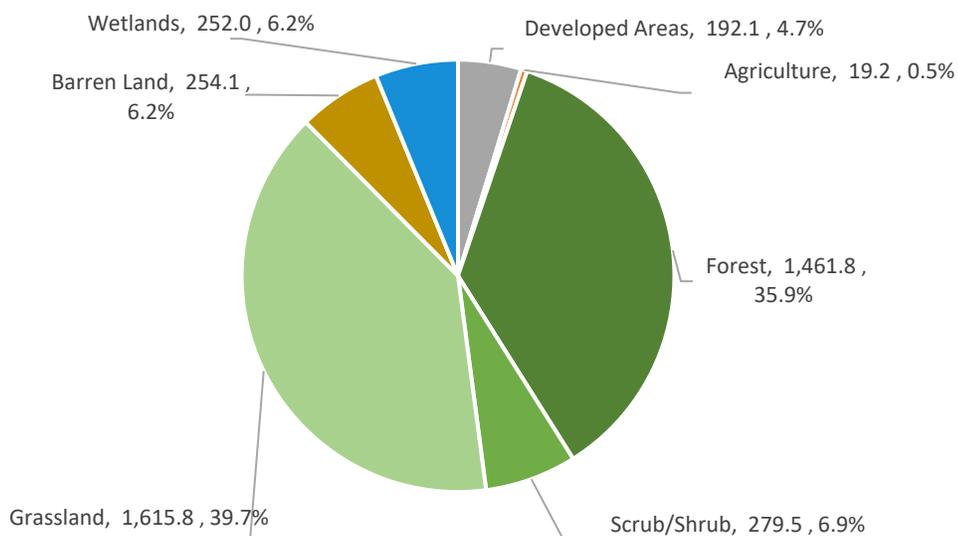


Figure 5. Land Use/Land Cover Distribution in Manell-Geus Watershed (acres, %)

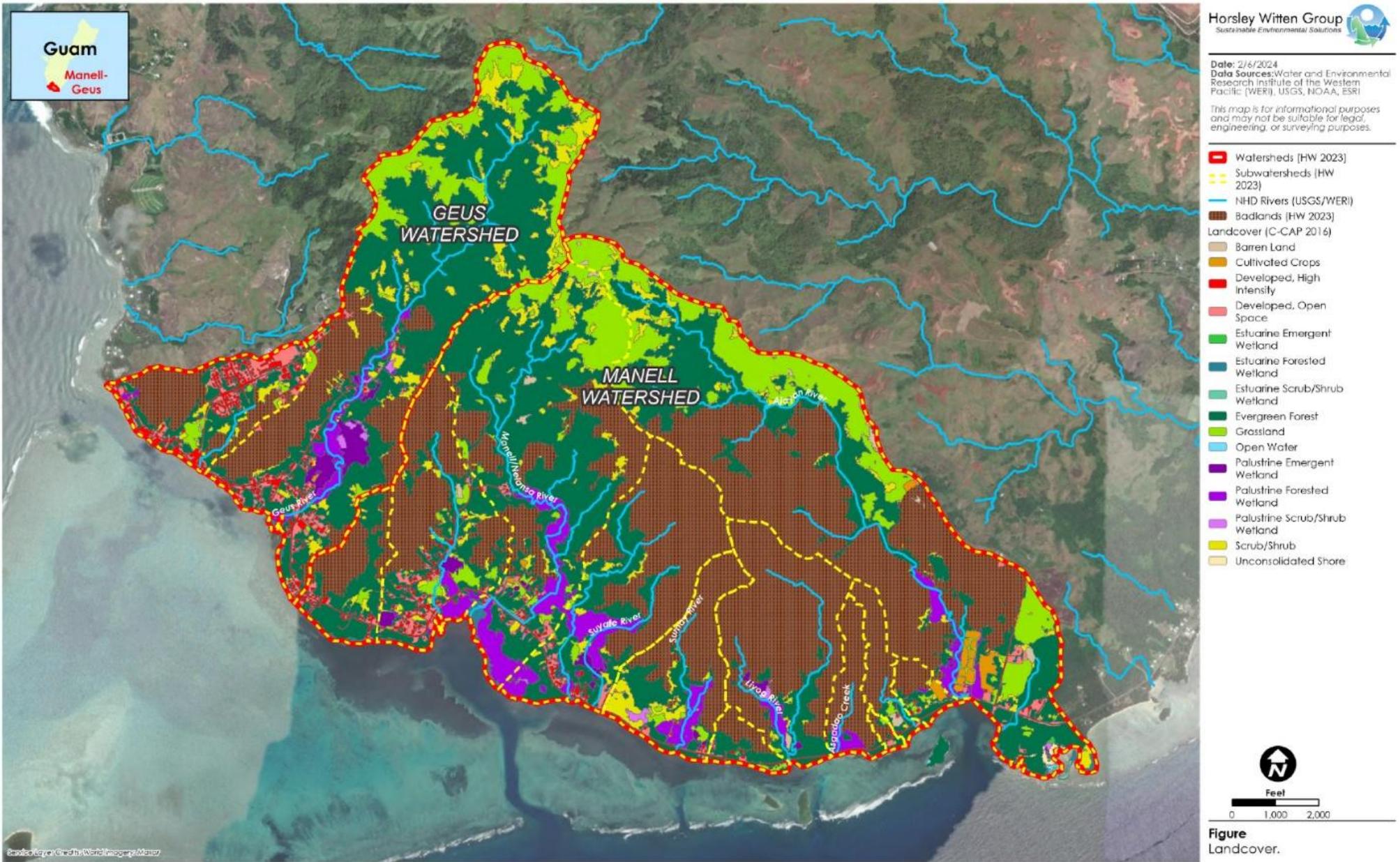


Figure 6. Land Cover

The Manell-Geus watershed has less than 3% impervious cover (98.8 acres), comprised of roads, buildings, and associated driveways (

Almost 40% of the Manell-Geus watershed is considered badland, based on a general evaluation of landcover and wildfire mapping, as well as field observations. Many of the subwatersheds in the Manell watershed, have ~80% of their contributing drainage area susceptible to high levels of erosion and sedimentation.

Table 2). However, the Pigua subwatershed is 15.4% impervious, which is the only area with impervious cover above the threshold of where impacts from development are expected to be seen on the hydrology, water quality, and biological health of small watersheds. Much of the developed areas of the watershed are also located in vulnerable coastal areas subject to flooding and inundation due to predicted sea level rise (**Figure 7 & Figure 8**). Of the total 424 buildings, 303 structures (71%) are currently located within the designated 100-yr flood zone (1% probability of a flood occurring in any given year) as designated by FEMA.

Almost 40% of the Manell-Geus watershed is considered badland, based on a general evaluation of landcover and wildfire mapping, as well as field observations. Many of the subwatersheds in the Manell watershed, have ~80% of their contributing drainage area susceptible to high levels of erosion and sedimentation.

Table 2. Manell-Geus Subwatershed Features

Watershed/ Subwatershed	Stream Miles	Impervious Cover (ac)	% Impervious	% Badlands*	Total Area (ac)
Geus					
Pigua	0.4	26.5	15.4%	34%	172.1
Geus	3.8	25.1	2.7%	15%	929.7
Subtotals	4.2	51.6	4.7%	18%	1,101.8
Manell					
Direct Drainage	0.0	5.9	5.4%	38%	109.7
Quinene	1.1	15.5	5.8%	45%	269.1
Manell	3.8	6.7	1.1%	18%	627.1
Suyafe	2.5	5.4	1.6%	53%	334.5
Sumay	0.9	2.4	1.4%	50%	174.5
Direct Drainage	0.0	1.7	4.9%	41%	35.4
Liyog	1.9	0.6	0.2%	81%	277.5
Asgadao	0.4	0.9	1.4%	79%	62.7
Direct Drainage	0.0	0.5	6.1%	48%	8.5
Tainatongo	0.4	1.0	1.9%	75%	50.7
Direct Drainage	0.0	1.7	5.3%	42%	31.6
Ajayan	4.8	4.9	0.5%	41%	991.5
Subtotals	15.7	47.2	1.6%	43%	2,972.7
Watershed Totals	20.0	98.8	2.4%	37%	4,074.5

* general area digitized by HW based on combination of field and mapping assessment. May include barren, scrub/shrub, and grassland landcovers.

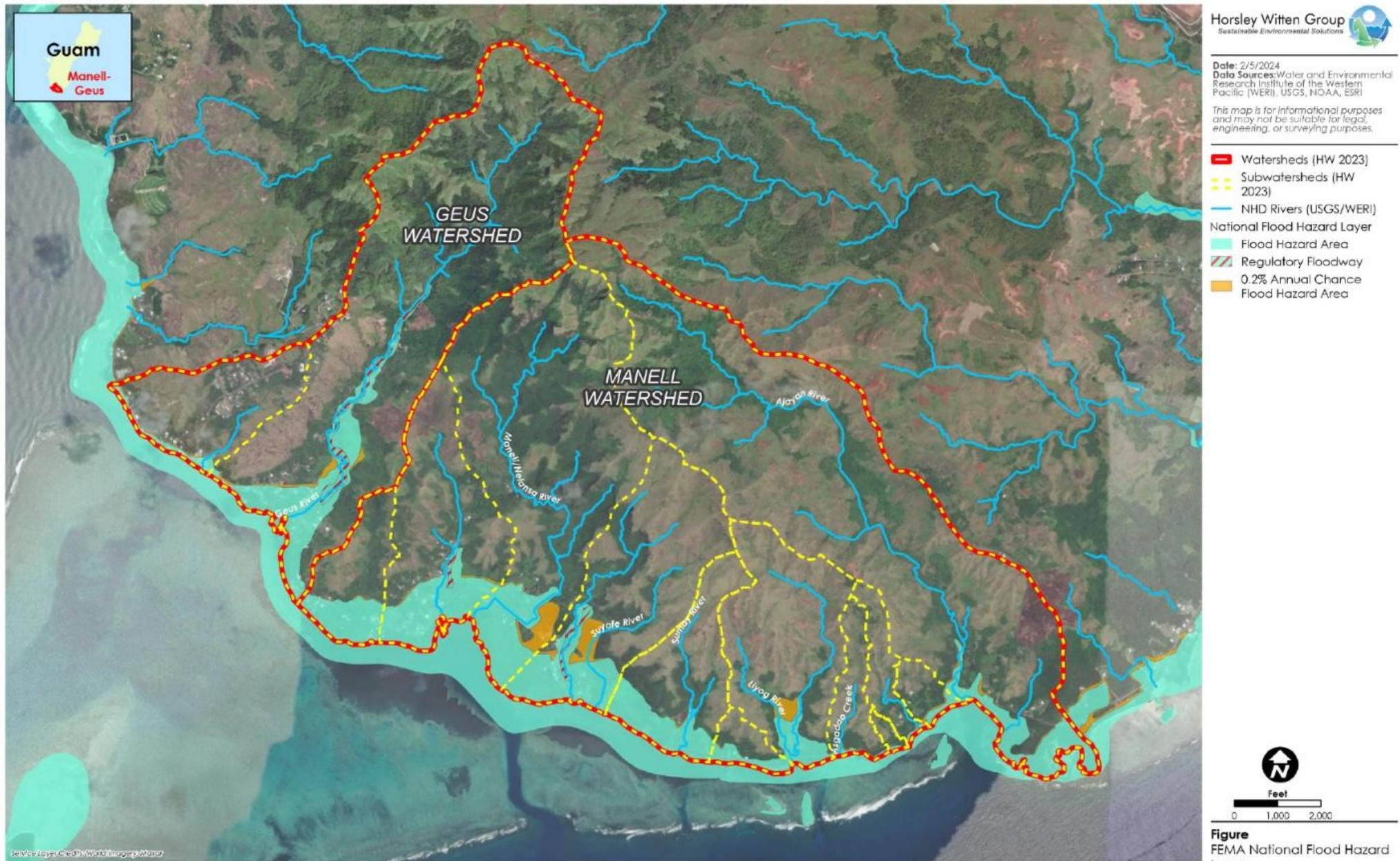


Figure 7. FEMA National Flood Hazard Layer

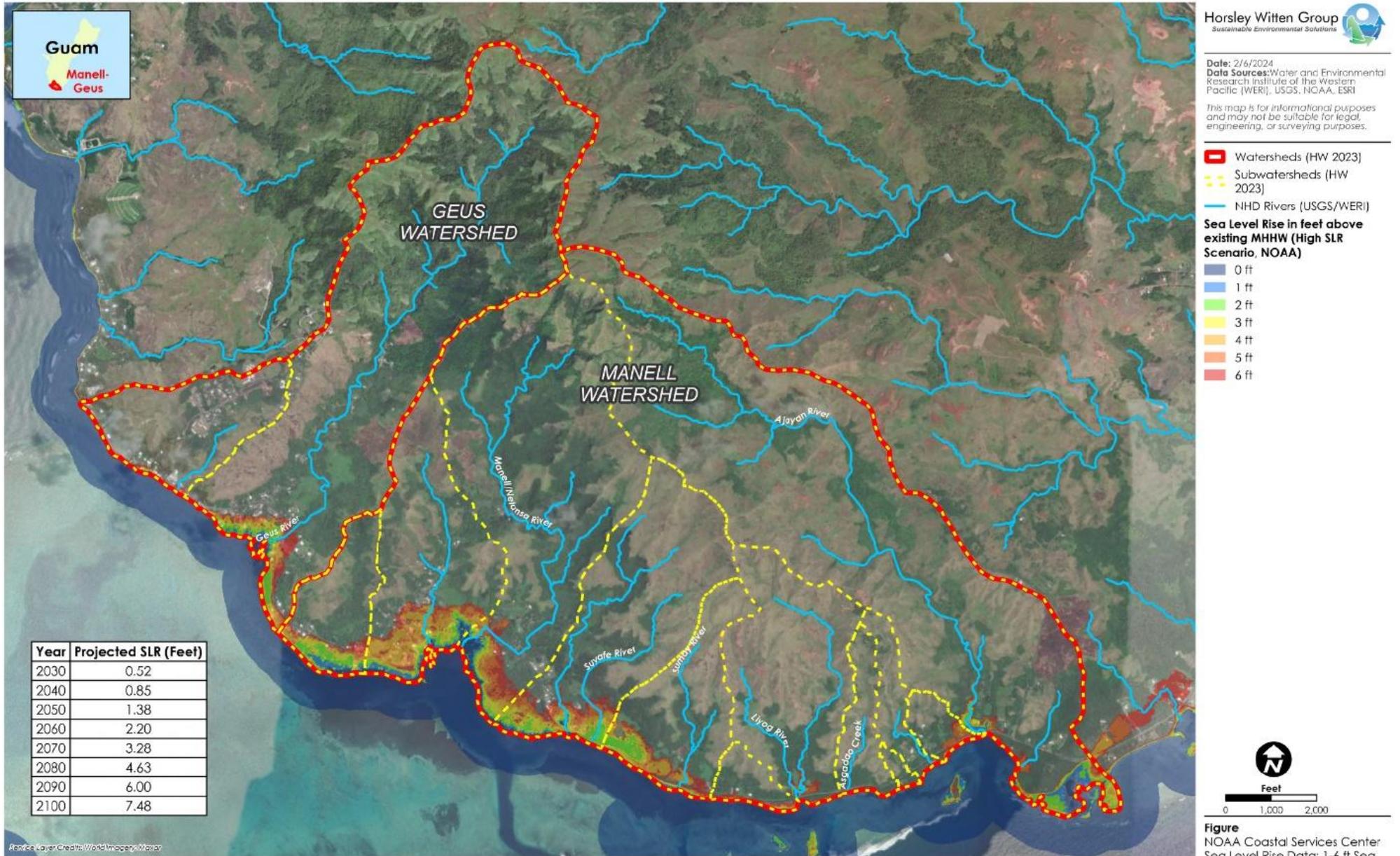


Figure 8. NOAA Coastal Services Center Sea Level Rise Data: 1-6 ft Sea Level Rise Inundation Extent

There are a total of 20 stream miles in the watershed, with just three rivers, Ajayan (~5 miles) Manell (~4 miles), and Geus (~4 miles), comprising more than half of that total. Streams and nearshore waters in Cocos Lagoon are impaired for turbidity, nutrients, dissolved oxygen, and bacteria. Historic sources of pollution in the watershed include stream and badland erosion, septic system failure, sanitary sewer overflows, and unmanaged stormwater runoff. Other water quality issues in Cocos Lagoon include contamination from a former US Coast Guard Station. Between 1944 and 1963, the U.S. Coast Guard operated a LORAN navigation station on Cocos Island. It appears that improper disposal of materials from the station resulted in contamination of soils and surrounding waters. Since 2006, there has been a fish consumption advisory for PCBs for all of Cocos Lagoon. In a 2019 NOAA assessment, results indicated that PCBs and DDT were found in highest quantities near the high-water mark of the former station and that direct uptake of these contaminants from the water column into biota in the nearshore is likely (Pait et al., 2019).

A portion of the watershed is sewered, with just over half of the buildings (217) connected based on mapped sewer connections. The sanitary sewer system takes wastewater to the Umatac-Merizo Wastewater Treatment Plant (UMWWTP), recently upgraded in 2019 to meet an USEPA 2011 court order and managed by Guam Waterworks Authority (GWA). The \$21 million project was a significant improvement in wastewater treatment as the original plant was constructed in 1981 with only primary treatment. The upgraded plant includes an improved aerated lagoon for primary treatment and ultraviolet (UV) disinfection and enhanced nature-based constructed treatment wetlands for secondary treatment. The plant is permitted for average dry weather wastewater flows of 0.4 million gallons per day but can handle up to 1.7 million gallons during the wet season, with all sewage treated and disinfected before it is released, whereas the old plant used to discharge raw sewage to the Toguan River (just to the north of the MG watershed) during rain events.



Evangeline "Vangie" Lujan, WMA, gives a tour of the upgraded Umatac-Merizo Wastewater Treatment Plant, which manages wastewater from over half the buildings in the watershed.

While many parcels within the watershed are privately owned, a large portion of the upland, mountainous area, as well as a few coastal parcels, are publicly owned (**Table 3 & Figure 9**). Of these, some are proposed to be incorporated into the Guam Forest System (**Table 4**). Public lands can be more cost effective for implementation of restoration opportunities than private parcels, removing the need to purchase land.

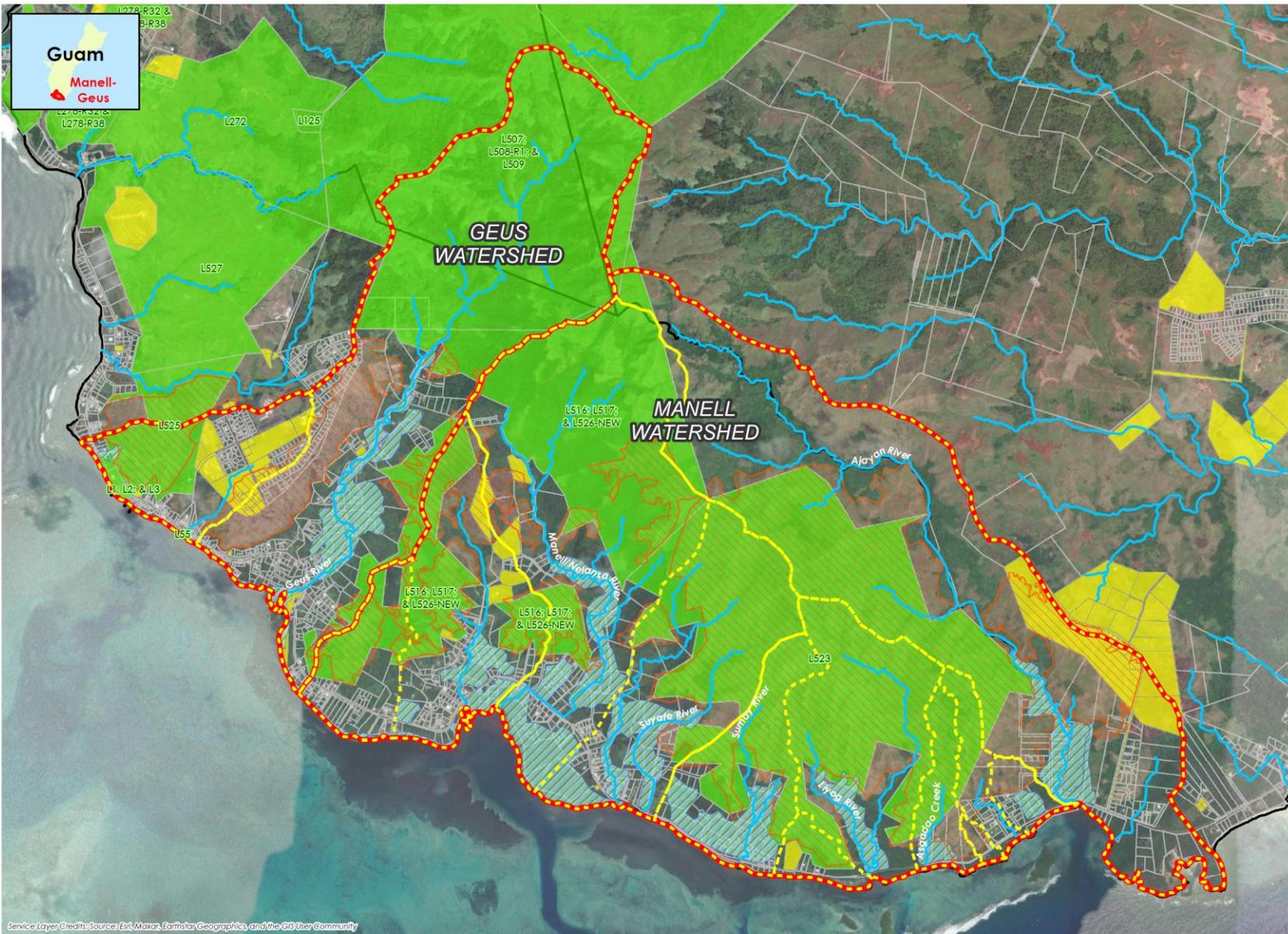
Table 3. Government-owned land by subwatershed

Subwatershed	Government-owned Land (ac)	Total Area (ac)	% Gov't-owned
Geus			
Pigua	97.2	172.1	56.5%
Geus	572.5	929.7	61.6%
Subtotals	669.6	1,101.8	60.8%
Manell			
Direct Drainage	50.2	109.7	45.8%
Quinene	115.1	269.1	42.8%
Manell	380.3	627.1	60.6%
Suyafe	190.5	334.5	56.9%
Sumay	96.1	174.5	55.1%
Direct Drainage	20.9	35.4	59.2%
Liyog	204.6	277.5	73.7%
Asgadao	37.7	62.7	60.1%
Direct Drainage	0	8.5	0%
Tainatongo	25.4	50.7	50.1%
Direct Drainage	0	31.6	0%
Ajayan	316.0	991.5	31.9%
Subtotals	1,436.9	2,972.7	48.3%
Watershed Totals	2,106.5	4,074.5	51.7%

Table 4. Lots Proposed for Inclusion in the Forest System Inventory in Manell-Geus Watershed (Forest System Plan, 2022)

Name	Lot #	Area (acres)	Municipality
Guam Territorial Seashore Park (Bolanos Atate)	507, 508-R1, & 509	2,807.7*	Humåtak
Guam Territorial Seashore Park	1	1.14	Malesso'
Guam Territorial Seashore Park	2	2.75	Malesso'
Guam Territorial Seashore Park	3	1.73	Malesso'
Guam Territorial Seashore Park (As Gadao)	523	828.716	Malesso'
Guam Territorial Seashore Park	525	101.309*	Malesso'
Guam Territorial Seashore Park (Manell-Geus)	526-New, 517, & 516	384.43*	Malesso'
Merizo Tot Lot	55	0.2	Malesso'

*Some of the lot acreage is located outside of the Manell-Geus Watershed



- Subwatersheds (HW 2023)
- Watersheds (HW 2023)
- NHD Rivers (USGS/WERI)
- Badlands (HW 2023)
- Wetlands (C-CAP 2016)
- Government-owned Parcels - proposed for inclusion in the Guam Forestry System
- Other Government-owned Parcels (CLTC2015 Final TaxMap)
- Parcels
- Municipalities

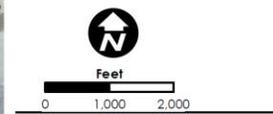


Figure
Government Owned Land.

Figure 9. Government Owned Land

Additional information about the people, local history, ecological characteristics, and past and ongoing studies of the Manell-Geus watershed is available in the Watershed Characterization Report in **Appendix D**.

Report Organization

This plan is organized into sections, starting with watershed goals, followed by recommended actions in six priority focus areas, and leading to the overall implementation strategy. Each watershed goal includes a discussion of why the goal is important and a list of recommended actions and opportunities identified to address that goal. For the focus areas, each highlighted project includes a summary of the existing conditions and 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 plan are several related documents with supplemental information:

Appendix A. Focus Area Concept Designs—includes detailed descriptions of recommended projects in the Focus Areas, as well as conceptual designs for the priority structural projects. These concept designs are intended to be support materials for grant applications and to inspire agencies to incorporate watershed objectives during future capital improvement projects in the Manell-Geus watershed.

Appendix B. Field Summary Memorandum—includes findings from field assessments, notes from various meetings, and infrastructure mapping and condition inventory. 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 C. Pollutant Load Modeling Report—details modeling methods and assumptions used to estimate current pollutant loads and potential load reductions for the Geus and Manell Watersheds based on priority restoration opportunities in the Focus Areas.

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

Incorporating EPA's Nine Elements

A watershed plan can be an effective way to map out and guide actions to improve and protect the quality of water in a particular waterbody. EPA supports the use of watershed plans to guide implementation funding under the Clean Water Act (CWA) and has been a leading proponent of using an integrated watershed approach to improve waters over the past several decades. EPA's nine minimum elements of a watershed plan have become a standard for watershed management to improve water quality and often serve as a prerequisite for federal water quality improvement grant awards.

The Manell-Geus WMP incorporates the nine minimum elements of a watershed plan adapted to protecting near-shore coral reef ecosystems and reducing coastal flooding issues rather than bringing a waterbody into compliance with numeric water quality standards. The summary below provides a general crosswalk of how each element is addressed herein.

Nine Elements of a Watershed Plan (EPA, 2008)

- A. Identify causes and sources of pollution
- B. Estimate pollutant loading into the watershed and the expected load reductions
- C. Describe management measures that will achieve load reductions and targeted critical areas
- D. Estimate amounts of technical and financial assistance and the relevant authorities needed to implement the plan
- E. Develop an information/education component
- F. Develop a project schedule
- G. Describe the interim, measurable milestones
- H. Identify indicators to measure progress

A. Sources

Pollution sources from the watershed are summarized in **Section 2**. More detail on source locations can be found in **Appendix B** Field Findings Memorandum and **Appendix D** Watershed Characterization Report. Key sources include unmanaged wastewater inputs, badland erosion, and to a lesser extent urban development. A TMDL for bacteria was established for the watershed in 2016 based primarily on estimated loads from wastewater overflows, leaking pipes, and treatment plant discharges. This WMP included estimates of existing loads of nitrogen (TN) and sediment (TSS), which are summarized in **Appendix C**. While water quality improvement is a goal of the WMP, other goals include reducing coastal flooding, improving habitat, and engaging the community - **Section 2** also includes causes for these other goals.

B. Load Reduction

One goal of this plan is to reduce the contribution of land-based sources of pollution (LBSP) to nearshore waters. Badland erosion was identified as the major source of sediment and estimated load reductions of up to 47% were modeled for implementation scenarios with aggressive badland restoration. Minor total nitrogen reductions of up to 6% were achieved when hooking

up remaining onsite wastewater systems to the sewer (see **Section 2, Goal #2** and **Appendix C**). Bacteria reduction targets were established and considered “easily achievable” based on upgrades to the WWTP (completed) and improvements to the pipe system (in progress), according to the TMDL report.

C. Management Measures

Watershed-wide and site-specific recommendations to address watershed goals are listed in **Section 2**. More detailed descriptions and concept designs for priority restoration opportunities are described for six focus areas in **Section 3** and **Appendix A**. Additional sketches for other opportunities can be found in **Appendix B**.

D. Implementation Strategy

Implementing the management strategies in this WMP will require varied sources of funding and financing, as well as creative partnerships. **Section 4** provides a list of partners, timing, and estimated planning-level costs for implementing priority actions.

E. WMP Outreach

The development of this plan was guided by a Working Group that represented many of the key stakeholders, including federal and local agencies involved in water quality protection, ecosystem conservation, and LBSP management. During the course of this planning effort, we met with local and federal agencies, community leaders, and residents virtually and in the field. We also participated in the quarterly Watershed Planning Committee meetings to provide progress updates and solicit guidance on management priorities. Outreach materials and relevant documents were posted to a project website. TNC’s community liaison met with local residents and the Merizo mayor’s office multiple times during the project. **Section 4** includes a recommended plan for getting the word out about the plan and implementation progress.

F. Schedule

The Implementation Strategy in **Section 4** includes a timeframe for implementing management actions in the near-term (1-2 years), medium-term (3-4 years), and long-term (>5 years). This schedule will be updated when the plan is reassessed in 2030.

G. Milestones

In addition, **Section 4** identifies milestones/tracking measures that can be used to periodically assess and evaluate progress toward each recommended management action’s implementation.

H & I. Indicators & Monitoring

Current and proposed monitoring approaches described in **Section 4** will be used to evaluate the achievement of flood reduction, water quality, habitat restoration, and engagement goals over time, as well as tracking of WMP implementation progress.



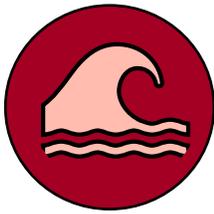
Mouth of the Ajayan River

2 WATERSHED GOALS & RESTORATION ACTIONS

The following watershed management goals were established with stakeholders and the community to help improve the health of the watershed, Village, and lagoon over the next 5 years.

- Goal 1 – Minimize flooding now and in the future
- Goal 2 – Reduce watershed-based pollutant loads to nearshore waters
- Goal 3 – Restore habitat and improve biodiversity
- Goal 4 - Support community engagement

The rationale supporting why these management goals and the actions recommended to address them are described below.



Goal 1 – Minimize Flooding Now and in the Future

Many residents' homes and lives are threatened by flooding, even when they are not in a designated floodplain. Priority actions include river realignment, wetland and floodplain restoration and protection, restoring natural hydrology and flow paths, drainage infrastructure improvements, and hazard planning.

Problem

Household survey results from 2016 indicate that more than half of Merizo residents are affected by flooding during heavy rain events or storms, which respondents indicated impact the local economy and travel in and out of the village. In a focus group that was included as part of this study regarding flooding concerns, participants discussed how they prepare households in anticipation of flooding, such as moving household items to higher ground, using sandbags, and clearing their property from debris prior to the start of rainy season. Infrastructure changes to village roads, such as concrete culverts to channel water, and urban development were also identified by participants as both potential problems and solutions (NMFS PIRO, in prep).

Residents in this watershed have significant flood hazard exposure across due to both precipitation-driven and coastal flooding. As described above, **Figure 7** shows the 100-year flood extents, or the extents of flooding that have a 1% chance of occurring in any given year. 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 303 buildings are currently located inside the 100-year flood zone, which is equivalent to over 70% of all existing buildings in the watershed.

The impacts from severe storm-related flooding will be further exacerbated by rising sea levels in Guam (). Low-lying infrastructure and buildings near Achang Bay and the mouth of Suyafe River are the most vulnerable to inundation from SLR predicted in the coming decades as shown in the zoomed in **Figure 10 & Figure 11**. Merizo already experiences tidal flooding regularly (Grecni et al., 2020). In a 2019 GIS spatial analysis of anticipated infrastructure impacts under different sea level rise scenarios, the southern region of Guam was anticipated to experience the greatest impacts to infrastructure overall.

Factors Contributing to Flooding in MG Watershed:

- Changes in natural hydrology such as impacts to wetlands and floodplains
- Undersized drainage infrastructure
- Changes in landcover due to development or badlands
- Erosion clogging streams and drainage infrastructure
- Invasive species impacting riverbanks and creating downstream dams
- Eroding shoreline along low-lying vulnerable roads
- Climate change – sea level rise and more rain more frequently will further exacerbate flooding
- Chronic wildfire's effects on foliage and soil

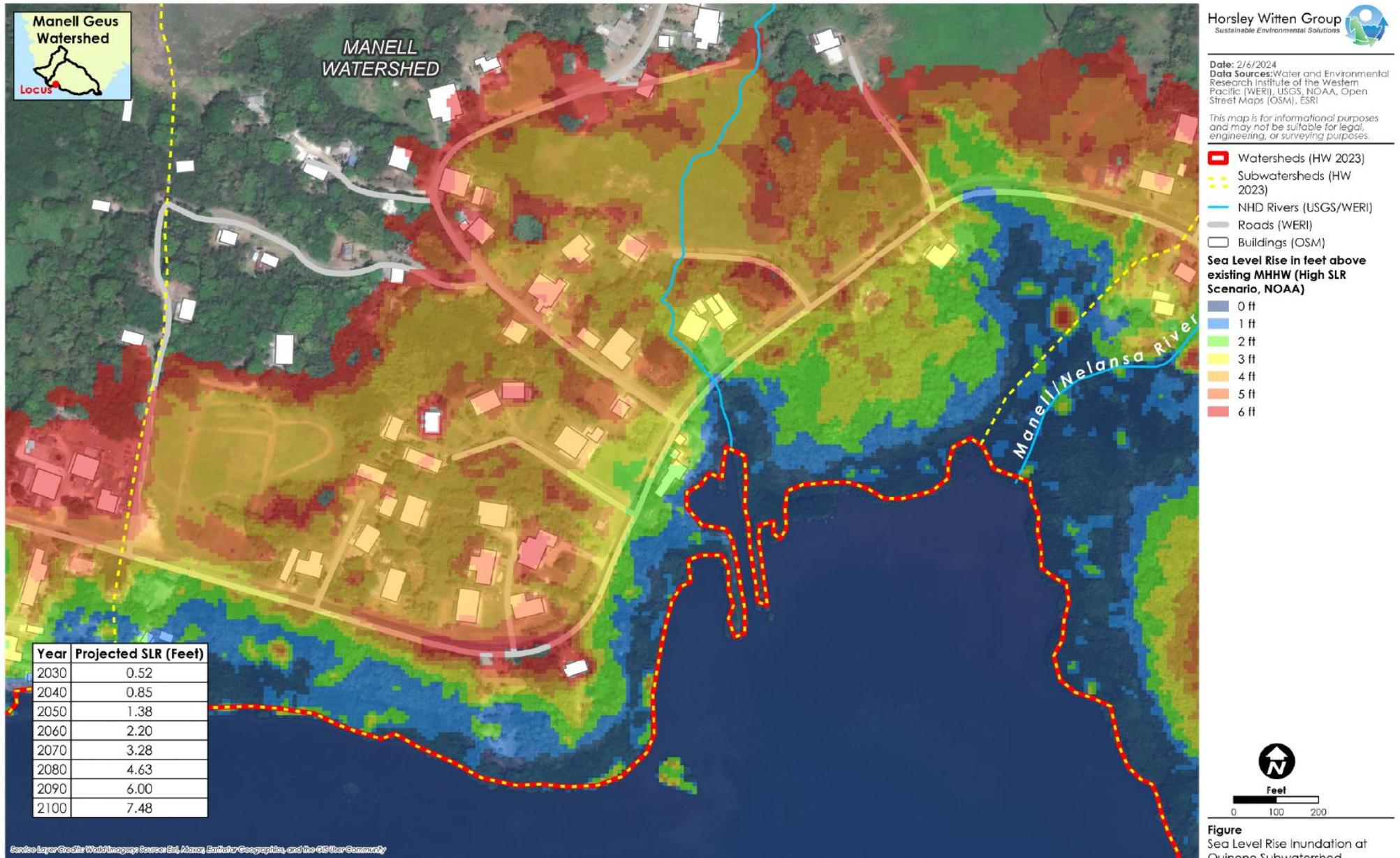


Figure 10. Projected Sea Level Rise Inundation at Achang Bay.

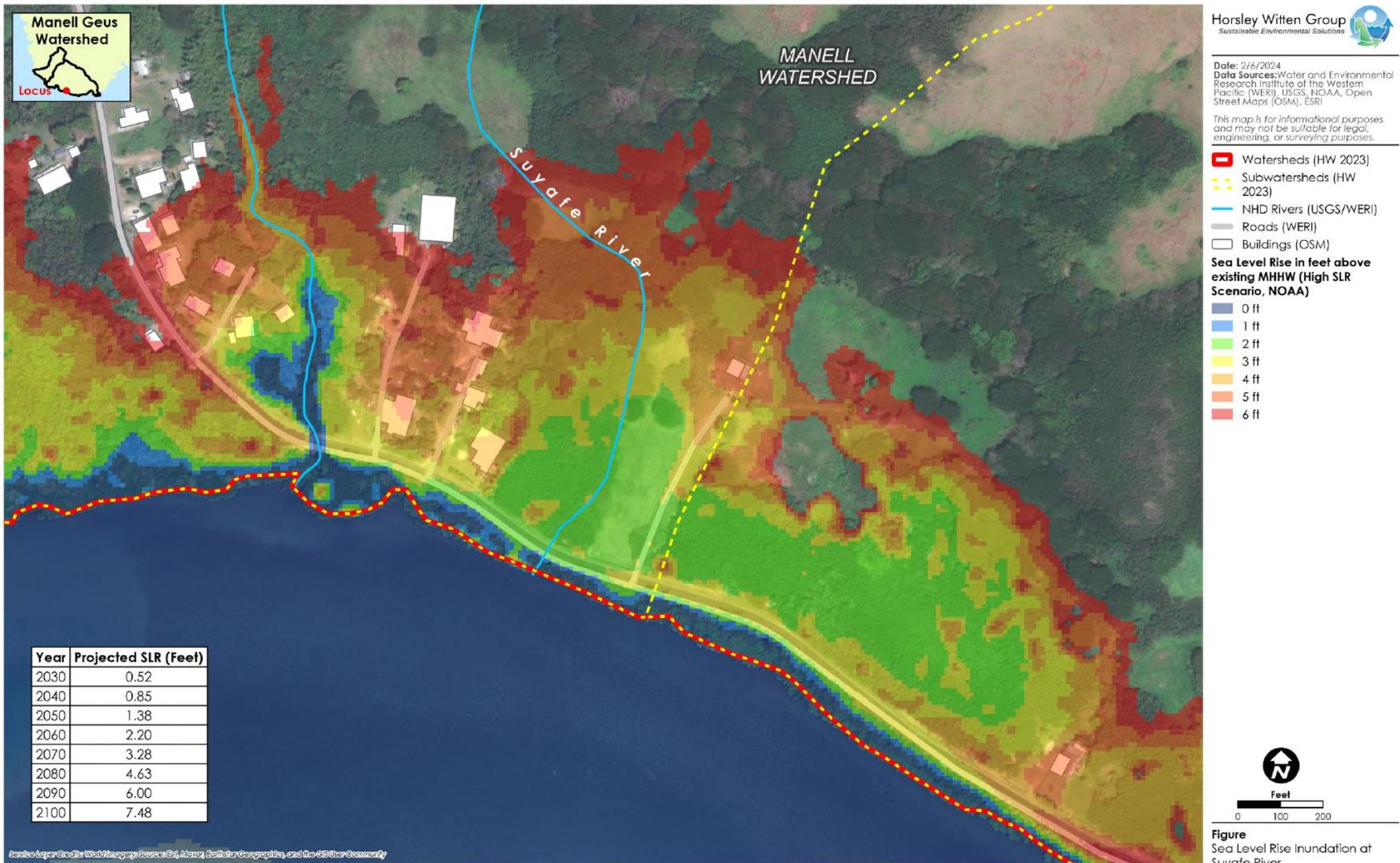


Figure 11. Projected Sea Level Rise Inundation at Suyafe River

With a three-foot rise in sea level, 73% of infrastructure (including electricity, wastewater, roads, bridges, and buildings) in the southern villages of Guam are expected to experience major impacts. In Merizo, under a three-ft sea-level rise scenario, it was projected that 100% of sewage pump infrastructure, 27% of bridges, and 20% of buildings would be affected (King et al., 2020).

A 2021 U.S. Army Corps of Engineers model estimated areas with populations at risk (PAR) due to flooding from sea level rise for Guam and identified Merizo as the village with second highest PAR in Guam. The assessment also indicated that Merizo would be likely to experience the most damages in Guam due to sea level rise (**Figure 12**) (ACOE, 2022).

Place	Damage Existing	Damage Future ¹	Increased Damage in Future
Agat	\$2,184,163	\$7,986,350	266%
Asan	\$16,408	\$49,158	200%
Chalan Pago-Ordot	\$256,097	\$703,748	175%
Hagåtña	\$0	\$80,038	New Risk ²
Inarajan	\$941,167	\$3,033,755	222%
Merizo	\$4,510,906	\$12,210,745	171%
Piti	\$95,967	\$788,929	722%
Tamuning	\$55,696	\$373,560	571%
Umatac	\$260,262	\$800,076	207%
Yona	\$75,031	\$198,151	164%
Total	\$8,395,697	\$26,224,511	212%

¹Estimates are rough order of magnitude and should not be used beyond screening level.

²Risk only appears in future model, not existing.

Figure 12. Existing and Future Damages from Sea Level Rise (U.S. Army Corps of Engineers, 2022)

Similarly, a 2021 National Fish and Wildlife Foundation assessment of Community Exposure Index using the Coastal Resilience and Evaluation Siting Tool identified areas where community assets are potentially exposed to flood-related threats identified several locations in the Manell-Geus watershed. The low elevation of Merizo’s coastline coupled with the siting of major roads and highways along these flood prone areas leads to higher exposure potential. The Threat Index tool similarly identified several areas within the watershed with storm surge scenarios and landscape characteristics that would exacerbate flood potential (Dobson et al., 2021).

Management Opportunities

Through observations in the field and discussions with residents and community members, the field team identified areas where roads and residential properties are currently flooding and will likely be subject to increased flooding in the future. Restoration actions identified to address this goal are included below.

Action 1.1 – Support the ACOE Manell River Project

The area with the worst flooding in the watershed is along Route 4 at the Manell River. ACOE is developing a concept for mitigating these flood impacts by realigning the river, reforestation,

and adding in more flood storage. This project is extremely important for the residents of this area, as well as downstream resources and habitat. Agency input during the next phase of design will be vital to stress the importance of implementing nature-based and resilient design components as described in Focus Area 1 – Manell River in **Chapter 3** and **Appendix A**.

Action 1.2 – Provide Maintenance Equipment

Until Action 1.1 is constructed, on-call equipment should be provided to (and stored in) the Village to help residents to proactively manage blockages before and after storm events at critical locations (e.g., removal of debris at the Manell River culverts along Route 4) during the wet season so they do not need to wait for DPW crews to come down south after storms. A village operator must be trained in equipment operations and standard maintenance.

Action 1.3 – Improve Wetlands and Floodplain Regulations and Zoning

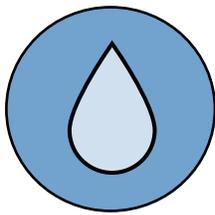
Wetlands and floodplains are vital for managing floodwaters. Unfortunately, there has been encroachment, un-permitted placement of fill, clearing and grading, and development in these areas. Spot zoning for commercial buildings or other urban uses commercial could threaten remaining wetlands in the future. Conservation zoning and land development regulations are needed to protect the natural flood storage benefits of wetlands. Protections should include setbacks from wetlands, streams and should also consider floodplains and flow paths beyond that of the mapped/perennial stream network. Consider establishing rules to purchase development rights and/or establish easements. The Guãhan 2050 Sustainability Plan currently underway offers an ideal opportunity to address this action, and the BSP and the Watershed Planning Committee could be a vehicle for proposing zoning protections.

Action 1.4 – Restore Wetlands and Floodplain Areas

There are a few locations in the watershed where encroachment/modifications to wetlands and floodplains were observed, such that they are no longer able to provide their natural services such as flood mitigation, pollutant reductions, and habitat (see Focus Areas 1 Manell River and 6 Ajayan River). These areas should be restored to their natural conditions to the extent possible.

Action 1.5 – Repair and Install Drainage Infrastructure

DPW produced a list of priority drainage infrastructure projects several years ago, which will benefit the watersheds if implemented. In addition, we observed and collected data on existing drainage infrastructure while on-site. Of the structures mapped, 53% need repair or replacement and 28% need routine maintenance. Existing drainage infrastructure, such as culverts, swales, and pipes range in condition and efficacy for the function they are intended to provide (see **Appendix B**). Unmaintained infrastructure can cause localized flooding. In addition, there are several locations in Focus Area 2- Quinene Rd. and Focus Area 3- Geus River/Rd. where natural flow paths have been disrupted by roads. DPW should reconnect these flow paths to their downstream waterways to prevent flooding in surrounding neighborhoods (see **Appendix A**).



Goal 2 – Reduce Watershed-based Pollutant Loads to Nearshore Waters

Streams and coastal waters are impaired for turbidity, bacteria, and nutrients. Focus on badland restoration and wildfire prevention, wastewater system and non-service area upgrades, green stormwater infrastructure for managing urban runoff, and feral pig best management practices.

Problem

Three rivers in the watershed are listed as impaired waters (2020 Guam EPA 303(d) list). Ajayan, As Liyog, and Sumay Rivers are impaired for dissolved oxygen, orthophosphates, and suspended solids. The Sumay River is also impaired for nitrates. The mountainous regions of the Manell-Geus watersheds where vegetation is sparse or lacking entirely (i.e., badlands) are hotspots for erosion, which is a leading cause of sedimentation issues further downstream. These badlands can be initiated and/or exacerbated by wildfires that are primarily anthropocentric in nature. Fire responders are greatly understaffed and require additional support for equipment and supplies to fight wildland fires on the island.

In addition, the Merizo Pier – Mamaon Channel (Waterbody ID S-08) was included in a bacteria TMDL along with 24 other Guam beaches due to exceedances of Guam’s Water Quality Standards for enterococci bacteria (Guam EPA, 2013). The TMDL determined that Merizo-Umatac treatment plant discharges, sewer line breaks/overflows, and/or faulty septic systems in Merizo were likely causes of the high bacteria levels, and target reductions for different flow regimes were set accordingly.

A 2017 study by the University of Guam found Enterococcus concentrations higher than the EPA limits at every upstream site in the tested rivers, which included Ajayan, Liyog, Sumay, Laolao (Suyafe), Manell, and Geus. A 2022 Ridge-to Reef Assessment showed that Manell and Sumay Rivers had high dissolved inorganic nitrogen levels, but only Manell’s levels had a corresponding relationship to rainfall, suggesting levels driven by non-point sources vs. point sources. The high concentration of nutrients, sediment, and bacteria in the outflow of the streams in the watershed has a negative impact on the health of the coral reef. Based on a 2019 NOAA study of turbidity, suspended sediments, and nutrients in the Ajayan, As Liyog, and Sumay Rivers, there was some evidence of decreasing concentrations, which could be an indication of benefits from

Factors Contributing to MG Watershed Pollutant Loading

- Badland erosion, exacerbated by wildland fires and offroading
- Failing/undersized sanitary sewer infrastructure
- Failing/undersized septic systems and/or cesspools
- Unmitigated urban development, including “hotspots”
- Eroding unpaved surfaces
- Eroding streambanks
- Feral pigs

badland restoration activities over the past few years. **Figure 14** shows the major sources of impairment to the waterbodies in the watershed.

Current Restoration Initiatives

Efforts to achieve the bacteria load reduction targets established under the bacteria TMDL for the Merizo Pier – Mamaon Channel are underway. The GWA has upgraded the Umatac-Merizo Sewer Treatment Plant and has identified within its capital construction plan the needed upgrades to the piping system needed to reduce sewage overflows near the pier during wet weather. Additional planning for connecting additional properties to the network has also been completed. Construction of these remaining projects should occur in the next few years and are anticipated to easily result in TMDL compliance. In February 2024, Guam EPA began a targeted water quality monitoring program for the Achang, Ajayan, Manell, Liyog, and Sumay Rivers.

The DOAG-FSRD, supported by partners from BSP-CZM and NOAA, has implemented two, ongoing badland restoration projects within the Manell watershed at Quinene and As Gadao over the past 10 years to: 1) reduce erosion and sedimentation to protect reefs and other marine resources; 2) restore tree cover to hillsides to shade out fire-prone grasses and to promote soil health for native tree restoration; 3) plant non-grass species that hold more water on the hillsides and help reduce flooding incidents in the village; and 4) restore native ravine forest habitat.



Christine Fejeran, Forestry Division Chief of the Guam Department of Agriculture FSRD, giving the field team a tour of the Quinene reforestation site in the Manell Watershed.

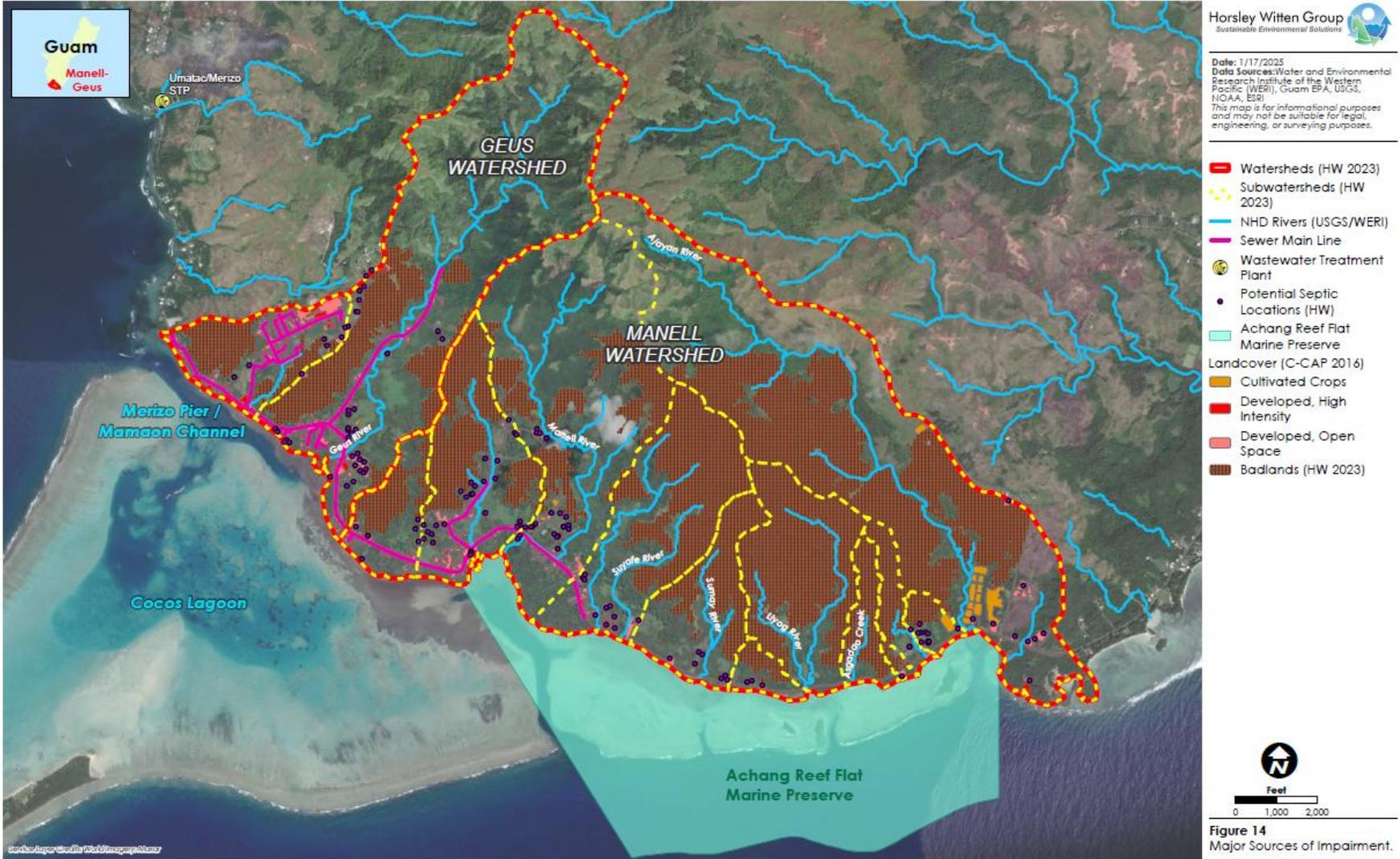


Figure 14. Major Sources of Impairment

Sites targeted for revegetation were selected based on the location of existing green spaces and firebreaks/fuel breaks to protect the plantings. The first trees planted to convert the predominant cover of invasive fire-prone grasses are acacia trees (*Acacia auriculiformis*), which are native to Australia, fire-resistant (creating a natural shaded fuel break/green belt), and are nitrogen fixers (provides soil amendments). Native species are then planted underneath the acacias and within the interior of the forest stand where grasses are shaded out. The native tree species planted include Pandanus (*Pandanus tectorius*), Nanåsu (*Scaevola sericea*), Pago (*Hibiscus tiliaceus*), Åbas duendes (*Glochidiion marianum*), Anasser (*Geniostoma micranthum*), Da'ok (*Callophylum inophyllum*), Lampauye (*Dodonea viscosa*), and Ladda'/noni (*Morinda citrifolia*), which are grown at the FSRD nursery. Once the native species grow larger, the Acacias are selectively pruned/removed as needed to facilitate transition to more native forest stands. The thinning and removal process is strategically timed to avoid opening too much area and reintroducing grasses that will outcompete the slower growing natives.

FSRD has developed good relationships with families in each area, which facilitates access through private property to the public forest lands. However, both forest project sites have been damaged by wildfires in recent years caused by arson and poaching activities and escaped backyard burning. FSRD is the primary responder for wildland fires in the remote sites where the reforestation projects take place across the island, but they are also supported near populated areas by the Guam Fire Department who focuses defensive efforts on protecting life and property within the urban setting. The FSRD coordinates USDA-FS fire operations and investigation trainings for FSRD personnel, the Guam Fire Department, and DoD fire partners.

Management Opportunities

Potential site-specific and village-wide opportunities to reduce LBSP were identified. Projects range from badland restoration, to installing green stormwater infrastructure to clean runoff, to improved wastewater management. Restoration actions identified to address this goal are included below.

Action 2.1 – Restore Badlands

The Forestry Division should continue progress with the planning, implementation, maintenance, and performance monitoring of the two existing revegetation projects in As Gadao (the worst sections are in Focus Area 6 Ajayan) and in Quinene (Focus Area 2). Also, additional staff and resources would help expand this work into other key locations in the watershed, particularly for Focus Area 3 – Geus River/Road.

Action 2.2 – Increase Wildfire Enforcement Capabilities

Authorities should initiate additional enforcement capabilities and fines related to wildfires that are intentionally set and unauthorized. Increased enforcement will help discourage people from setting these fires and threatening the health of residents, fire fighters, and the watershed. Continue preventative measures, like installing firebreaks.

Action 2.3 – Fund the “Munga Masongge Guahan: Don’t Burn Guam!” Outreach Campaign

This outreach campaign needs funding to be fully implemented. This campaign was a collaborative effort between the DOAG FSRD and BSP Guam Coastal Management Program. This campaign must be designed with robust community involvement to be sustainable.

Action 2.4 – Implement On-site Stormwater Management Opportunities

There are numerous locations within the Manell-Geus watershed where on-site stormwater management practices could be implemented in public spaces to provide water quality treatment. Nature-based designs, or green stormwater infrastructure (GSI), such as bioretention basins, vegetated swales, rain gardens, and constructed wetlands, can be resilient solutions to water quality issues caused by urban development. Paved or impervious surfaces collect sediment, nutrients, bacteria, oils, and other pollutants. When it rains, these pollutants are often just washed into the nearest storm drain, stream, wetland, or coastal waters without treatment. GSI designed for the water quality volume as defined in the CNMI/Guam Stormwater Management Manual (2006) can reduce this pollutant loading. Stormwater management opportunities were mostly identified in the more developed Geus Watershed (Focus Area 4 – Pigua Public Places & Focus Area 5 – Merizo Pier Park), with a few along Route 4 (Focus Area 3 – Geus River/Road) and at a public boat ramp in the Manell Watershed (Focus Area 2 – Quinene).

Action 2.5 – Complete Sewer Upgrades (MP-WW-Pipe-24)

There is an active GWA project to replace existing gravity piping with larger diameter pipes. Modeling identified that 98% of the target pipe does not currently have sufficient capacity for existing peak wet weather flows, and the remainder does not have capacity for future flows (Brown and Caldwell, 2018). This project is identified as a priority project in Focus Area 5 – Merizo Pier Park. The cost estimate is \$2.73 million (in 2017 dollars), and construction is scheduled for 2025. This project is expected to reduce the number of sanitary sewer overflows in the heart of Merizo and address the bacteria TMDL for Merizo Pier–Mamaon Channel.

Action 2.6 – Connect Remaining Onsite Septic/Cesspools to Sewer (MP-WW-Pipe-27)

GWA proposed an on-site disposal system reduction strategy to connect unsewered properties (starting with those located within 200 feet of a sewer main and within wellhead protection zones) and prohibit the construction of new, conventional onsite systems. A 20-year plan was developed to connect remaining properties with septic/cesspools in conjunction with construction of new sewer lines at the rate of 5,000 ft per year (Brown and Caldwell, 2018).

Estimates from GIS indicate 3.2 miles of additional sewer line are needed (0.2 miles in the Geus watershed; 3 miles in Manell). At this rate, this project will take 3.4 years and be roughly \$16.9 million (\$1,000 per LF, in 2017 dollars). GWA's current priority systems for this effort are those located over the Northern Guam Lens Aquifer (NGLA). For this action, GWA should review the on-site disposal system reduction strategy to ensure that connections in Focus Area 5 – Merizo Pier Park are also prioritized to address the bacteria TMDL.

Action 2.7 – Address Pollution Hotspots

At least one pollution hotspot was observed—where stormwater flows through the Shell gas station located west of Nicholas Reyes Street on Route 4. Stormwater runoff should be managed in this location to prevent pollutant loading from the higher concentration of hydrocarbons and oil present at the gas station property.

Action 2.8 – Stabilize Unpaved Roads

There are a few locations in the watershed where unpaved roads and parking areas are contributing sediment to downstream locations during rain events. These eroding surfaces should be stabilized with pervious pavers or other type of paving. This will also make these surfaces easier for residents to use and will require less maintenance. See Focus Area 4 – Pigua Public Places & Focus Area 5 – Merizo Pier Park for priority locations for this action.

Action 2.9 – Stabilize Eroding Streambanks

Areas with severe streambank erosion should be stabilized to reduce sediment loading. While a detailed stream assessment was not completed, known areas on the Geus, Quinene (unnamed stream), Manell, and Ajayan Rivers. Bank erosion appears to coincide with high density bamboo stands. A streambank project was completed in Piti (central west coast) could serve as a model for techniques, such as gabions covered with soil and vegetated with live stakes.

Action 2.10 – Eradicate Feral Pigs

Develop a feral pig eradication program for this watershed (i.e., hunting, birth control, or other techniques). Swine foraging, rooting, and wallowing damages landscaping, crops, recreational fields, etc. and could impact restoration sites. Runoff from areas impacted by pigs may carry pollutants and disease into the marine waters of Merizo.

Action 2.11 – Enhance GEPA's Water Quality Monitoring Program

Guam EPA began a more targeted water quality program in 2024 in Achang, Manell, Liyog, and Sumay. Consider measuring turbidity (or other parameter) in streams below badland restoration areas, at structures close to the restoration as possible in Asgadoo Creek or in the unnamed stream in Quinene. In-stream monitoring to quantify the impact of landscape-scale revegetation efforts can be challenging for many reasons, and input from researchers in the Ugum watershed on Guam or the Talakhaya watershed on Rota, CNMI should be solicited.



Goal 3 – Restore Habitat and Improve Biodiversity

Endemic/native species can return with improved habitat. Key projects include the restoration of badlands and wetlands, feral pig best management practices, invasive bamboo removal, shoreline stabilization/mangrove restoration, and a dam removal study.

Problem

Biodiversity in the watershed’s forests, wetlands, and coastal areas is threatened by habitat degradation. Arson wildfires have burned native forests, making way for savanna grasses. These grasses are even more flammable, leading to more extensive fires. Soil nutrients are lost over time, creating areas of bare soil called badlands with very little habitat value not to mention the erosivity described above under Goal 2. In addition, development has encroached into sensitive areas and has caused impacts to downstream streams and wetlands. Invasive plants species have taken over from native particularly along streambanks, and feral pigs and deer herbivory threatens ravine forest habitats. Historical natural seed dispersal from birds has been impacted by population reductions from the brown tree snake. The coconut rhinoceros beetle is another threat to forest health. This habitat loss impacts important plant and animal species. **Table 5** includes a list of Endangered Species Act (ESA) listed species potentially present in the watershed and their relevant habitat preferences. Improving habitat for these species, in addition to other more common but vital plants and animals, is the focus of this goal.

Factors Contributing to Habitat Degradation in the MG Watershed:

- Arson Wildfire
- Deforestation
- Invasive species
- Pig and deer herbivory
- Urban development/wetland encroachment
- Eroding banks and shoreline

Table 5. Terrestrial ESA-listed species potentially present in the watershed (NFWF 2022, ACOE 2022)

Species Type	Species Name	ESA Status	Habitat Preferences (relevant to watershed)
Bat	Mariana Fruit Bat <i>Pteropus mariannus mariannus</i>	Threatened	Ravine forests
Bird	Guam Rail <i>Rallus owstoni</i>	Endangered	Ravine forests/savanna
	Guam Kingfisher <i>Todiramphus cinnamominus</i>	Endangered	Ravine forests
	Mariana Common Moorhen <i>Gallinula chloropus guami</i>	Endangered	Near freshwater
Reptile	Slevin's Skink <i>Emoia slevini</i>	Endangered	Ravine forests
Invertebrate	Fragile Tree Snail <i>Samoana fragilis</i>	Endangered	Ravine forests
	Guam Tree Snail <i>Partula radiolata</i>	Endangered	Ravine forests
	Humped Tree Snail <i>Partula gibba</i>	Endangered	Ravine forests

Species Type	Species Name	ESA Status	Habitat Preferences (relevant to watershed)
Plant	<i>Phyllanthus saffordii</i>	Endangered	Savanna
	Pao Dedu, Paodedo, Paodedo <i>Hedyotis megalantha</i>	Endangered	Savanna
	Siboyas halumtanu <i>Bulbophyllum guamense</i>	Threatened	Ravine forests
	<i>Dendrobium guamense</i>	Endangered	Ravine forests
	<i>Tinospora homosepala</i>	Endangered	Forest Edge
	<i>Nervilia jacksoniae</i>	Threatened	Ravine forests
	<i>Tabernaemontana rotensis</i>	Threatened	Ravine forests
	<i>Tuberolabium guamense</i>	Threatened	Ravine forests
	Fadang <i>Cycas micronesica</i>	Threatened	Ravine forests/savanna

Existing Mangroves on the Manell-Geus Coast

Mangrove forests are important habitats in the watershed. Based on satellite imagery studies of land cover, Guam has been reported to contain ~182 acres of mangrove swamp forested wetland. Guam’s second largest stand of extant mangrove forest (~ 25 acres) is found along the southern coastline in the Manell-Geus Habitat Focus Area (HFA), which encompasses the Manell and Geus watersheds, Cocos Lagoon, and Achang Reef Flat Marine Preserve. The existing stand of mangrove forest lines the coast from the Achang Marine Preserve to the village of Merizo.

The most common species of mangrove trees recently observed along the southern coastline of the Manell-Geus watersheds include *Rhizophora apiculata*, *Avicennia marina*, and *Brugueria gymnorhiza*, with *R. apiculata* being the most abundant of the three. *Rhizophora mucronate* and *Xylocarpus moluccensi* have also been observed locally (per. communication Cara Lin). A historic map from 1944 indicates that mangrove forest existed in locations of the Manell-Geus coastline where they are no longer present, specifically in the eastern portion Achang Reef Flat Marine Preserve. Globally, impacts and losses to mangrove forests have been caused by development in the form of conversion to agricultural and aquacultural uses, resulting in a 35% loss of mangrove areas since the mid to late 1900s; however, declines in Guam are more likely the result of military-related development and removals by private landowners. Given the lack of military-related developments along the southern coast of Guam, historic impacts/losses within the Manell-Geus watersheds are more probably attributable to private landowner removals and/or other environmental stressors (e.g., storms, disease, invasive species, sea level rise, erosion, sedimentation, climate change, pollution, and unsustainable harvesting). Two documented cases of mangrove cutting in Achang have been reported.

Currently, there are two known locations along the coast of the Manell-Geus watersheds where mangrove restoration has been initiated. The primary restoration site is located adjacent to the Ajayan river, where the property owners (Guam Preservation Trust) have agreed to allow the

Guam Department of Agriculture to oversee restoration planting. Mangrove propagules were grown out and installed at the primary restoration site in 2021, with subsequent, ongoing monitoring of the planting's survival taking place at designated post-planting intervals. A secondary, privately-owned restoration site was identified within the Achang Reef Flat Marine Preserve. Plantings were installed at the secondary site in 2022. These restoration activities were initiated with collaboration and support from former Guam Coral Reef Initiative watershed coordinator, Patrick Keeler, the 2020-2022 Guam Coral Reef Management Fellow, as part of the National Coral Reef Management Fellowship.

Management Opportunities

Potential site-specific opportunities exist for improving habitat conditions in conjunction with infrastructure protection. Several actions associated with other watershed goals are also relevant to habitat improvements:

Action 1.4 – Wetlands and Floodplain Restoration

Action 2.1 – Badland Restoration

Action 2.2 – Increase Wildfire Enforcement Capabilities

Action 2.10 - Eradication of Feral Pigs

Action 3.1 – Manage Invasive Bamboo in Riparian Areas

Within the Manell-Geus watersheds, a common species of clumping bamboo (*Bambusa vulgaris*) is the most prevalent and problematic invasive species of concern, as it relates to watershed planning. The bamboo was observed to be growing along the riverbanks throughout the watersheds, in large, mono-specific stands. These invasive plant stands cause issues with stream bank erosion/downstream sedimentation, habitat/biodiversity loss, and flooding, as they outcompete native riparian species. Large sections of these bamboo stands often break free from the stream banks or fall across the streams, causing blockages to the stream's flow, which is most problematic within the Manell and Geus River systems.



Bamboo outcompetes more desirable, native riparian vegetation and creates debris jams that block flow, causing flooding and bank erosion.

Previous efforts led by Patrick Keeler (former Guam Coral Reef Initiative Watershed Coordinator, now with TNC) to remove and manage the bamboo stands in Manell-Geus watersheds have been made with some limited success. Increased funding and efforts should be considered for

continued progress in removing and managing this invasive species, and reduce downstream flooding, within these watersheds. Methodology includes using small (16") chainsaws to cut bamboo, and then pouring 2 oz (1/4 cup) glyphosate (herbicide) into each stalk and on top of a fresh cut. Extreme care should be used when handling herbicides to prevent exposure to skin. Continuous maintenance will be required for three to six months after the initial cut and herbicide application to ensure successful eradication. New growth will need to be trimmed down with a sharp knife or machete with herbicide painted on the freshly cut stump. Approximately 3-4 people and two chainsaws can clear out ~120 stalks in ~10 hours. More equipment and training required for large-scale bamboo removal and stream buffer restoration.



Extensive manpower and constant maintenance are required to remove bamboo stalks lodged in culverts, such as this one in Manell.

Action 3.2 – Install Living Shorelines

Successful establishment of mangroves under the existing mangrove restoration project near the mouth of the Ajayan River could inform practices applied to other coastal stabilization sites. The Ajayan River Focus Area Shoreline Stabilization (Project R-1) identifies ~400 lf of the shoreline that needs to be stabilized to protect Route 4. This is an area where conditions may be favorable for using natural, vegetated solutions, including mangrove planting (see **Chapter 3** Focus Area 6 and **Appendix A**).

In other locations where a hybrid approach using both “soft” and “hard” techniques is recommended (e.g., R-48/43 in the Merizo Pier Park Focus Area 5), eroded shorelines can be repaired through a combination of vegetation, coir logs, and half-wall stone toe protection provide more of a “dynamic” revetment compared to fixed wall structures. Installation of

breakwaters (submerged rock or other hard structures placed below mean high water) modeled after the ancient Chamorro weir “stone Gigao” could further protect shorelines using nature-based solutions.



Marie Auyong, NOAA’s Guam Coral and Coastal Zone Management liaison, evaluates shoreline erosion at Santa Marian Kamalen Park south of the Merizo Pier Park.

Action 3.3 – Conduct a Dam Removal Assessment

A dam impact study for a few small dams on the Geus River showed negative impacts to downstream species. The reservoir is the actual barrier for wildlife, not the dam itself. Native fish are vulnerable to stream blockage. It is vital that rivers are left clear of dams or other blockage for returning fish to travel upstream to find suitable habitat. An ongoing study by GDAWR is monitoring the effect a dam has on native stream fauna (Guam Wildlife Action Plan). An assessment should be done to determine the expected impacts if the Geus River dams are removed.



Goal 4 – Support Community Engagement

This community is well-positioned for watershed engagement. Priority actions include designating a watershed coordinator, annual progress reporting, K-5 lesson plans, watershed signage, encourage participation in the Sustainability Plan and Forest Health Plan, public involvement/training with badland restoration, and resident education/training on neighborhood drainage, wildfires, off-roading & septic systems, etc.

Problem

Residents of Merizo have not always been invited to the table when it comes to land/water use management decisions. It is vital that the residents are actively involved in the implementation of this watershed plan. In a recent survey, most respondents agreed that residents should be involved in caring for the watershed and the reef, which is a great opportunity. Several project partners involved in the HFA initiative have engaged the community in watershed events such as planting projects, snorkeling to see a coral farm, kayaking trips, trash pickups and more. Building on this momentum, the following actions were identified to further this goal.

Factors that impact public involvement in MG Watershed:

- Distance from decision-makers
- Distrust based on past actions, both historical and modern
- Landowners primarily reside elsewhere, with a secondary “ranch” property in the south
- Landowners work elsewhere, reduced time due to commuting
- Socioeconomic barriers
- Residents have other main concerns such as jobs and kids

Recommended Actions

Village-wide opportunities exist to promote watershed education and citizen science for students, residents, businesses, and government agencies.

Action 4.1 – Designate a Watershed Coordinator

Designate a watershed coordinator to champion WMP implementation, reporting, and engagement actions. The coordinator could be a new CZMP hire or an individual(s) representing members of the Watershed Planning Committee, HFA partners, or Mayor’s office representative, as examples.

Action 4.2 – Report Watershed Accomplishments

The watershed coordinator is responsible for the annual reporting of watershed achievements to community leaders and residents at a meeting at the community center and/or at either of the village festivals (Fiestan Tãsi or Crab Festival). The report should inform stakeholders on the status of badland reforestation efforts, the implementation of flood mitigation and green infrastructure projects, and community outreach events. Part of this reporting should include

updates on the HFA, Cocos Lagoon remediation, management activities of the Achang Reef Flat Preserve, and any anticipated development/renovation activities that might impact watershed conditions. The watershed coordinator(s) should track qualitative metrics, such as the number of homes connected to the sewer, water quality trends, and the number of flood days. These annual updates could be summarized in a brief watershed report card to be distributed at meetings and/or published in the newspaper to grow watershed awareness island wide. The coordinator(s) will also solicit comments, feedback, and reports of any new related issues or improvements in their experience. At the end of 5 years, these reports could be used to evaluate the implementation progress of the watershed plan.



The community center and school across the street offer great locations to engage residents.

Action 4.3 - Develop Watershed Science PreK-5 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. Staff from the Merizo Martyrs Memorial School can reach out to university, agencies, and watershed professionals to tap into existing programs (such as WERI's Water Kids program) 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. Specific class activities might include:



- Delineating drainage areas in the school yard with street chalk during dry weather and confirming flow path of surface runoff during wet weather. Older students can calculate the size of drainage catchments and runoff volumes for 1 inch of rain.
- Measuring air and stormwater runoff temperatures generated by paved vs vegetated surfaces.
- Installing a CoCoRaHS rain gauge and assigning students or classrooms to record, report, and analysis data using the programs online platform. See <https://www.cocorahs.org/>.
- Following the school's (or home's) rainwater discharge to the ocean and identify potential sources of pollution and impacts on biological and human communities. For

example, students could release biodegradable “boats” or balls to see where they end up or make visual observations of water clarity in streams. Older students might collect water samples at key locations and submit them to Guam EPA for lab analysis or use field test kits for measuring basic water quality parameters.

- Inviting guest speakers from partner agency staff to discuss watershed ecology, drinking and wastewater management, pollution control regulations, drainage infrastructure, or mitigating for climate change.
- If the school wanted to pursue any of the proposed stormwater retrofits, students could participate in the design development process, installation (plantings), maintenance, and monitoring.
- Newly constructed GSI and/or nature-based shoreline demonstration projects could be visited by classes, particularly during or after rainstorms and high wave events, to see how these infrastructure operate 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 Guam, and the GSI demonstration projects installed in Manell-Geus could be used as field trip destinations.



Mission statement and student outcomes painted on the Merizo Martyr’s Elementary School wall.

Action 4.4 - Raise Watershed Awareness with Signage

At highly visible locations, stream crossings, and 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. Signs could show the various depths of road flooding during

extreme rain events and information such as, “water depth recorded from 4” of rain in 4 hours on Aug 2, 2019.”

Action 4.5 – Encourage participation in the Guåhan 2050 Sustainability Plan and Guam Forest System Plan

Participation in developing these important plans will help shape the future of Merizo and the watershed. The watershed coordinator could help facilitate this process, especially when zoning and land conservation discussions impacting Merizo are taking place.

Action 4.6 – Encourage Residential Stewardship

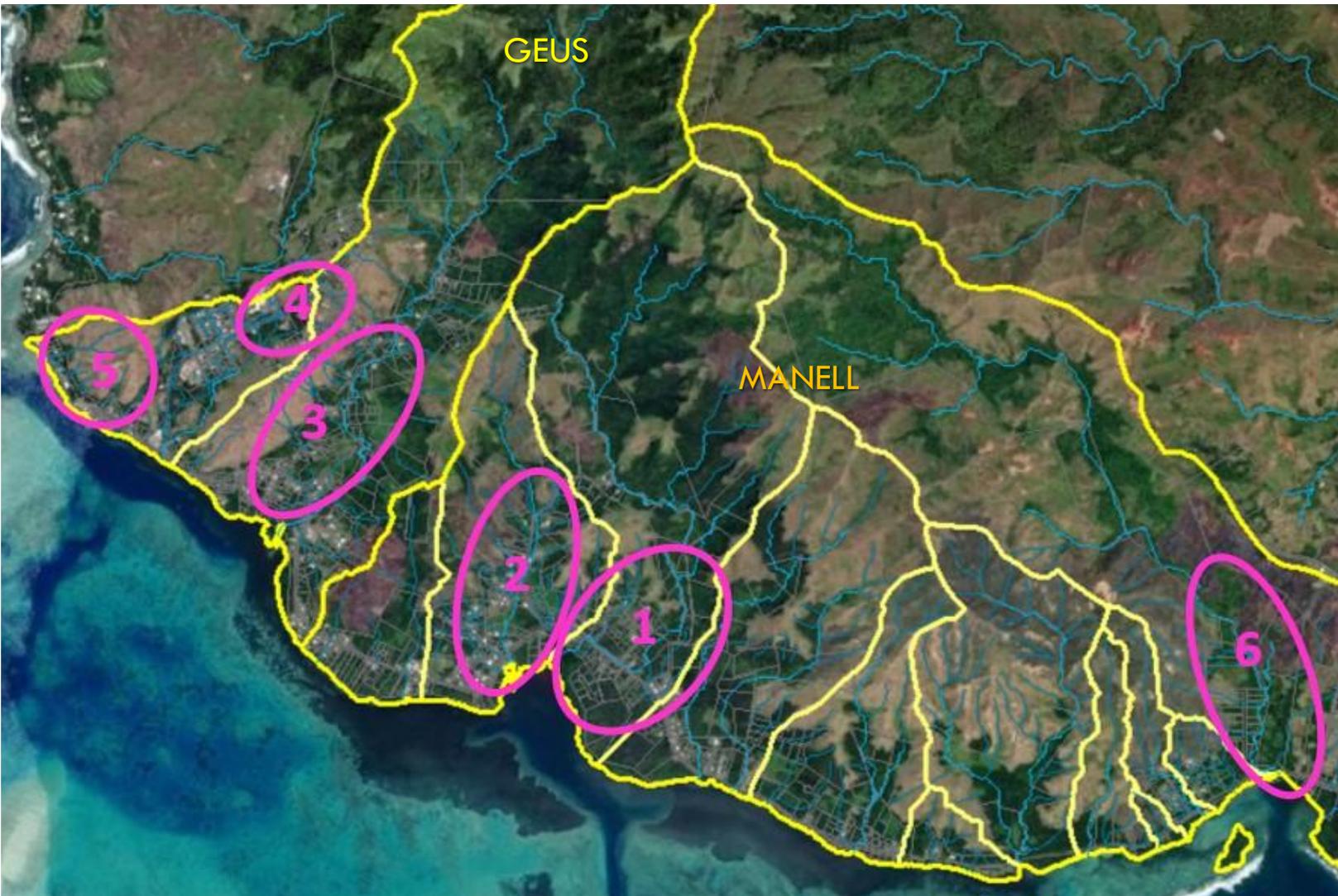
Given the local interest in protecting the reef, many residents may be open to learning about how they can support watershed goals at their homes and properties. Education should be provided on wildfire prevention, community wildfire protection planning, best practices for farming/ranching, maintaining existing mangroves, stormwater flow paths and issues, off-roading impacts, pollution prevention practices, and how these issues cause downstream problems on the reef and fisheries. Residents may be eligible to enroll in the DOAG FSRD’s Forest Stewardship program, which offers technical assistance in developing conservation plans and obtaining planting materials. These types of stewardship are most important in the identified focus areas. For example, many Pigua residents have directly connected stormwater drainage and could improve stormwater management onsite. Residents in Quinene and Geus could improve stewardship behavior related to wetland encroachment and keeping drainageways open.

Action 4.7 – Continue to Support Volunteer Projects

Volunteer projects such as planting and bamboo removal should be continued and expanded if the interest and funding are available. This helps provide local ownership in the success of these projects. Include funds to support these activities in conjunction with project construction budgets.

Action 4.8 – Use MG for 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 as an example in other watersheds on Guam. Where possible, professional development should be offered for staff in the mayor’s office, school staff, and professionals within the village in arborist training, invasive species management, and wildfire suppression if desired.



Priority areas to focus restoration efforts on in the Manell-Geus watershed

3 MANAGEMENT FOCUS AREAS

In Manell-Geus watershed, restoration opportunities were prioritized within six focus areas based on monitoring data; field observations; and discussions with residents, local leaders, and agency staff. The six focus areas include: (1) Manell River, (2) Quinene Road, (3) Geus River/Road, (4) Pigua Public Spaces, (5) Merizo Pier Park, and (6) Ajayan River. Restoration actions in each focus area are summarized in **Table 6** and shown in **Figure 15**. A description of each focus area is included below, with more details in **Appendix A**, as well as concept designs for key structural projects. **Appendix B** includes additional notes and sketches for opportunities identified during fieldwork. Where relevant, pollutant load reductions of total suspended solids (TSS) and total

nitrogen (TN) were modeled using the Watershed Treatment Model (WTM). Results indicate the following:

- Restoration scenario results in 47% and 14% TSS reductions in Geus and Manell, respectively. Modeling supports the focus of badland restoration as the watershed management priority for reducing sediment loads.
- Nitrogen loads are more complicated given the lack of information on specific sources and their relative level of contribution. Limited nitrogen load reductions can be achieved through wastewater and stormwater retrofits, although the benefits/costs are not clear. The WTM predicted 6% and 4% reductions in TN in Geus and Manell, respectively.

Input data and results are discussed in detail in **Appendix C**.

The following factors were considered while determining the focus areas:

- **Flood Reduction:** the potential impact of the identified restoration opportunities on reducing coastal and/or rain-based flooding, addressing Goal 1.
- **Pollutant Removal:** the ability of the identified restoration opportunities to capture land-based sources of pollution, addressing Goal 2.
- **Habitat:** the potential of the identified restoration opportunities to improve habitat for important forest, freshwater, and coastal species, addressing Goal 3.
- **Visibility/Education:** the potential for the identified restoration opportunities to be seen by the public, used as a demonstration site, or provide watershed education, addressing Goal 4.
- **Co-Benefits:** the degree to which the identified restoration opportunities may provide other benefits such as shade, biodiversity, recreation, or safety.
- **Feasibility:** the extent to which the identified restoration opportunities are easy to implement or construct, maintenance burden, and site ownership.

Table 6. Key Restoration Opportunities by Focus Area

ID	Project	Description	Planning Level Cost	Goals Met
Focus Area 1 - Manell River				
R-29*	River Realignment and stream restoration	<ul style="list-style-type: none"> • ACOE study underway to restore natural channel closer to historic flow path with new culvert/bridge crossing • Add stream bank stabilization and bamboo management in segment upstream of road as part of design • Consider wetland/Floodplain restoration rather than large basins (as proposed by ACOE) 	\$5,000,000 (ACOE estimate, may not include land acquisition costs)	 
Focus Area 2 - Quinene Road				
R-28	Reconnect Tributaries to River	<ul style="list-style-type: none"> • Redirect tributaries at 7 locations to the natural path via road crossings to run directly to the river to reduce flow through neighborhoods on Quinene Road. • Includes drainage infrastructure improvements (install culverts, swales, headwalls) 	\$50,000 design and permitting; \$250,000 construction	  
R-06	Residential Stewardship	Outreach by coordinator and Village mayor's office to the neighborhood on importance of keeping flow paths open to reduce flooding	\$10,000 (part of overall residential outreach program)	 
R-37	Badlands Restoration	<ul style="list-style-type: none"> • Use Forestry Division's reforestation practices • Expand total program staffing, equipment, and monitoring elements • Consider alternative erosion control methods with low combustible potential. 	\$200,000 in staff hires; \$250,000 in materials/ equipment; \$50,000 in associated fire breaks; \$25,000 in monitoring	  
R-33	Wetland Enhancement/ Protection	<ul style="list-style-type: none"> • Evaluate the restoration potential of wetland areas along the river. • Protect wetland areas from future development/ alteration via conservation zoning and development regulations 	\$5,000 (part of zoning updates under Sustainability Plan); \$20,000 more detailed assessment of wetlands	  
R-11	Achang Boat Ramp Stormwater	<ul style="list-style-type: none"> • Direct parking lot and possibly road runoff to bioretention systems. 	\$25,000 for design and permitting; \$50,000 construction	 

ID	Project	Description	Planning Level Cost	Goals Met
		<ul style="list-style-type: none"> Provide public engagement with volunteer planting. Educational signage. 		
R-30	Bamboo Removal	<ul style="list-style-type: none"> Remove bamboo and treat cut stems with herbicide (applicators should use extreme caution). Remove fallen bamboo & other debris from stream. This is labor intensive and requires multiple maintenance efforts over time Contest for reuse of harvested bamboo 	\$100,000 labor, materials, and incentives	
Focus Area 3 - Geus River/Road				
R-47	Reconnect Tributaries to Geus River	<ul style="list-style-type: none"> Redirect 5 tributaries to the natural path via road crossings to run directly to Geus River to reduce flow through neighborhoods on Geus Road. Includes drainage infrastructure improvements and associated streambank restoration. 	\$40,000 design and permitting; \$200,000 in construction; (does not include cost of easements)	
R-39	Badlands Restoration	<ul style="list-style-type: none"> Private land, access is complicated Village could apply for USDA grant Consider alternative erosion control methods with low combustible potential. 	\$10,000 grant writing for private land; \$250,000 for implementation; \$25,000 testing new techniques	
R-46	Wetland Enhancement/Protection	Target wetland areas along Geus River in new conservation zoning.	\$5,000 (part of zoning under Sustainability plan)	
R-31	Bamboo Removal	<ul style="list-style-type: none"> Remove bamboo and treat cut stems with herbicide (applicators should use extreme caution). Remove fallen bamboo & other debris from the stream. This is labor intensive and requires multiple maintenance efforts over time Contest for reuse of harvested bamboo 	\$150,000 for labor, materials, and incentives	
ME-118	Upgrade Geus River Culvert	<ul style="list-style-type: none"> Existing DPW project Upsize culvert along Route 4 to allow flows to pass under the road without backing up. 	\$1.3M (DPW estimated)	

ID	Project	Description	Planning Level Cost	Goals Met
R-21*	Helmani Apartments	<ul style="list-style-type: none"> Direct parking lot and possible road runoff to bioretention systems. Permeable pavers 	\$50k for design and permitting \$100k for construction of bios and permeable pavers	  
R-25	Floodplain Restoration	<ul style="list-style-type: none"> Convert cleared empty lot next to public housing into a floodplain area. Not public land 	\$25k in design and permitting; \$75,000 for grading and replanting (does not include easement)	  
Focus Area 4 - Pigua Public Spaces				
R-10/ R-20*	School Stormwater Management	<ul style="list-style-type: none"> Install cutoff trench along base of adjacent steep slope to intercept groundwater flowing through this area and divert it to proposed stormwater features. Stabilize steep slope with vegetation. Install a bioretention/dry swale system along the school entrance and road. Provide educational signage. 	\$25k for design and permitting (does not include archeological survey); \$75,000 construction; \$25k for student and volunteer engagement	 
R-14*	Mayor's Office Stormwater Management	<ul style="list-style-type: none"> Convert existing depression into a constructed wetland for treatment and storage. Should have been part of gym construction Direct parking lot and road runoff to constructed wetland via a swale; include forebay. 	\$25k design and permitting; \$100k for constructing	 
R-13*	Public Library Stormwater Management	<ul style="list-style-type: none"> Direct parking lot and road runoff to bioretention systems via a swale. Provide educational signage Volunteer opportunity for planting. 	\$125,000 for design, permitting, and installation, includes signage	  
R-42	Pigua Water Tank Upgrade	<ul style="list-style-type: none"> Guam Waterworks Authority priority project Inspect and repair the existing water tank. 	\$1M in GWA capital plan	 
R-09*	Pigua Water Tank Parking Upgrades	<ul style="list-style-type: none"> Pave driveway leading to the water tank. Convert grass area currently used for parking to permeable pavers. Pave the unpaved access road Cost savings possible if lumped in with R-42 	\$25k to coordinate with GWA, design, and permitting; \$150,000 construction	

ID	Project	Description	Planning Level Cost	Goals Met
Focus Area 5 - Merizo Pier Park				
R-44	Badlands Restoration	<ul style="list-style-type: none"> Highly visible from Park Public land, add to Forestry Division's reforestation efforts Plan site access 	\$350,000 (see other badland restoration costs)	  
R-48/ R-43*	Shoreline Stabilization	<ul style="list-style-type: none"> Public parks Stabilize eroding coastal shoreline. Revegetate bank with mangroves or other appropriate vegetation; hybrid approach where needed Provide public education/signage 	\$50,000 Design and permitting (may include ACOE permitting) and coordination with other partners; \$700,000 construction (assumes some hard structural components and includes public engagement and signage)	  
R-08*	Parking Stabilization	<ul style="list-style-type: none"> Convert paved and grass area currently used for roadside parking to permeable pavers. 	\$25k design and permitting; \$300,000 (pavement, pavers and swale)	 
R-16 – R-19*	Pier Park Stormwater Management	<ul style="list-style-type: none"> Direct flows from parking lots and courts into bios at each downgradient corner of the parking lots. Install a rain garden for community building roof runoff. Provide public education. 	\$35k design and permitting; \$150,000 construction \$25,000 for signage and public engagement with rain garden	 
R-43	Umatac-Merizo Sewer Replacement	<ul style="list-style-type: none"> By Guam Waterworks Authority. Replace existing gravity piping with new larger diameter piping. Help reduce sewer overflows 	\$2.7M (per GWA)	
Focus Area 6 - Ajayan River				
R-40	Badlands Restoration	<ul style="list-style-type: none"> Continue reforestation efforts by expanding existing As Gadao site. This could be one of the biggest contributors of sediment to the Lagoon Investigate other points of access for reforestation. 	\$100,000 staff; \$250,000 materials and equipment \$25,000 for monitoring	  

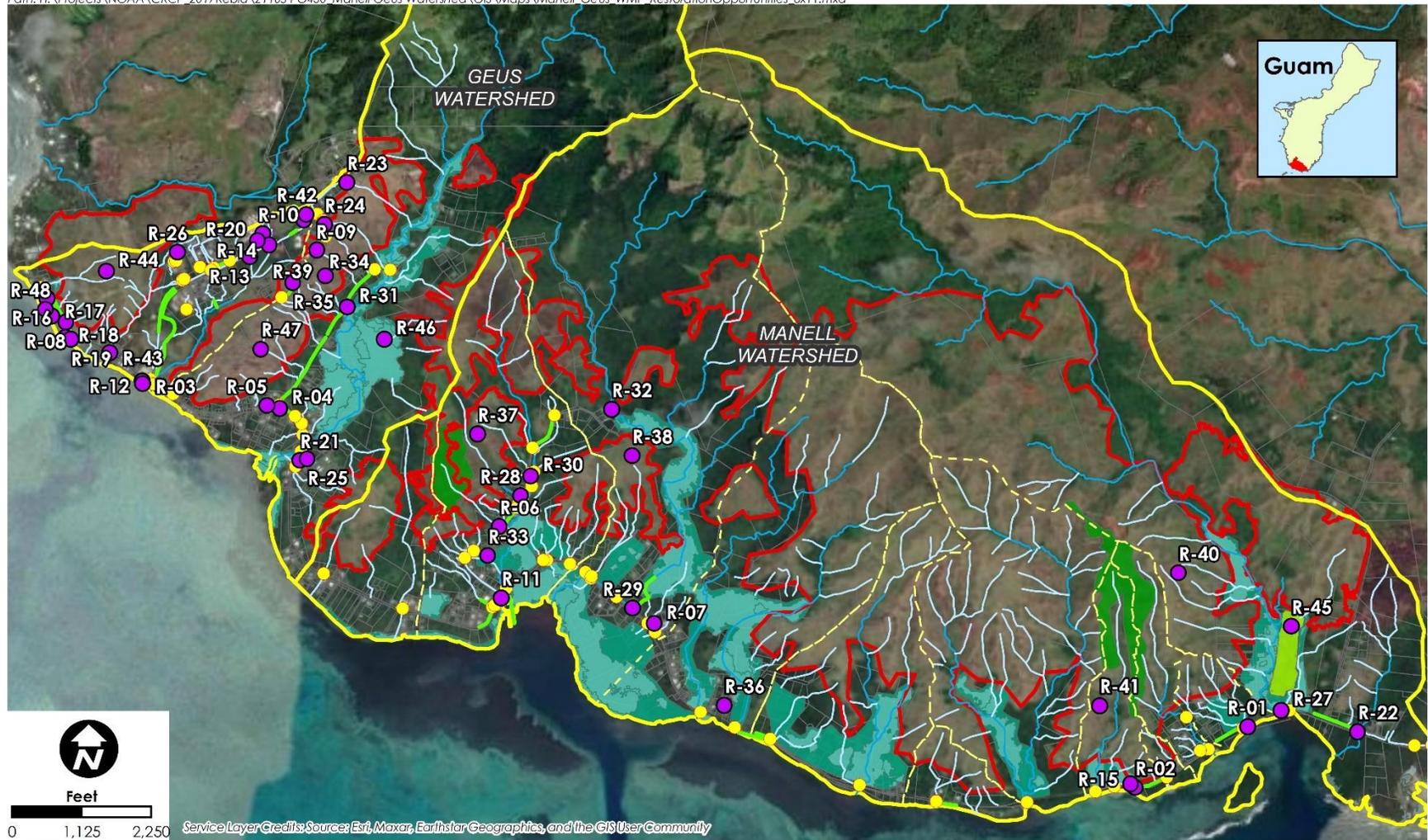
ID	Project	Description	Planning Level Cost	Goals Met
R-45	Floodplain/wetland Restoration	<ul style="list-style-type: none"> Coordinate with landowner Convert abandoned fishponds into a natural floodplain/wetland area. 	\$25,000 evaluation of options	  
R-27	River Restoration	<ul style="list-style-type: none"> Restore and stabilize stream bank with living shoreline plus hard solutions upstream of the Rt 4 bridge. Bridge replacement in DPW list of projects 	\$24M (per DPW) \$250,000 dedicated for living shoreline component	
R-1*	Shoreline Stabilization	<ul style="list-style-type: none"> Stabilize with living shoreline Revegetation of banks with mangroves or other appropriate vegetation should be part of DPW's project 	\$250,000 for design, permitting, and implementation	 

* sites with detailed concept plans (Appendix A)

-  Minimize flooding now and into the future.
-  Reduce watershed-based pollutant loads to nearshore waters.
-  Restore habitat and improve biodiversity.
-  Support community engagement.

Figure 15. Restoration Opportunities

Path: H:\Projects\NOAA\CRCP_2017Rebid\21105 PO430_Manell Geus Watershed\GIS\Maps\Manell_Geus_WMP_RestorationOpportunities_8x11.mxd



Service Layer Credits: Sources: Esri, Maxar, Earthstar Geographics, and the GIS User Community

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| <p>Date: 7/9/2024
 Data Sources: WERI, NOAA, USGS, HW, ESRI</p> <p><i>This map is for informational purposes and may not be suitable for legal, engineering, or surveying purposes.</i></p> | <ul style="list-style-type: none"> ● Restoration Projects (HW) ● Infrastructure — Field Lines — Flow Paths — Rivers (NHD) | <ul style="list-style-type: none"> ▭ Badlands (HW) ▭ Existing Reforestation Sites (HW) ▭ Wetlands Area (CCAP) ▭ Manell Geus WS Revised (HW) ▭ Manell Geus Subwatersheds (HW-revised) | <ul style="list-style-type: none"> ▭ Parcels ▭ Wetlands Opportunities (HW) ▭ Floodplain Restoration ▭ Wetland Protection ▭ Wetland Restoration |
|---|--|---|---|

Focus Area 1 – Manell River

River realignment, floodplain/wetlands restoration and protection, bamboo removal/bank stabilization

This focus area was chosen based on the frequency of flooding caused by the channelization/realignment of the Manell River at Route 4. In 1986, the river crossing was altered with the construction of a new concrete channel with two 90-degree bends and multiple box culverts. Initial analysis by ACOE (2022) shows that the channel is undersized, and now, the area's 26 residential buildings and the main road connecting southern Guam communities experience frequent flooding and associated safety concerns and property damage. Residents living next to the channel have videos of roaring floodwaters arriving in the middle of the night. Significant bamboo, sediment, and other debris clog the channel and culverts, exacerbating the flooding issues and requiring cleaning 15 to 20 times a year (ACOE 2022).

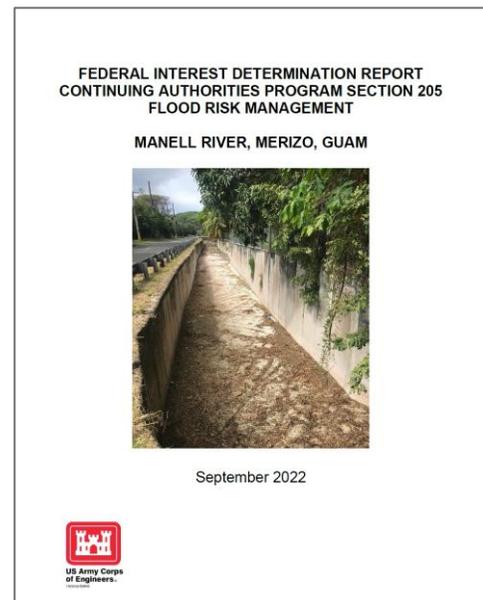


The existing paved Manell River channel along Route 4 (top left); existing box culverts and flow splitter (top right); and the 90-degree turn in the dry riverbed at Route 4 (bottom).



Photos from ACOE’s Federal Interest Determination Report (2022) showing water marks on a residential home typical of those in the impacted flood area.

ACOE, in coordination with the Government of Guam, has developed management alternative concept designs for this area that include: (1) reforestation of burned non-native savannah grasslands with native ravine forest species; (2) Channel realignment to restore a more natural flow path; (3) in-stream detention basin and overland basins; and (4) non-structural, dry floodproofing of the roughly 26 buildings in the impact area. Initial modeling, design, and cost/benefit analyses have been completed, with the conclusion that this is a project that should move forward. This project could greatly improve flooding issues in this focus area; however, the watershed management goals could be better achieved by this project with a few modifications as the design progresses. These recommendations are included in Site R-29 (ACOE Manell River Project) and include a more nature-based, resilient channel design for the Manell River and floodplain/wetland restoration instead of detention basins in the identified areas. The recommended restoration opportunities for this site are described in further detail in **Appendix A**. With these modifications, this project can address all four watershed goals and would be more resilient in the long-term.



Focus Area 2 – Quinene Road

Drainage improvements, residential stewardship, badland restoration, wetland enhancement/protection, stormwater management

Focus Area 2 is located in the Quinene residential area, which is facing a combination of issues. First, when the road was built in this neighborhood, it blocked off natural flow paths for the western portion of this subwatershed, preventing wet weather flows from reaching the unnamed river to the east of the road. Over time, some drainage infrastructure was installed to help with this problem, including culverts and roadside ditches. However, these features have filled in with sediment from upgradient eroding badlands (to the north of the Quinene Reforestation site managed by FSRD), causing dirty runoff to flow down the road, and



Example of one of the Bamboo stands along Quinene Rd.

sometimes into homes, instead of reaching the river. There are sections of road where water ponds and other sections where these combined flows have eroded new gullies to the river, taking large amounts of sediment with it. Large stands of invasive bamboo along the river cause bank erosion as they fall and block or divert flow. Many residents in the area experience flooding and try to divert floodwaters with sandbags or build berms to keep runoff on the road. Much of this road runoff flows down to and across Route 4 into the Achang Boat Ramp area. There are encroachments into the large wetland in the coastal plain portion of this focus area, which reduces its natural flood mitigation capacity and habitat quality. The natural stream channel out to Achang Bay may have been impacted by private landowners, forcing flows through other culverts under Route 4. If those are blocked with sediment or just reach their capacity, Route 4 floods and can even contribute to the flooding along the Manell River.

The proposed restoration opportunities to address watershed goals in Focus Area 2 include R-28 (Restore Natural Hydrology/Reconnect Tributaries to River), R-6 (Residential Stewardship), R-37 (Badlands Restoration), R-30 (Bamboo Removal), R-33 (Wetland Enhancement/Protection), and R-11 (Achang Boat Ramp Stormwater Management). These are described in more detail in **Appendix A**.

Focus Area 3 – Geus River/Road

Drainage improvements, badland restoration, bamboo removal, floodplain/wetland conservation, drainage infrastructure improvements, stormwater management

Focus Area 3 stretches from the residential area along Benny Espinosa Road including adjacent badlands down to Route 4. Much like in Quinene, when the road was built in this neighborhood, it blocked off the natural flow paths for the western portion of this subwatershed, preventing wet weather flows from reaching the Geus River. This road does have a concrete drainage ditch along most of its

length (0.6 miles) that intercepts and combines the flows, conveying them back into the river down along Route 4. However, these ditches have filled in with sediment from upgradient badland erosion, allowing vegetation to grow and causing runoff to flow down the road, and sometimes into homes, instead of reaching the river. The culvert where the river crosses the road is undersized, adding to flood and stream erosion issues. Large stands of bamboo were observed along the river, and often, will be carried downstream, clogging the culvert at Route 4. There is a large floodplain/wetland system in the focus area, but some encroachment was observed, as well as GIS parcel lines where future development may be desired within these sensitive areas. Stormwater runoff from public housing along Route 4 currently carries sediment and other pollutants to the river.

The proposed restoration opportunities to address watershed goals in Focus Area 3 include R-47 (Restore Natural Hydrology/Reconnect Tributaries to River), R-39 (Badlands Restoration), R-31 (Bamboo Removal), R-46 (Wetland/Floodplain Protection), R-21 (Public Housing Stormwater Management), R-25 (Geus River Floodplain Restoration), and two infrastructure projects (I-39: Merizo Inland Culvert Rehabilitation & ME-118: Geus Culvert Upgrade). These are described in more detail in **Appendix A**.



Conditions along the road in Focus Area 3, showing undersized concrete swales, erosion, and swales filled with sediment and vegetation.

Focus Area 4 – Pigua Public Spaces

Stabilization, infrastructure improvements, stormwater management & education at community locations

Focus Area 4 is located in the upper portion of the Pigua Subwatershed. This area is mostly comprised of public spaces, such as a ball field, school, mayor's office, community center, and library. It is also one of the most urbanized portions of the watershed in the sense of impervious cover. There are no existing stormwater management practices or infrastructure in this area. When it rains, stormwater flows across bare dirt, carrying sediment-laden runoff into the parking lots and roads of these important places, in some locations, forming puddles. The proposed restoration opportunities to address watershed goals in Focus Area 4 include R-9 (Pigua Water Tank Paving), R-10 (School Courtyard Cutoff Trench), R-13 (Rose Aguigui Reyes Memorial Library, Merizo Branch), R-14 (Merizo Mayor's Office Constructed Wetland), R-20 (School Parking Lot Bioretention Areas), and R-43 (Pigua Water Tank Upgrade). These are described in more detail in **Appendix A**.

Focus Area 5 – Merizo Pier Park

Stormwater management, shoreline stabilization, badland restoration, and infrastructure repair

While this focus area is the smallest of the six, the Merizo Pier area is arguably the busiest location in the watershed as a boat launch into Mamaon Channel, but also because the park is a community gathering place. Unfortunately, sediment flows down from the adjacent eroding badlands to the road. Stormwater from the two parking lots in this area flows to the channel with no treatment, and the shoreline is eroding, threatening the adjacent recreational infrastructure. The proposed restoration opportunities to address watershed goals in Focus Area 5 include R-44 (Badland Restoration), R-48 (Shoreline Stabilization), R-08 (Parking Stabilization), R-16-19 (Merizo Pier Park Stormwater Management), and R-43 (Umatac-Merizo Sewer Replacement). These are described in more detail in **Appendix A**.



Shoreline at Merizo Pier Park

Focus Area 6 – Ajayan River

Badland restoration, floodplain expansion, shoreline stabilization, and infrastructure repair

The Ajayan River subwatershed is roughly 1,000 acres in size, almost 25% of the entire Manell-Geus watershed. While mostly undeveloped, the almost 5-mile long river flows through large swaths of badlands exacerbated by recent large-scale wildfires. Some of these badlands are on government land proposed to be incorporated into the Guam Forest Inventory. Near the mouth where the river enters the Ajayan Bay/Achang Preserve, the river takes a sharp almost 90-degree turn to first flow parallel to the road and then another 90 degrees to flow under the Ajayan Bridge. This alignment causes sedimentation along the inside bend as well as erosion along the outside. Large sediment deltas are visible at the mouth and into the bay. The erosion is undermining the bridge's support structures. Inspections have found the bridge in poor condition, and it is on DPW's list for reconstruction. Wetlands are present along portions of the river's floodplain; however, there are abandoned aquaculture ponds that were built along the east side of the river. In addition, Route 4 is very close to the shoreline in this area with evidence of coastal erosion threatening this vital infrastructure. Already located in the flood zone and with expected climate-related sea level rise pressures, this road is quite vulnerable.

The proposed restoration opportunities to address watershed goals in Focus Area 6 include R-27 and ME-130/IV-120 (River Restoration and Infrastructure Improvement), R-40 (Badlands Restoration), R-1 (Shoreline Stabilization), and R-45 (Wetland/Floodplain Restoration). These are described in more detail in **Appendix A**.



4 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, Village, agency, and non-government partners will first need to identify an individual or establish a committee to coordinate management activities, secure funds, leverage partnerships, and report progress to residents.

Implementation progress of this WMP should be a standing agenda item during Watershed Planning Committee meetings and will require collaboration with other initiatives such as the Guam Silver Jackets Committee, Guam State Hazard Mitigation Plan, and the Guam Forest System Plan, to name a few.

Implementation Schedule & Budget

Error! Reference source not found. outlines an initial strategy for watershed managers to consider, describing implementation over the next few years, including a planning level cost estimate and identification of potential lead agent(s). The table includes actions that have already been funded (but not yet implemented).

Table 7. Proposed Implementation Strategy & 5-YR Budget (red font denotes an already funded project)

Action	YR 1-2	YR 3-4	YR 5+	Lead
Goal 1. Minimize flooding now and in the future				
1.1 ACOE Manell river realignment	Planning and Design \$250,000	Planning and Design \$250,000	\$5 million (estimated)	ACOE with GEPA
1.2 Temporary maintenance equipment	Provide on-site backhoe during wet season \$20,000	Provide on-site backhoe during wet season \$20,000	Provide on-site backhoe during wet season \$10,000	Village Mayor/DPW
1.3 Wetland Zoning & Regs	ID zoning areas as part of the Guåhan 2050 Sustainability Plan)	--	--	BPS
1.4 Wetland restoration	Combined with ACOE project and Ajayan Bridge project	Detailed assessment in Focas Area 2- Quinene & Area 3 Geus Rd. \$20,000 R-25 floodplain restoration \$100,000	Combined with ACOE project and Ajayan Bridge project	DPW
1.5 Drainage infrastructure repairs and installations	R-28 &R-47 (7 connections on Quinene Rd. & 5 on Geus Rd) \$90,000 design and permitting R-27 Ajayan Bridge Replacement- Construction (Grant Funded) \$24M	R-28 & R-47construction \$450,000 ME-118 Culvert Rehab Construction - \$1.3M	Monitor impacts and plan for additional restoration as needed	DPW (In Guam Transportation Improvement Plan)
1.6 Update asset management system	\$25,000 update mapping	\$5,000 update	\$5,000	DPW
1.7 Pigua water tank (MP-PW-Tank 32)	Already funded and scheduled (include access road paving & pervious parking) \$1M	--	--	GWA
1.8 Align hazard planning	Part of Watershed Planning Committee meetings	Host an interagency meeting \$10,000	--	Watershed Planning Committee/Coordinator
Total \$ for Goal 1	\$385,000 + \$25M (funded)	\$855,000 + \$1.3M (funded)	\$5.02M	

Action	YR 1-2	YR 3-4	YR 5+	Lead
Goal 2. Reduce watershed-based pollution loads to nearshore waters				
2.1 Badland reforestation in focus Areas 2 Quinene, 3 Geus River Rd., 4- Merizo Pier Park, and Ajayan	Hire additional staff, equipment, supplies, access, grant writing, planting phase 1 in multiple areas \$500,000	Planting in additional areas, shift to phase 2 native trees \$800,000	Additional areas \$200,000	DOAG-FSRD
2.2 Wildfire enforcement	1-mile fire breaks at Quinene Restoration Site \$40,000	Continue Quinene and expand to additional areas \$100,000	Continue Quinene and expand to additional areas \$100,000	DOAG-FSRD with support from REPI (partially funded)
2.3 Don't Burn Guam Campaign	\$50,000	\$25,000	\$25,000	FSRD, GCMP, GEPA
2.4 On-site stormwater management (see priority sites in each Focus Area)	Surveys, design, permitting, and grant writing \$250,000	Permitting and construction \$750,000	Education, and Monitoring \$125,000	GCMP
2.5 GWA Umatac-Merizo Sewer Replacement (R-43)	Design and Construction (prioritize due to bacteria TMDL) \$2.7M	--	--	GWA (in Water Master Plan)
2.6 GWA sewer connections for septic systems/cesspools	Planning \$500,000	Priority connections \$6.5M	Remaining connections \$10M	GWA (in Water Master Plan)
2.7 Pollution hotspots		\$200,000	\$100,000	GEPA, landowners
2.8 Unpaved roads	Complete in conjunction with GWA tank replacement \$175,000	Merizo Park unpaved area stabilization \$325,000		GWA, DPW
2.9 Eroding streambanks	Included with Bamboo removal and major restoration of Manell and Ajayan rivers	Included with Bamboo removal and major restoration of Manell and Ajayan rivers	Included with Bamboo removal and major restoration of Manell and Ajayan rivers	DOAG
2.10 Eradicate feral pigs	\$10,000	\$50,000	\$10,000	DOAG
2.11 Water quality monitoring	\$25,000	\$25,000	\$25,000	GEPA
Total \$ for Goal 2	\$1M + \$3.2M (funded)	\$2.3M + \$6.5M (funded)	\$585,000 + 10M (funded)	

Action	YR 1-2	YR 3-4	YR 5+	Lead
Goal 3. Restore habitat and improve biodiversity				
3.1 Bamboo removal	R-30 in Focus Area2- Quinene Rd and 3 Gues Rd. \$150,000	R-30 in Focus Area2- Quinene Rd and 3 Gues Rd. \$50,000	R-30 in Focus Area2- Quinene & 3 Gues \$25,000	CZMP
3.2 Living shorelines	Design and permitting for (R-48/43) \$50,000	Construction (R-48/43) \$700,000	Monitoring \$10,000	ACOE, UOG, Sea Grant
3.3 Dam removal study	--	Flow meters and surveys \$25,000	Recommendations \$25,000	GDAWR
Total \$ for Goal 3	\$200,000	\$775,000	\$60,000	
Goal 4. Support community engagement				
4.1 Watershed Coordinator (portion of time)	\$50,000	\$50,000	\$50,000	BPS
4.2 Report out	\$10,000	\$10,000	\$5,000	Watershed Planning Committee/coordinator
4.3 School lesson plans	--	\$10,000	--	GEPA, CZMP, FSRD
4.4 Watershed signage	Design \$10,000	Manufacturing & installation \$20,000		CZMP
4.5 Participation in Sustainability plan	Included	--	--	BPS
4.6 Residential Stewardship	---	\$15,000 targeted messaging	---	TNC, GCMP, Mayors Office
4.7 Volunteer participation in habitat planting projects	Included in project costs	Additional planting support \$10,000	Additional planting support \$10,000	FSRD, GCMP
4.8 Offer training opportunities (part of other conference and workshops)	Funds to support transportation to sites and instructors \$5,000	\$10,000	\$10,000	Watershed Planning Committee/Coordinator
Total \$ for Goal 4	\$75,000	\$125,000	\$75,000	
Total by Time Period	\$1.7M + \$28M (already funded)	\$4.1M + \$7.8M (already funded)	\$5.7M + (10M (already funded))	
Grand Total	\$11.5M + \$46M (already funded) = \$57.6M			

Implementation Oversight

This WMP is a voluntary, non-regulatory plan, and as such does not have regulatory oversight or reporting requirements. Instead, implementation of the plan should be overseen by a watershed coordinator or committee, with support from watershed stakeholders. We recommend that the Watershed Planning Committee initially be tasked with oversight, but that the Guam watersheds coordinator position ultimately be responsible for coordination, tracking, and reporting of watershed actions.

Education and Outreach

The success of this WMP begins with awareness. Building support through education and outreach to the public and agency stakeholders is important, especially as some actions require additional studies and data gathering, multiyear commitments of fiscal and staff resources, and endorsement and/or adoption by different governing bodies. Most importantly, some of the key action items fall within initiatives or are already included in capital improvement budgets of other agencies (e.g., GWA, DPW).

Developing the WMP involved engaging with federal, territorial, and local stakeholders beyond the Working Group to gather local knowledge, foster collaboration, and extend the reach of the WMP. That collaboration and information-sharing should continue, led by the Watershed Planning Committee, or watershed coordinator. At a minimum, stakeholders should be re-engaged as part of an annual (or biannual) monitoring and reporting cycle to assess progress on implementation actions.

The Implementation Strategy is intended to be consistent with and supportive of other local plans and ongoing initiatives. The WMP identifies a set of clear, actionable next steps toward reducing LBSP and improving watershed health. Stakeholders involved in the development of the WMP are encouraged to cross-post the WMP to their websites, share progress on relevant implementation actions across their communication channels, and incorporate information and implementation actions from the WMP into other planning documents. As appropriate, agencies that oversee planning and infrastructure may consider providing resolutions or statements of support to this WMP.

Because of the bacteria TMDL, watershed implementation progress should be reported in GEPA's Integrated Water's report. DPW should also consider incorporating any progress on drainage improvements, illicit discharge elimination, and public education in the MS4 reporting.

Finally, continued education and outreach to the public around watershed management and best practices to protect water quality are essential for making environmental stewardship the status quo. This WMP highlights specific opportunities to engage with the public, including

residents, property owners, and the development community, around watershed management challenges to improve stewardship and build support.

Monitoring Progress

Tracking implementation progress can be challenging but is essential for maintaining transparency, measuring effectiveness, coordinating resources, and adapting to changing conditions and priorities. The Watershed Coordinator or Planning Committee will have four key monitoring responsibilities:

- Assess how implementation is progressing and report out to stakeholders,
- Add or delete actions as the WMP is amended periodically,
- Refine ongoing actions to enhance their implementation or improve their effectiveness, and
- Archive (and celebrate) actions when fully complete.

Measures of progress will be used to periodically assess and evaluate implementation progress. These measures, listed in **Table 8**, are based on quantifiable data (e.g., number of, percentage reduced/increased) that are easily understandable to a wide audience. Not all actions should be measured by the same indicators. The Watershed Planning Committee or coordinator should refine the list of indicators and interim milestones. Implementation milestones are also suggested to identify early achievements and to inform an adaptive management approach that may shift management priorities.

Table 8. Example implementation metrics and milestones

Goal	Metric/Indicator	Interim Milestone
Goal 1. Minimize flooding now and in the future	<ul style="list-style-type: none"> • # flood days/yr • # of culverts installed • # Maintenance days at key culverts 	<ul style="list-style-type: none"> • Engineering designs complete for river realignment (or other projects) • Land acquisition and permitting completed • Construction underway • Construction completed • Equipment provided
Goal 2. Reduce watershed-based pollution loads to nearshore waters	<ul style="list-style-type: none"> • # water quality exceedances for each parameter/yr (sediment) • Annual beach closures (days) • Acres badland revegetation • Miles of sewer pipe replaced • # of properties connected to sewer • Acres of impervious cover managed by green infrastructure • Grant \$ secured/spent 	<ul style="list-style-type: none"> • Positive trends and delisting of impaired waterbody in biannual Integrated waters report • Initiation and completion of sewer pipe enlargement project • Identification of properties to connect & noting of 25-100% completion stages • Stages of badland restoration completed

Goal	Metric/Indicator	Interim Milestone
Goal 3. Restore habitat and improve biodiversity	<ul style="list-style-type: none"> • Area of bamboo removal (Sq Ft) • # person days bamboo removal • Diversity of riparian vegetation • Linear ft of riparian, stream, or shoreline restoration 	<ul style="list-style-type: none"> • Completion of phases of project • Targeted focus area completion
Goal 4. Support community engagement	<ul style="list-style-type: none"> • Number of events • Number of volunteers/participants • Number of lesson plans developed 	<ul style="list-style-type: none"> • Development of watershed report card • Completion of annual watershed reporting • School educational material

Funding Resources

Implementation of this plan will require a wide variety of funding resources and creative funding approaches on the part of many stakeholders. Existing funding has been allocated for ACOE to study the Manell river-realignment, GWA wastewater infrastructure improvements, DOAG badlands restoration, DPW drainage improvements, GEPA water quality monitoring, and grants for TNC outreach and mangrove restoration. Additional funding will be needed for other specific action items in the WMP.

Federal sources of funds are available for infrastructure repairs, rural land restoration, as well as water quality and habitat restoration. Guam also has an opportunity to apply for coastal resiliency funds and grants targeting tribal, territorial, and underserved communities. NOAA supports incorporating green infrastructure practices to treat stormwater runoff, mitigate coastal flooding, and stabilize eroding shorelines through several external funding opportunities managed by the Coral Reef Conservation Program, the Coastal Zone Management Program, the Office of Habitat Conservation, and in partnership with the National Fish and Wildlife Foundation. In addition, US EPA has applicable funding under the 319 and non-point source program grants and the USDA has landowner eligible funds for stabilizing rural lands and expanding native forests. Stakeholders are encouraged to think creatively about how to work together, incorporate LBSP reduction project elements into other planned work, and seek opportunities with partners and programs sharing common goals.

Keys to Writing Grants for Implementation Projects

If grant funds are to be used for implementing structural projects, it is important to understand the process (steps and timing) for design, permitting, and construction. As an example, structural engineering projects, such as a stormwater retrofit or wetland restoration project, may generally include the following tasks:

Year 1: Getting Started

- Site selection with approval from property owner and neighboring residents
- Advance to 25% design with input from Mayor, stakeholders, and permitting authorities.
- Develop cost estimate and acquire project funding, to hire a Designer. Break costs out into design, permitting, construction, and maintenance.

Design Phase: 6 months – 1 year (depends)

- Conduct topographic survey, conduct archaeological survey as needed, conduct hydrologic and hydraulic models, delineate any nearby wetlands or critical habitat, evaluate soils, conduct baseline monitoring (biota, water quality, flow parameters) etc. in proposed restoration area.
- Develop permit-level design plans (75%) for wetland restoration. Permit ready plans should include an erosion control plan, landscape plans. Be sure to research what permits will be needed and what information you need to complete an application. Archeological assessments can be tricky and expensive.
- Generally, there should be impact area calculations, drainage calculations, project narrative, etc.
- Cost estimates
- Present plans to the community and gain approval.

Permitting Phase: 3- 6 months (depends)

- Submit plans for permitting. NEPA permits may be required for federally funded projects.
- Revise plans (if needed)
- Upon permitting approval, advance plans to construction-level design (100%). These will often require accompanying material specifications.
- Present plans to the community for final approval.

Construction: 3 months (depends)

- Determine who will be responsible for construction.
- Prepare a bid package and put project out to bid. Do not necessarily go with the lowest bid, should balance price with qualifications.
- Contractor selection and agreement on construction schedule, inspections and oversight, staging, planting, as-builts, and demobilization.
- Host event to celebrate the beginning of construction for residents.
- Supervise construction process.
- Invite residents to help plant native vegetation. Consult with agencies for plant species suggestions.

Maintenance and Monitoring: forever

- Ensure plant establishment and function, may need to include additional time in grant and in construction contracts for watering and replacing plants.
- Conduct post-construction monitoring.
- Conduct trainings and host public events.

Permits

The following permits and approvals may be required to complete the strategies outlined in this implementation plan.

Table 9. List of possible permits required for proposed projects (NFWF 2022)

Permit Type	Approval Authority	Statute	Estimated Time Required
Historic Preservation	Guam State Historic Preservation Office (GSHPO)	National Historic Preservation Act, Section 106 Historical & Cultural	6 Months
Federal Consistency	Bureau of Statistics and Plan - Guam Coastal Management	Coastal Zone Management Act Section 307(c)(1) and 15 CFR Part 930	2 Weeks
National Environmental Policy Act (NEPA)	U.S. Environmental Protection Agency (EPA)	83 Stat. 852	2 Months
Guam Environmental Protection Agency (GEPA)	GEPA	10 Guam Code Annotated (GCA) Chapters 45-54B, 76, 76A, 90	1 Month
Guam Seashore Protection Commission (GSPC)	GSPC	21 GCA Chapter 63 Guam Territorial Seashore Protection Act of 1974	2 Weeks
Tree cutting/ Depredation	Guam Department of Agriculture (DOAG)	5 GCA Chapter 60	1 Week
Section 7 Consultation	U.S. Fish and Wildlife Service	Section 7, Rare, Threatened & Endangered	2 to 4.5 Months

REFERENCES

- Amidon, F., Metevier, M., and Miller, S. 2017. Vegetation Mapping of the Mariana Islands: Commonwealth of the Northern Mariana Islands and the Territory of Guam. Pacific Islands Fish and Wildlife Service.
- Brown and Caldwell. 2018. Guam Waterworks Authority - Water Resources Master Plan Update. Volumes 1 & 2.
- Dobson, J., Johnson, I., Kowal, V., Rohdes, K., Lussier, B., and Byler, K. 2021. Guam Coastal Resilience Assessment. *UNC Asheville National Environmental Modeling and Analysis Center, Asheville, NC. Prepared for the National Fish and Wildlife Foundation.*
- French Tropical Wetlands Network. 2018. *Mangrove Restoration: the key elements to be considered in any restoration project. Technical guide, Pôle-relais zones humides tropicales.*
- Government of Guam Department of Public Works and US Department of Transportation Federal Highway Administration. February 2024. Guam Transportation Improvement Plan Fiscal Years 2024-2027.
- Greco, Z., Miles, W., King, R., Frazier, A., and Kenner, V. 2020. Climate Change in Guam: Indicators and Considerations for Key Sectors. Report for the Pacific Islands Regional Climate Assessment. Honolulu, HI: East-West Center.
- Guam Department of Agriculture Division of Aquatic and Wildlife Resources (DOG DAWR). 2019. Guam Wildlife Action Plan. Mangilao, Guam.
- Guam Department of Agriculture Forestry & Soil Resources Division (DOG FSRD). 2022. Guam Forest Action Plan. Mangilao, Guam.
- Guam EPA. 2013. Bacteria TMDL's for Twenty-Five Beaches.
- Guam EPA. 2020. 2020 Integrated Report.
- King, R. and M. Higgs, K. Bautista, EL. Guerrero. 2020. Vulnerability Assessment of Built Infrastructure Near Coastal Bays Using Three Sea Level Rise Scenarios – Guam. Fifth Assembly of Planners Symposium. Presented by Evangeline Lujan, Chair of the Climate Change Resilience Commission.
- Lin, C. and Hoot, Whitney (Ed.). 2021. Guam's Seagrasses and Mangroves – A literature review to guide future nature resource management and research. Guam National Coral Reef Fellowship Program.

- NFWF. 2022. Guam REPI Habitat Conservation Initiative: Implementation Plan 2022-2027. With local liaison contractor, Galaide Group.
- NMFS PIRO. (2017). Manell-Geus habitat focus area implementation plan. Tiyán, Guam: NOAA Fisheries.
- NMFS PIRO. (in prep). Socioeconomic assessment results for the Manell-Geus habitat focus area, Merizo, Guam. Honolulu, HI: NOAA Fisheries Technical Report.
- NOAA. [Manell-Geus Habitat Focus Area StoryMap](#)
- Pait, A., Mason, A., Hartwell, S., and Apeti, D. 2019. An Assessment of Chemical Contaminants in the Waters Around Cocos Island, Guam Using Polyethylene Passive Water Samplers. NOAA Technical Memorandum NOS NCCOS 261. Silver Spring, MD.
- Parsons Public Transportation Group, Inc. 2010. Stormwater Drainage Master Plan. Government of Guam Department of Public Works.
- Raymundo, L., Goldstein B., Baker, D., Kim, K., McIlroy, S., Thompson, P., Lapack, V., Duprey, N., Cybulski, J., LaRoche, C., Geeraert, N. (2018). Atlas of the Nearshore Shallow Benthic Habitats Within the Manell-Geus Habitat Focus Area. University of Guam Marine Laboratory Technical Report No. 163.
- Spalding, Mark D and Leal, Maricé. 2021. The State of the World's Mangroves 2021. Global Mangrove Alliance.
- U.S. Army Corps of Engineers (ACOE). 2022. Manell River, Merizo, Guam. Federal Interest Determination Report, Continuing Authorities Program Section 205, Flood Risk Management.
- U.S. Army Corps of Engineers. 2022. Guam Final Watershed Plan.
- USEPA (U.S. Environmental Protection Agency). 2008. Handbook for Developing Watershed Plans to Restore and Protect Our Waters. Washington, DC: U.S. Environmental Protection Agency. EPA-841-B-08-002.
- Wongbusarakum, S., Brown, V., Loerzel, A., Gorstein, M., Kleiber, D., Quinata, M., Iwane, M., and Heenan, A. (2019). Achieving social and ecological goals of coastal management through integrated monitoring. *Journal of Applied Ecology*, 56, 2400-2409.
- World Bank. 2016. Managing Coasts with Natural Solutions: Guidelines for Measuring and Valuing the Coastal Protection Services of Mangroves and Coral Reefs. M. W. Beck and G-M. Lange, editors. Wealth Accounting and the Valuation of Ecosystem Services Partnership (WAVES), World Bank, Washington, DC.

APPENDIX A – FOCUS AREA CONCEPTS

APPENDIX B – FIELD REPORT

ATTACHMENT C – POLLUTANT LOAD MODELING

APPENDIX D – WATERSHED CHARACTERIZATION
