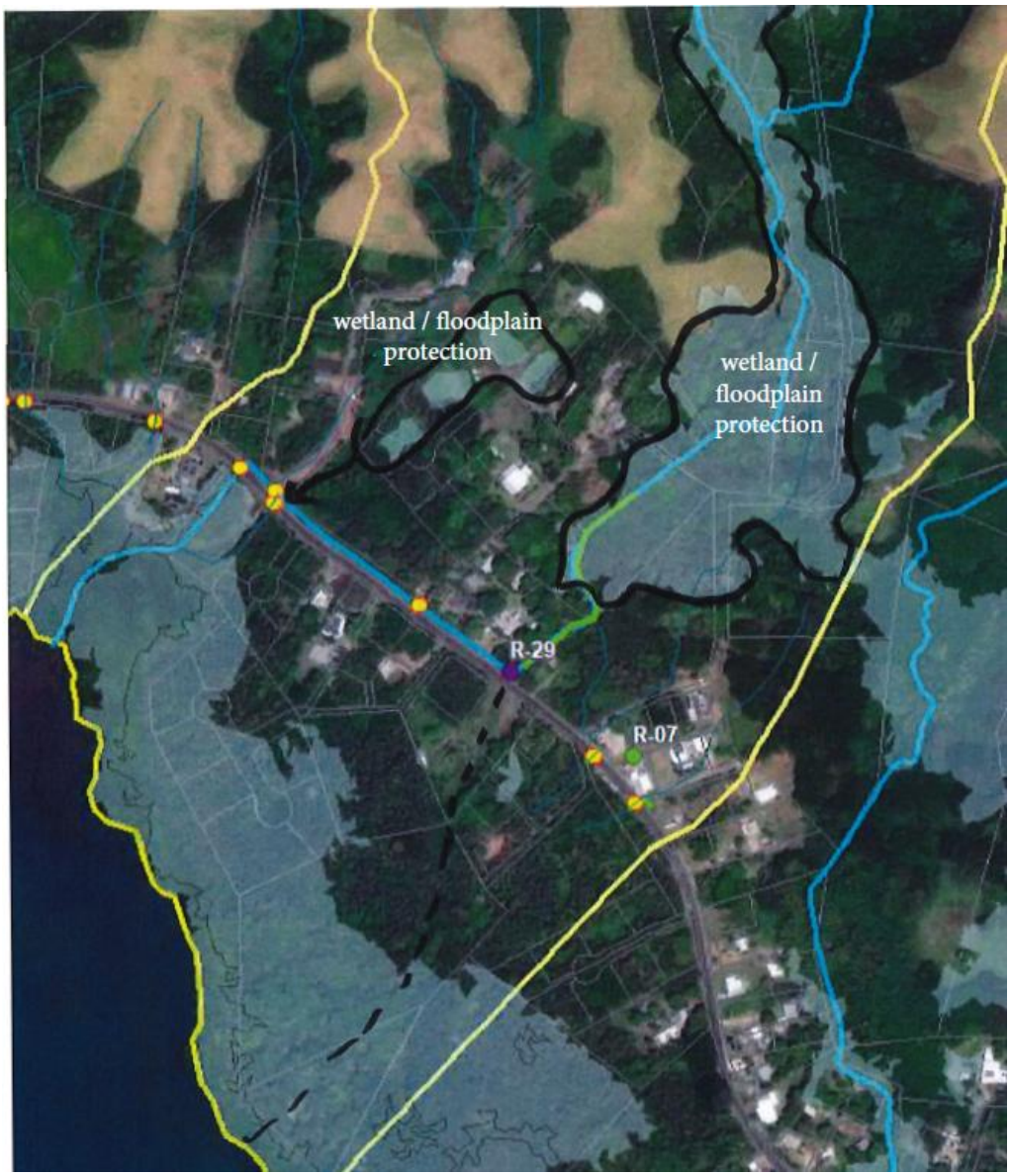
APPENDIX A. FOCUS AREA CONCEPTS

Focus Area 1 – Manell River



Screen capture of map showing project locations in the Manell River Focus Area

R-29 ACOE Manell River Project

ACOE, in coordination with the Government of Guam, has been evaluating several alternatives for reducing flood impacts at the Manell River Focus Area, as described in their Federal Interest Determination (2022). These alternatives 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 as well as overland basins; and (4) non-structural dry floodproofing of the roughly 26 buildings in the impact area. The alternative focused on fully

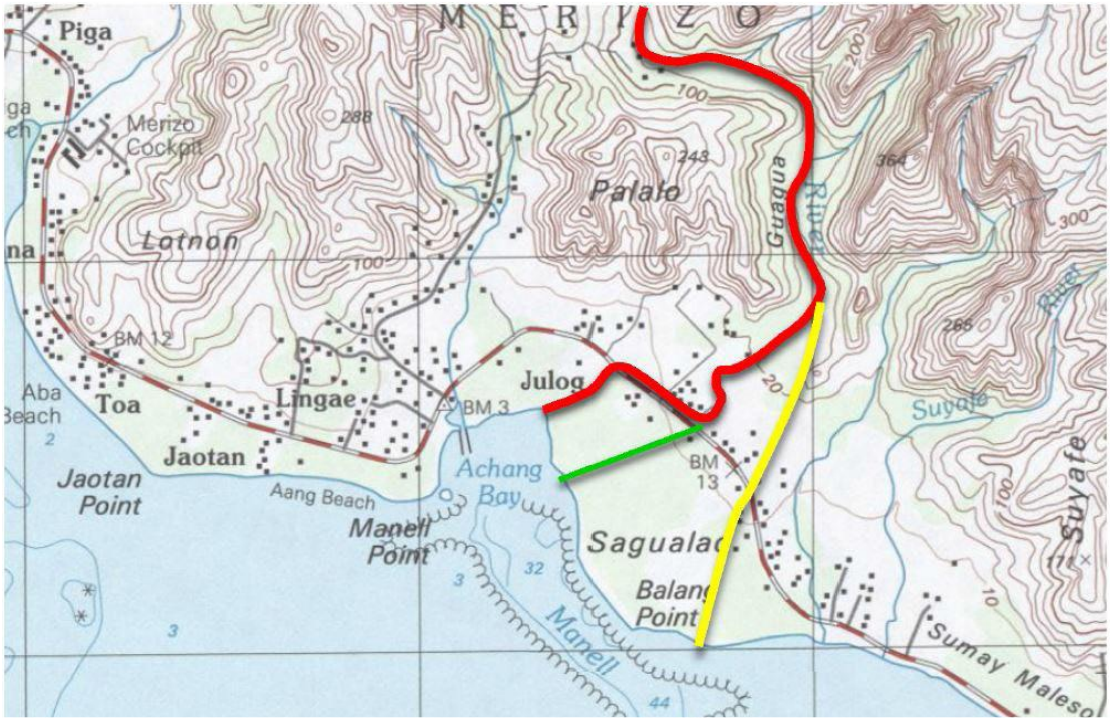
managing the 5-year flood event, while also decreasing flood impacts for larger storms. They have done preliminary hydrologic/hydraulic modeling, design concepts, and cost/benefit analyses for all alternatives. At this stage, they have determined that there are sufficient benefits to continue with the feasibility study. The estimated construction costs for all four are approximately $4,000,000, which includes engineering and design, supervision and administration, and contingency, but not including any real estate costs.

This is a very important project for the Manell River Focus Area. However, we recommend that the ACOE and partners consider the following items when advancing this design for the greatest long-term benefits to the watershed. A more detailed concept is shown for this restoration opportunity at the end of this appendix.

Channel Realignment

At this stage of design, ACOE is analyzing a new culvert under Route 4 and a realigned straight, trapezoidal channel in the location shown on **Figure 1**, while maintaining the existing paved channel for overflows during flood events larger than the 5-year return interval as well as managing road runoff. As shown on our concept below, we recommend a bridge instead of a culvert to reduce continued clogging impacts from bamboo and other debris getting caught on one or more culverts similar to existing. In addition, we recommend creating a more natural channel shape (both in cross-section and longitudinally) that is planted with native vegetation and meanders with the existing contours given parcel ownership constraints. This naturalized realignment will require less maintenance over time, provide more water quality and habitat benefits as well as flooding and also be more resilient to climate change.

Figure 1. Current (red), Proposed (green), and Historical (yellow) Path of the Manell River – Excerpt from ACOE 2022.

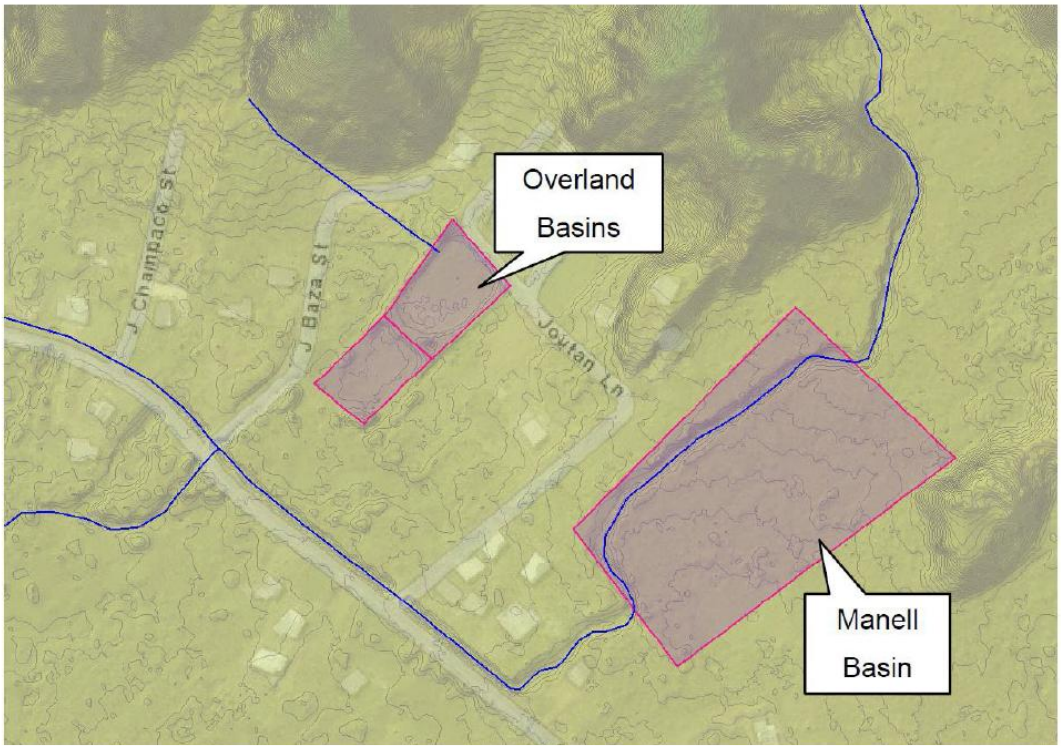


Floodplain/wetland Restoration rather than Detention Basins

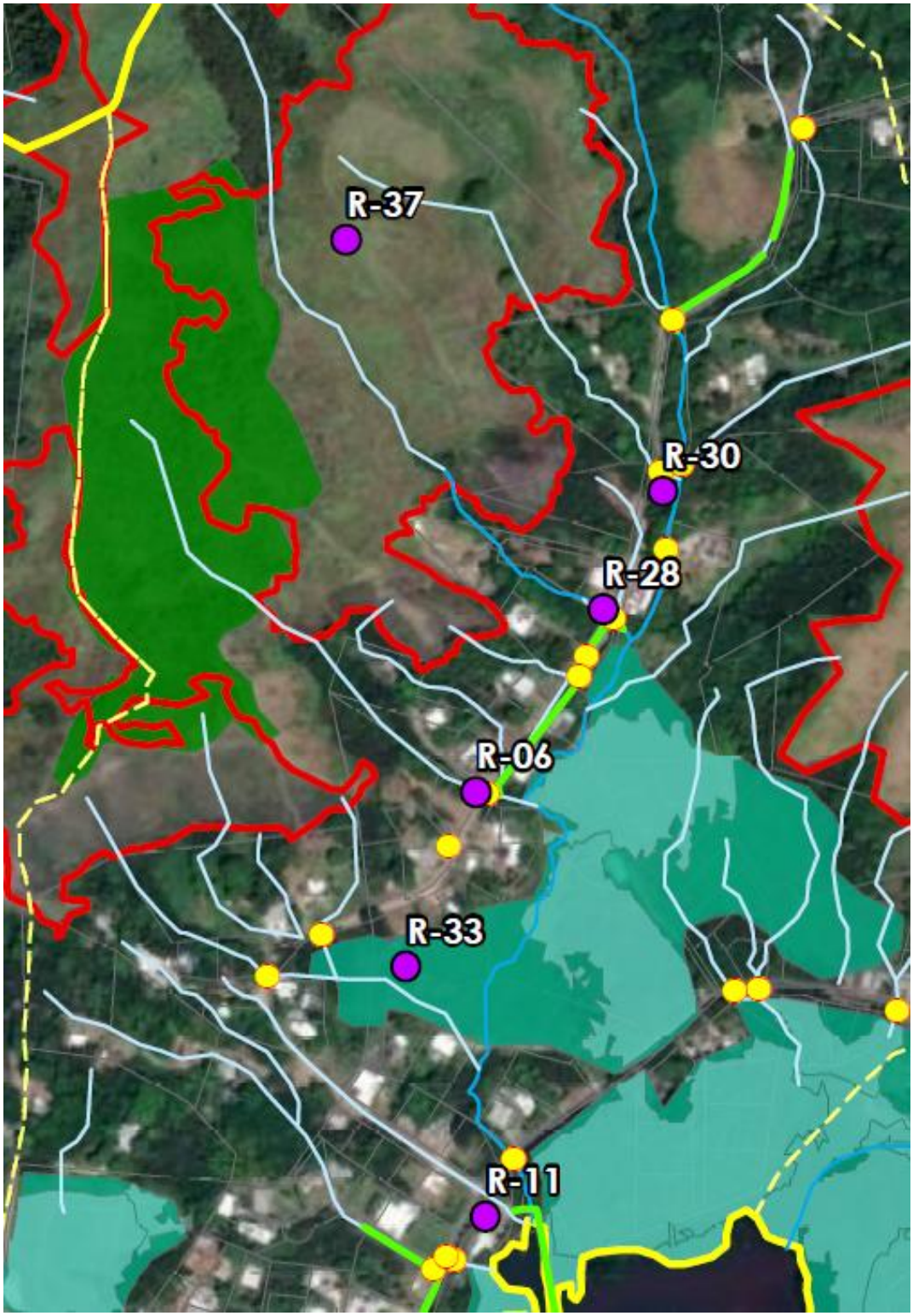
The detention basin concept currently shows an in-stream "Manell Basin" (proposed as 6.4 acres at 5 feet deep) and two "Overland Basins" (3 feet deep) (**Figure 2**). Both of these proposed basins are located in existing vegetated wetland areas. The overland basins are proposed where previous basins may have existed, based on topography. As shown in our concept, we recommend modifying this alternative to floodplain/wetland restoration instead of detention basins. Detention basins will remove vegetation and habitat while creating a feature that will require on-going and frequent maintenance to ensure long-term functionality. Instead, reconnecting the river to a natural floodplain and removing invasive bamboo will provide more resilient flood control as well as other benefits to water quality and habitat. The overland basin location appears to have been a flow path from upland areas down to the river before the area was developed – this natural flow path can be re-established with the proposed culvert through a restored wetland area and then overflows would be safely directed to the existing concrete channel.

ACOE notes that the alternatives could be implemented independently of one another; while that is true, we recommend that they be implemented as a total package if possible for the greatest impact. For example, the new channel will function better if an upstream restored floodplain reduces flows, sediment, and bamboo debris. The restored wetlands in the overland basin area will better control flooding if they can discharge to an "empty" concrete channel if the new channel is handling most of the flow. Each practice will be more effective if combined.

Figure 2. Proposed detention basin sites – excerpt from ACOE 2022.



Focus Area 2 – Quinene Road



Screen capture of GIS data showing the proposed restoration opportunities for the Quinene Focus Area. The green area is the Quinene Reforestation Site while red loosely outlines grasslands/ badlands; dry flow paths shown with white lines, while designated streams shown with blue lines; turquoise indicates wetland enhancement/ protection areas; restoration sites indicated with purple dots, and existing drainage infrastructure with yellow dots and green lines.

R-28: Restore Natural Hydrology/Reconnect Tributaries to River

This restoration opportunity focuses on restoring the natural connection at **7 flow paths** along the road to reduce flooding and sediment loading (**Photo 1**). New, larger culverts should be installed under the road to convey flow into the river. Sediment forebays should be constructed on the upstream side for maintenance purposes. Existing roadside ditches should be maintained just for road runoff, not for the upland flows.

R-6: Residential Stewardship

To complement the larger roadside project described above, public outreach and involvement with the residents in this neighborhood would help reduce flooding. Residents can learn the importance of vegetative debris management and material stockpiling to keep reconnected flow paths to the river open (**Photo 2**).

Photo 1. Various locations along the Quinene Road showing stains from ponding, clogged culverts, scouring, and sand bags where residents are trying to protect their homes from floodwaters.

Photo 2. Vegetative debris is blocking the flow path upgradient from a headwall in the Quinene neighborhood.

R-37: Badlands Restoration

The existing Quinene Reforestation site has already made such an impact in this area stabilizing soils, creating habitat, and providing outreach activities. For this restoration opportunity, the focus should be on continuing these efforts by expanding into the 30-acre patch of grasslands/badlands to the north.

R-30: Bamboo Removal

Large stands of bamboo were observed in this focus area, as well as fallen bamboo in the stream. Continuing with existing efforts in the watershed, the live bamboo should be cut, following with herbicide application to the cut stems. Remove fallen bamboo and other debris from the stream.

R-33: Wetland Enhancement/Protection

Natural wetlands are located along the unnamed river's floodplain where the land starts to level out in the coastal plain. Residential development has encroached on this wetland over time, and there are many additional undeveloped, private parcels in this area. This restoration opportunity involves protecting 17 acres of existing wetland/floodplain area from future development while also encouraging wetland vegetation to grow back where disturbance has occurred.

R-11: Achang Boat Ramp Stormwater Management

The boat ramp is an important public access to the Bay and Lagoon. However, stormwater runoff flows down the road and driveway to the water, carrying with it sediment and other pollutants, as well as eroding the edges of the ramp itself. This is a tight area adjacent to a private residence with associated utilities; however, there is some space to incorporate some

bioretentions to help reduce and clean runoff. In addition, the edges of the boat ramp should be stabilized to prevent continued scouring. This is also a great location for a sign to help provide information to the public on the watershed and restoration work. The estimated drainage area to this site is 0.3 acres, and the total proposed bioretention footprint would be ~550 sf. A detailed concept plan is included for this site at the end of this appendix.

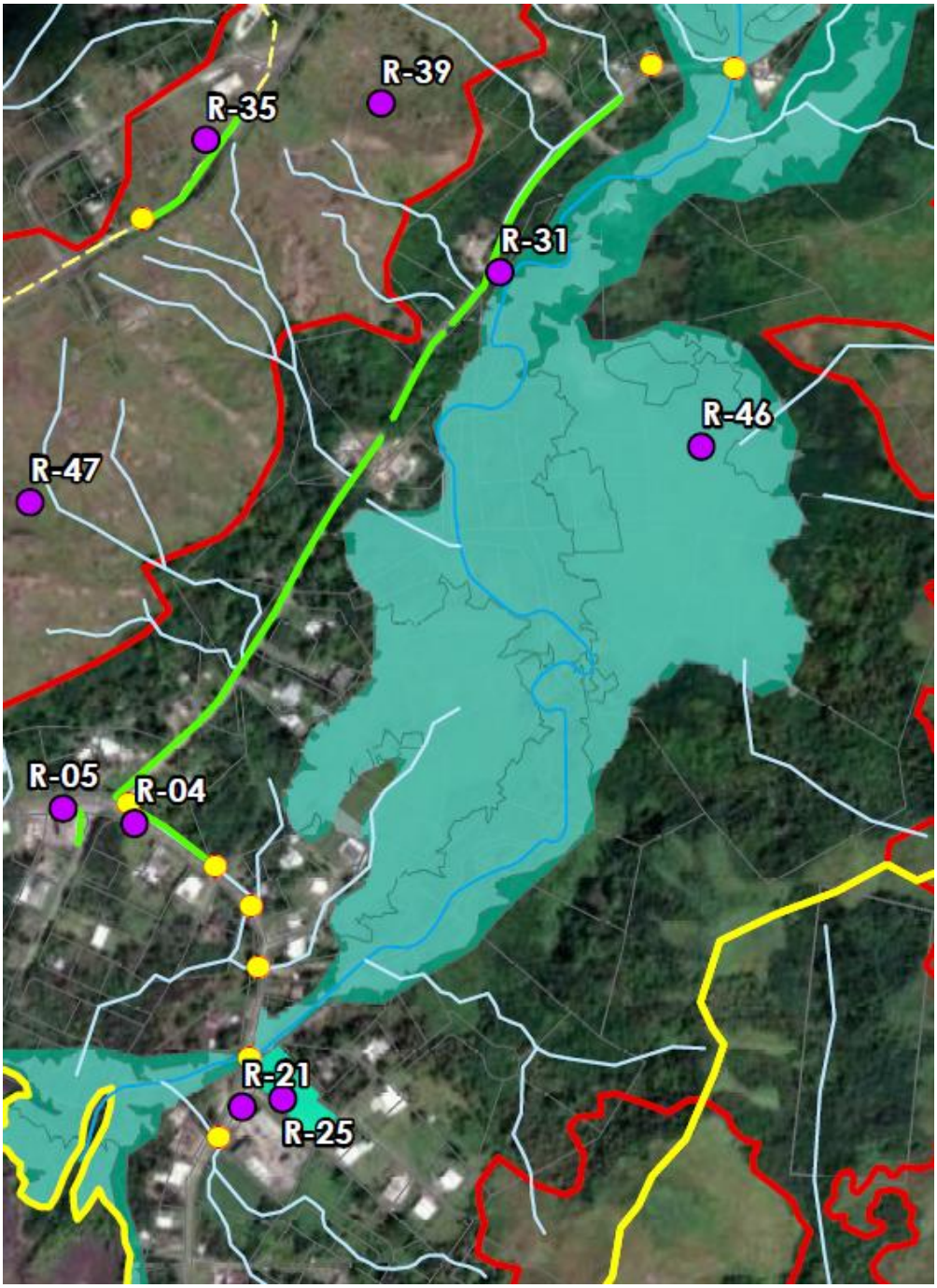
Available space for a bioretention between the driveway and the stakes (left); eroding boat ramp leading into Achang Bay (right).

These restoration projects would be best implemented at the same time to maximize effectiveness. For example, if new, larger culverts are installed, but the badlands are not addressed, the new culverts will be hard to maintain. If the boat ramp bioretention is installed before the new culverts, there may be too much flow for it to manage.

Focus Area 3 – Geus River/Road

R-47 Restore Natural Hydrology/Reconnect Tributaries to River

Much like in Quinene, this restoration opportunity focuses on restoring the natural hydrologic connection to the Geus River with culverts and natural swales at **5 flow paths** along the road to reduce flooding and sediment loading from upland flows. Sediment forebays should be constructed on the upstream side for maintenance purposes. Easements may be required for any channel work required on private property between the road and the river. Existing roadside ditches should be maintained just for road runoff, not for the upland flows, modified with natural features and sediment traps for pollutant removal and maintenance before discharging into the new connections to the river.



Screen capture of GIS data showing the proposed restoration opportunities for the Geus Focus Area. The red loosely outlines grasslands/badlands; dry flow paths shown with white lines, while designated streams shown with blue lines; turquoise indicates wetland protection areas; restoration sites indicated with purple dots, and existing drainage infrastructure with yellow dots and green lines.

R-39 Badland Restoration

Roughly 100 acres of grasslands/badlands contribute sediment to the Geus Focus Area. This would be a good location for another FSRD reforestation site. However, as shown in Figure 11 of the Manell-Geus WMP, this area is not currently proposed to be included in the Forest System Inventory. More work is needed to determine ownership of these areas, and opportunities for restoration.

R-31: Bamboo Removal

Large stands of bamboo were observed in this focus area, as well as fallen bamboo in the river and clogging downstream infrastructure. Continuing with existing efforts in the watershed, the live bamboo should be cut, following with herbicide application to the cut stems. Remove fallen bamboo and other debris from the river.

I-39 Merizo Inland Culvert Rehabilitation

This is a DPW project slated for implementation in 2024. The culvert is comprised of three 24-foot box culverts with wingwalls. Various pipes are present along the stretch. Erosion was observed undermining the concrete bottom and along the edges. The rehabilitation should ensure that the culverts are sized correctly for anticipated future storm events, angled for both the river flow as well as the flows coming down from the badland area to the west, and protective of important water and sewer infrastructure.

R-46 Wetland/Floodplain Protection

There are roughly 65 acres of freshwater wetland associated with Geus River and its floodplain. Some residential encroachment was observed in this area, and the area is divided into many separate lots per GIS parcel data. This restoration opportunity involves protecting these areas from future development as well as encroachment through outreach, regulations, and enforcement. The wetlands and floodplain area around the Geus River are vital for long-term flood control and habitat.

R-21 Public Housing Stormwater Management

The Helmani Apartments are located along Route 4 near Geus River. The whole area is located in the FEMA flood zone. The site has two large buildings with parking and a driveway between. The area is quite flat, and ponding was observed during the site visits. The shoulder along the road near the entrance is also eroding, perhaps from parking in the ROW.

The concept for this site is to regrade the parking lot to direct runoff into two bioretention areas in the existing grass. In addition, use permeable pavers along the shoulder for stabilization. This is also a great location for a sign to help provide information to the residents on the watershed and restoration work. The estimated drainage area to this site is 0.95 acres, and the total proposed bioretention footprint would be ~1,200 sf. A detailed concept plan is included for this site at the end of this Appendix. It would be most cost effective to implement this restoration opportunity in conjunction with other upgrades at the site, such as repaving. Also, if the buildings are upgraded for flood protection or if the roofs are replaced, gutters connected to cisterns should be considered at this site.

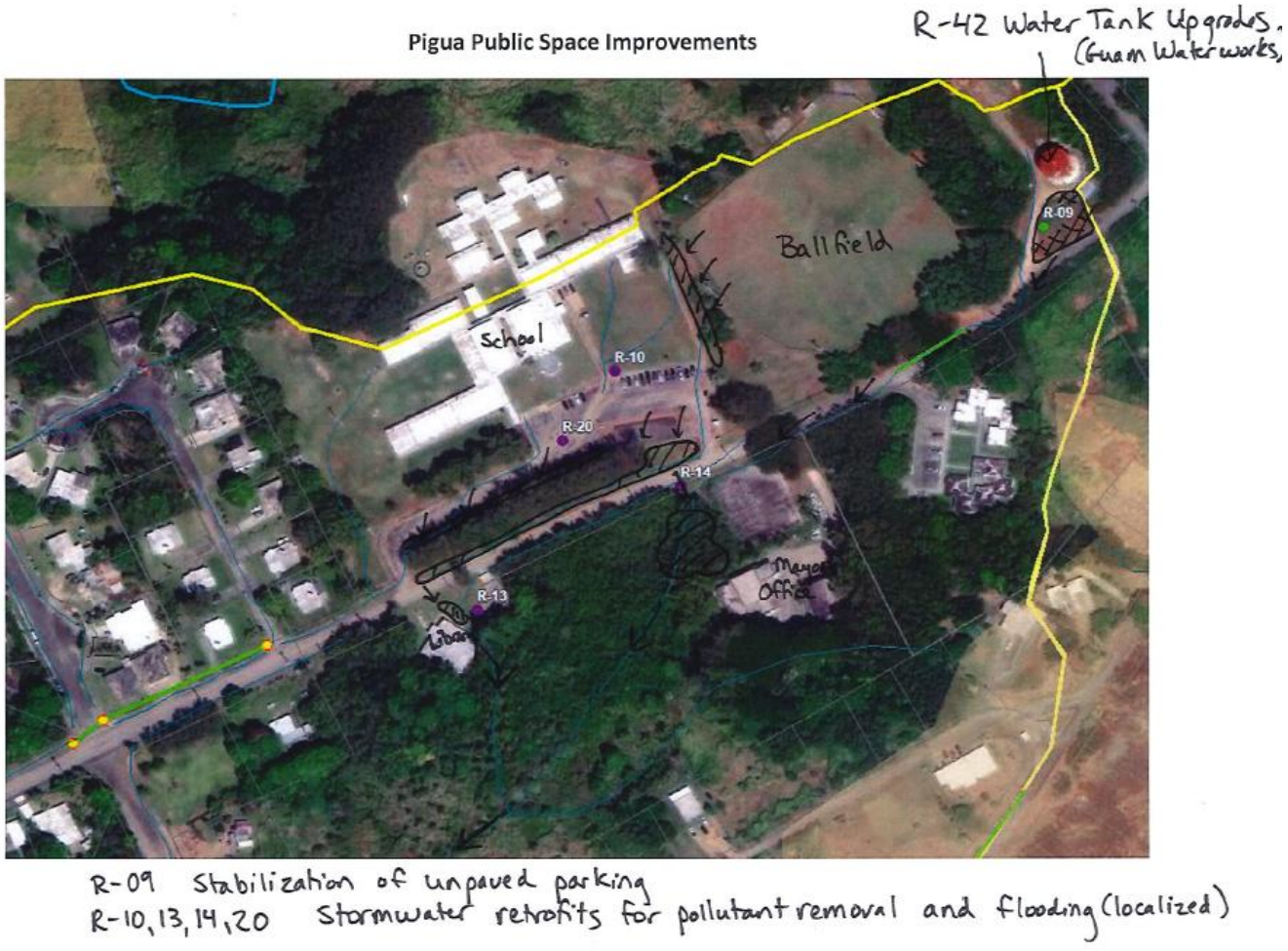
Ponding in the parking lot (upper left); grassy area available for a bioretention (upper right); and screenshot from Google Streetview showing the eroding shoulder along Route 4 (bottom photo).

ME-118: Geus River Culvert Upgrade & R-25 Geus River Floodplain Restoration

The culvert under Route 4 for the Geus River is comprised of 4 12'x18' box culverts. These culverts appear to be undersized, causing debris build-up on the upstream side, with evidence of flooding and erosion. The DPW does have this project listed as one of their priority sites, but the identified action is just debris/sediment removal. Instead, the DPW should model the capacity of these culverts and consider constructing a bridge in this area as a more resilient and sustainable alternative to protect the road, and sanitary sewer, into the future. In addition, there may be an opportunity to restore a cleared portion of floodplain near the culverts for additional flood storage. The 0.7-acre undeveloped parcel is already located within the floodplain, but could be enhanced for better connection with the river.

Exposed sanitary sewer along the Geus River box culverts, with bamboo debris in the river (left); swale (middle) where flooding from the river flows into an undeveloped lot (right).

Focus Area 4 – Pigua Public Spaces



Screenshot of the projects in Focus Area 4

R-9: Pigua Water Tank Paving

The area in front of the water tower is unpaved and eroding, likely exacerbated from parking for the adjacent athletic field. When it rains, sediment from this area washes down the street and clogs drainage infrastructure. Proposed restoration opportunity here is to pave the driveway for the water tower (2,500 sf) and add stabilized paver parking for the ballpark (3,500 sf). Addressing this source of sediment will benefit downgradient proposed restoration opportunities (R-13, R-14). The estimated drainage area to this site is 0.3 acres, and the total proposed bioretention footprint would be ~550 sf. A detailed concept plan is included for this site at the end of this appendix.

R-10: School Courtyard Cutoff Trench

Staff at Merizo Martyrs' Memorial Elementary School let us know that the area next to the school along a steep slope below the athletic field often is very soggy. Brown water then flows off the grassy courtyard into the parking lot and road – the pavement is stained in this area. Maintenance vehicles then drive through the area, getting stuck and creating muddy holes. The proposed restoration opportunity here is to intercept this groundwater source along the base of the slope with a stone infiltration trench (150 lf), diverting it downhill to the proposed features for R-20. Keeping the grassy courtyard dry will prevent the sediment/mud from causing problems in the parking lot and for maintenance. In addition, the steep slope should be revegetated (6,000 sf) to better hold soil in place. A detailed concept plan is included for this site at the end of this appendix.

R-13: Rosa Aguigui Reyes Memorial Library, Merizo Branch

Currently, stormwater runoff from the road and school flows into the driveway and parking lot for the library, leaving sediment and causing ponding in front of the building. The proposed restoration for this area is to first manage some of the drainage area with other stormwater management features (R-9, R-10, R-20, R-14) and build a series of bioretentions at the library to manage the remaining stormwater. This smaller drainage area would be roughly 1.2 acres, with 0.36 acres of impervious cover. The bioretention areas should be planted with important local species to beautify the library's entrance and help educate visitors about stormwater. This would be a great location for educational signage. A detailed concept plan is included for this site at the end of this appendix.

R-14: Merizo Mayor's Office Constructed Wetland

Currently, stormwater runoff from the water tower, road, and a portion of the school ponds along the road by the Mayor's Office, leaving sediment and staining. The proposed restoration for this area is to first manage some of the drainage area with other stormwater management features (R-9, R-10, R-20) and build a constructed wetland to manage the remaining stormwater. The total drainage area would be roughly 7.7 acres, with 1.8 acres of impervious cover, which also includes runoff from the Mayor's Office, Community Center, and newly upgraded basketball courts. The constructed wetland would be built in an existing undeveloped low area adjacent to the unnamed stream. A detailed concept plan is included for this site at the end of this appendix. In addition to reducing sediment and road flooding, this restoration opportunity would also reconnect the natural hydrology in the area, getting runoff of the roads and back into the stream.

R-20: School Parking Lot Bioretention Areas

Stormwater runoff from the school's parking lot and driveways currently flows out to the main road with no stormwater management, including the runoff from the athletic field/courtyard (described in R-10). The parking lot is quite flat, which leads to ponding after rain events. Sediment has built up along the curb, allowing vegetation to grow in the parking lot. The restoration opportunity here is to construct bioretention areas/swales in the grassy area alongside the parking lot. Runoff would enter the bioretentions through curb cuts spaced to prevent ponding. Sediment forebays would be used for pretreatment and easy maintenance. The total drainage area would be roughly 2.4 acres, with 0.9 acres of impervious cover. A detailed concept plan is included for this site at the end of this appendix. This is also a good location for educational signage on stormwater and watershed issues.

R-43 Pigua Water Tank Upgrade

GWA owns and operates a water tank at the top of the Pigua Subwatershed. Residents have observed this tank overflowing at times, sending water down the roads. The replacement of this tank is on GWA's priority list and is scheduled in the next five year.

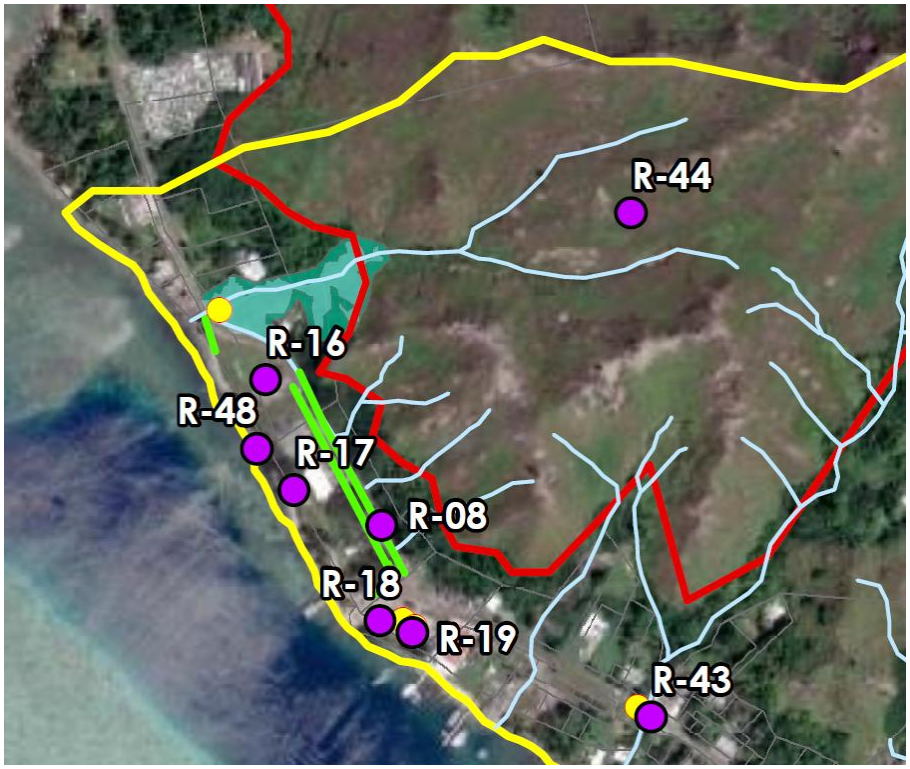
Pigua Tank	
Project Number	MP-PW-Tank-12
Description	Inspect and repair the existing 500,000-gallon tank.
Justification	The existing tank is in poor condition.
Proposed Schedule	Begin Design: 2019
Cost Estimate	$990,000
Reference Documents	WRMPU Volume 2, Table 6-2

Existing tank in 2016

This proposed project is subject to change. Projects will generally include an engineering study, detailed design, and field verification to refine the exact project scope and budget. Costs are presented in 2017 dollars and do not account for increases due to inflation and escalation. See Volume 1, Appendix D for cost estimate assumptions.

Excerpt from GWA's Water Resources Master Plan Update (2016) describing the Pigua Tank project.

Focus Area 5 –Merizo Pier



Screen capture of GIS data showing the proposed restoration opportunities for the Merizo Pier Focus Area. The red loosely outlines grasslands/ badlands; dry flow paths shown with white lines; turquoise indicates wetland enhancement/ protection areas; restoration sites indicated with purple dots, and existing drainage infrastructure with yellow dots and green lines.

R-44 Badland Restoration

There are steep, eroding grasslands/badlands (~40 acres) contributing sediment to the Merizo Pier Park area. This restoration opportunity involves applying FSRD's reforestation techniques from As Gadao and Quinene to this important area. This land is proposed to be included in the Forest System Inventory, but appropriate long-term access would need to be acquired. This prominent location would also serve as effective public outreach, as reforestation efforts could be viewed by boats coming into the pier.

R-48 Shoreline Stabilization

The shoreline along the park is severely eroding, which will soon threaten both infrastructure and recreational use in this area (photo). Given public safety and limited space issues in this location, a hard-edge shoreline restoration (800 lf) using both large rocks and vegetation is recommended. A detailed concept plan is included for this site at the end of this appendix under "Coastal Shoreline Restoration."


R-08 Parking Stabilization

Runoff currently flows from the adjacent steep, eroding slope (5.7-acre drainage area) to the main road at Merizo Pier Park. This area is a popular parking location for the park, where vehicles are often parked on both sides of the road (photo). Based on discussions with maintenance staff, we learned that sediment used to flow from the slope and cover the road, leaving many inches that needed to be removed whenever there was significant rainfall. As a result, maintenance staff built an informal berm to redirect sediment-laden flows to the north toward a stream. However, the roadsides still receive runoff from the road itself and are often wet, leading to erosion and sedimentation from the vehicles.

The restoration opportunity here is to repave/regrade the road (11,000 sf) to better direct runoff to a stabilized concrete swale (450 lf), install permeable pavers for the parking areas (8,000 sf) to allow for some infiltration as well as stabilization, and formalize the maintenance efforts to keep the hillside runoff off the road with a grass swale (350 lf). This project will reduce sediment, improve a public amenity in this popular area, and reduce runoff currently flowing to the community center parking lot (R-16) and toward the pier itself. A detailed concept plan is included for this site at the end of this appendix. This is also a good location for educational signage on stormwater and watershed issues.



R-16 Merizo Pier Park Court Parking Lot Bioretentions

Stormwater runoff from a portion of the road flows into the parking lot next to the basketball court. From there, the runoff flows along the edge of parking lot, ponds, and then overflows toward a picnic table, adding to the shoreline erosion in this area (photo). The stormwater management could be improved at this site with two bioretentions in both corners of the parking lot, to capture sediment and other pollutants, while also improving the condition of the parking lot and picnic area. While a detailed concept plan was not prepared for this site, a rough sketch is included in the field forms included in **Appendix B.**


Impervious surfaces and opportunities for green stormwater infrastructure.

R-17 Community Center Rain Garden

This site is at the Merlyn G. Cook School, a historic former school located in Merizo Pier Park that serves as an important community meeting location. Currently, roof runoff flows off the roof in all directions (no gutter), ponding behind the building (photo). The concept for this site is to hold a hands-on community workshop in this location on watershed issues and then build a rain garden with the participants. The existing dripline could be stabilized/formalized with stone to reduce erosion, and the rain garden would be planted with native vegetation. This is a great location for educational signage that could cover information on R-08, R-16, as well as R-48. A rough sketch is included in the field forms included in **Appendix B.**


Historic Merlyn G. Cook School (left); visible ponding in the roof dripline behind the building (right).

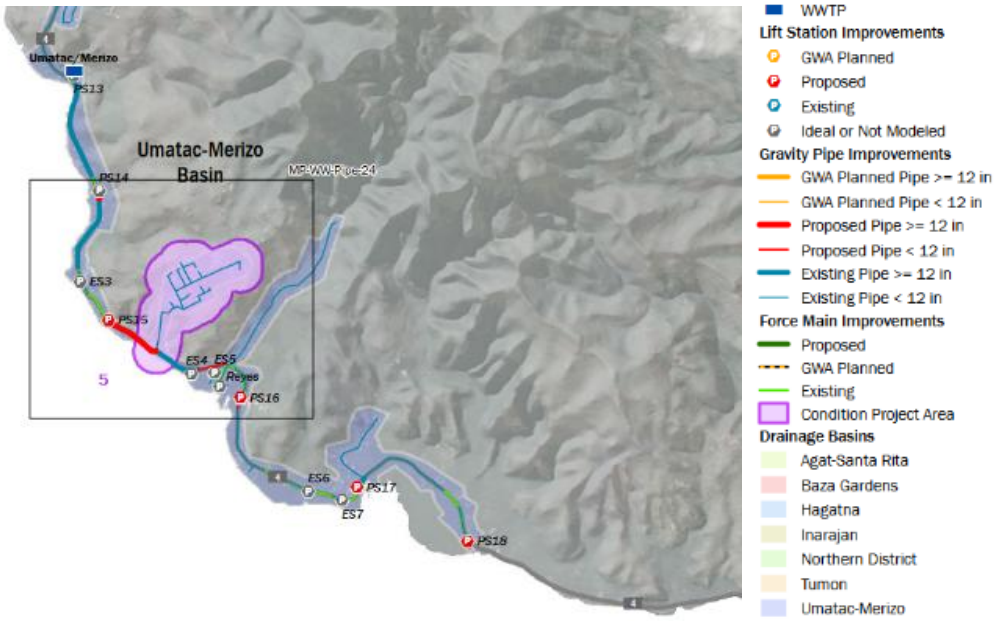
R-18-19 Merizo Pier Parking Lot Bioretentions

Stormwater runoff from the pier parking lot either flows overland or is collected in catchbasins and directly discharged to the channel with no treatment. The restoration opportunity here is to construct two bioretentions in the grassy areas alongside the parking lot. For R-18, a curbcut would direct flows to the bioretention, while for R-19, the existing catchbasins would be retrofit to send runoff from small storms to the bioretention, while larger flows continued to the channel. Sediment forebays would be used for pretreatment and easy maintenance. The total drainage area would be roughly 2 acres, with 0.5 acres of impervious cover. A detailed concept plan is included for these sites at the end of this appendix. This is also a good location for educational signage on stormwater and watershed issues, or these retrofits could be included in the sign for R-17.

The Pier Parking Lot discharges stormwater directly to the Mamaon Channel. Grassy areas next to the parking lot are great for stormwater management

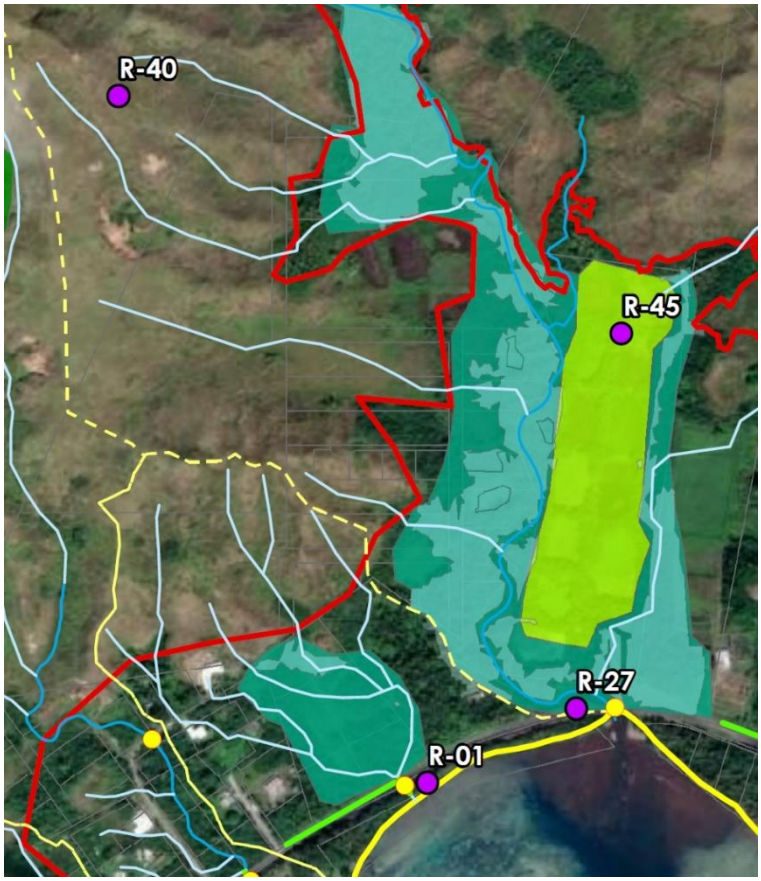
R-43 Umatac-Merizo Sewer Replacement

Along Route 4 just east of Merizo Pier Park and west of the belltower, an undersized sewer pipe has overflowed during rain events. GWA has prioritized the replacement of this pipe (Project MP-WW-Pipe-24 Umatac-Merizo Capacity Replacement), and it is expected to be implemented in the next five years. This project is very important for reducing bacteria and nutrient loading into the Mamaon Channel and maintaining public safety.



Excerpt from GWA (2016) showing the location of the proposed pipe to be upgraded and the impacted service area.

Focus Area 6 –Ajayan River



Screen capture of GIS data showing the proposed restoration opportunities for the Ajayan River Focus Area. The red loosely outlines grasslands/badlands; dry flow paths shown with white lines, while designated streams shown with blue lines; turquoise indicates wetland protection areas; restoration sites indicated with purple dots, and existing drainage infrastructure with yellow dots and green lines.

R-27/ME-130/IV-120: River Restoration/Infrastructure Improvements

This restoration opportunity combines the Ajayan Bridge Repair (DPW priority project ME-130/IV-120) with riverbank stabilization techniques. The alignment of the bridge relative to the geometry of the river causes sedimentation along the inside bend, erosion along the outside, and has contributed to structural deficiencies of the bridge itself. Large sediment deltas are visible at the mouth and into the preserve. While DPW is scheduled to repair the bridge in the next five years, they should also consider adjusting the span/geometry to better match the river flow, as well as adding hard and soft bank stabilization in this area.

R-45: Floodplain/wetland Restoration

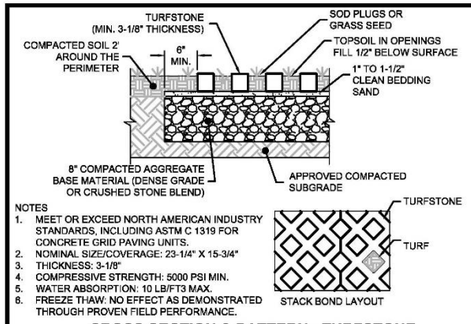
Ten acres of former aquaculture ponds were constructed within the wetlands/floodplain to the Ajayan River. This restoration opportunity should explore how much additional flood mitigation, sediment trapping, and habitat could be gained by removing the berms and restoring these ponds back to natural floodplain.

R-40: Badlands Restoration

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. This restoration project involved expanding FSRD's As Gadao Reforestation site to stabilize some of the hotspots. Other access points should be investigated to prevent overuse of the As Gadao site access road.

R-1: Shoreline Stabilization

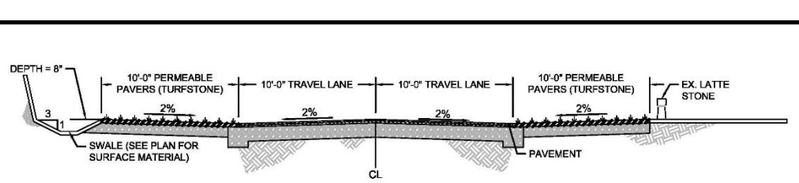
Route 4 (400 lf) is threatened by coast erosion in this Focus Area. This may be a good location adjacent to the marine preserve to implement natural shoreline restoration, building a living shoreline to protect infrastructure but also restoring mangroves in this area. The nearby University of Guam Experimental Agriculture Station may be interested in propagating appropriate species for this site. A more detailed concept is included at the end of this appendix under Shoreline Concept Plan.



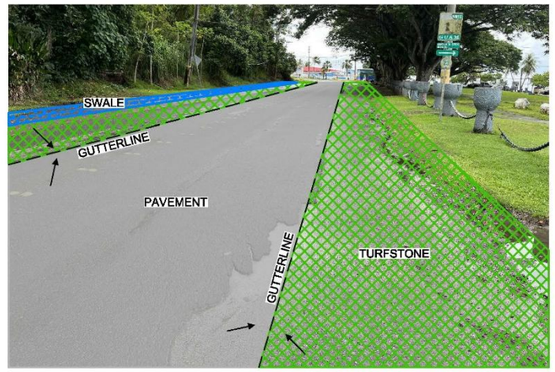
NOTES
1. MEET OR EXCEED NORTH AMERICAN INDUSTRY STANDARDS, INCLUDING ASTM C 1319 FOR CONCRETE GRID PAVING UNITS.
2. NOMINAL SIZE/COVERAGE: 23-1/4" X 15-3/4"
3. THICKNESS: 3-1/8"
4. COMPRESSIVE STRENGTH: 5000 PSI MIN.
5. WATER ABSORPTION: 10 LB/FT3 MAX.
6. FREEZE THAW: NO EFFECT AS DEMONSTRATED THROUGH PROVEN FIELD PERFORMANCE.

CROSS SECTION & PATTERN - TURFSTONE
NOT TO SCALE

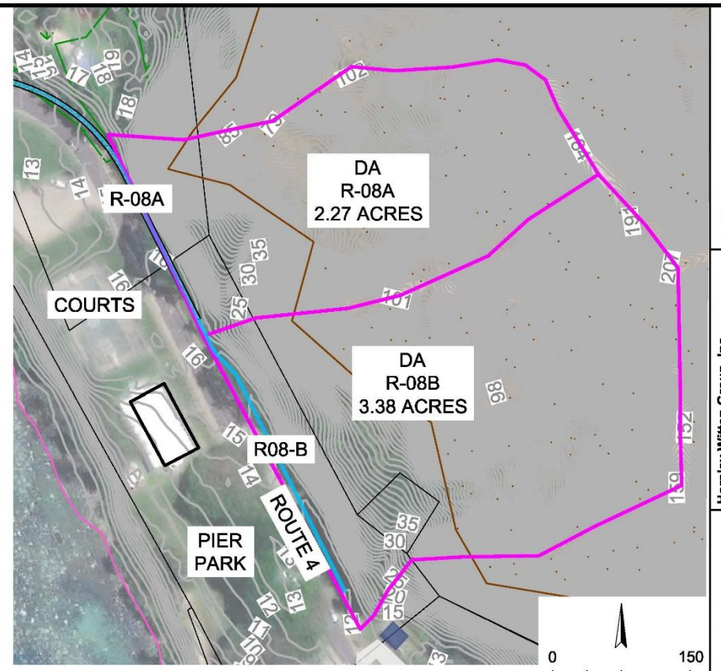
TURFSTONE LAYOUT



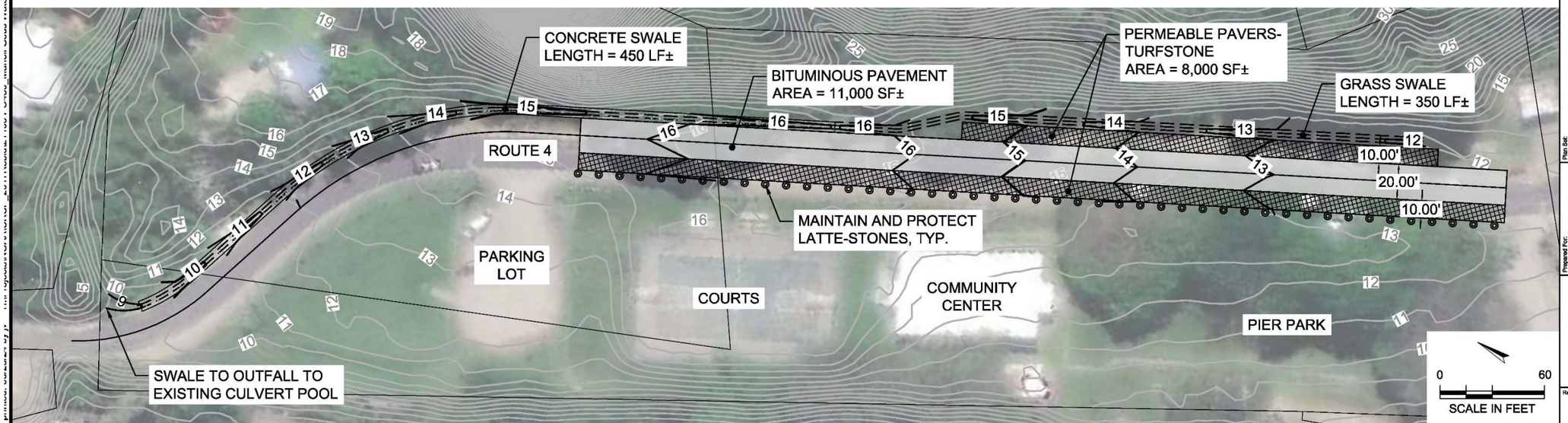
TYPICAL PIER PARK ON-STREET PARKING SECTION
NOT TO SCALE



SITE LAYOUT



DRAINAGE AREA MAP



CONCEPT PLAN

MERIZO PIER PARK- STREET PARKING IMPROVEMENTS (ID# R-08)
PIER PARK FOCUS AREA

Revisions

Horsley Witten Group, Inc.
Sustainable Environmental Solutions
www.horsleywitten.com
90 Route 64
Sandwich, MA 02563
508-833-6600 voice
508-833-3150 fax

Date: JUNE 2024
Design By: JLV
Drawn By: JLV
Checked By: MW

MANELL-GEUS WATERSHED MANAGEMENT PLAN
MERIZO, GUAM

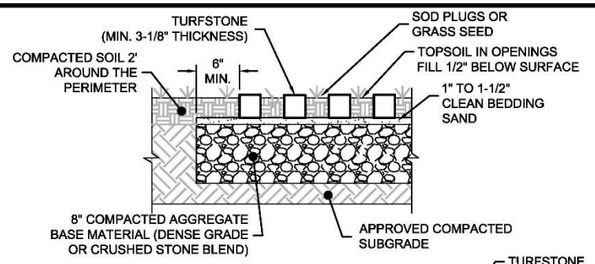
R-08 CONCEPT PLAN

Prepared For:
National Oceanic and Atmospheric Administration (NOAA)
200 GRANBY STREET
NORFOLK, VA 23510

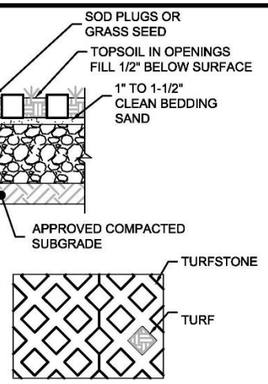
Registration:

Project Number: 21105

Sheet Number: 1 of 11



NOTES
1. MEET OR EXCEED NORTH AMERICAN INDUSTRY STANDARDS, INCLUDING ASTM C 1319 FOR CONCRETE GRID PAVING UNITS.
2. NOMINAL SIZE/COVERAGE: 23-1/4" X 15-3/4"
3. THICKNESS: 3-1/8"
4. COMPRESSIVE STRENGTH: 5000 PSI MIN.
5. WATER ABSORPTION: 10 LB/FT3 MAX.
6. FREEZE THAW: NO EFFECT AS DEMONSTRATED THROUGH PROVEN FIELD PERFORMANCE.

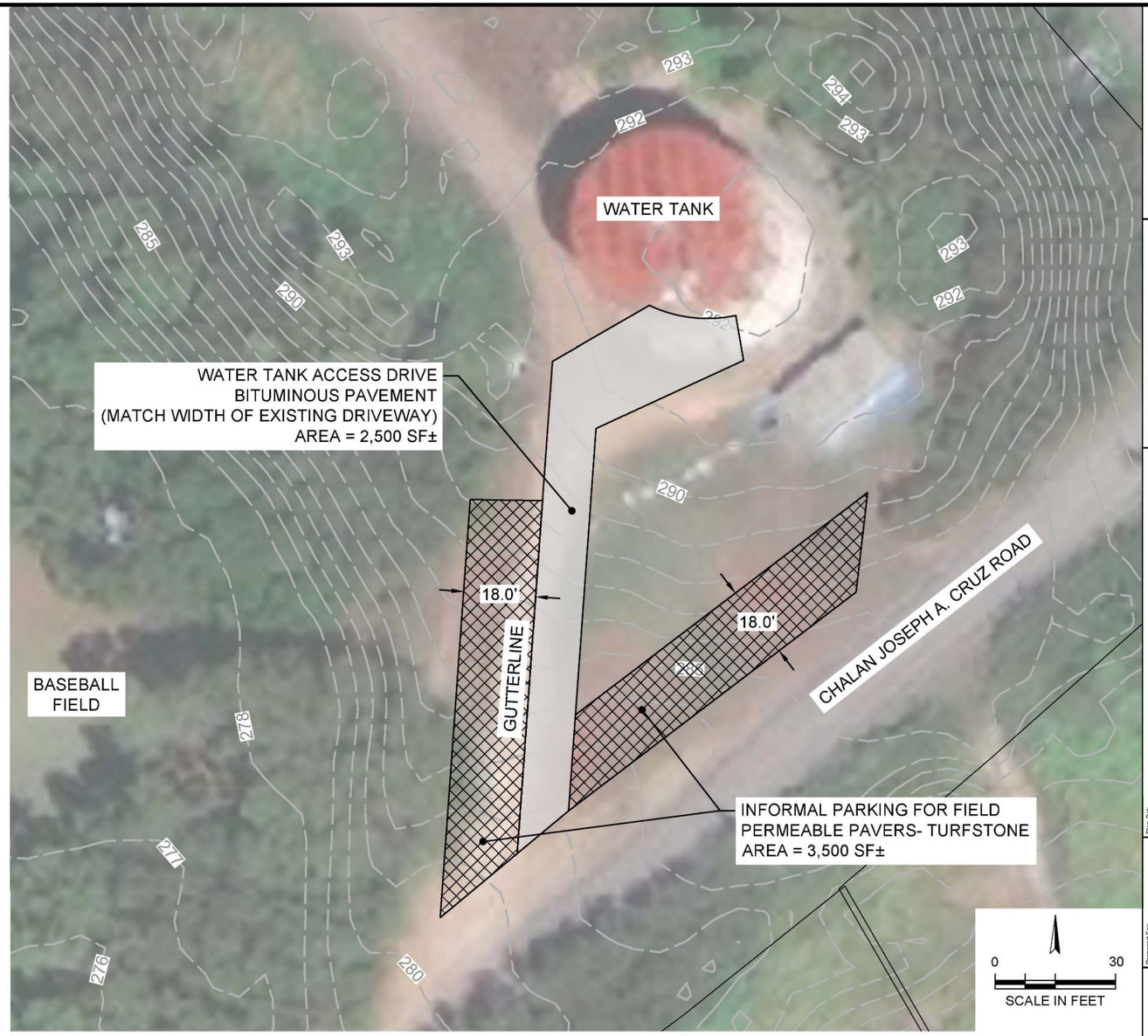


STACK BOND LAYOUT

CROSS SECTION & PATTERN - TURFSTONE
NOT TO SCALE

TURFSTONE LAYOUT

SITE LAYOUT



CONCEPT PLAN

WATER TANK PAVING (ID# R-09)
PIGUA FOCUS AREA

Revisions

Rev	Date	By / Appr	Description

Horsley Witten Group, Inc.
Sustainable Environmental Solutions
www.horsleywitten.com
90 Route 6A
Sandwich, MA 02563
508-833-6600 voice
508-833-3150 fax

Date: JUNE 2024 | Design By: JLV | Drawn By: JLV | Checked By: MW

Plan Set: MANELL-GEUS WATERSHED MANAGEMENT PLAN MERIZO, GUAM

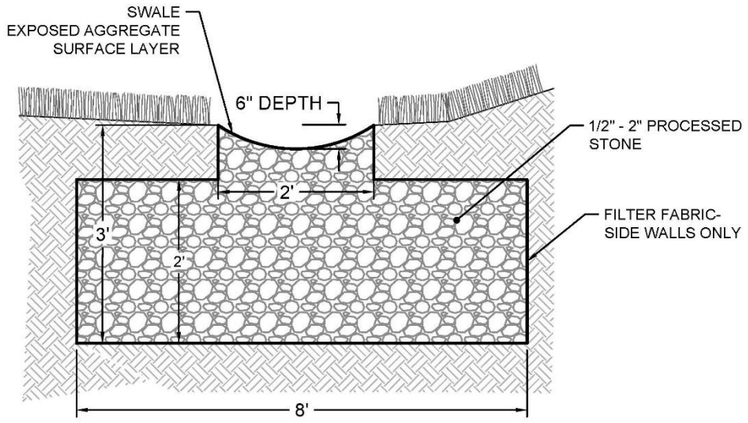
Plan Title: R-09 CONCEPT PLAN

Prepared For: National Oceanic and Atmospheric Administration (NOAA) 200 GRANBY STREET NORFOLK, VA 23510

Registration:

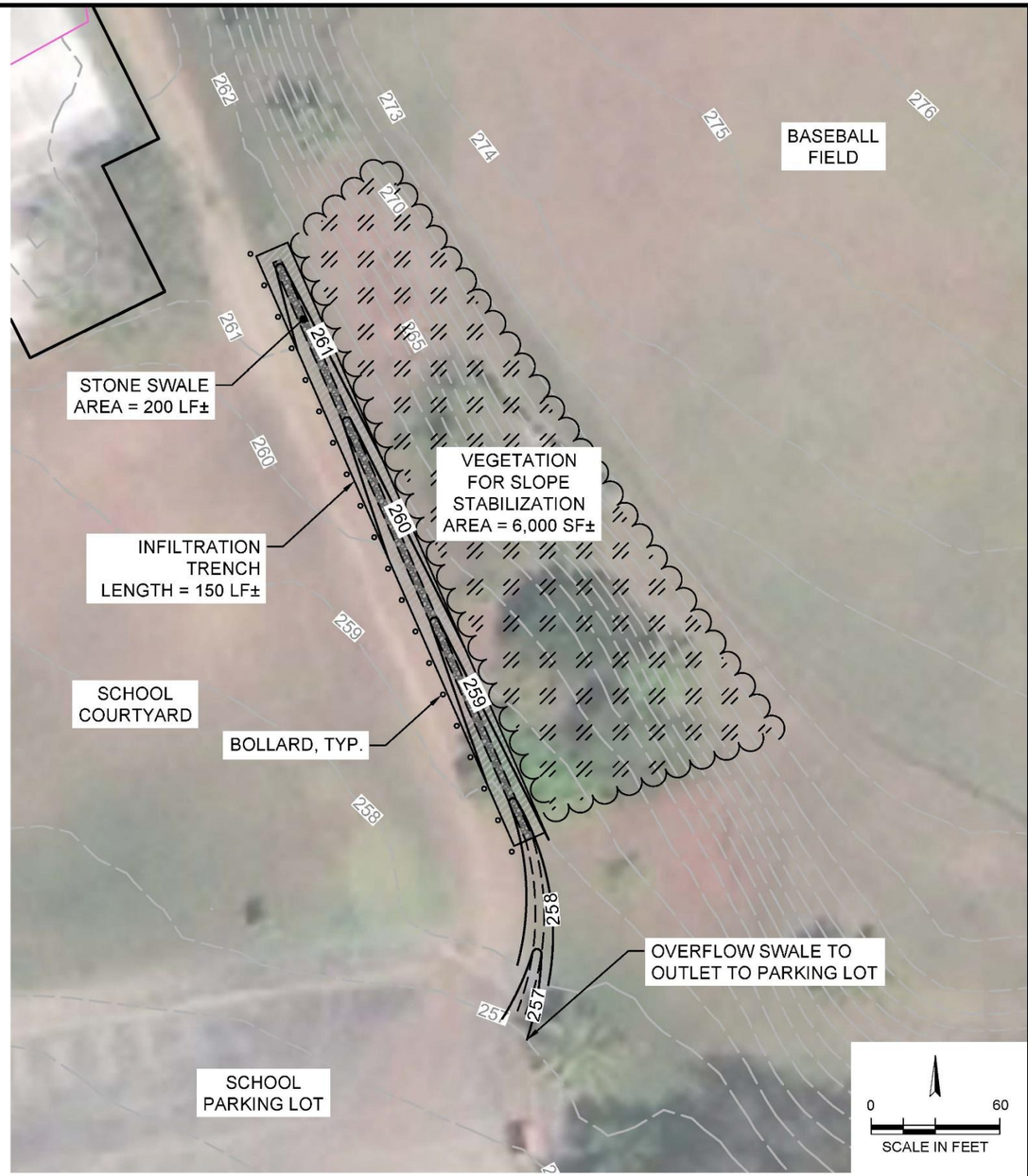
Project Number: 21105

Sheet Number: 2 of 11



INFILTRATION TRENCH
NOT TO SCALE

SITE LAYOUT



CONCEPT PLAN

SCHOOL COURTYARD CUTOFF TRENCH (ID# R-10)
PIGUA FOCUS AREA

Revisions

Rev	Date	By	Appr	Description

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Sustainable Environmental Solutions
www.horsleywitten.com
90 Route 6A
Sandwich, MA 02563
508-833-6600 voice
508-833-3150 fax

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Drawn By: JLV
Design By: JLV
Date: JUNE 2024

Plan Set: MANELL-GEUS WATERSHED MANAGEMENT PLAN MERIZO, GUAM

Plan Title: R-10 CONCEPT PLAN

Prepared For:
National Oceanic and Atmospheric Administration (NOAA)
200 GRANBY STREET
NORFOLK, VA 23510

Registration:

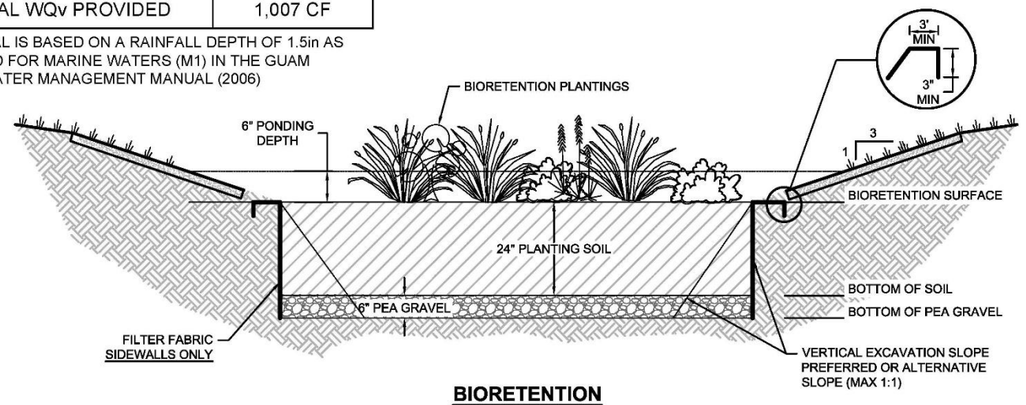
Project Number: 21105

Sheet Number: 3 of 11

SITE LAYOUT

PROJECT ID# R-11 SUMMARY TABLE	
TOTAL DRAINAGE AREA	0.30 ACRES
TOTAL IMPERVIOUS AREA	0.18 ACRES
TOTAL BIORETENTION AREA	550 SF
TOTAL WQv GOAL	1,007 CF
TOTAL WQv PROVIDED	1,007 CF

*WQv GOAL IS BASED ON A RAINFALL DEPTH OF 1.5in AS REQUIRED FOR MARINE WATERS (M1) IN THE GUAM STORMWATER MANAGEMENT MANUAL (2006)



BIORETENTION
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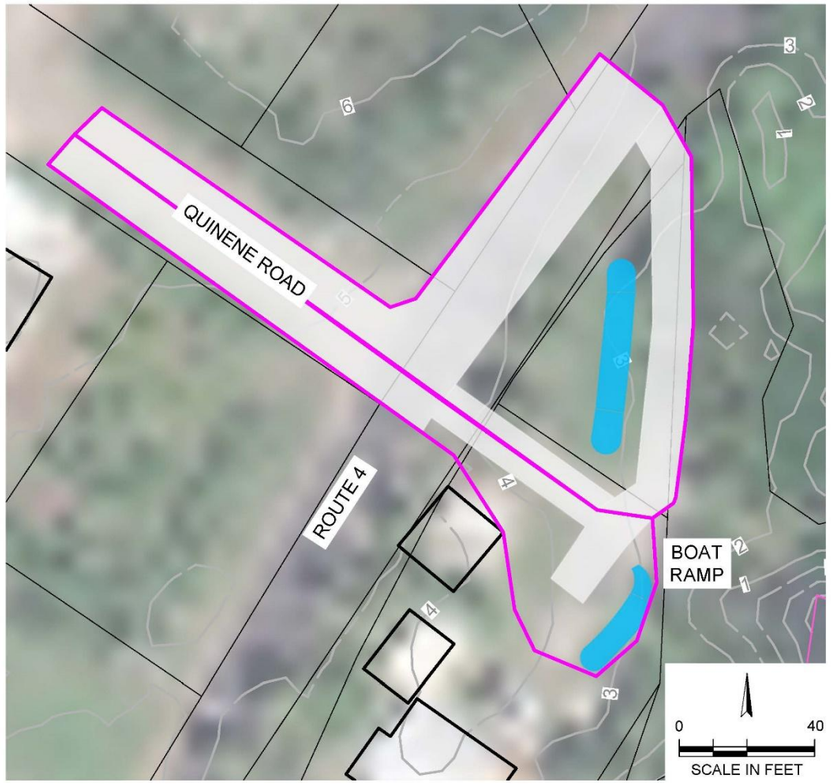
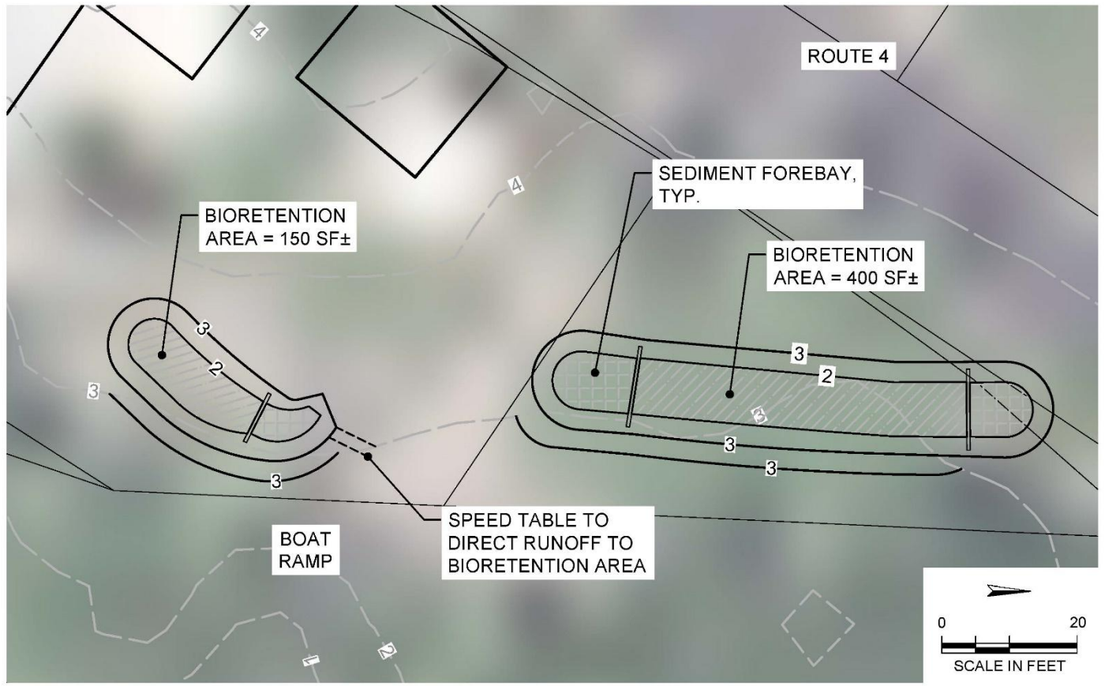


DRAINAGE MAP



CONCEPT PLAN

BOAT RAMP RAINGARDENS (ID# R-11)
QUINENE FOCUS AREA

Revisions

Rev.	Date	By / Appr.	Description

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www.horsleywitten.com
90 Route 6A
Sandwich, MA 02563
508-833-6600 voice
508-833-3150 fax

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Design By: JLV
Date: JUNE 2024

Plan Set: MANELL-GEUS WATERSHED MANAGEMENT PLAN MERIZO, GUAM

Plan Title: R-11 CONCEPT PLAN

Prepared For: National Oceanic and Atmospheric Administration (NOAA) 200 GRANBY STREET NORFOLK, VA 23510

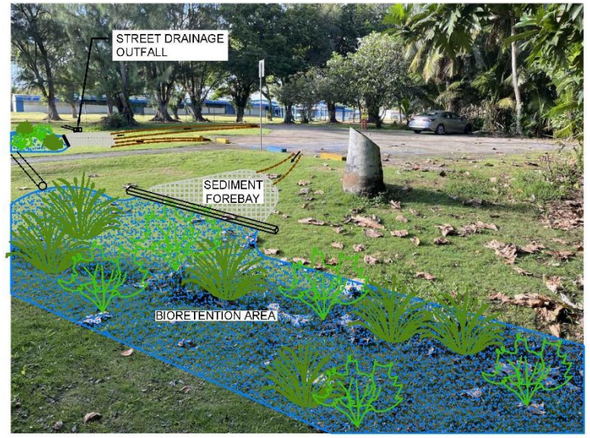
Registration:

Project Number: 21105

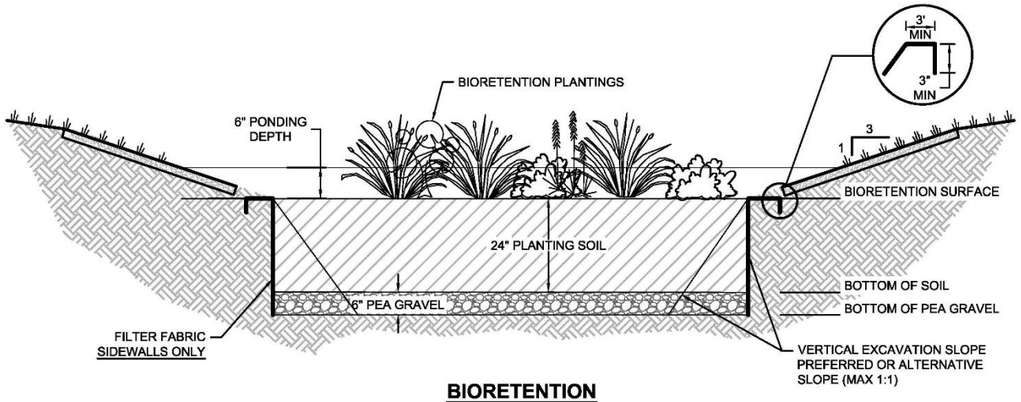
Sheet Number: 4 of 11

PROJECT ID# R-13 SUMMARY TABLE	
TOTAL DRAINAGE AREA	1.24 ACRES
TOTAL IMPERVIOUS AREA	0.36 ACRES
TOTAL BIORETENTION AREA	700 SF
TOTAL WQv GOAL	1,038 CF
TOTAL WQv PROVIDED	1,038 CF

*WQv GOAL IS BASED ON A RAINFALL DEPTH OF 0.8in AS REQUIRED FOR SURFACE WATERS (S2) IN THE GUAM STORMWATER MANAGEMENT MANUAL (2006)



SITE LAYOUT



BIORETENTION
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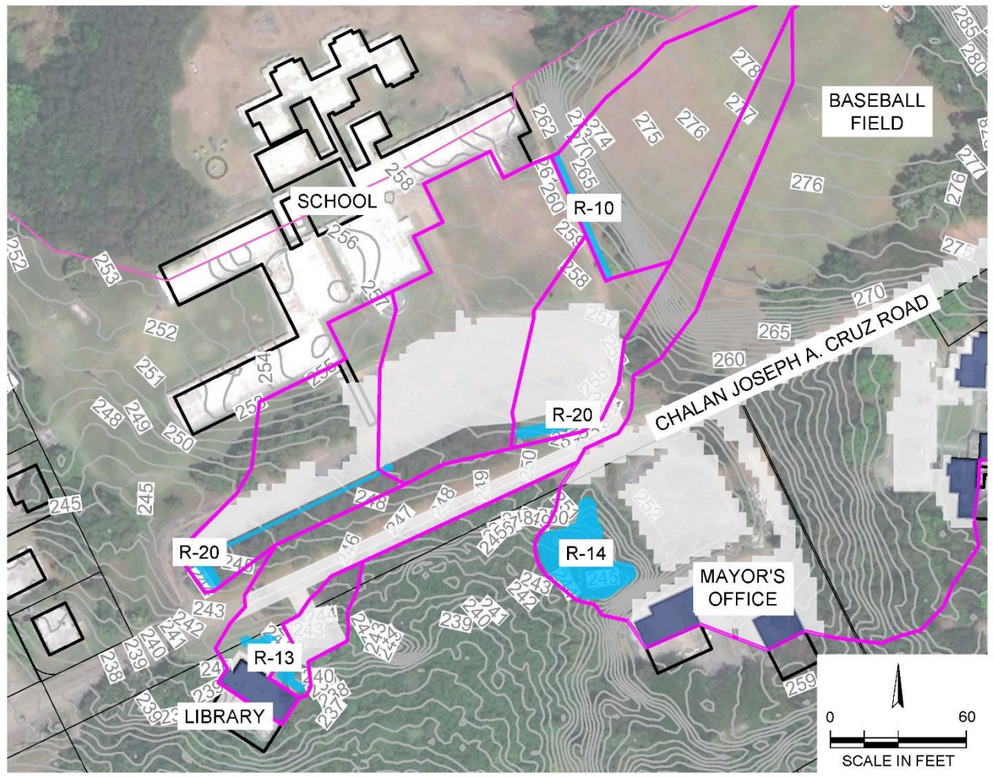

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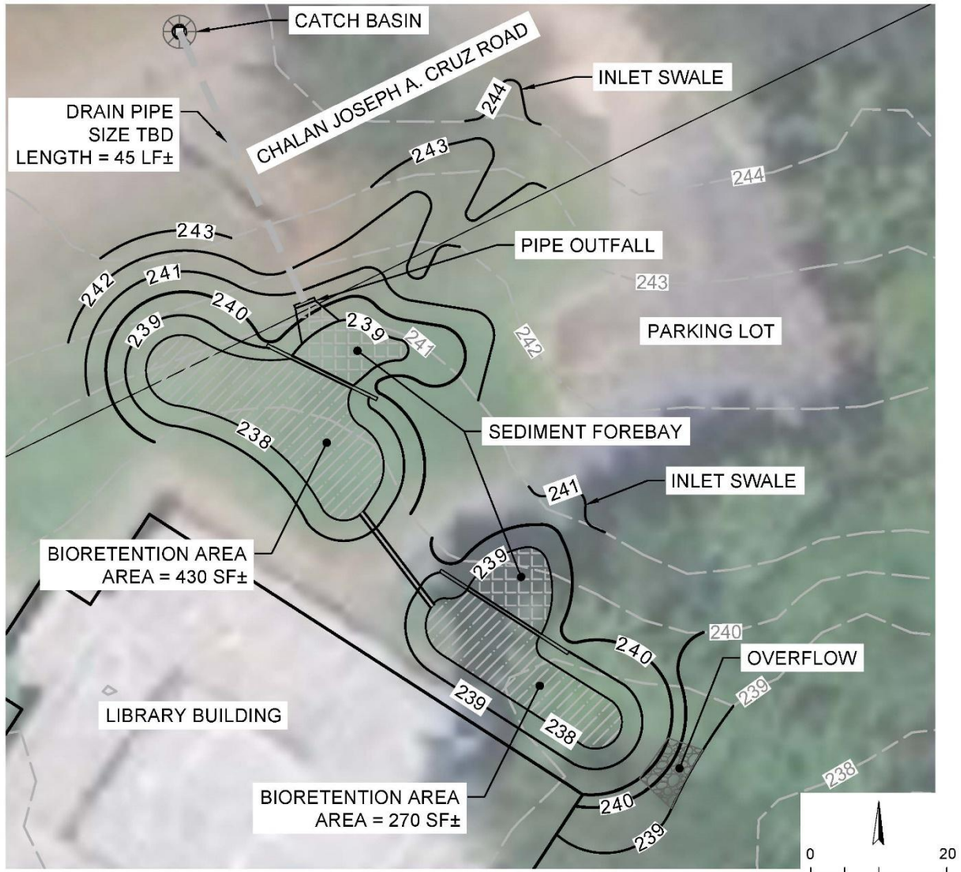

CONCEPT PLAN

ROSA AGUIGUI REYES MEMORIAL LIBRARY (ID# R-13)
PIGUA FOCUS AREA

Revisions

Rev	Date	By	Appr	Description

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90 Route 6A
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508-833-6600 voice
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Drawn By: JLV
Design By: JLV
Date: JUNE 2024

MANELL-GEUS WATERSHED MANAGEMENT PLAN
MERIZO, GUAM
Plan Set:

R-13 CONCEPT PLAN
Plan Title:

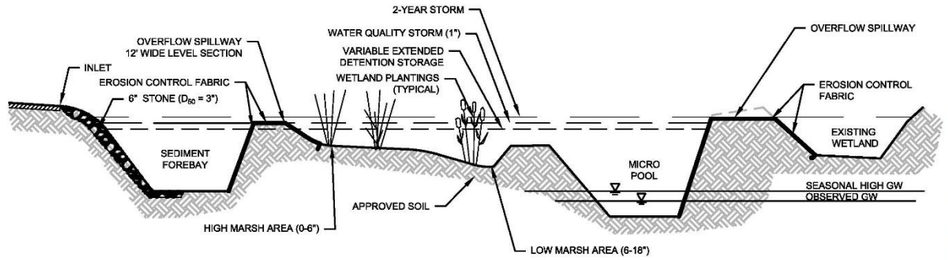
Prepared For:
National Oceanic and Atmospheric Administration (NOAA)
200 GRANBY STREET
NORFOLK, VA 23510

Registration:

Project Number: 21105

Sheet Number: 5 of 11

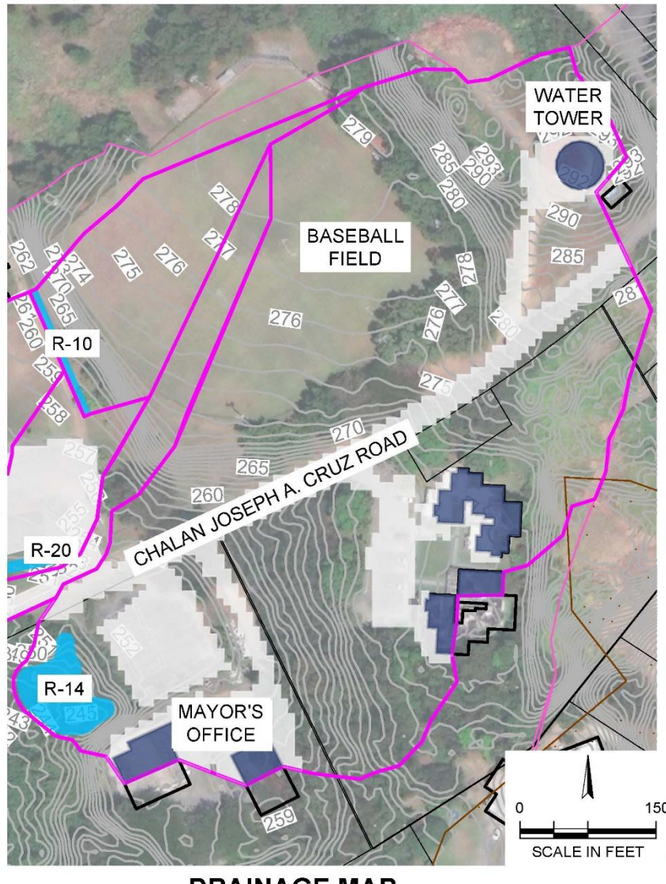
SITE LAYOUT



CONSTRUCTED WETLAND
NOT TO SCALE

PROJECT ID# R-14 SUMMARY TABLE	
TOTAL DRAINAGE AREA	7.67 ACRES
TOTAL IMPERVIOUS AREA	1.82 ACRES
TOTAL CONSTRUCTED WETLAND AREA	5,000 SF
TOTAL WQv GOAL	5,289 CF
TOTAL WQv PROVIDED	5,289 CF

*WQv GOAL IS BASED ON A RAINFALL DEPTH OF 0.8in AS REQUIRED FOR SURFACE WATERS (S2) IN THE GUAM STORMWATER MANAGEMENT MANUAL (2006)



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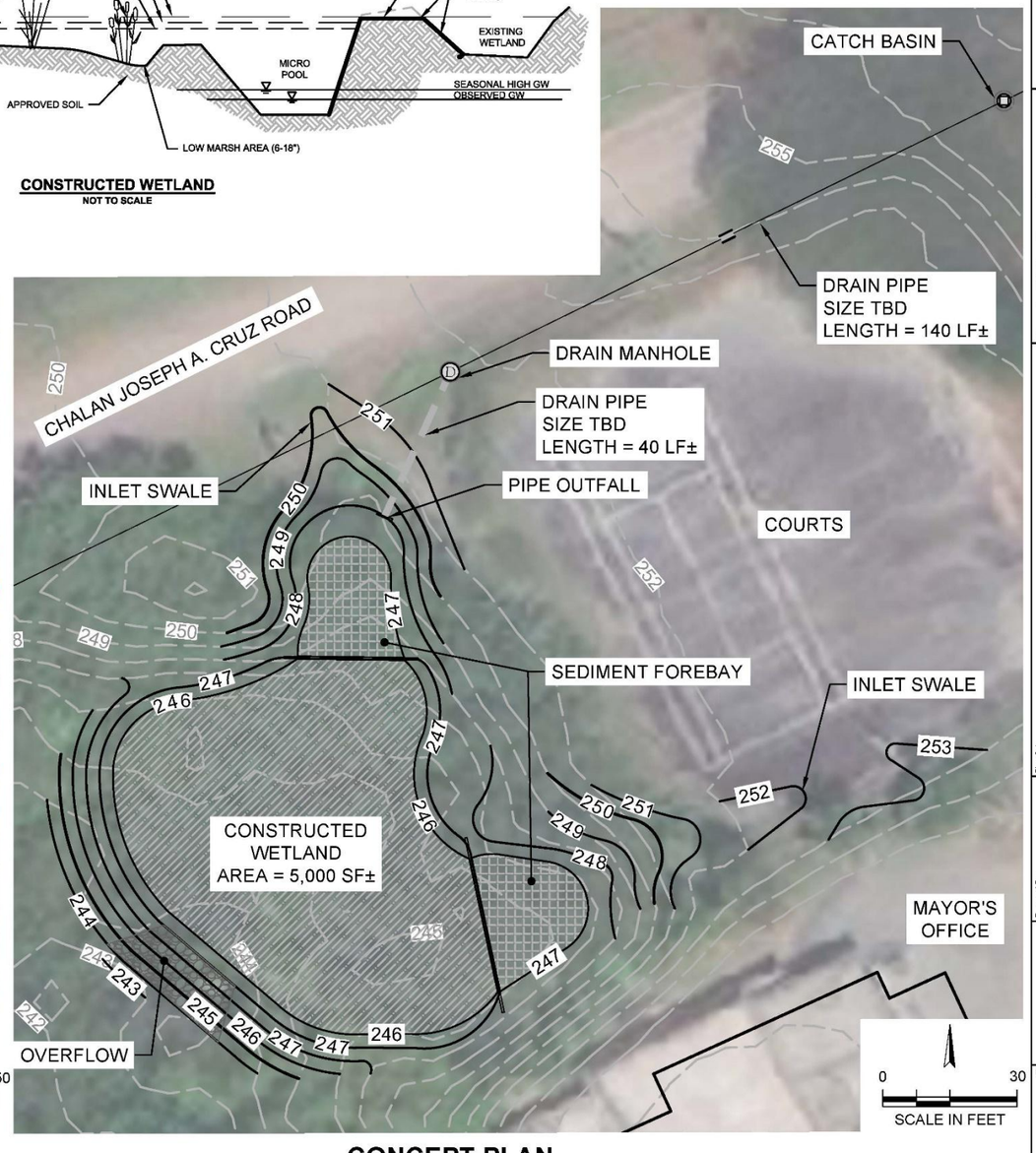

CONCEPT PLAN

MERIZO MAYORS OFFICE CONSTRUCTED WETLAND (ID# R-14)
PIGUA FOCUS AREA

Revisions

Rev	Date	By	Appr	Description

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90 Route 6A
Sandwich, MA 02563
508-833-6600 voice
508-833-3150 fax

Date: JUNE 2024
Design By: JLV
Drawn By: JLV
Checked By: MW

Plan Set: MANELL-GEUS WATERSHED MANAGEMENT PLAN MERIZO, GUAM

Plan Title: R-14 CONCEPT PLAN

Prepared For: National Oceanic and Atmospheric Administration (NOAA) 200 GRANBY STREET NORFOLK, VA 23510

Registration:

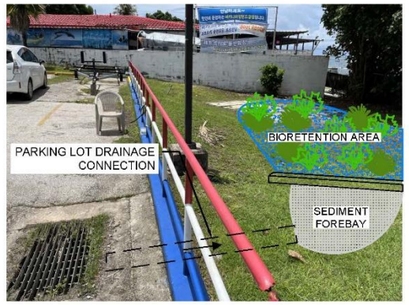
Project Number: 21105

Sheet Number: 6 of 11

R-18 SITE LAYOUT

PROJECT ID# R-18 SUMMARY TABLE	
TOTAL DRAINAGE AREA	0.17 ACRES
TOTAL IMPERVIOUS AREA	0.15 ACRES
TOTAL BIORETENTION AREA	300 SF
TOTAL WQv GOAL	797 CF
TOTAL WQv PROVIDED	797 CF

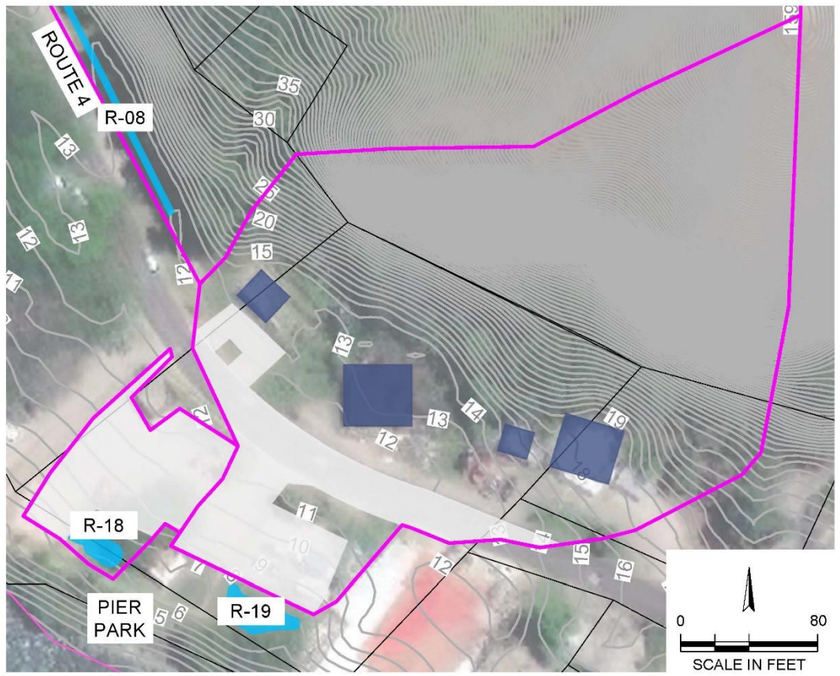
*WQv GOAL IS BASED ON A RAINFALL DEPTH OF 1.5in AS REQUIRED FOR SURFACE WATERS (S2) IN THE GUAM STORMWATER MANAGEMENT MANUAL (2006)



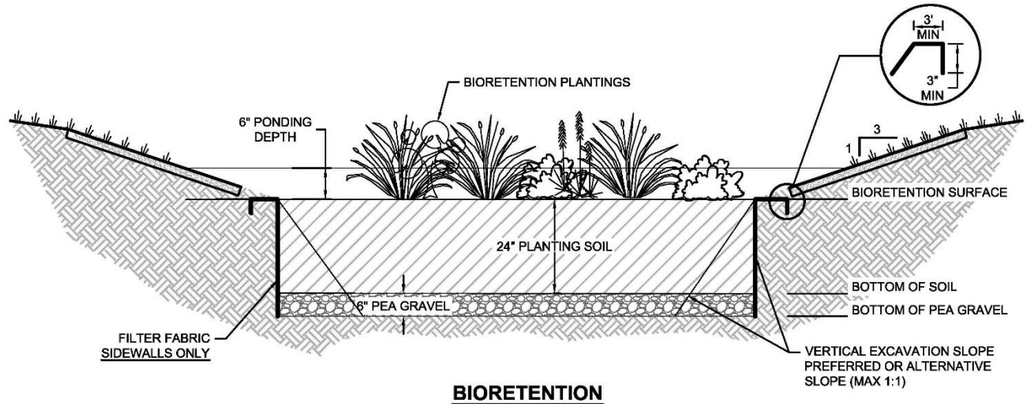
R-19 SITE LAYOUT

PROJECT ID# R-19 SUMMARY TABLE	
TOTAL DRAINAGE AREA	1.88 ACRES
TOTAL IMPERVIOUS AREA	0.34 ACRES
TOTAL BIORETENTION AREA	610 SF
TOTAL WQv GOAL	1,854 CF
TOTAL WQv PROVIDED	1,117 CF (60%)

*WQv GOAL IS BASED ON A RAINFALL DEPTH OF 1.5in AS REQUIRED FOR SURFACE WATERS (S2) IN THE GUAM STORMWATER MANAGEMENT MANUAL (2006)



DRAINAGE MAP



BIORETENTION
NOT TO SCALE

CONCEPT PLAN

MERIZO PIER PARKING LOT BIORETENTIONS (ID# R-18 & R-19)
PIER PARK FOCUS AREA

Revisions

Rev	Date	By	Appr	Description

Horsley Witten Group, Inc.
Sustainable Environmental Solutions
www.horsleywitten.com
90 Route 6A
Sandwich, MA 02563
508-833-6600 voice
508-833-3150 fax

Checked By: MVF
Drawn By: LLV
Design By: JLV
Date: JUNE 2024

Plan Set: MANELL-GEUS WATERSHED MANAGEMENT PLAN MERIZO, GUAM

Plan Title: R-18 & R-19 CONCEPT PLAN

Prepared For: National Oceanic and Atmospheric Administration (NOAA) 200 GRANBY STREET NORFOLK, VA 23510

Registration:

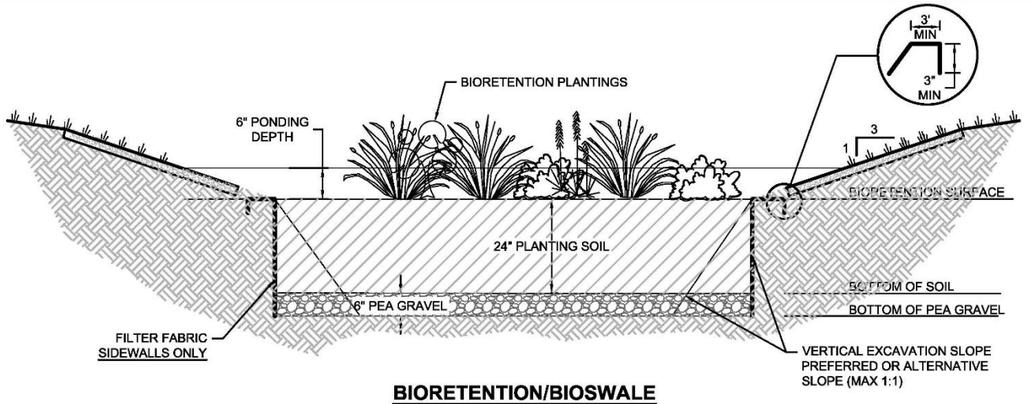
Project Number: 21105

Sheet Number: 7 of 11

PROJECT ID# R-20 SUMMARY TABLE	
TOTAL DRAINAGE AREA	2.40 ACRES
TOTAL IMPERVIOUS AREA	0.90 ACRES
TOTAL BIORETENTION AREA	1,430 SF
TOTAL WQv GOAL	2,621 CF
TOTAL WQv PROVIDED	2,621 CF

*WQv GOAL IS BASED ON A RAINFALL DEPTH OF 0.8in AS REQUIRED FOR SURFACE WATERS (S2) IN THE GUAM STORMWATER MANAGEMENT MANUAL (2006)

SITE LAYOUT



BIORETENTION/BIOSWALE
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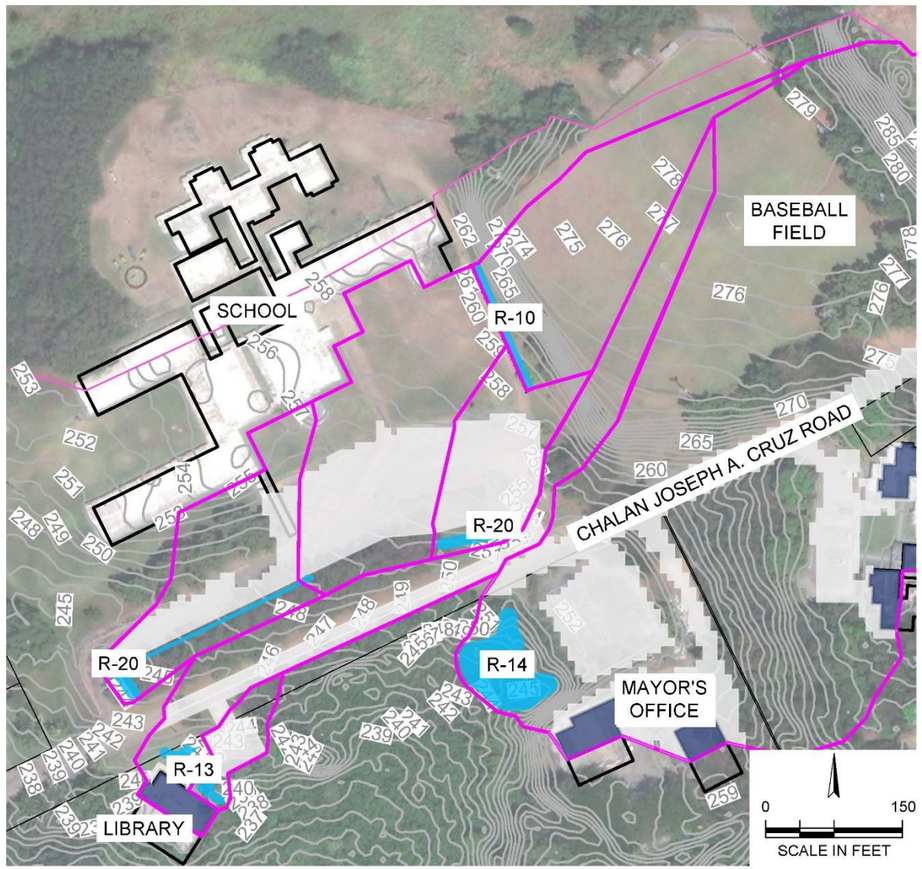
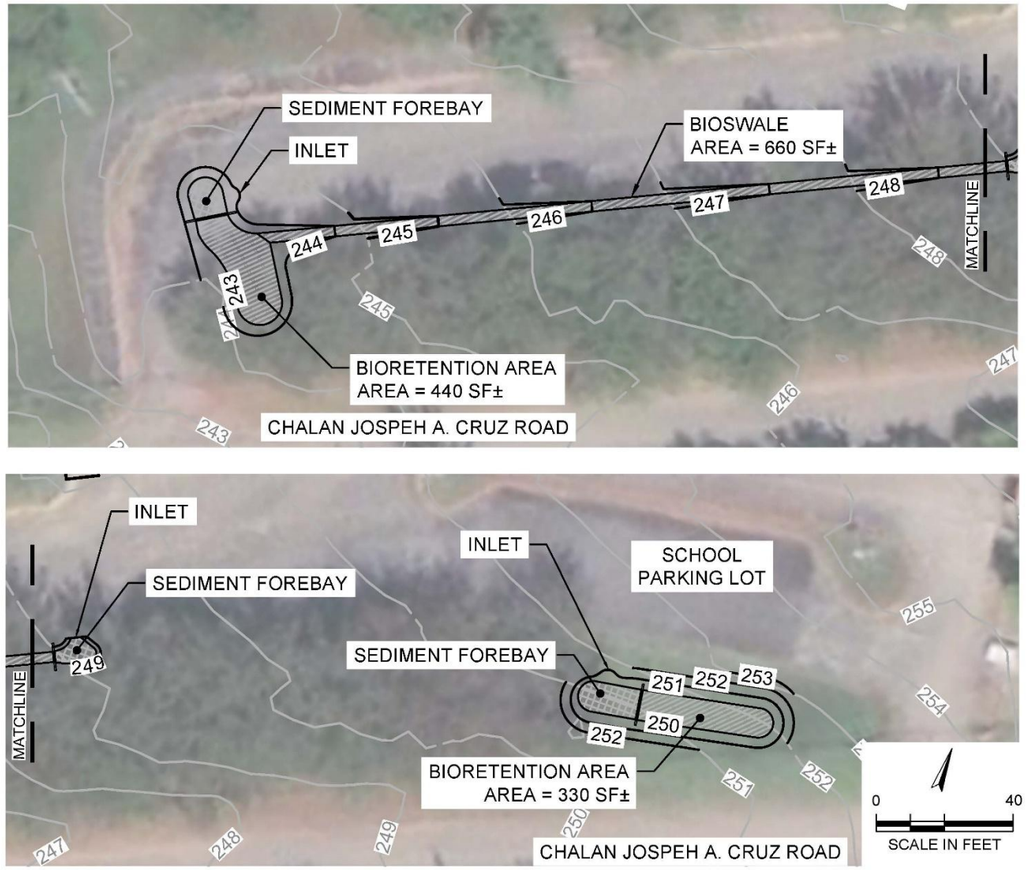


DRAINAGE MAP



CONCEPT PLAN

SCHOOL PARKING LOT BIORETENTION AREAS (ID# R-20)
PIGUA FOCUS AREA

Revisions

Rev.	Date	By	Appr.	Description

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Sustainable Environmental Solutions
www.horsleywitten.com
90 Route 6A
Sandwich, MA 02563
508-833-6600 office
508-833-3150 fax

Drawn By: JLV
Checked By: MW
Design By: JLV
Date: JUNE 2024

MANELL-GEUS WATERSHED MANAGEMENT PLAN
MERIZO, GUAM

Plan Set:
Plan Title: R-20 CONCEPT PLAN

Prepared For:
National Oceanic and Atmospheric Administration (NOAA)
200 GRANBY STREET
NORFOLK, VA 23510

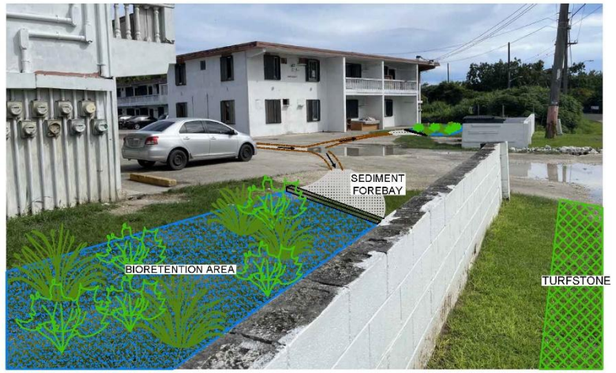
Registration:

Project Number: 21105

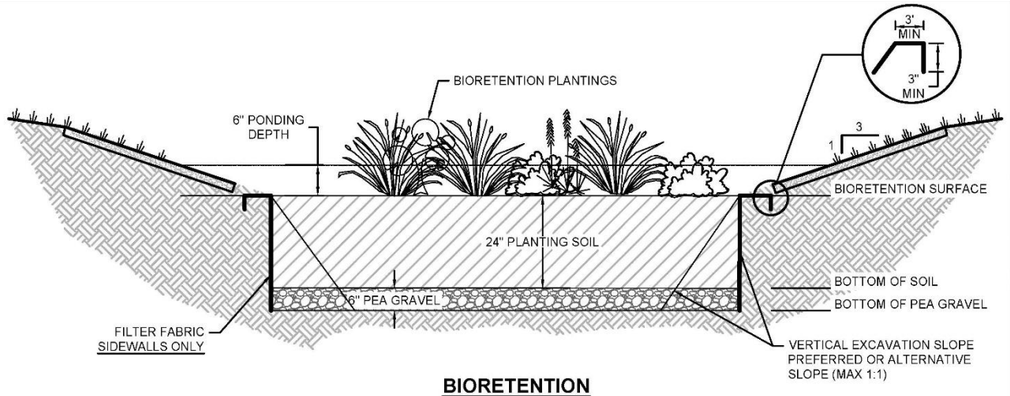
Sheet Number: 8 of 11

PROJECT ID# R-21 SUMMARY TABLE	
TOTAL DRAINAGE AREA	0.95 ACRES
TOTAL IMPERVIOUS AREA	0.58 ACRES
TOTAL BIORETENTION AREA	1,200 SF
TOTAL WQv GOAL	3,173 CF
TOTAL WQv PROVIDED	2,155 CF (68%)

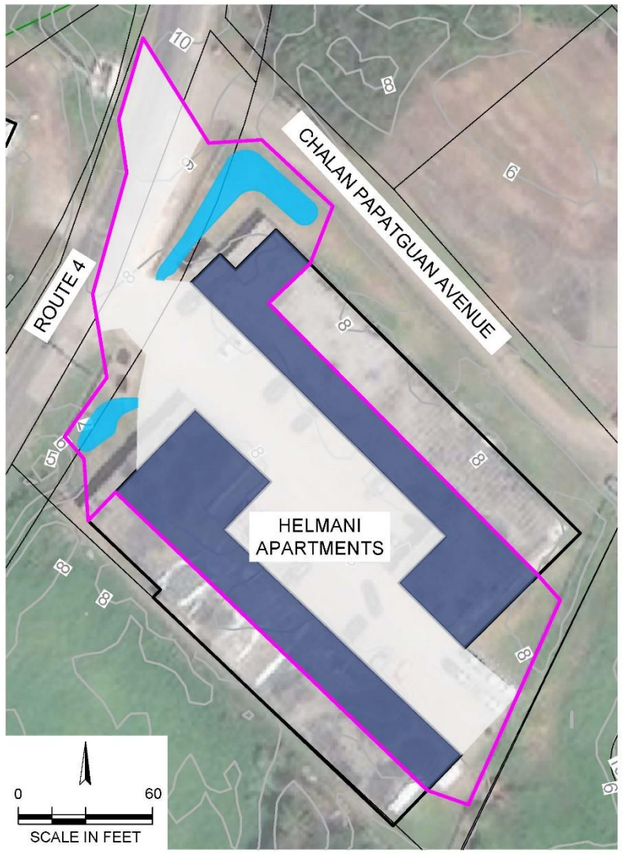
*WQv GOAL IS BASED ON A RAINFALL DEPTH OF 1.5in AS REQUIRED FOR MARINE WATERS (M1) IN THE GUAM STORMWATER MANAGEMENT MANUAL (2006)



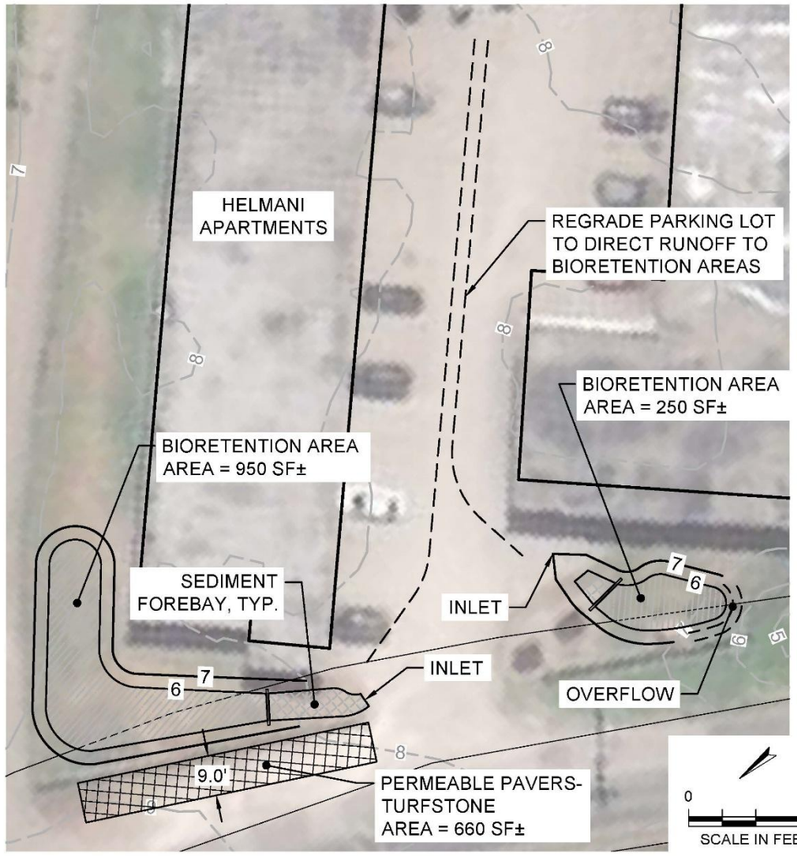
BIORETENTION LAYOUT



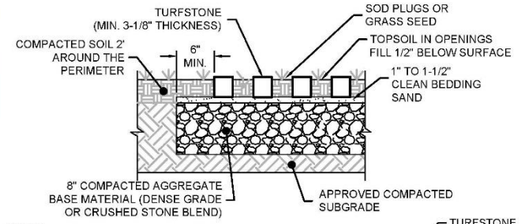
BIORETENTION
NOT TO SCALE



DRAINAGE MAP



CONCEPT PLAN



NOTES
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2. NOMINAL SIZE/COVERAGE: 23-1/4" X 15-3/4"
3. THICKNESS: 3-1/8"
4. COMPRESSIVE STRENGTH: 5000 PSI MIN.
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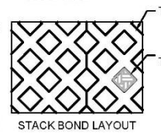
6. FREEZE THAW: NO EFFECT AS DEMONSTRATED THROUGH PROVEN FIELD PERFORMANCE.



CROSS SECTION & PATTERN - TURFSTONE
NOT TO SCALE

HELMANI APARTMENTS BIORETENTIONS (ID# R-21)
GEUS FOCUS AREA

Revisions

Rev	Date	By	Appr	Description

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Sustainable Environmental Solutions
www.horsleywitten.com
90 Route 6A
Sandwich, MA 02563
508-833-6600 voice
508-833-3150 fax

Checked By: MW
Drawn By: JLV
Design By: JLV
Date: JUNE 2024

Plan Set: MANELL-GEUS WATERSHED MANAGEMENT PLAN MERIZO, GUAM

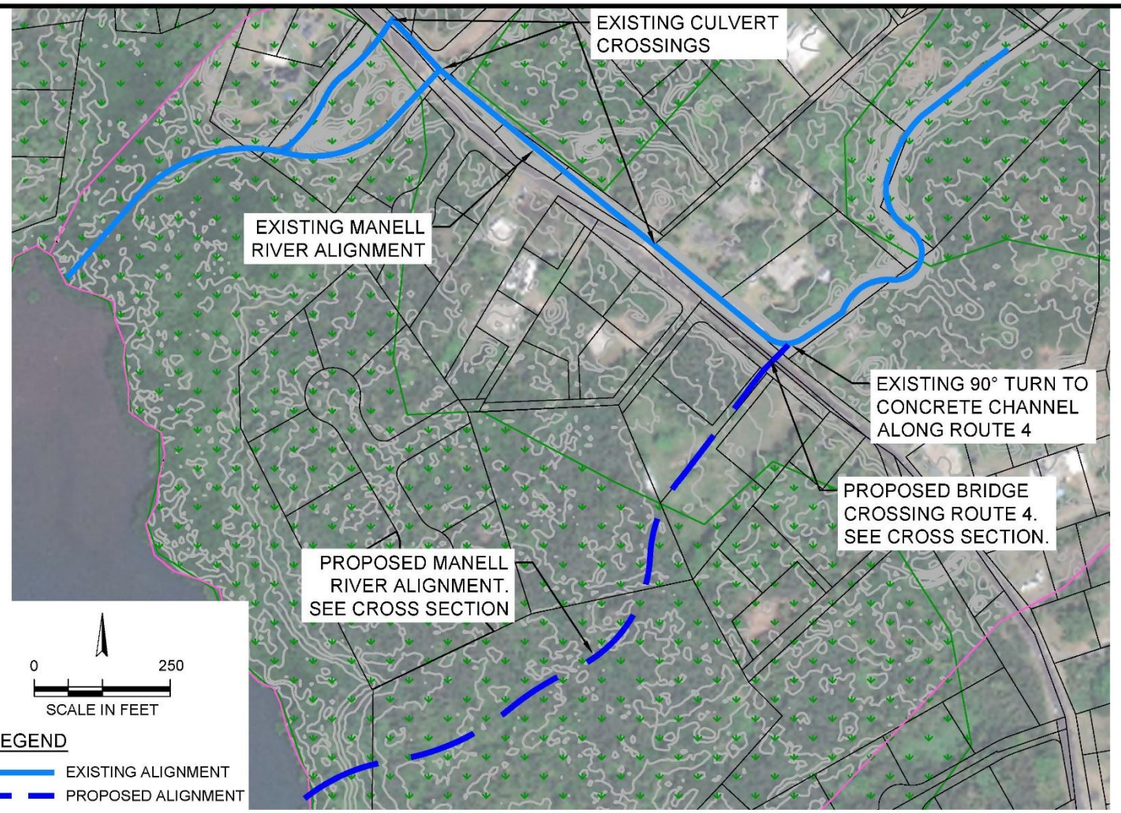
Plan Title: R-21 CONCEPT PLAN

Prepared For: National Oceanic and Atmospheric Administration (NOAA) 200 GRANBY STREET NORFOLK, VA 23510

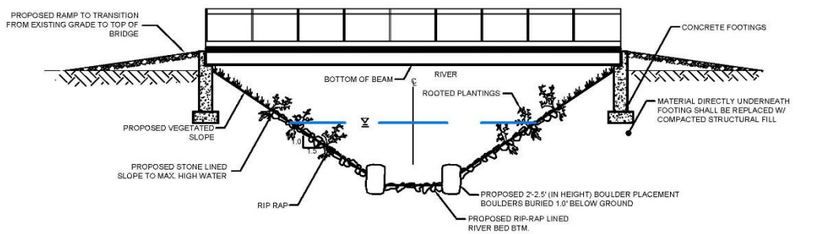
Registration:

Project Number: 21105

Sheet Number: 9 of 11



MANELL RIVER REALIGNMENT PLAN



PROPOSED BRIDGE CROSSING SECTION
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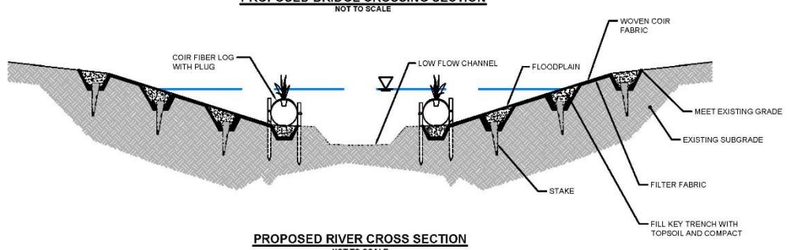

PROPOSED RIVER CROSS SECTION
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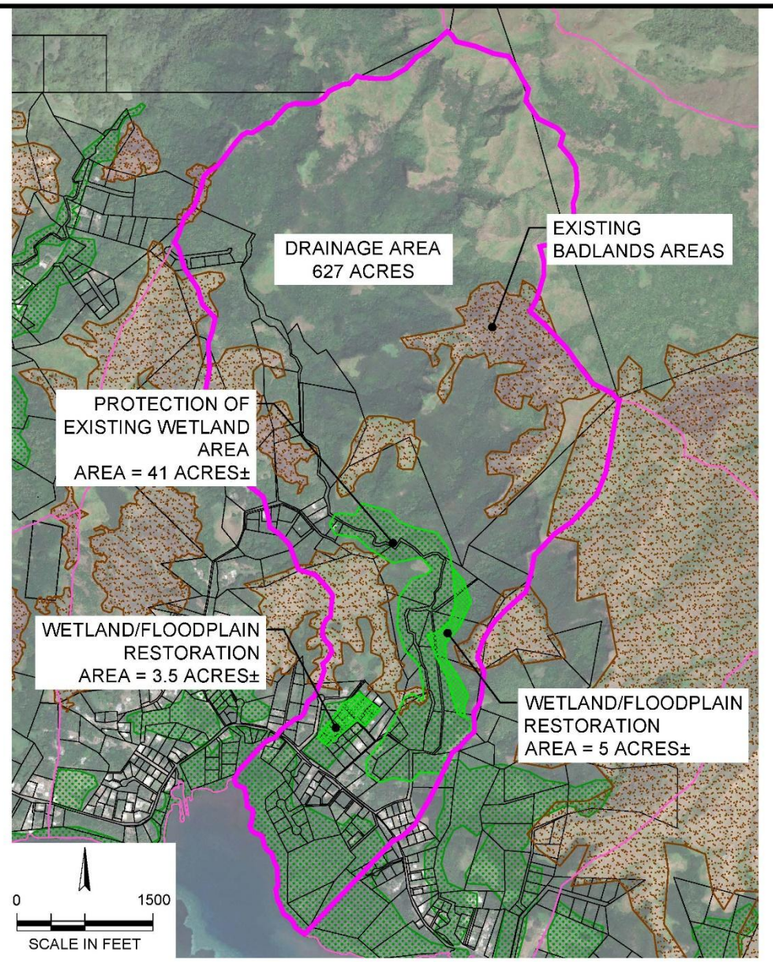

DRAINAGE AREA

MANELL RIVER REALIGNMENT AND RESTORATION (ID# R-29)
MANELL RIVER FOCUS AREA

Revisions

Rev.	Date	By	Appr	Description

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Sustainable Environmental Solutions
www.horsleywitten.com
90 Route 6A
Sandwich, MA 02563
508-833-6600 voice
508-833-3150 fax

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Date: JUNE 2024

Plan Set: MANELL-GEUS WATERSHED MANAGEMENT PLAN MERIZO, GUAM

Plan Title: R-29 CONCEPT PLAN

Prepared For:
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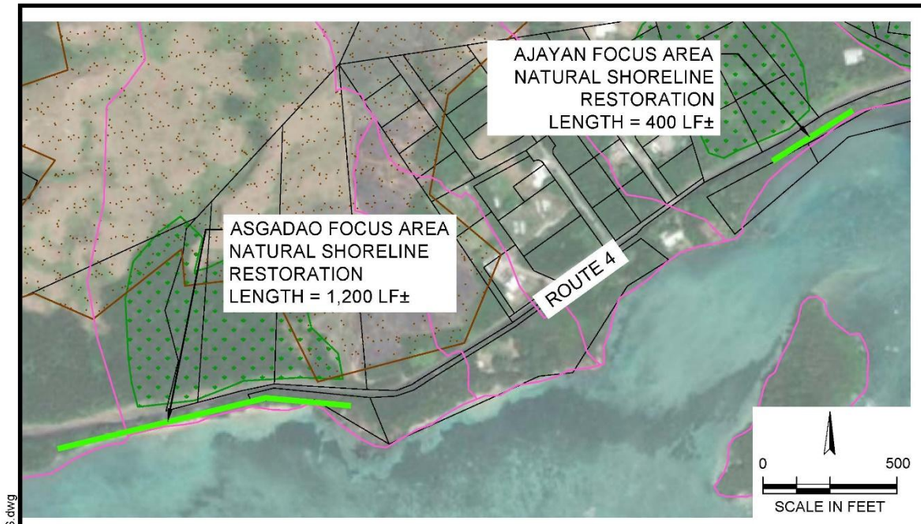
200 GRANBY STREET
NORFOLK, VA 23510

Registration:

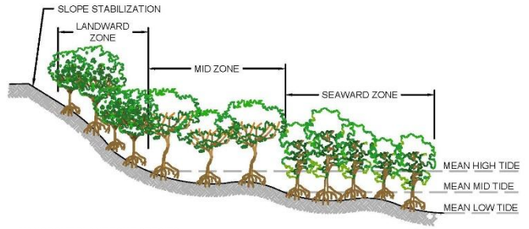
Project Number: 21105

Sheet Number: 10 of 11



NATURAL RESTORATION LOCATIONS

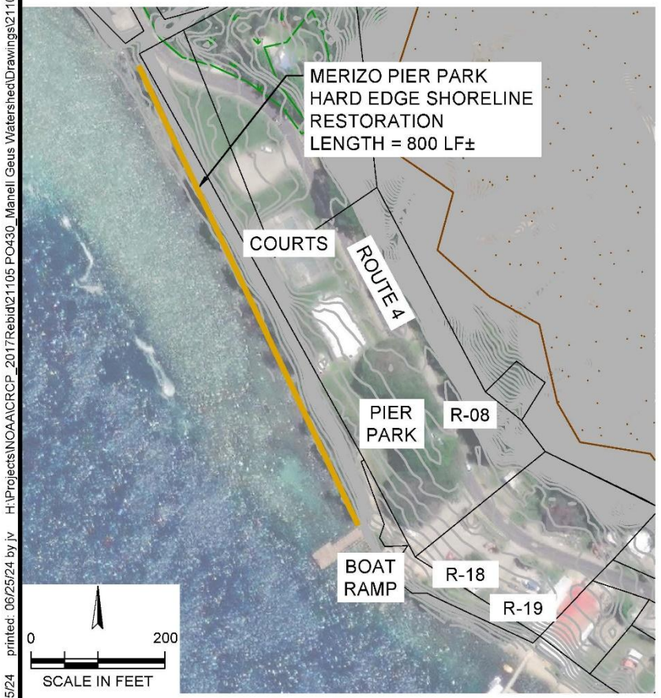
EXAMPLE NATURAL RESTORATION LAYOUT

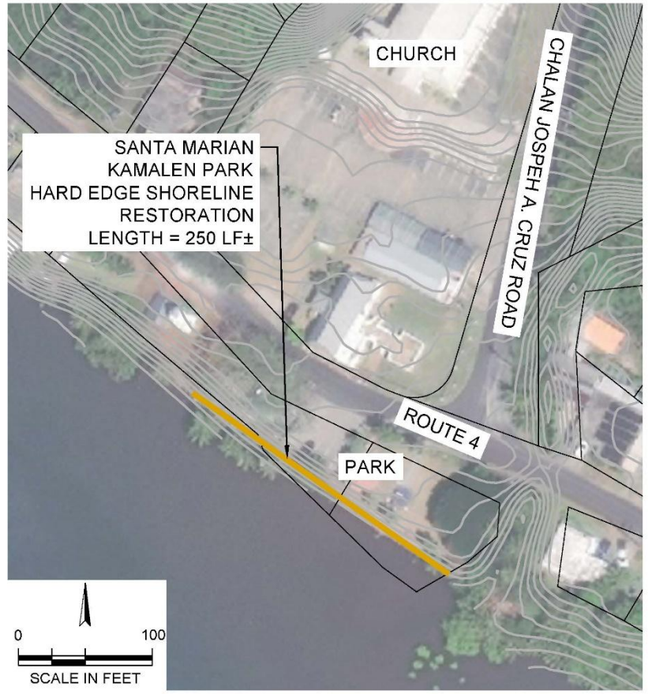


MANGROVE PLANT ZONE SPECIES:

SEAWARD ZONE: TALL-STILT MANGROVE (*Rhizophora apiculata*)
MID ZONE: GREY MANGROVE (*Avicennia marina*)
LANDWARD ZONE: LARGE-LEAVED/ORANGE MANGROVE (*Bruguieria gymnorrhiza*)

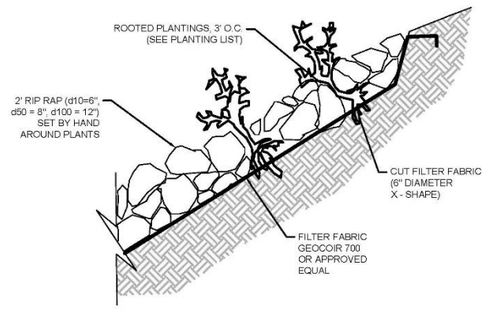
NATURAL RESTORATION DETAIL
NOT TO SCALE





HARD EDGE RESTORATION LOCATIONS

EXAMPLE HARD EDGE RESTORATION LAYOUT



HARD EDGE RESTORATION DETAIL
NOT TO SCALE

COASTAL SHORELINE RESTORATION

Revisions

Rev	Date	By	Appr	Description

Horsley Witten Group, Inc.
Sustainable Environmental Solutions
www.horsleywitten.com
90 Route 6A
Sandwich, MA 02563
508-833-6600 Voice
508-833-3150 fax

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Design By: JLV
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Plan Title: SHORELINE CONCEPT PLAN

Prepared For: National Oceanic and Atmospheric Administration (NOAA) 200 GRANBY STREET NORFOLK, VA 23510

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