Achugao Watershed
Existing Conditions and Opportunities
Interim Report

December 2020
DRAFT

Prepared for:
CNMI Bureau of Environmental and Coastal Quality
Division of Coastal Resource Management

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1.0 Introduction

The Achugao watershed was identified by BECQ and NOAA as a priority area for watershed assessment and management (**Figure 1**). As a contributing drainage area to the northern segment of Saipan Lagoon (also called Tanapag Lagoon), this watershed includes the northern portion of the lower base industrial complex, the coastal villages of Tanapag and San Roque, several operational resorts, two public schools, and the steep grasslands between Middle Road and Wireless Ridge (**Figure 2**). This moderately developed watershed is just north of Garapan and is experiencing increased development pressure. Significant investment has been made in sanitary sewer infrastructure and there are three active hotel/villa construction sites: Saipan Globe, Imperial Casha (formerly Sinopan), and Beverly. This watershed contains several large freshwater wetland complexes, including the Falig mitigation site, and has been the focus of stream investigations in 2014 and 2020. Coastal receiving waters and streams are impaired for one or more parameters including dissolved oxygen, marine benthic habitat, heavy metals, and bacteria. Site contamination from past military operations, piggeries, unmanaged stormwater runoff, failing septic systems, and wildfires are some of the known issues in this watershed effecting water quality.

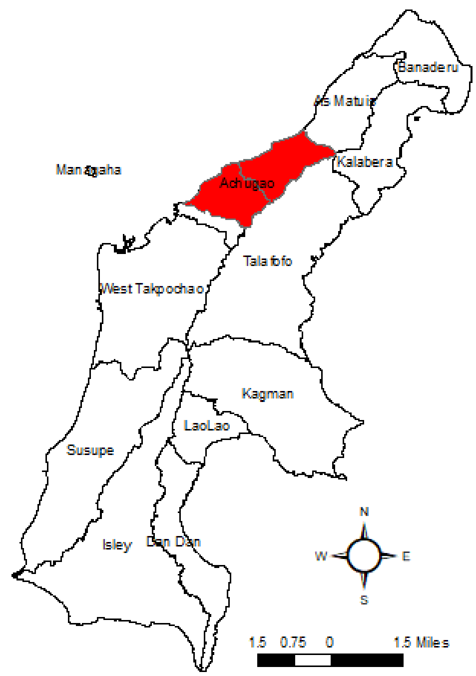

Figure 1. Achugao Watershed (with proposed boundary revisions, 2020)

This interim report provides an initial characterization of watershed conditions and a summary of potential watershed restoration and conservation opportunities identified during a watershed inventory conducted in early 2020. It is intended to summarize information compiled to date, identify gaps in data, and provide background material for future public engagement activities. COVID19 has delayed much of this effort. Ultimately, the information provided here will be used as a foundation for a comprehensive Watershed Management Plan to guide the CNMI's stewardship of this watershed over decades to come.

2.0 Watershed Conditions

For the purposes of this report, the Achugao Watershed is defined as 1,607 acres of land (2.5 square miles) that contributes surface drainage from Wireless Ridge down to the Saipan Lagoon via four major streams: Agatan, Dogas, Achugao, and San Roque (**Figure 3**). The watershed is currently divided into two subwatersheds: Achugao North (836 acres in the San Roque area) and Achugao South (771 acres in the Tanapag area). There are two notable modifications to the original subwatershed boundaries that result in a departure from the watershed delineations currently used by BECQ. It was determined through field assessments that the Tasi Stream (formerly part of Achugao South) is routed along Middle Road and through the Lower Base to a discharge outlet at DFW beach south of the CUC power plant. As such, the decision was made to move the Tasi catchment to the North West Takpochao watershed given the similarities in land use and breaks in shoreline morphology. It was also determined that the drainage boundary between the North and South subwatersheds did not split the Tanapag Middle School as depicted in the LIDAR-derived drainage mapping. For this watershed study, Achugao South extends along the coast from the traffic light in Lower Base through Tanapag and includes the middle school. The North Subwatershed stretches to the Kensington hotel.

Figure 2. Looking across the vegetated slopes of the Achugao watershed from the headwaters near Mt. Susu to the moderately developed shoreline of Saipan Lagoon (top photo). This watershed has several operating resorts, including Kensington Hotel that maintains this beach outfall structure (middle photo), as well as four major stream systems (bottom photo).

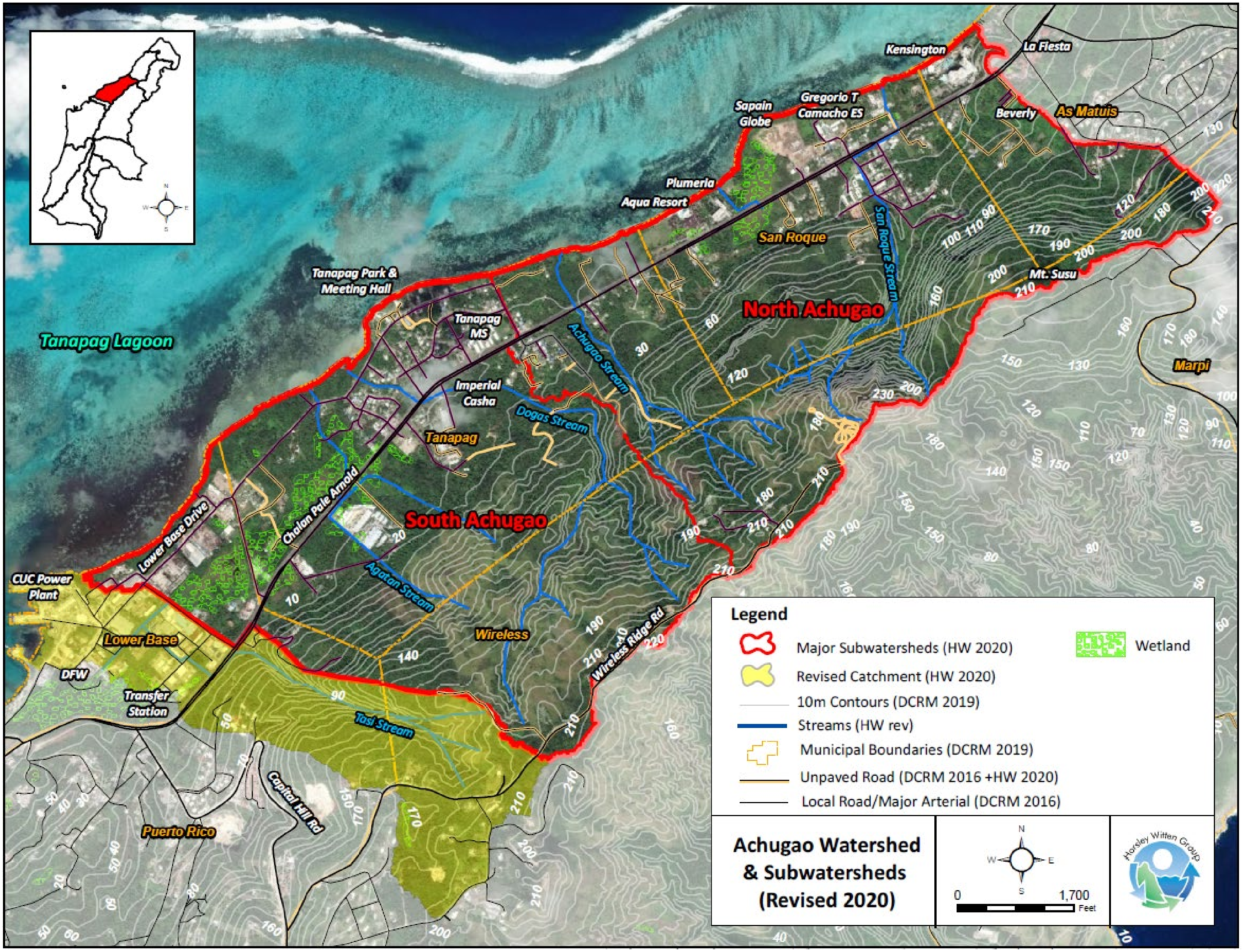

Figure 3. Revised Achugao Watershed (Tasi stream catchment, as shown, should be further modified to include wetland and discharge to DFW beach).

Land Use/Cover

The headwaters of the Achugao subwatershed is steep, mostly vegetated, and contains several streams. The highest point in the watershed is Mt. Susu. The flatter coastal plain is interspersed with freshwater wetland complexes (including a mitigation wetland) and is where most urban land and infrastructure is concentrated. Vegetation consists mostly of mixed introduced forest, a swath of native limestone forest along the Achugao stream, and extensive grasslands. In addition to habitat and climate benefits, the forests and savannahs are used for local recreation (hashers, hikers, bikers) and homesteads. Large areas dominated by Tangantangan and patches of urban vegetation can be found interspersed through developed and previously disturbed areas upland of San Roque and Tanapag (**Figure 4**).

Middle Road transects the watershed, runs parallel to the coast, and represents the primary development corridor in Achugao. Medium to high density residential and commercial development exists along this corridor (between the shoreline and steep terrain). Land use in the Achugao South subwatershed is dominated by undeveloped land. Development consists primarily of medium to high density residential in the village of Tanapag, closed garment factories, workers barracks, and a portion of the lower base industrial complex. The Tanapag Middle School, meeting house, and beach park/boat ramp are important features of Achugao South, as well as the Imperial Casha hotel construction site. Achugao North is slightly more developed and includes the San Roque village, the San Roque Elementary school, as well as three large beachfront resorts, including Aqua, Kensington, and the abandoned Plumeria. There are several smaller hotels and villas/condos in the subwatershed and two additional hotel construction sites Saipan Globe and Beverly. The abandoned Fiesta mall is just outside of the watershed and is considered part of As Matuis, however the areas immediately surrounding the mall to the south are within the San Roque drainage network. A few agricultural areas, including piggeries, have been noted in the watershed, but not to the extent of other areas on Saipan. Low-density, single-family homes and a small cemetery are found along Wireless Road, which is mostly an unpaved road running along the island's ridgeline.

A land use map is presented in **Figure 5a**, which is a modified version of the current land use map provided by BECQ based on field observations. Field adjustments primarily reflect residential parcels and areas of active construction. **Figure 5b** shows impervious cover based on NOAA 2005 land use analysis and shows a breakdown of four major stream catchments used for watershed modeling. Overall, the Achugao watershed contains approximately 10% impervious cover, which is the typical threshold for mainland watersheds at which water quality, hydrology, and aquatic biology impairments begin to show signs of degradation. For a more detailed breakdown of watershed land use and other characteristics, see Section 3 of this report on watershed modeling input.

Table 1 is an excerpt from the major siting and resort development permits in the watershed (FY2015-2019). Estimates of proposed infrastructure demands (water, power, sewer, parking, etc.) are not included in this summary.

There are over 360 acres of public land in the watershed (mostly in South Achugao), of which only 54 acres are already developed (**Figure 6**). There is a large consolidated area (over 290 acres) of undeveloped public land spanning the upper portion of the Achugao South subwatershed and Tasi stream catchment.

Table 1. CUC Capital Improvement Projects Update (Achugao, as of 2019)

Location	CRM Permit No.	Description	Status
Chalan Pale Arnold Road, Tanapag	SMS-2019-X-001	The New Century Hotel. Proposed renovation/conversion of an existing 3-story office building to a 48-room hotel. The hotel will include 36 parking spaces – 2 ADA compliance parking stalls, 27 guests parking, and 7 for hotel operation use. The building is connected to the CUC power, water, and sewer line. The project site is located in Tanapag Village south of Tanapag Elementary School, east of the Youth Center, and west of Chalan Pale Arnold Rd. The size of the property is ~ 1,800 sq meters.	Approved, 12/27/2018; Construction must be completed by January 31, 2021 per mandatory condition #2.
Tanapag	SMS-2018-X-020	Saipan Garden Resort (Imperial Casha). To be constructed and operated on three lots totaling about 24.71 acres on Chalan Pale Arnold Rd in Tanapag Village. The proposed project includes a hotel with ten 6-story buildings, two 6-story Service Apartments, 6-story staff housing, cafeteria, 2 single story restaurants, 2 single story hotel dining rooms, 1 single-story banquet hall, 3 pools, Admin building, generator room, and open space landscape	Application approved on 2/13/2018; Construction must be completed by 8/6/2021. Permittee is requesting for extension on the sewer connection permit.
San Roque	SMS-2017-X-055	Saipan Globe. Large new "container" hotel (1,184 rooms) that will impact approximately 3,500 sq meters of private land. The plan for the hotel is to have a resort complex with 438 hotel room tower, 98 villas, 60 employee dorms, 2 restaurants, 3,800 square feet of retail space, 14,500 square feet of event space, swimming pool, parking and support services.	Application approved on 9/13/2017; Construction must be completed by October 15, 2020.
As Matius	SMS-85-X-25 (formerly Nikko Hotel & Palms Resort)	Kensington Hotel with gift shops, restaurants, watersports and other amenities	Ongoing renovations during hotel operation.
Achugao	SMS-2015-007	Villora Condotel .2-3 Story Condominium & Villa Complex (150 rooms)	Application approved on 7/15/2015; Construction must be completed by Sept. 2018 (Permit Expired)

Wildfires for land clearing have been a recurring issue in this area and in other headwaters in Achugao (**Figures 7** and **8**). Achugao had large acreages burned in 2017 and 2019 (**Table 2**). Fires in 2016 were smaller but more distributed. Fires in 2018 only burned a small area in Achugao, but a large portion of the adjacent Talafofo watershed. The loss of vegetation and soil exposure associated with fires were identified in the 2017 bacteria TMDL as a likely and significant source of sediment and *Enterococci* (Paradigm Environmental, 2017).

In addition, un-remediated contamination sites, brown fields, and above and underground storage tanks are in the watershed, including a former WWII dump and the Tanapag fuel tank farm (**Figure 9**).

Table 2. Wildfire coverage in Achugao*

Year	Area (ac)	% of Watershed*
2016	59.9	3.2
2017	192.6	10.2
2018	45.2	2.4
2019	170.2	9.0

**calculation based on inclusion of Tasi catchment and former watershed boundary (1901 acres).*

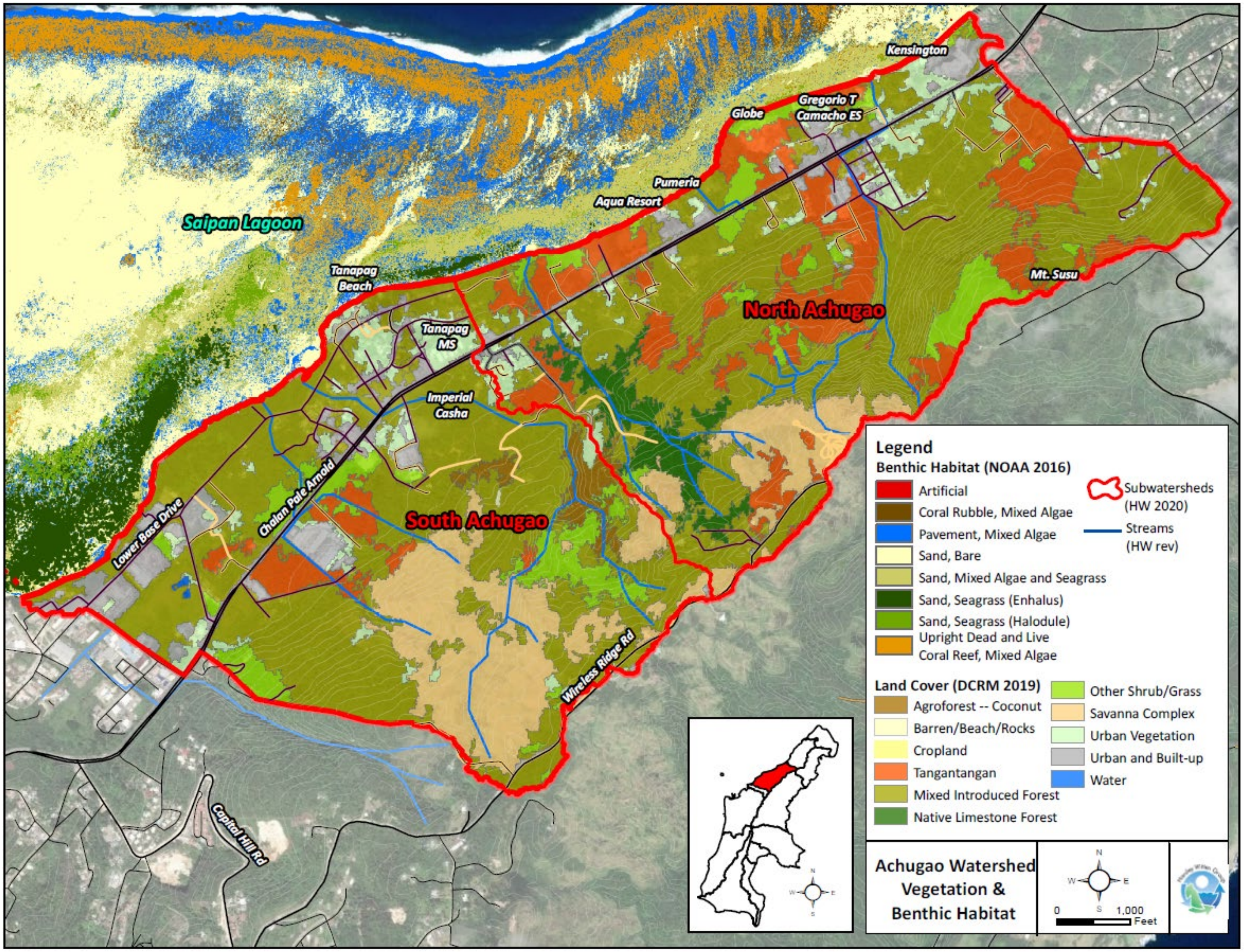

Figure 4. Vegetative Land Cover (USFW, 2005) and Benthic Habitats in the Achugao Watershed

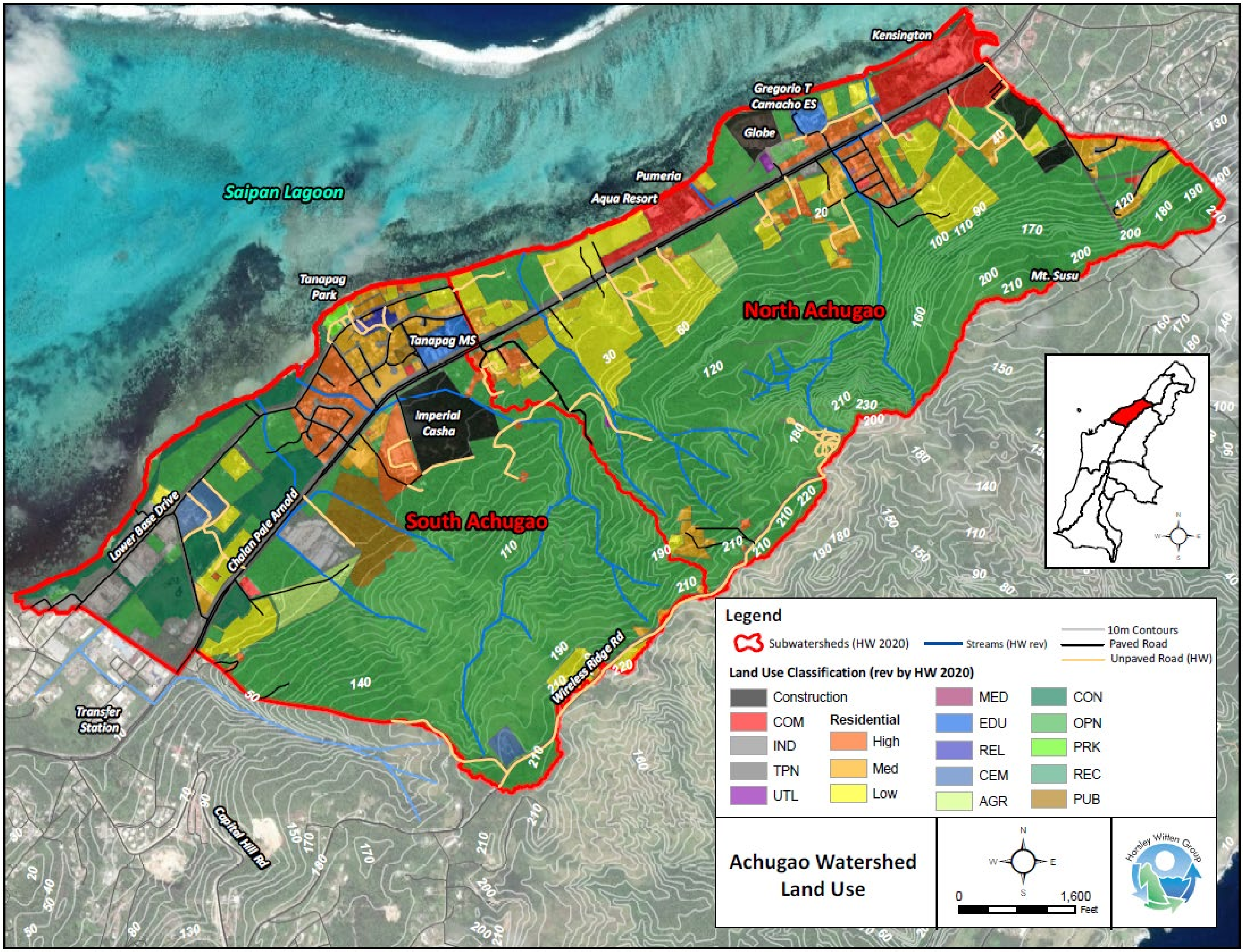

Figure 5a. Achugao Watershed Land Use Map with some revisions by HW based on verification during field assessments in 2020.

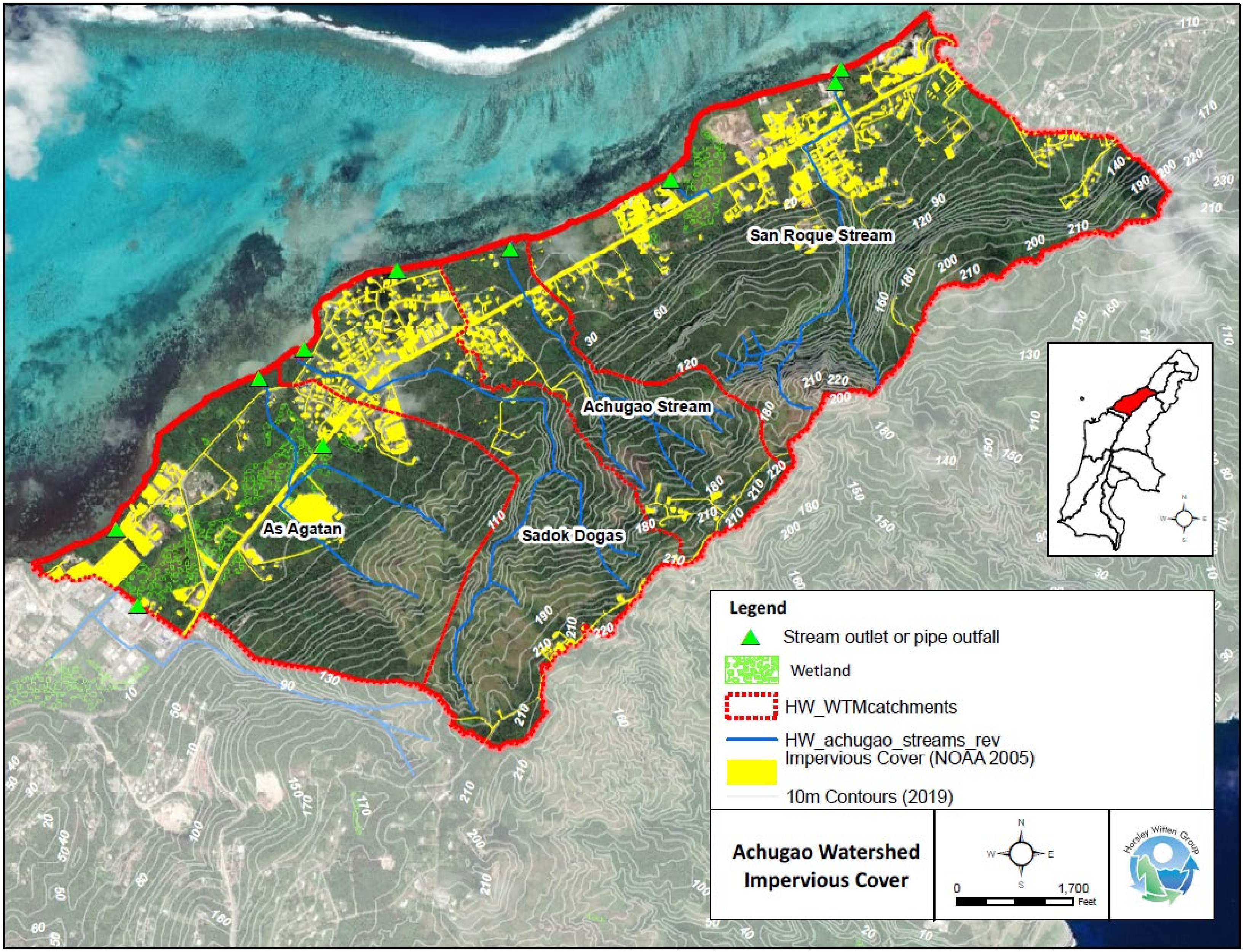

Figure 5b. Achugao impervious cover and major stream catchments (NOAA 2005)

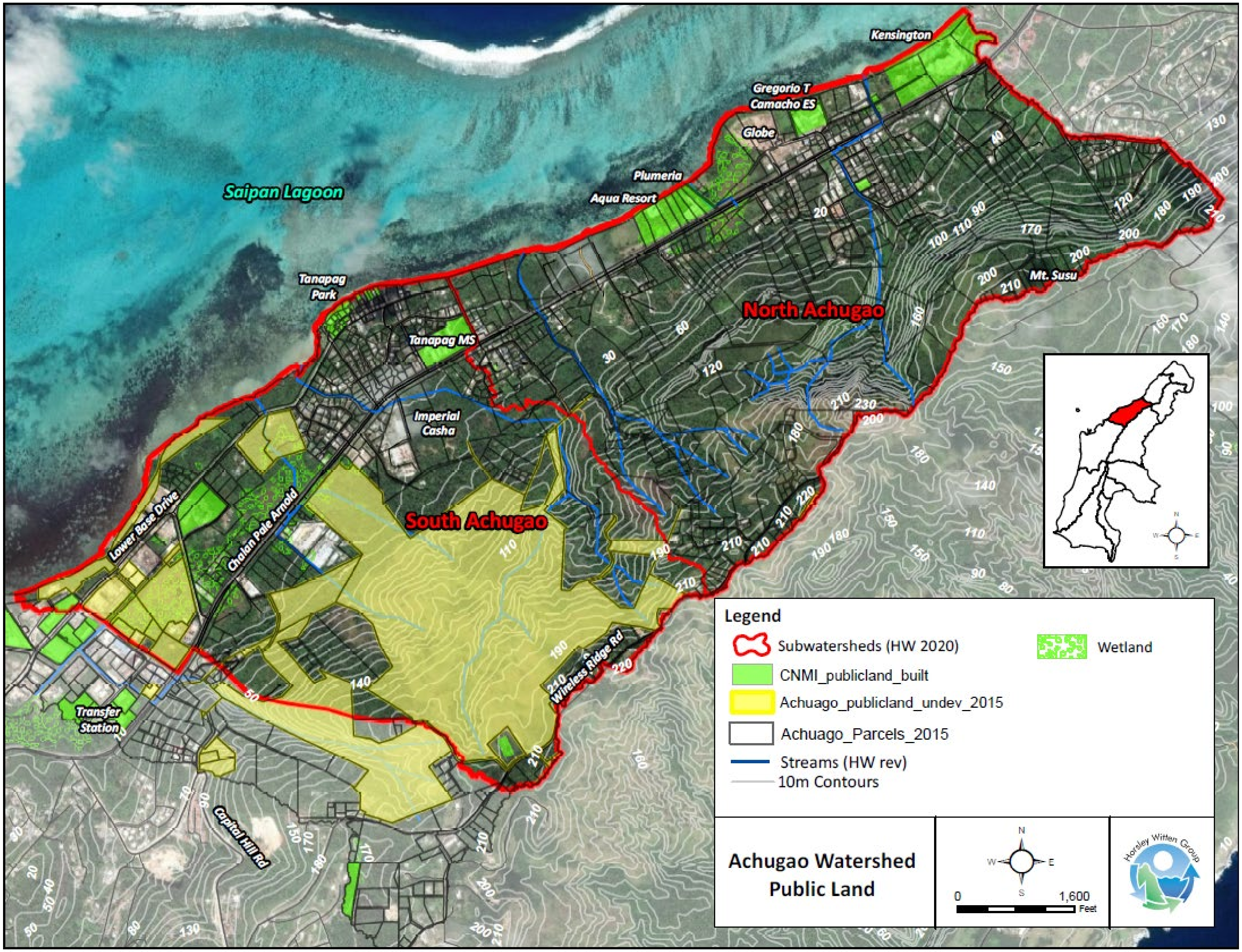

Figure 6. Developed and undeveloped public lands in the Achugao watershed. Some of these areas may be suitable for conservation.

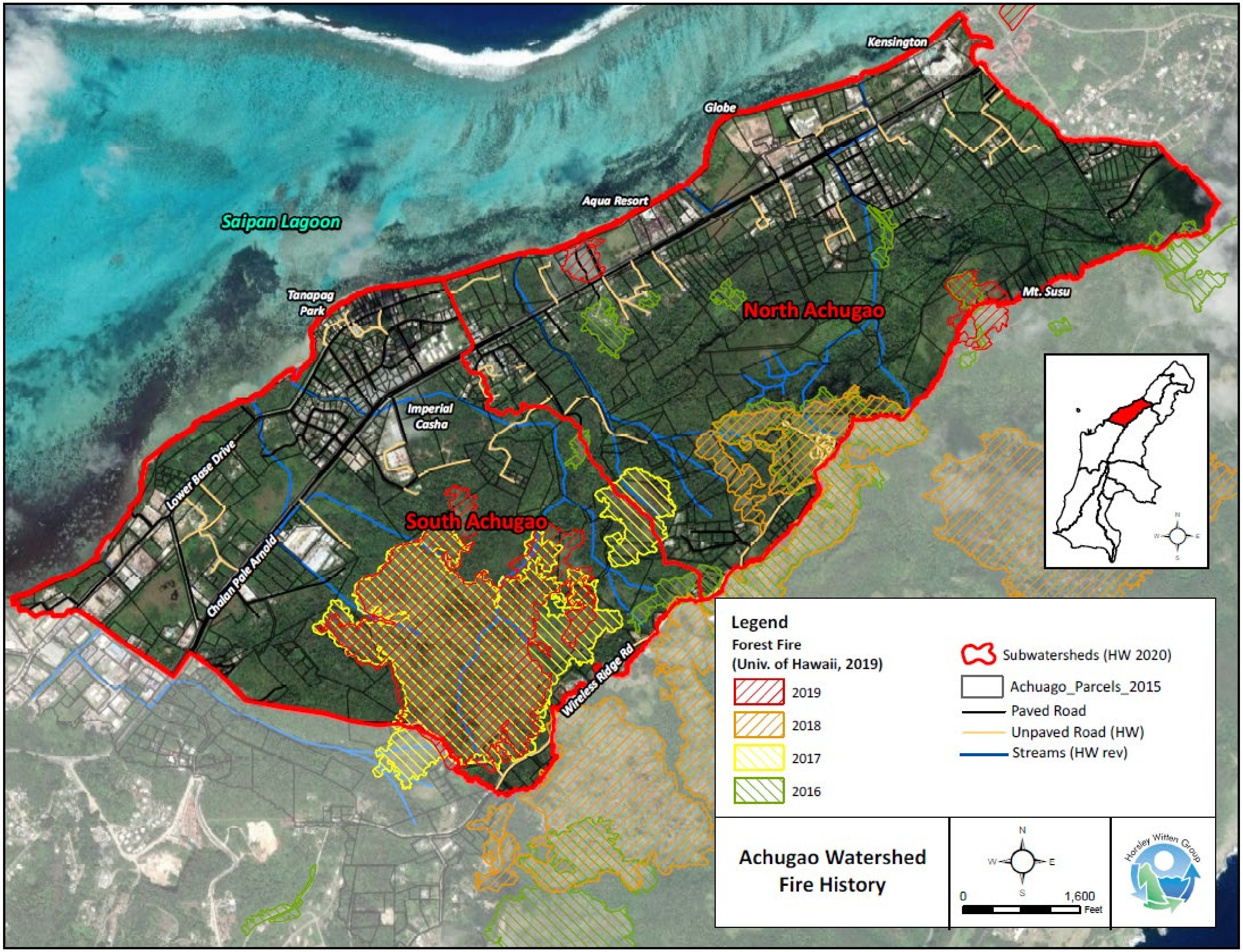

Figure 7a. Forest fire extent between 2016-2019.

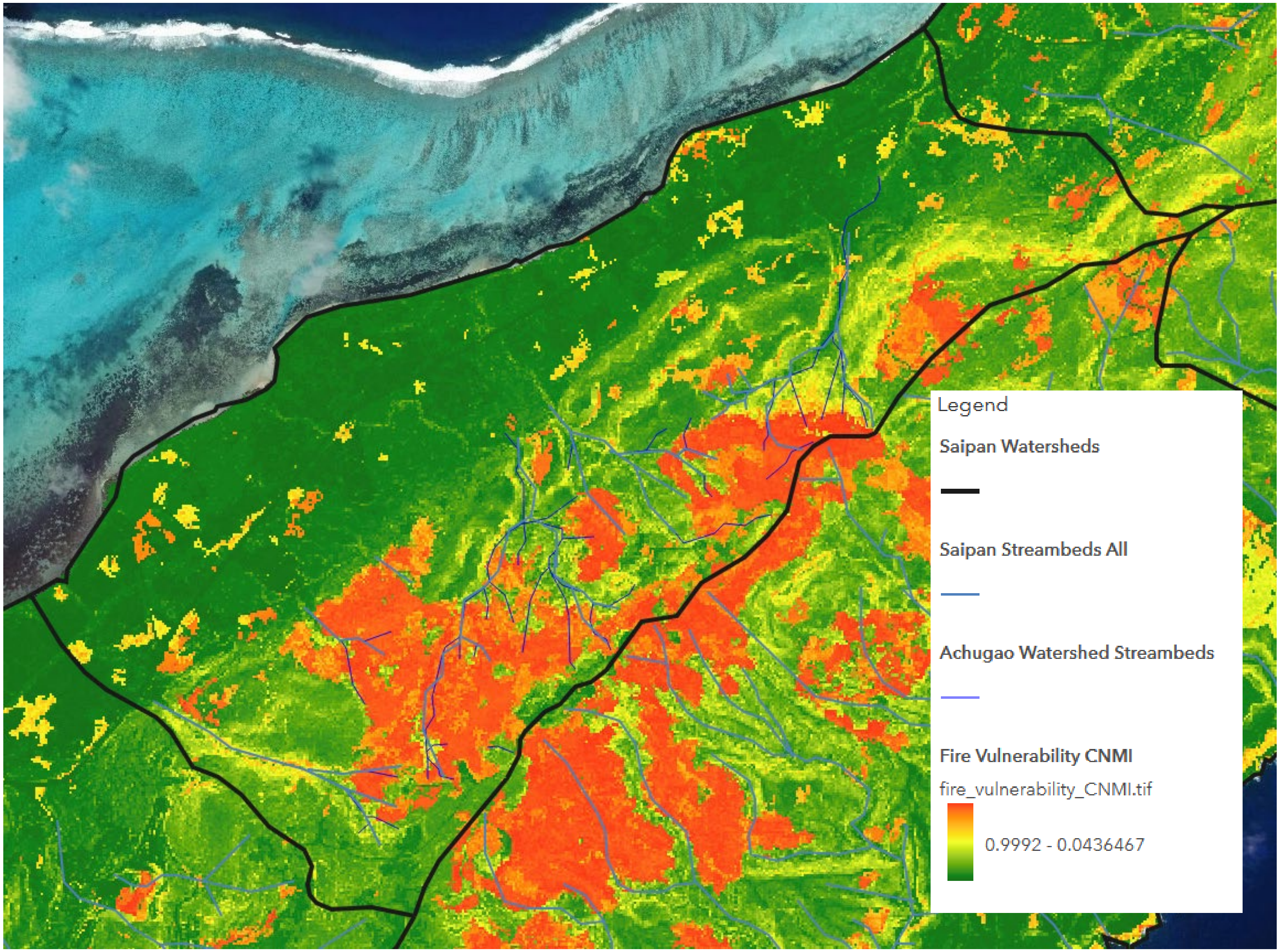

Figure 7b. Fire vulnerability in Achugao (CRMOGIS, 2020)

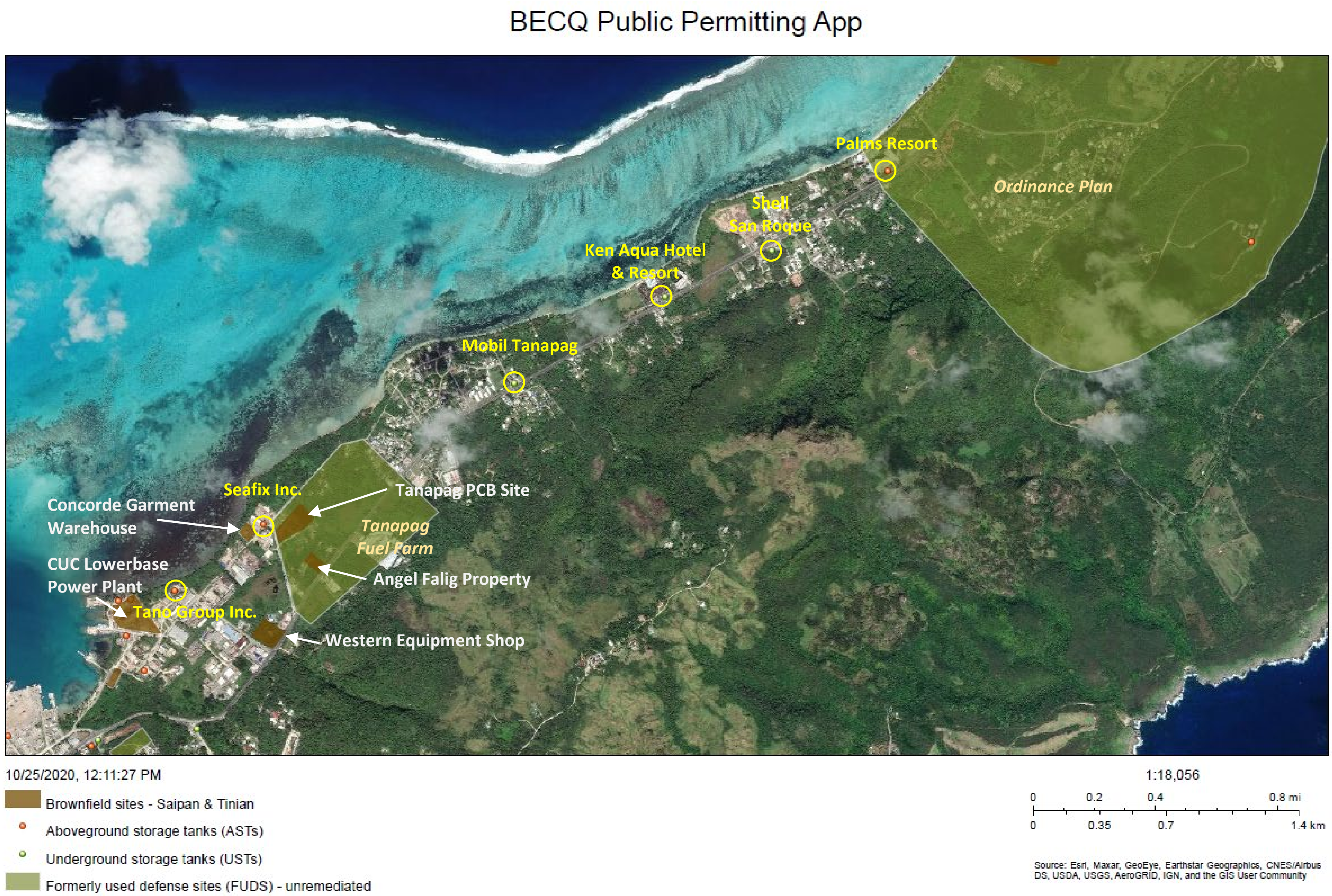

Figure 8. Map of potential contamination sites and storage tanks in Achugao

Areas of Particular Concern & Historic Sites

Figure 9 shows the designated Areas of Particular Concern within the Achugao watershed, which include the Saipan Lagoon, shoreline, FEMA flood zones, the Seaport District/Industrial area, and wetlands. The 2017 Update to the Saipan Lagoon Use Management Plan identifed Achugao as one of the prioruty watersheds for protection due to its influene on Lagoon quality and the potential for additional development in the watershed to cause further impacts (**Figure 10**).

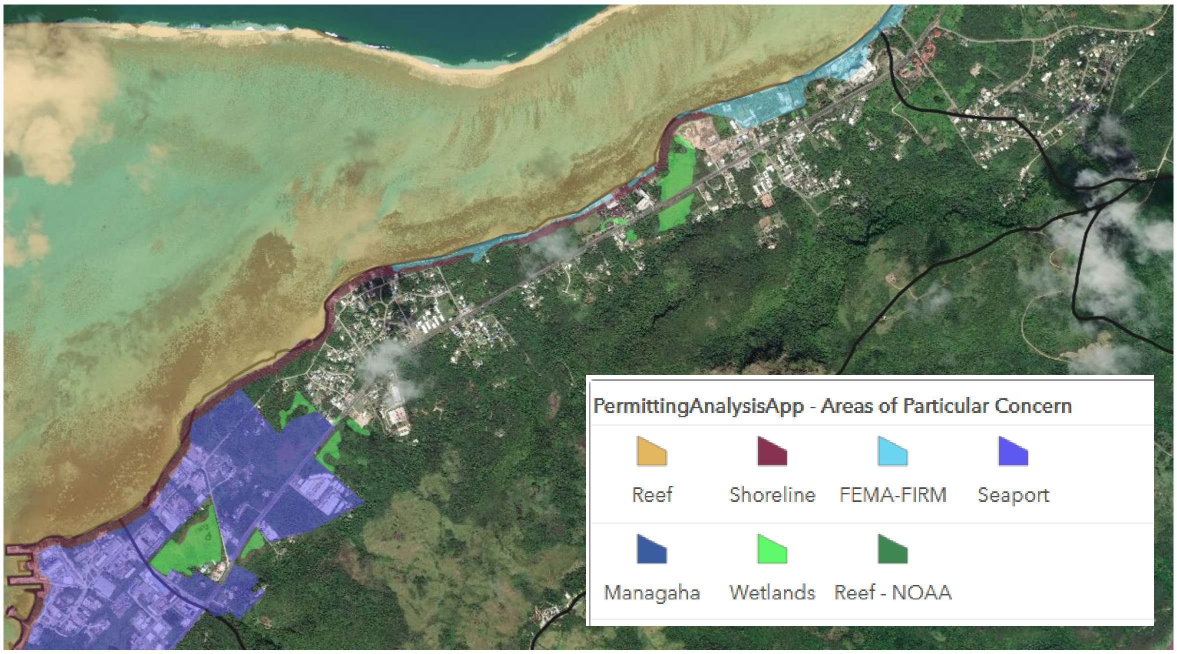

Figure 9. Areas of Particular Concern (from CRMOGIS, 2018).

Figure 10a. Excerpt from 2017 SLUMP update showing three priorities for protection:1) Live (x) and dead stands (o) of Acropora; 2) the northern watersheds of Achugao and As Matuis; and 3) the sea grass beds (green shades).

Much of the immediate coast is considered a sensitive area for archaeological resources by the Historic Preservation Office (**Figure 10b**). Unai Achugao is a major archaeological site that was listed on the National Register of Historic Places in 1996. Here, early habitation of the island was radiocarbon dated to 3500 BCE, excavations yielded more than 3,000 pottery fragments used to develop the regional pottery classification system, and a nearly-intact habitation surface was found within a protective fossilized coral reef. Another site, the Samoan Village, is located in Lower Base and is the site where ten chiefs from German Samoa (now Independent) Samoa were exiled between 1909 and 1915.

Figure 10b. Sensitive archeological areas (from CRMOGIS, 2018) and historic sites.

Infrastructure

Most of the development in Tanapag and San Roque falls within the sewer service area for the Sadog Tasi Wastewater Treatment Plant (**Figure 11**). The sewer main runs north along Lower Base Rd. and transitions up to Middle Rd. in Tanapag. Upgrades and repairs to several pump stations over the last few years are considered a primary factor in improved water quality at monitoring stations in the Lagoon. A new lift station/or replacement of an existing lift station was completed as part of the Globe construction. It is unclear if additional network upgrades between the Globe and the WWTP are needed (i.e., Imperial Casha infrastructure improvements).

Municipal water lines also extend along Middle Rd. into Tanapeg and San Roque, connecting to wells and storage tanks in the central watershed.

Table 3 provides a list of active and pending CUC Improvement Projects (as of 2019) in the Achugao watershed. This list for water and sewer infrastructure projects was provided by CUC during the watershed working group meeting held in January 2020.

Table 3. CUC Capital Improvement Projects Update (Achugao, as of 2019)

Project #	Project Name	Funding Amount	Status
S14-038	Pretreatment and FOG evaluation (island-wide, Garapan high density)	$3,100	• Hiring of manager pending • Funds redirected to SanVicente tank replacement
S15-042	Lift Station Renovation (SR-2 -Achugao, A-2, A-6)	$1.75M	SR-2 to go out to bid by Jan 2020
S16-046	Isa Dr. sewer realignment (NW Topachao, Achugao wetland)	$410,000	100% complete
W16-050	Leak detection and repair (island-wide)	$600,000	DO1 complete, DO2on-going, DO3 permitting underway
S17-058	Lower Base Sewer Replacement PHII. This would eliminate S1, route around the wetland, and improve WQ	$2M	SOW and Bid schedule to be finalized
EDA Grant # 07-01-07128 and PL 17-90	Lower Base Sewer PHI- Lift station and Forcemain	$1.9M	• OFCI material by HES at CUC warehouse • GPPC continues with trench excavation • Generator building 90% complete • IARII continues to monitor excavation
S17-059	Sadog Tasi WWTP upgrades (this is where Achugao wastewater is treated)	$1.7M	• IFB for clarifier canceled, new SOW • Sludge dewatering equipment

More information is needed on the following to better characterize wastewater management in the watershed:

1. Updated stream walk information on the observed presence of failing septic systems;
2. Closer look at recent bacteria monitoring identifying human sources (indicative of sewage);
3. Estimates of homes not connected to the sewer system and any onsite septic system surveys that have been conducted; and
4. Clarification on the planned upgrades to main sewer lines associated with Saipan Globe and Imperial Casha development projects.

Storm drain network mapping was not available. During the week of January 20, 2020, HW and KOA field crews assisted by BECQ mapped and assessed over 100 drainage structures (e.g., inlets and catch basins, culverts, manholes, BMPs, outfalls, stream outlets, and other). The condition, dimensions, and invert elevations were documented for each structure (**Figure 12**). Based on field observations, almost 60% of the structures evaluated require maintenance, repair, or other attention due to clogging, high sediment accumulation, visible damage, associated erosion, or other observations.

Tables 4-8 summarize the data collected on each structure.

A web map can be accessed detailing information and photos at each location information: https://www.arcgis.com/home/webmap/viewer.html?webmap=ddf0e4fd056b4211a5b6f53ca83425f8&extent=145.6635,15.1289,145.9171,15.2707

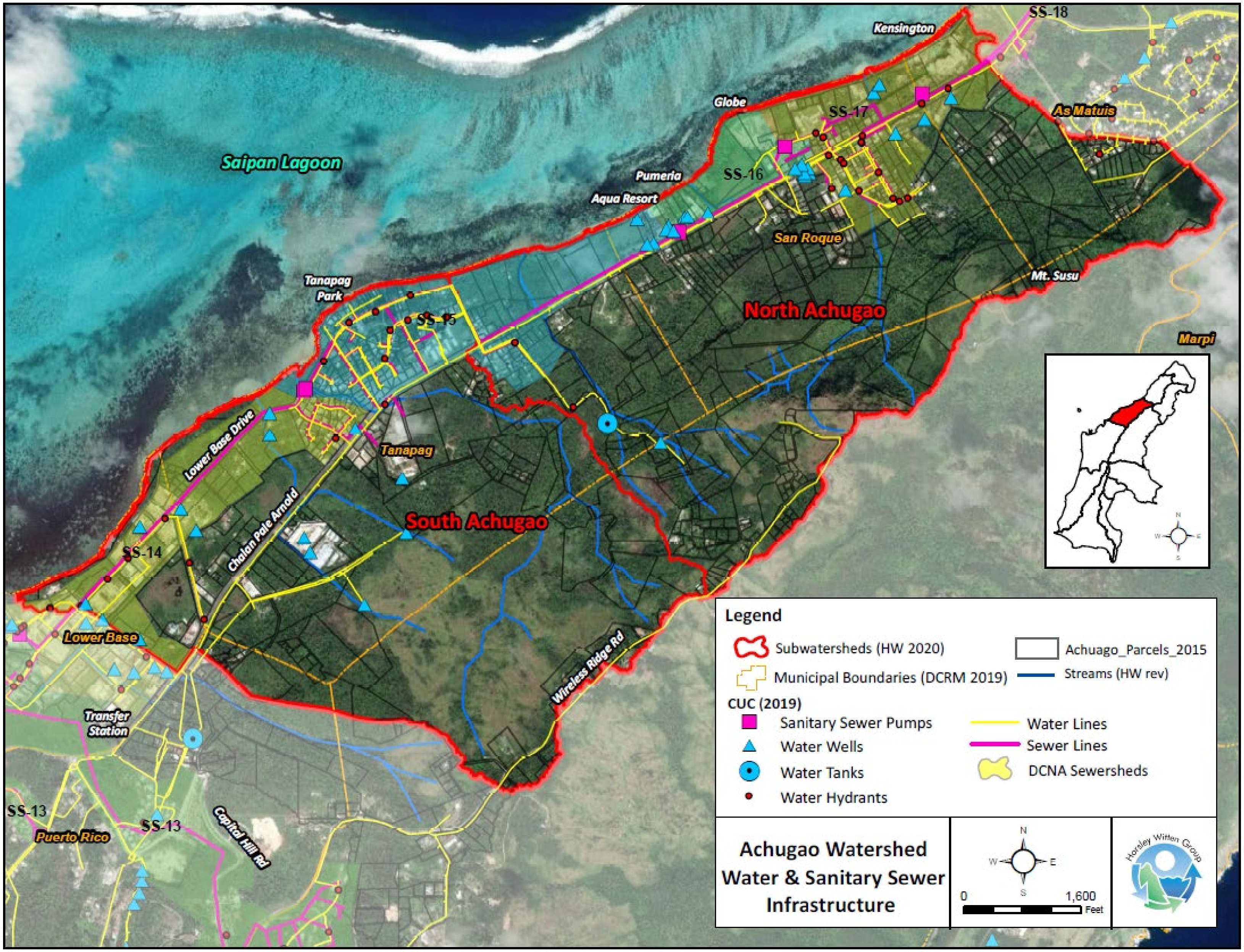

Figure 11b. Water and Sewer (CUC data)

Table 4. Achugao Drainage Infrastructure Inventory—Inlets and Catch Basins

ID	Description/Notes	Sediment[1]	Damage[2]	Flow[2]	Erosion[1]	Needs Attention[3]
AN300	Concrete. Pipe: 2ft w x 5 in H.	◖	●		◖	🔴
AN301	Metal. Pipe: CB 10ft deep. Inv: 10 ft.	?				
AN306	Concrete. Pipe: 2.5' x5'. Leads to structure in grass.	◖	●			🔴
AN307	Clay. Pipe: 6". Inv: 0.9 ft. Sump. Shallow- standing water.	◖			○	🔴
AN309	Concrete. Pipe: 2". Inv: 0.08 ft. No sump. along Aqua Resort walkway.	○				
AN310	Trench drain. Concrete. Pipe: 1.5’ W x 2’ deep. Inv: 2 ft. Trench drain across Magazine Dr. leads to concrete channel alongside of perpendicular road.	●	●		○	🔴
AN311	Pipe: 3'W x 2'L x 4’ ft deep. Inv: 4 ft. Pipe likely continues downhill next to house; tree growing in structure.	○			○	
AN313	Continue trench drain. Concrete. Pipe: 18"W x 12" deep. Inv: 1 ft. No sump. veg and other debris covering part of grate. The trench drain extends across the school parking lot and into fenced off veg area.	◖				🔴
AN317	Pipe: 3'w x 2'L x 4’ ft deep. Inv: 4 ft.	○			○	
AN324	Concrete. Pipe: 2’ Wx1’ H. Inv: 1.5 ft. No sump. Inlet from parking lot at Kensington to concrete channel.	◖			○	🔴
AN325	Concrete. Pipe: 30”W x2”H. Inv: 0.2 ft. No sump. Concrete swale to catch basin- feeds in from other side of road.	●			◖	🔴
AN326	Concrete. Pipe: 30”W x2”H. Inv: 0.2 ft. No sump. concrete drainage structure runs along the side of the road and turns this corner.	○			○	
AN327	Concrete. Pipe: 30”W x2”H. Inv: 0.2 ft. No sump. Runs along launch road and Marpi St.	○			○	
AN329	Concrete. Pipe: 3”. Inv: 0.5 ft Sump. Market parking lot.	◖			○	🔴
AN330	Concrete. Pipe: 3”. Inv: 0.83 ft. Sump. Floating layer, no sheen, leaves.	●			○	🔴
AN339	Concrete. Pipe: 5x5’. Inv: 2.5 ft. No sump. Flows towards aqua property across street.	◖			◖	🔴
AN340	Concrete. Pipe: 2’Wx0.17"H (inlet on road) , CB 4’x2.5’. Inv: 2.5 ft. No sump. invert is depth of catch basin.	○			○	
AN341	Concrete. Pipe: 2”x3’. Inv: 3.5 ft. No sump. catch basin has vegetation growing out it. Should be cleaned out.	●			◖	🔴
AN346	Concrete. Pipe: 4’Lx 0.5’W CB; culvert 2.3’W x 3” H. Inv: 0.2 ft. No sump. Repair needed on structure. Clean out debris.	●	●			🔴
AN348	Concrete. Pipe: Inlet 5’Wx3”H;24” RCP, GRATE 4’x4’. Inv: 5 ft. Sump. Corner of school 2 inlets and CB.	◖				🔴
AN349	Concrete. Pipe: 2’x 1’. Inv: 0.2 ft. No sump.	●	●		○	🔴
AN352	Trench Drain. Concrete. Pipe: 18”W x12” deep. Inv: 1 ft. No sump. No sediment forebay. No controlled outlet. Vulnerable near school.	●			○	🔴
AS100	Concrete. Pipe: 6’ x 8in parabolic. Inv: 0.6 ft. No sump. Rob: overflows during rainy season, very high velocity. Pulls out veg. Goes under road 100yds downstream.	○				
AS103	Concrete. Did not see pipe, had water.	○				
AS107	Concrete. No pipes seen. Full.	●				🔴
AS110	Concrete. No sump. Inlet for channel to AS109.	◖				🔴

ID	Description/Notes	Sediment[1]	Damage[2]	Flow[2]	Erosion[1]	Needs Attention[3]
AS111	Concrete. Pipe: 15” Inv: 1.5 ft. Culvert from curbed ditch goes across road to CB that is clogged. Goes to outfall into maybe leaching area? rain garden?	○				
AS117	Ductile iron pipe. Pipe: 36". Inv: 5.9 ft.	○				
AS118	Concrete. Pipe: 36". Inv: 6.2 ft. No sump.	○				
AS121	Concrete. No pipes seen. No sump. Inlet concrete swale to Dogas Stream right above AS120 culvert. Needs cleaning.	○			○	🔴
AS124	Concrete. Pipe: 2-2’x3”. Others up road.	?				
AS160	Concrete. Pipe: 8’x4”. No sump. Box CB. 36” pipe to S along middle rd.	○				
AS161	Concrete. Pipe: 36". Inv: 6.4 ft. Sump. Box 4.5’x4.5’. Needs cleaning.	◖			○	🔴
AS163	Concrete. Pipe: 2x3’ box. Inv: 3 ft. No sump.	○				
AS164	Leaching catch basin. Pipes with hoods coming in from bldg?. Concrete.	?				
AS165	Leaching catch basin. 6” in from bldg.	?				
AS166	Concrete. Pipe In: 2’ diameter with 3’ invert. Out: 3’ with 3.9’ invert. 4’x4.5’ box across street with 3.15’ invert.	○	●		○	🔴

[1] Sediment accumulation and dry weather flow observed is ●high, ◖medium, ○low, or ? unknown
[2] Visible damage or observed erosion is ●yes or ? unsure
[3] Structure was identified as 🔴yes, needs cleaning, repair, or inspection due to clogging, sediment levels, damage, or other.

Table 5. Achugao Drainage Infrastructure Inventory—Culverts

ID	Description/Notes	Sediment[1]	Damage[2]	Flow[2]	Erosion[1]	Needs Attention[3]
AN302	Concrete. Pipe: 3ft Wx2ft H. Inv: 10 ft. Leads into veg swale alongside road - potential for trash rack.	○				
AN303	Concrete. Pipe: 3 ft 3 in W x2 ft 2inH. Inv: 10 ft. Trash. Connects to inlet on sidewalk and likely to other side of road.	○				🔴
AN304	Concrete. Pipe: 5’W x3’H. Inv: 12 ft. Pipe running underground on top of structure leads to swale.	○			○	
AN305	Concrete. Pipe: 5’W x3’H. Inv: 12 ft. Standing water. Visible trash- 2 pipes can hear water flowing; can’t see where 45° pipe comes from, layer on top looks like fat or grease; no odor no sheen.	○		◖	○	🔴
AN314	Concrete. Pipe: 5’Hx10’W. Inv: 5 ft. Lots of debris, channel coming from residential area.	●	●			🔴
AN316	Concrete. Pipe: Length of road, 4'W, 6' deep. Inv: 6 ft. Same concrete channel- culvert.	○				
AN331	Concrete. Pipe: 4’W x2.5’H. Inv: 2.5 ft. Filled with veg overgrown.	●		◖	○	🔴
AN336	Concrete. Pipe: 7’Wx16” H. Inv: 2 ft. Culvert is clean. Connects to trench drain in front of Aqua.	○			○	
AN337	Concrete. Pipe: 4’Wx1’H. Inv: 2 ft. Old access drive. Catch basin connects to culvert.	◖			◖	🔴
AN338	Concrete. Pipe: 18". Inv: 2 ft. Vegetated swale runs along property in front of Aqua Resort and through these culverts.	◖			○	🔴
AN342	Concrete. Pipe: 6’Wx3’H. Inv: 3 ft. Overgrown veg should be cleaned out.	○			◖	🔴

ID	Description/Notes	Sediment[1]	Damage[2]	Flow[2]	Erosion[1]	Needs Attention[3]
AN343	Concrete. Pipe: 6.5'Wx3'H. Inv: 5 ft. Connects wetlands on both sides.	◖			○	🔴
AN344	Concrete. Pipe: 6'Wx3'H. Inv: 3 ft. Serious damage to structure, electrical or phone line damaged and laying above.	◖	●			🔴
AN345	Concrete. Pipe: 2'Hx4'W. Inv: 4.5 ft. Lots of trash-leads into wetland area.	○				🔴
AN347	Concrete. Pipe: Unknown. connects to culvert across street; couldn't get a good view and/or measurements of the box culvert on this side due to veg and steep drop off from road.	?		?		
AN350	Concrete. Pipe: 10'Wx2'H large one, small one - 8'W x 1.5'H. Inv: 2 ft. 3 concrete structures inside fenced area with ponding, visible water, need to clean out whole area.	●			○	🔴
AN353	Concrete. Pipe: 4'Wx4'H, 4x6 other side facing house. Inv: 8 ft. Private area, natural channel coming from hill, headwater.	◖	●		◖	🔴
AN354	Concrete. Pipe: 3.5Wx1.5H. Inv: 2 ft. Private, downstream from piggery, odor in air from piggery.	?				
AN355	Concrete. Pipe: 5'Hx10'W. Inv: 5 ft. same as AN314 - connects to AN314 across street.	○			○	
AN356	Grass infiltration basin. Pipe: 0. Inv: 1 ft.	○				
AS101	Concrete. Pipe: 24". Inv: 3.4 ft. Double conc culvert. Inlet to box 24". No cover to box (6.5x2'). Trash.	○				🔴
AS104	Concrete. Pipe: Box 2.5x1.2. Inv: 4.2 ft. Erosion on sides, recently cleaned.	●			◖	🔴
AS113	Concrete. Bridge w culvert. Rob: very full in rainy season. Floods over bridge. 10 ft wide, 2ft deep. Sewer line in air across channel.	◖		◖		🔴
AS115	Concrete. Pipe: 14x4.5'. Lots of trash. Pipe over channel. Gabion walls on uphill side. Greywater discharges upstream. .	●		◖		🔴
AS119	Concrete. Pipe: 29x7'. Bridge w culvert, 36" pipe discharges from AS 117/118.	○			◖	🔴
AS120	Concrete. Pipe: 29x7'. Upstream end of culvert AS119 across middle road. Dogas stream.	◖	●		○	🔴
AS123	Concrete. Pipe: 11x3'. Coming out of Imperial Casha site. scour below step down.	○			○	
AS125	Concrete. Pipe: 12'x5' (to top of water). Bridge/culvert. Greywater discharges.	?		◖		
AS127	Concrete. Bridge/culvert. Water line in headwall. Possibly dug during WW2 to drain wetland.	◖	●		○	🔴
AS130	Concrete. Pipe: 17'x6' but clogged. Water pipes across channel. Very sediment clogged. Agatan stream. Flowing.	●		◖	○	🔴
AS131	Concrete. Pipe: 36". Dry, headwalls. Very clogged.	●			○	🔴
AS133	Concrete. Clogged culvert. See AS132/135.	●			○	🔴
AS135/136	Concrete. Pipe: 3x2'.	○		◖	○	
AS144	12" PVC	○				
AS146	Two 8" ductile iron pipes.	○		◖		
AS158	Concrete. Should be cleaned. Unclear which direction flows. .	●		◖	○	🔴
AS167	Concrete.	○		◖	○	
AS169	Concrete. Inv: 3 ft. 3x3' box. 100% clogged.	●			○	🔴

ID	Description/Notes	Sediment[1]	Damage[2]	Flow[2]	Erosion[1]	Needs Attention[3]
AS200	Concrete. Inv: 4 ft. Standing water, trash and veg, pipe filled with sediment is next to it.	●	●		◖	🔴
AS201	Concrete. Inv: 6 ft. Standing water/trash on open side—trash/large veg/no standing water on other.	◖				🔴

[1] Sediment accumulation and dry weather flow observed is ●high, ◖medium, ○low, or ? unknown
[2] Visible damage or observed erosion is ●yes or ? unsure
[3] Structure was identified as 🔴yes, needs cleaning, repair, or inspection due to clogging, sediment levels, damage, or other.

Table 6. Achugao Drainage Infrastructure Inventory—Outfalls and Stream Outlets

ID	Description/Notes	Sediment[1]	Damage[2]	Flow[2]	Erosion[1]	Needs Attention[3]
AN308	Concrete. Inv: 5 ft. Storm gate - needs repair.	◖	●			🔴
AN312	Metal pipe: 12". Inv: 1 ft. Sediment filled up halfway up the pipe.	●			○	🔴
AN318	Stream outlet. Outlet for culvert near Dogas Ln.	◖	●		●	🔴
AN322	Stream outlet. Pipe: 4'W x2'H. Inv: 2 ft. Visible flow, might be coming from Middle Rd. culverts.	●	●	◖	◖	🔴
AN-500	Concrete outfall on beach draining Kensington ponds: 4'W x2'H (buried). Inv: 2 ft. Flowing.	●		◖	◖	
AS112	Concrete.	◖			○	
AS114	Concrete. Pipe: 14'x6'. depth of water 2'. Bridge/culvert aka DPW bridge. Outfall of south end of south Achugao.	○		◖		
AS116	Outlet of Dogas Stream below culvert AS115. Largest sea grass beds in Saipan right below outfall. LOTS of trash, incl diapers (fecal source).	◖		◖		🔴
AS126	Outfall from Agatan (culvert AS125).	○		◖		
AS129	Concrete. Pipe: 8' wide arch. Old tide gate at end of channel. Possibly pre-war.	○	●	◖	◖	🔴
AS143	Outfall from AS142 (retrofit). Looks good.	○				
AS162	Concrete. Pipe: 36". No sump. Headwall to wetland from box CB.	◖			○	🔴

[1] Sediment accumulation and dry weather flow observed is ●high, ◖medium, ○low, or ? unknown
[2] Visible damage or observed erosion is ●yes or ? unsure
[3] Structure was identified as 🔴yes, needs cleaning, repair, or inspection due to clogging, sediment levels, damage, or other.

Table 7. Achugao Drainage Infrastructure Inventory—BMPs

ID	Description/Notes	~DA *(total/IC acres)*	Sediment[1]	Damage[2]	Flow[2]	Erosion[1]	Needs Attention[3]
AN320	Sediment trap at base of concrete drainage ditch. Flow observed. Ditch overflowing into swale along road. *Clean*	1.0/0.7	●		◖		🔴
AN323	Series of ponds and stormwater wetland at Kensington. *Check design plans to evaluate drainage system components (vs. aesthetic feature). Outlet structure collecting organic debris. Clean. Great spot for a WQ and educational retrofit.*	10/8	○		◖	○	🔴
AN356	Grass infiltration basin at San Roque School. Inv: 1 ft.	3.5/3.0	○				

ID	Description/Notes	~DA *(total/IC acres)*	Sediment[1]	Damage[2]	Flow[2]	Erosion[1]	Needs Attention[3]
AN510	Ponding basin at Saipan Globe built in a natural wetland. May serve as a temporary sediment basin. *Design plans should be further evaluated. See Restoration Opportunities section.*	5.0/2.5					🔴
AS141	Stone infiltration trench. 3” pipe along wall of Tanapag MS.	0.2/0.2	○			○	
AS145	Rain garden at school. *Clean out inlet. Widen and clean outlet/spillway (may need to lower spillway elevation or deepen RG. Maintain positive drainage on outlet side to road.*	0.5/0.4	◖			○	🔴
AS148/149	Ponding basin is 4-6’ deep, varies in width; up to 20’. Outfall in corner by trench drain in the NW corner of school. Takes roof, walkway and field runoff. Veg is overgrown and should be cut and maintained. Standing water observed. Water overtops in the SW corner of basin and contributes to drainage issues at AS142. *Clean basin. Explore expanding capacity and address overflow (see restoration opportunity AS149.*	3.7/1.0	○			○	🔴
AS155	Swale w/o culvert. Lots of trash.	3.2/1	◖	●		○	🔴
AS500	Sediment basins at Imperial Casha need to be inspected. Two near entrance have erosion on side slopes, are full of sediment, and require removal of accumulated material. Others on east side not investigated.	10/0	●			●	🔴

[1] Sediment accumulation and dry weather flow observed is ●high, ◖medium, ○low, or ? unknown
[2] Visible damage or observed erosion is ●yes or ? unsure
[3] Structure was identified as 🔴yes, needs cleaning, repair, or inspection due to clogging, sediment levels, damage, or other.

Table 8. Achugao Drainage Infrastructure Inventory—Uncategorized

ID	Description/Notes	Sediment[1]	Damage[2]	Flow[2]	Erosion[1]	Needs Attention[3]
AN315	Natural channel. Channel goes to concrete channel on diablo. Path on the side of the road leads to gorge - stream flows during wet season.	○				
AN319	Channel. Concrete. Pipe: Length of road, 4’W ,6 ‘ deep. Inv: 6 ft. Extends entire road up to concrete swale, intersection of Matsuri and San Roque.	○			○	
AN328	Concrete swale. Low point on road near market and gas station collects sediment. Milky substance near gas station.	●			●	🔴
AN351	Concrete swale running the length of the road. Recommend cleaning out swale.	●			◖	🔴
AS108	Convergence of two concrete swales.	●				🔴

[1] Sediment accumulation and dry weather flow observed is ●high, ◖medium, ○low, or ? unknown
[2] Visible damage or observed erosion is ●yes or ? unsure
[3] Structure was identified as 🔴yes, needs cleaning, repair, or inspection due to clogging, sediment levels, damage, or other.

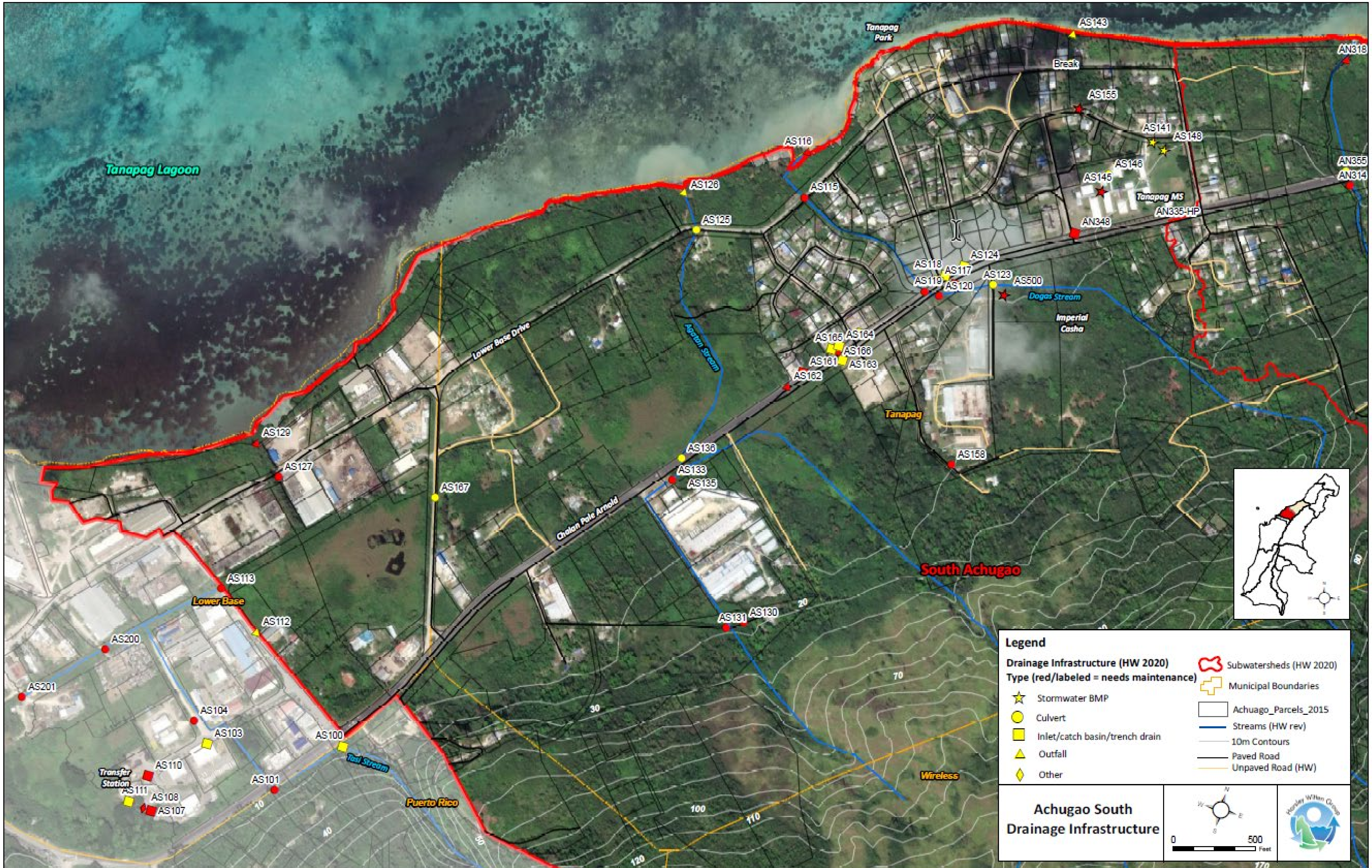

Figure 12a. Drainage structures in Achugao South assessed by HW in 2020 (red indicates needing attention)

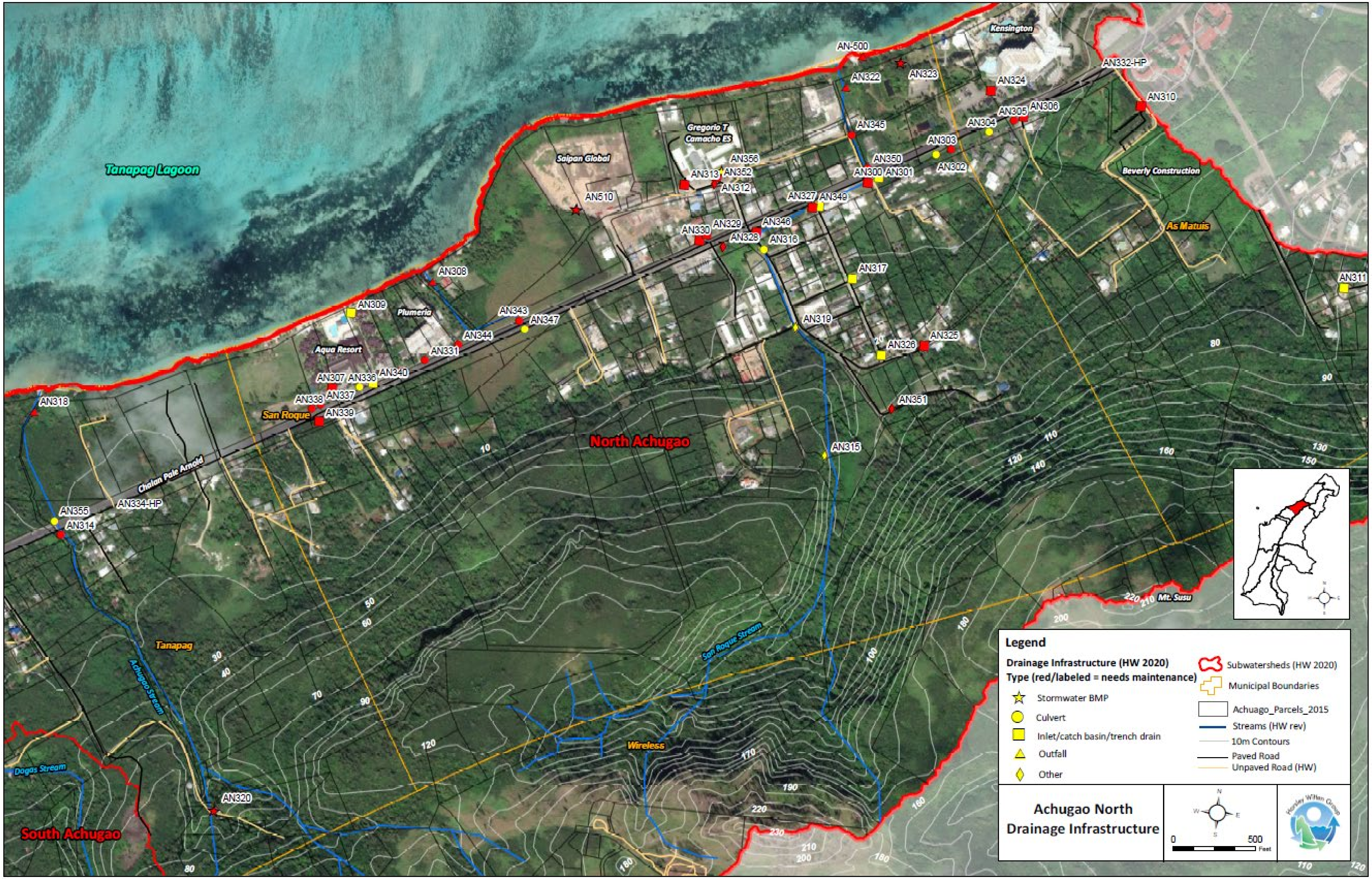

Figure 12b. Drainage structures in Achugao North assessed by HW in 2020 (red indicates needing attention)

Hydrology

Mean annual precipitation for the watershed is approximately 85 inches per year, of which most occurs between July and November (2006, Stormwater Manual). **Figure 13** shows average monthly rainfall at the Saipan Airport from 1999-2016 (Paradigm, 2017). For stormwater management purposes, recharge of 1.5” of precipitation is required in limestone areas and management on 0.80”-0.10” (depending on soil HSG) is required in volcanic areas. Water quality targets of 1.5” or 0.80” of rainfall are required in areas draining to high and moderate quality waters, respectively. Most of the development in the coastal plain of Achugao is subject to 1.5” recharge and 0.80” water quality targets.

Month	Average Monthly Rainfall	% of total
Jan	3.79	4.9%
Feb	2.95	3.8%
Mar	2.32	3.0%
April	2.83	3.7%
May	4.05	5.2%
June	5.01	6.5%
July	8.14	10.5%
Aug	15.46	20.0%
Sept	12.14	15.7%
Oct	10.57	13.7%
Nov	5.58	7.2%
Dec	4.51	5.8%

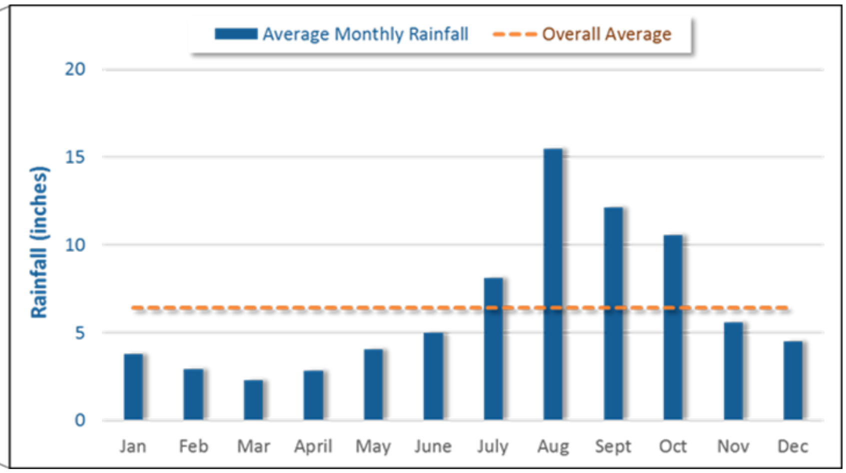

Figure 13. Average monthly rainfall at Saipan Airport 1999-2016 (from Paradigm, 2017)

There are several low-discharge springs and seeps in the central uplands of the watershed, that partially drain high-level aquifers. Carruth (2003) documents that an average of 0.22 Mgal/day were contributed to the municipal water supply from Tanapag I and II Springs and Achugao Spring. Water level in the high-level aquifers (and flow from springs) fluctuate seasonally and are sensitive to periods of low rainfall. **Figure 14** shows the delineation of groundwater management zones, location of water wells, water table and groundwater flow map, and municipal supply spring locations.

The CNMI has few streams that are wet most of the year; none have measurable flow volumes year-round through their entire length. The four major stream systems in the watershed include (from south to north): As Agatan, Saddok Dogas, Achugao, and San Roque. These ephemeral streams flow only during rain events; however, there are perennial freshwater pools located in the headwaters. Agatan Stream is deep enough near the mouth to maintain standing water. Visual stream assessments were conducted by BECQ in 2020 for the Agatan, Dogas, and Achugao streams using the new CNMI SVAP method. The 2020 Integrated Waters Report states that stream teams observed shrimp and eel in mid and upper reaches of Agatan and Dogas streams above Middle Rd. WWII dumpsites were confirmed in the mid to upper reaches of Dogas. Information from these assessments will be used to supplement watershed restoration project lists and inform management priorities.

There are over 56 acres of freshwater wetlands in the Achugao watershed, mostly located seaward of Middle Rd. There are three large wetland complexes: the Falig Wetland mitigation site in Lower Base, a similarly sized and connected complex to the north in the As Agatan drainage system, and an area spanning both sides of Middle Rd. between the Plumeria Hotel and the Saipan Globe construction site in San Roque. These natural systems likely provide water quality, flood attenuation, and habitat services unique to Saipan despite significant physical and hydrologic alterations (past and present). The two active construction sites at Saipan Globe and Imperial Casha offer examples of active buffer encroachment and wetland alteration/loss. Comprehensive wetland habitat and functional assessments of these systems has not been conducted recently.

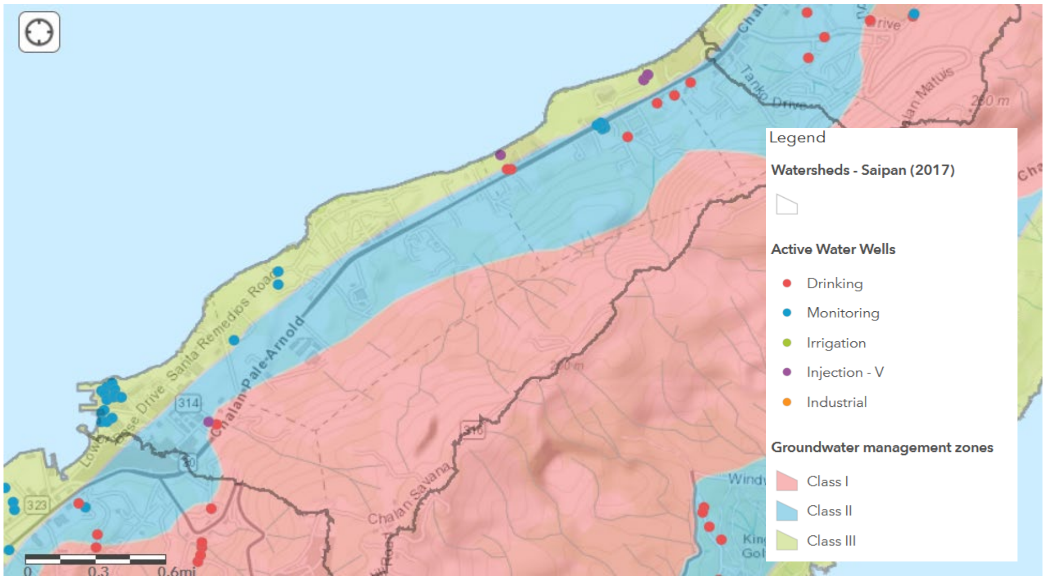

Figure 14a. Groundwater management zones and wells from CRMOGIS (BECQ, 2017).

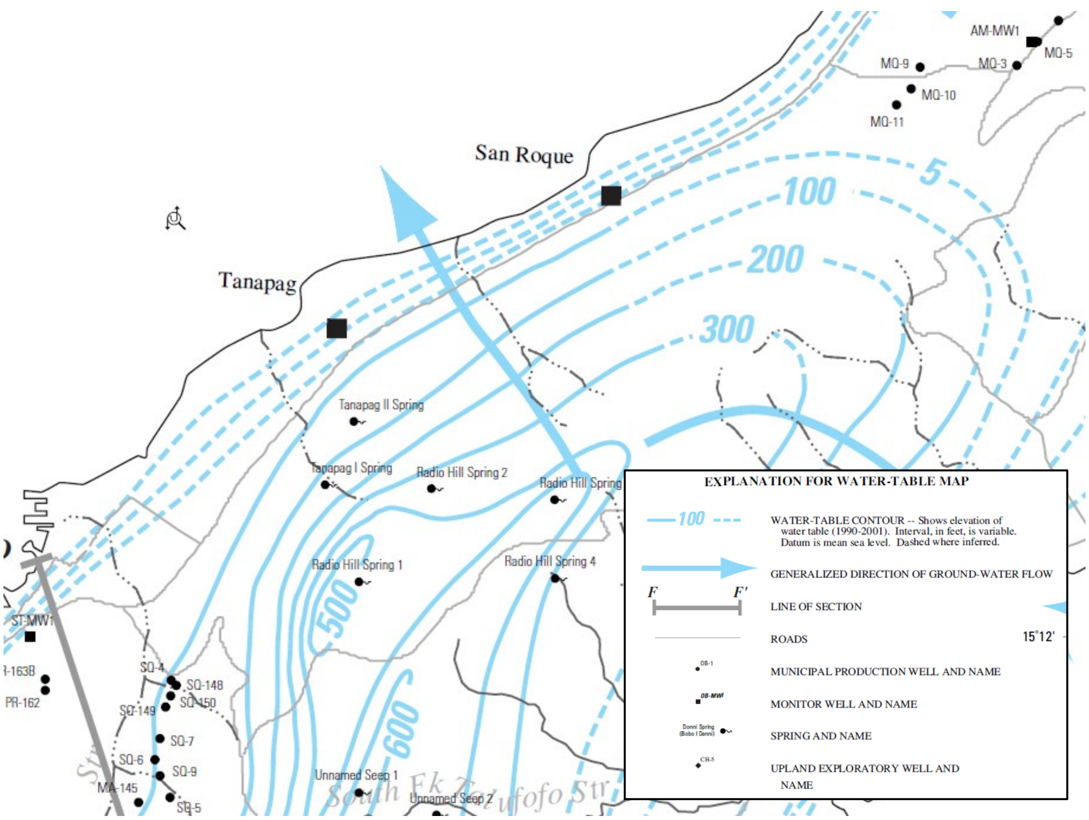

Figure 14b. Water table contour and flow map (Carruth, 2003)

Climate Vulnerability

There is extensive and critical infrastructure in the low-lying portion of Achugao, much of which is vulnerable to coastal flooding. The Lower Base industrial area, portions of Tanapag and San Roque, several resorts, and utilities that are seaward of Middle Rd. are within FEMA flood hazard areas (**Figure 15**) and vulnerable to sea level rise impacts (**Figure 16**). The 100-year flood could affect up to 0.3 miles inland, which is the most populated area of the watershed.

The reef provides some measure of shoreline protection from storm damage. Maximum Tsunami impacts are predicted to have a strong influence in the watershed (**Figure 17**). Designated shelters appear to be within the predicted impact zone.

The social vulnerability index completed in 2014 as part of the NOAA-funded Climate Change Vulnerability Assessment indicates a medium to med-high vulnerability for the communities in the Achugao watershed (**Figure 18**). The vulnerability index values range from 26 (dark green) to 72 (red) with higher values equating to greater vulnerability.

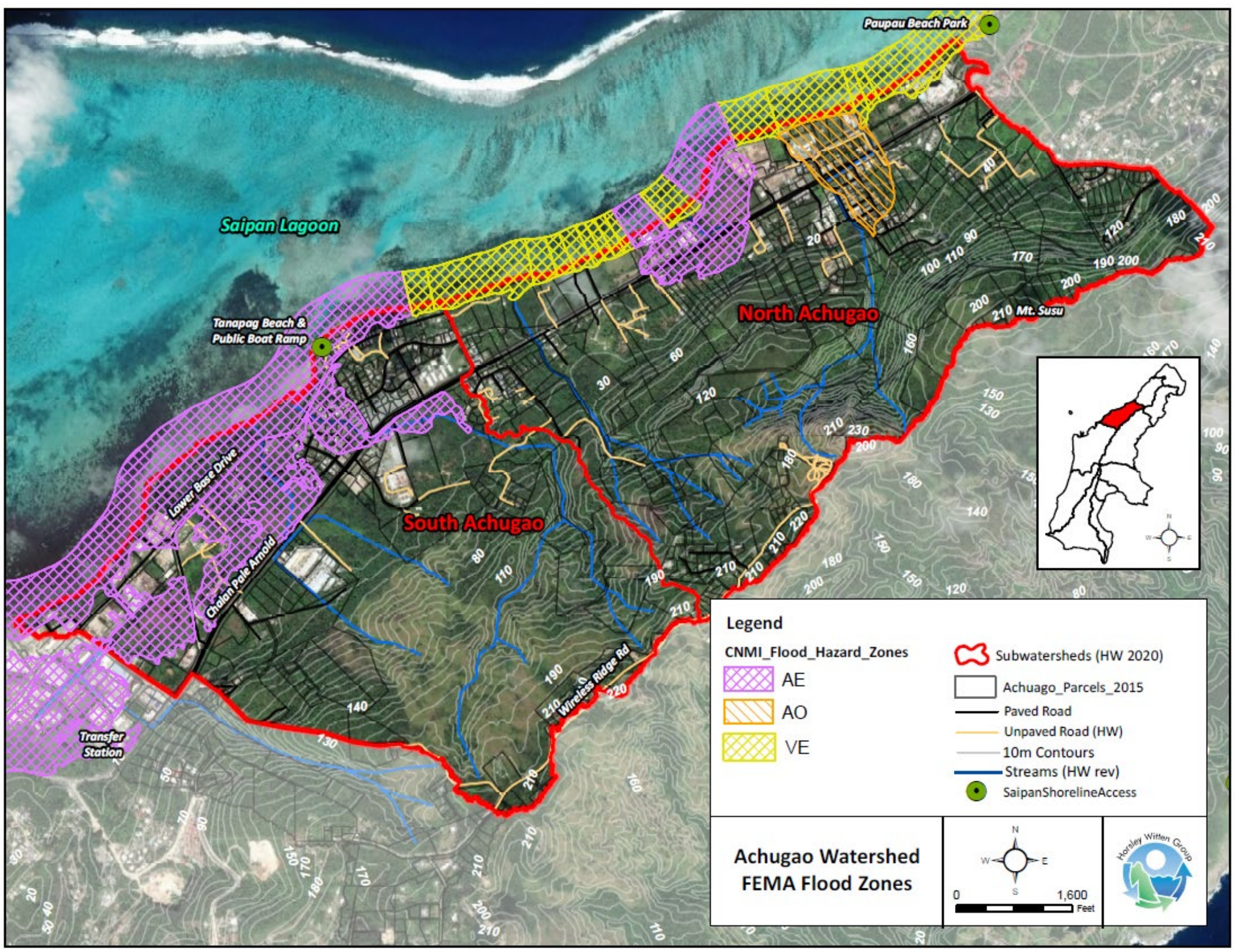

Figure 15. FEMA flood hazard zones.

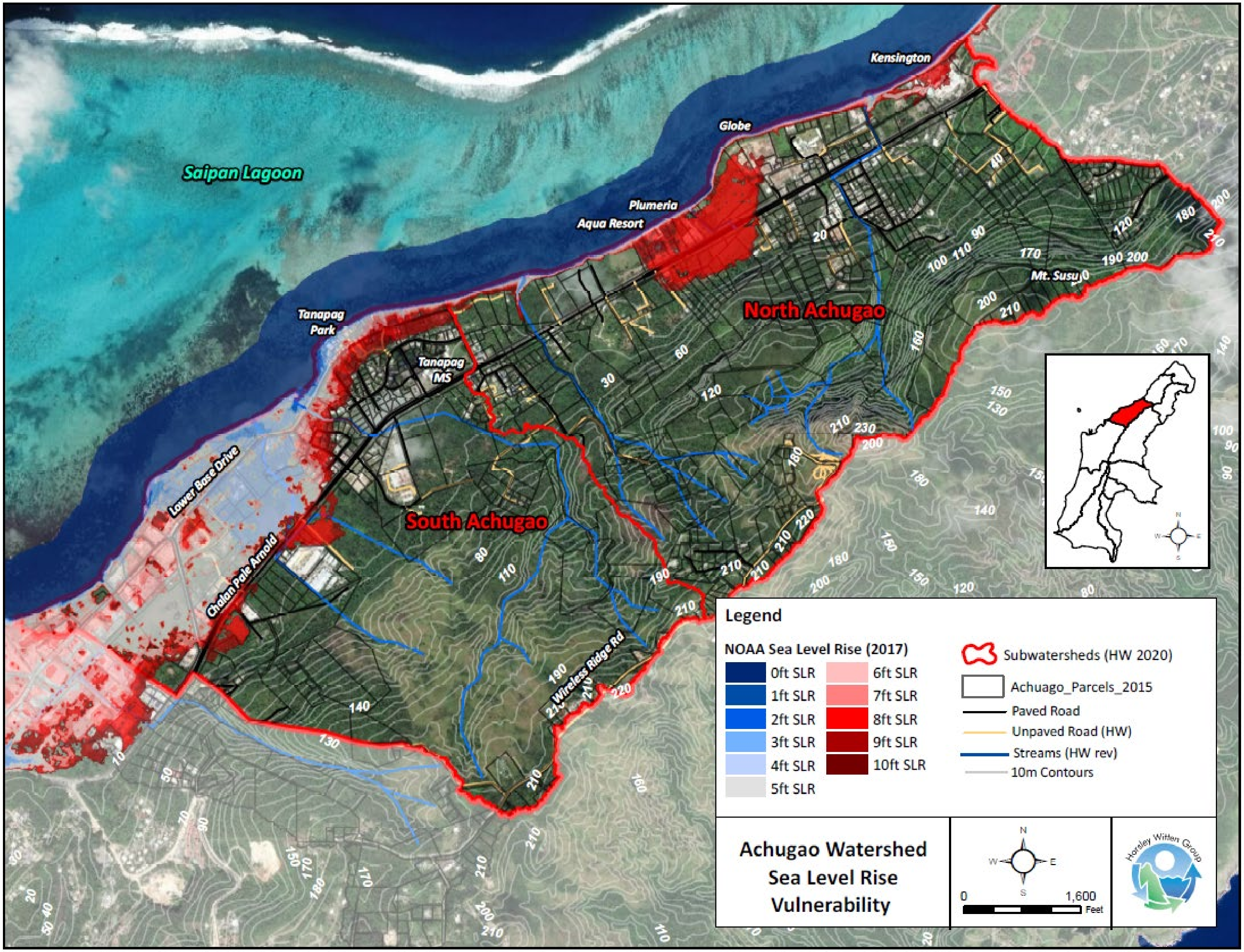

Figure 16. Sea Level Rise estimates (NOAA 2017) predict significant inland inundation.

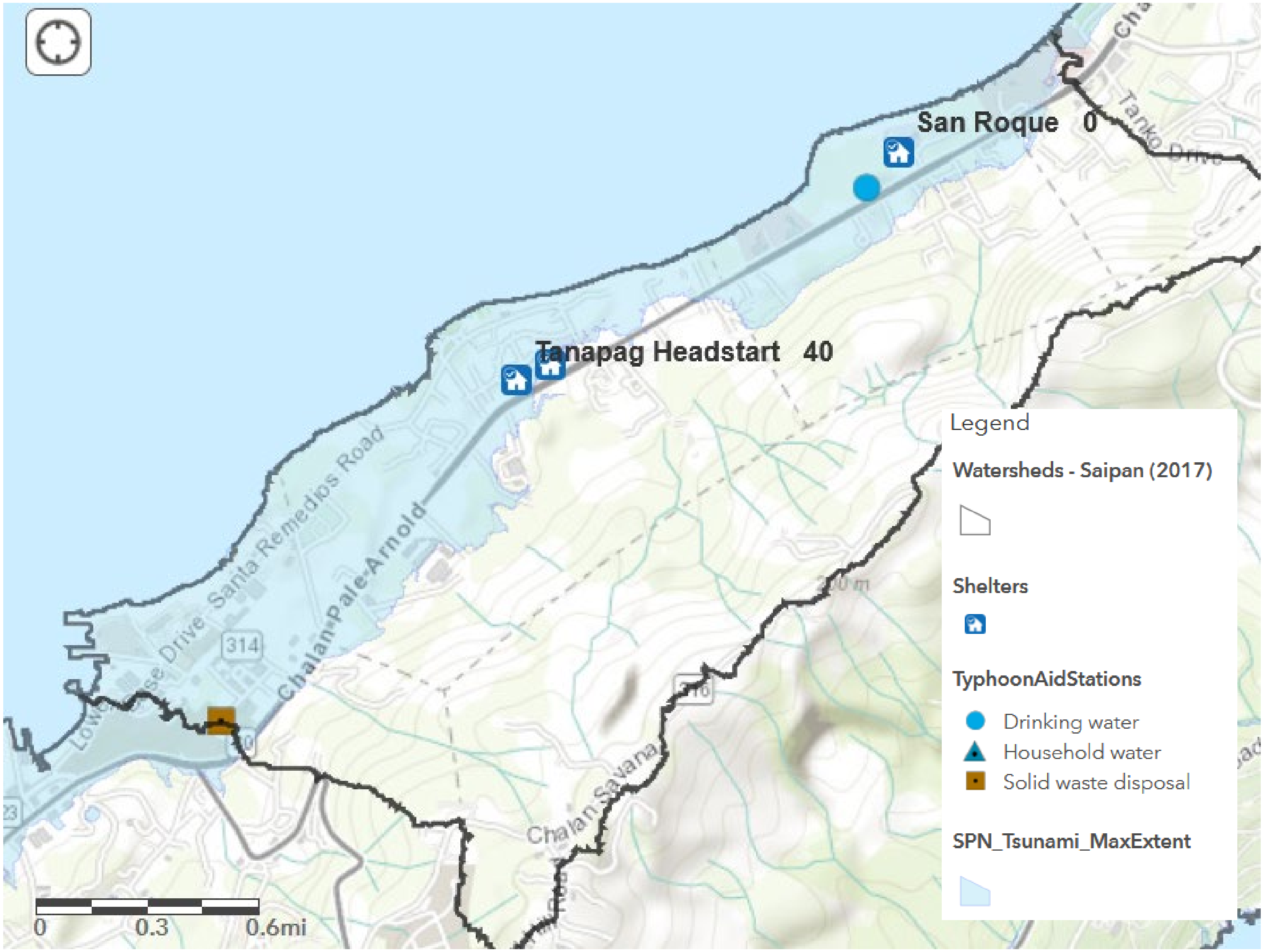

Figure 17. Tsunami maximum extent predictions (CRMOGIS, 2020)

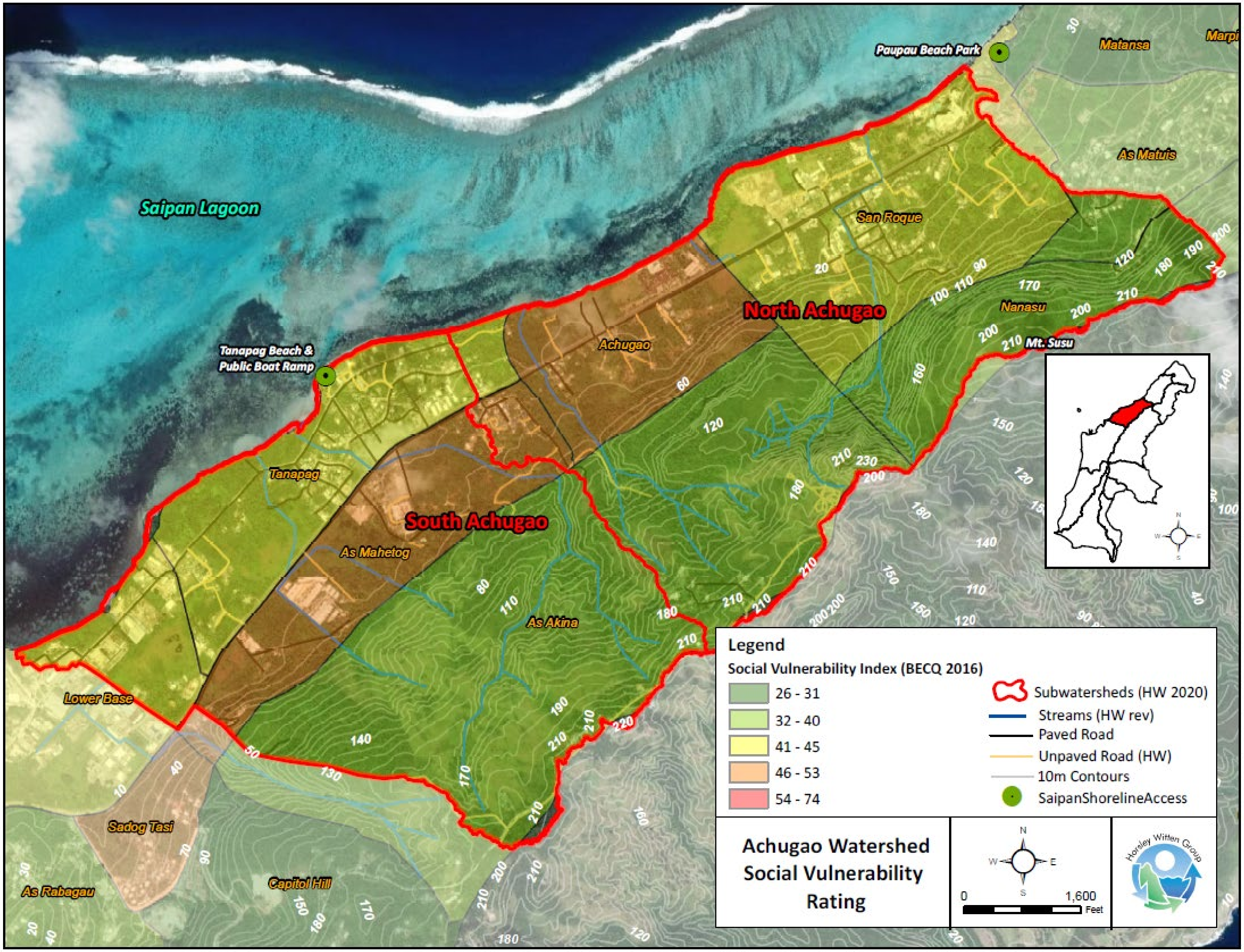

Figure 18. 2016 Climate vulnerability rating in Achugao

Hydrodynamics

The Tanapag Lagoon is relatively shallow, with an average depth of approximately 4 m—2 m or less nearshore in Tanapag and San Roque (**Figure 19**). There is a barrier reef to the north and a shipping channel to the west. Two hydrodynamic studies (Damlamian and Kruger, 2010 and SEA Engineering 2019) describe predominant wave-driven flows over the northern reef, into the lagoon, and out the shipping channel or further south into the lagoon depending on tides (**Figure 20**).

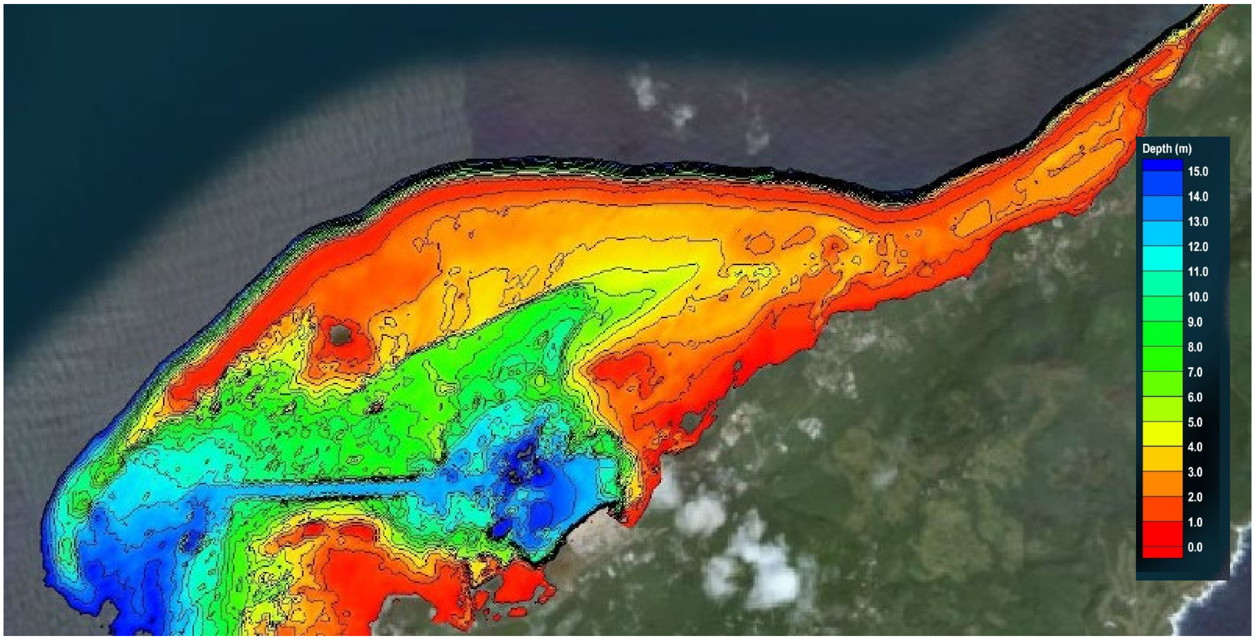

Figure 19. Bathymetery of Tanapag Lagoon (from Sea Engineering, 2019)

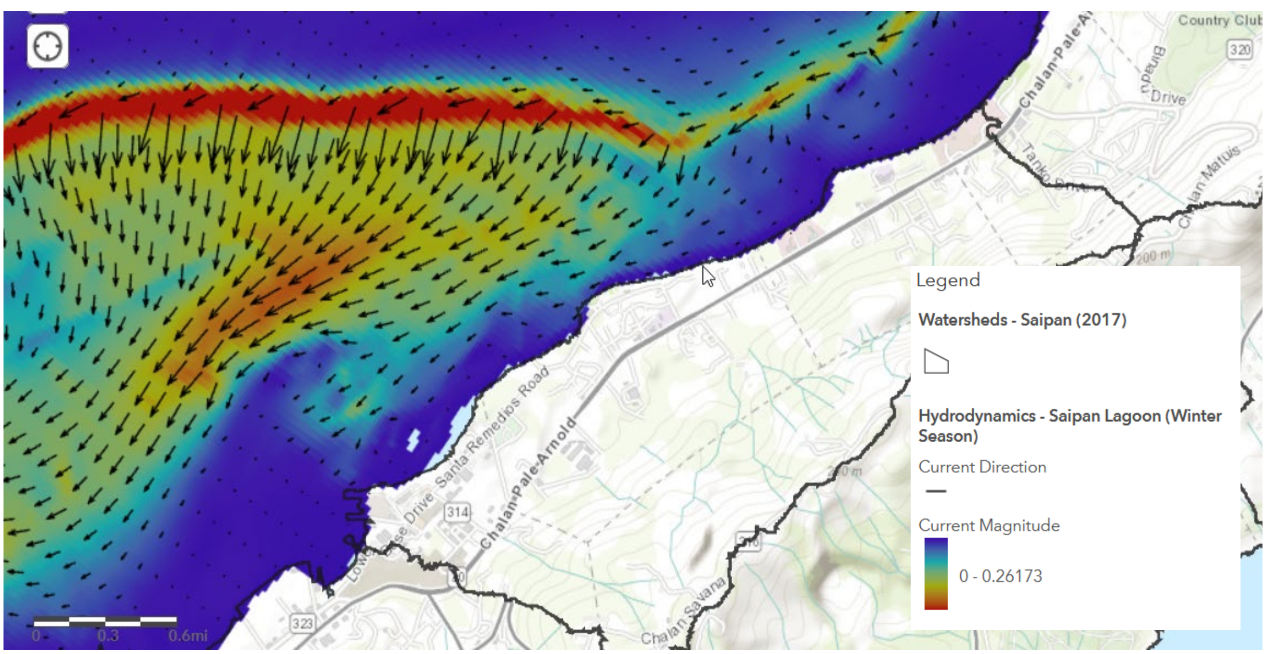

Figure 20. Predominant winter tradewind currents (from CRMOS, 2020, data from SEA Engineering, 2019)

Damlamian and Kruger (2010) show in coming ocean currents from the shipping channel can create a large eddy off Tanapag when the wave and wind pattern is predominantly from the east. This can create lower wave stress on the northern reef, slower southward currents in the lagoon, and increased in-flow from the shipping channel. Waves breaking on the northern barrier reef meet incoming oceanic waters creating anti-clockwise eddies and northward flows (**Figure 21**).

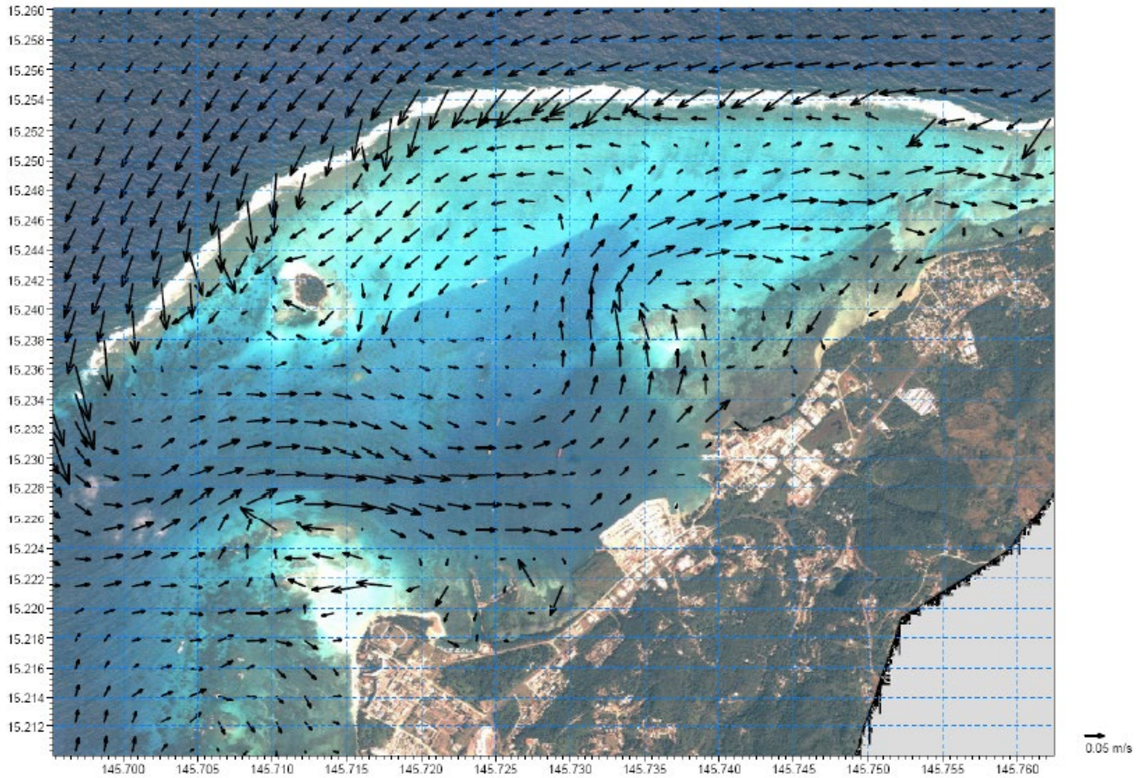

Figure 21. Eddies shown east of Managaha and north of lower base (from Damlamian and Kruger, 2010).

During either winter or summer scenario, there are slow currents along the shoreline which may influence dispersal patterns and accumulation rates of land-based pollution from stream outlets and outfall pipe discharges. Die tracing studies by Sea Engineering (2019) show not much movement along the shoreline (**Figure 22**).

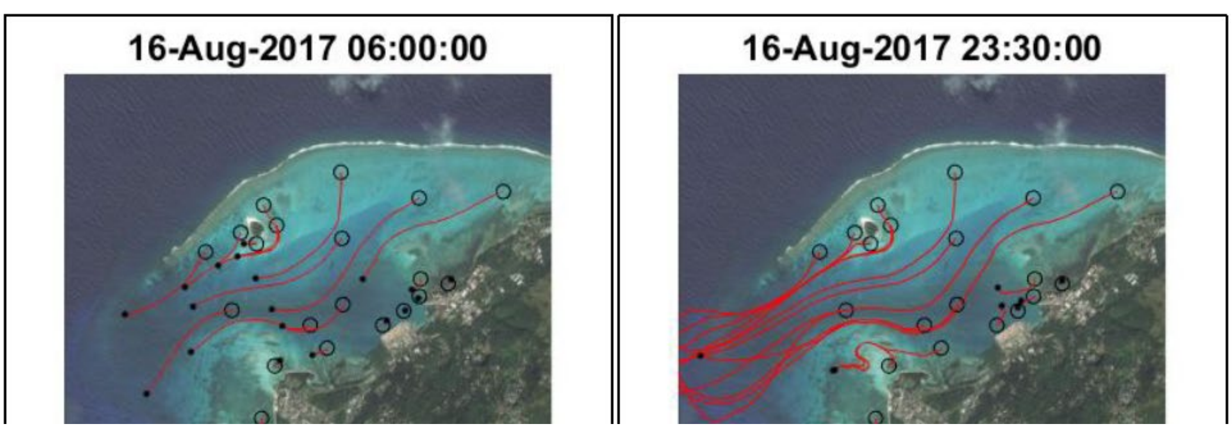

Figure 22. Tracer paths during typical winter trade winds wave conditions (from Sea Engineering, 2019)

Geology & Soil

The geology of Saipan consists of limestone over older volcanic rock and. In the Achugao Watershed, limestone is found in the western coastal plain and is more predominant in the southwestern portion of the watershed. Volcanic rocks become more with prominent in the central uplands and the headwaters of the watershed (**Figures 23**-**25**).

Per the USGS soil classification hydrologic soil groups (HSGs), most of the watershed is HSG C and D soils (low infiltration capacity and high runoff potential), with a HSG A and B soils (higher infiltration capacity and lower runoff potential) along the coastal plain (**Figure 26)** shows the location of hydrologic soil groups across the watershed.

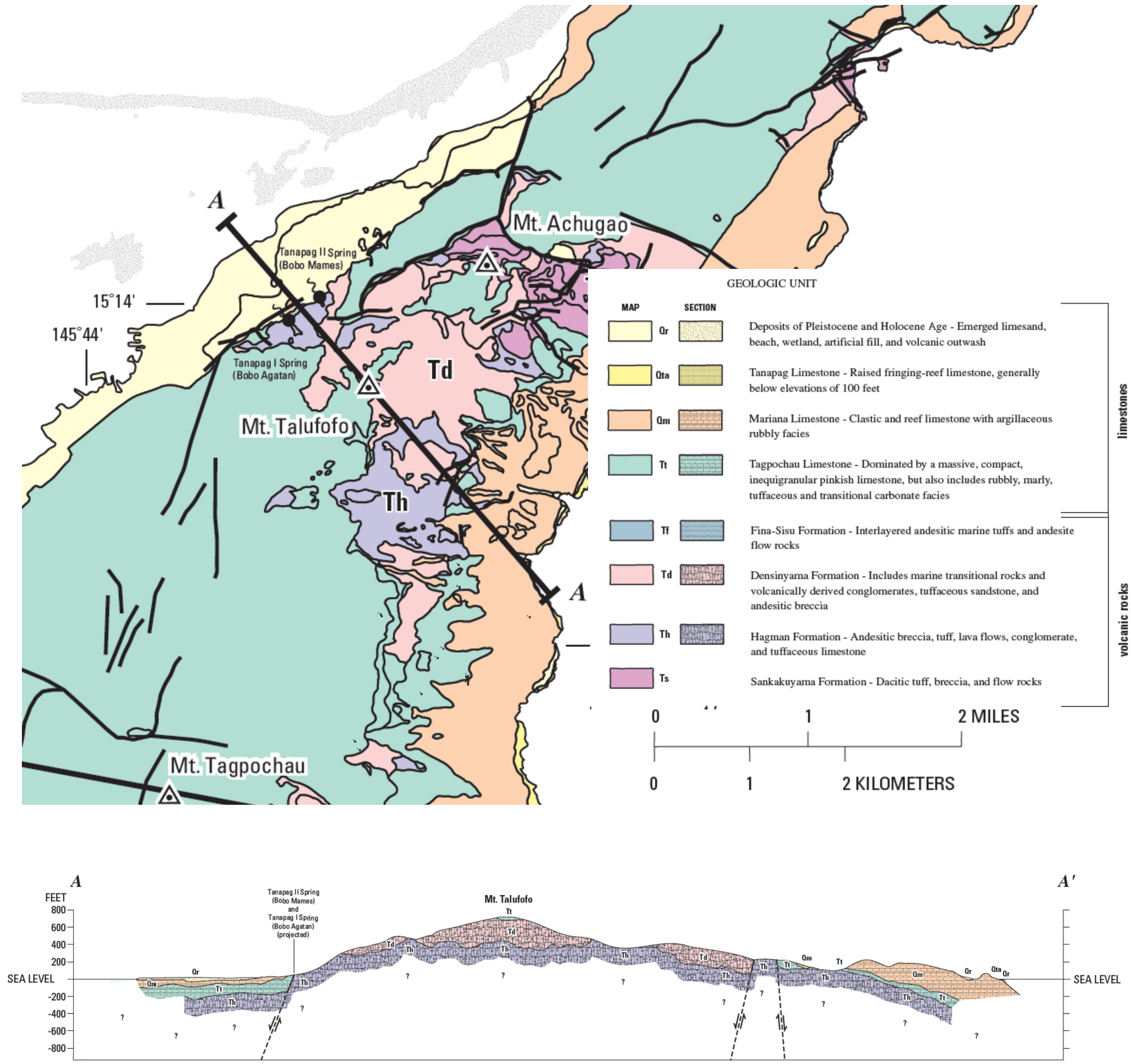

Figure 23. Geological units and representative cross-section (from Carruth 2003)

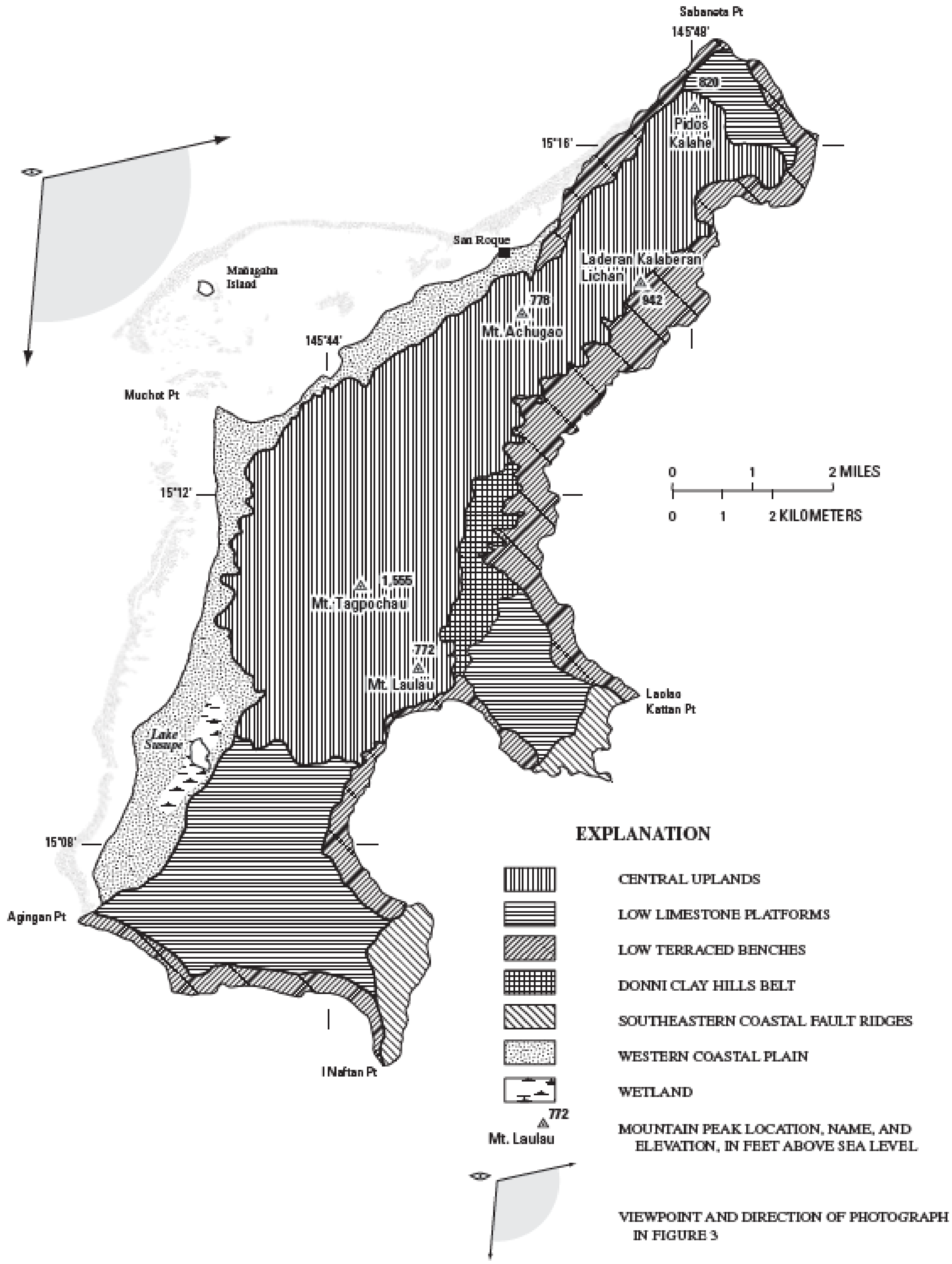

Figure 24. Geological formations of Saipan (from Carruth 2003)

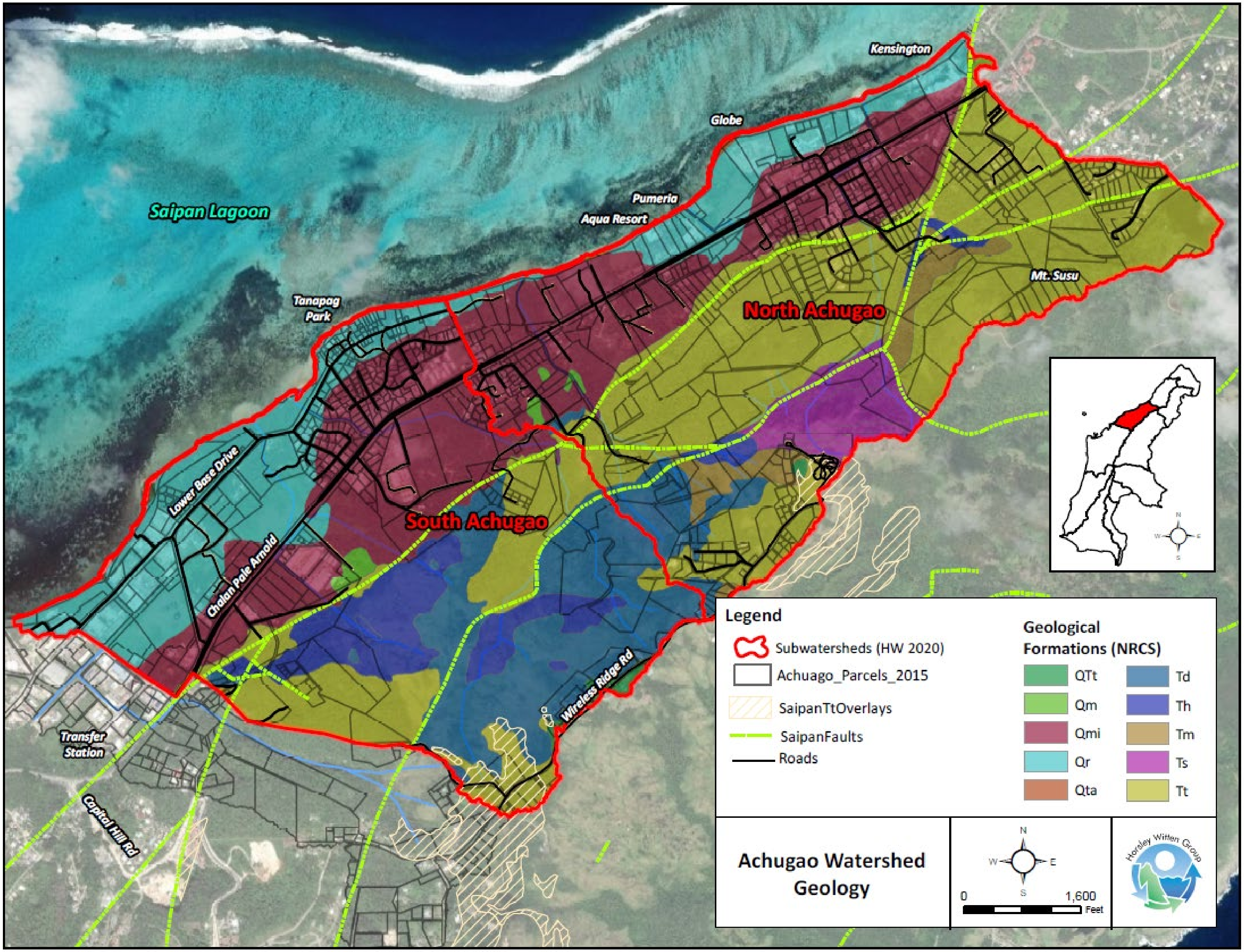

Figure 25. Achugao geological formations and faults (NRCS, 2019)

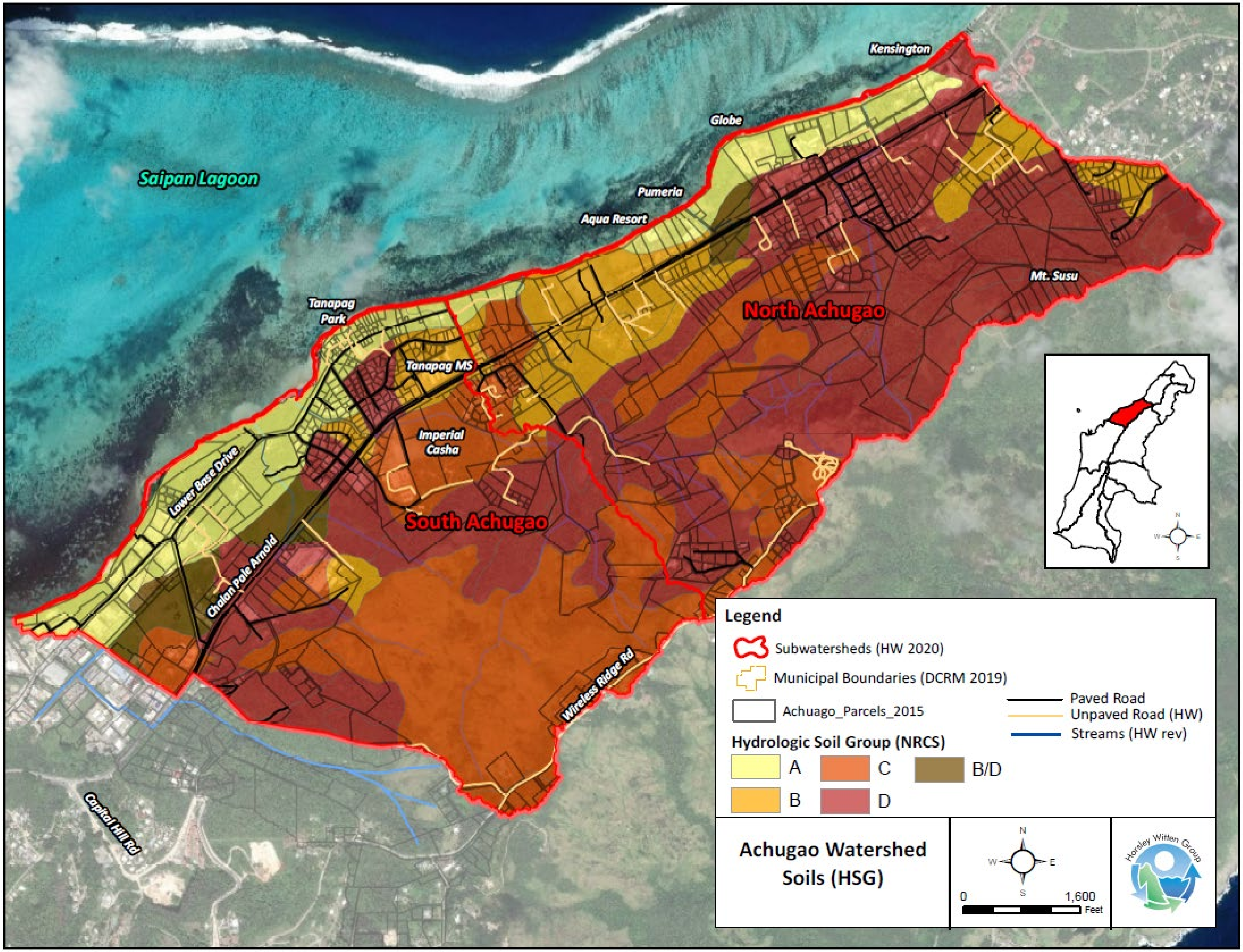

Figure 26. Achugao hydrologic soil groups (NRCS, 2019)

Ecology

In 2017, NOAA updated the shallow water benthic habitat maps for Saipan Lagoon to reflect changes in coverage and habitat distribution due to previous bleaching events and tropical storms (Kendall, et al 2017). This mapping effort used a combination of remote sensing and underwater video and photos to produce high-resolution mapping of substrate and cover types to characterize habitat diversity, including sea grass beds and coral cover (living and dead) (refer to **Figure 4**). The benthic maps show important seagrass and coral resources in the northern part of the Lagoon, including live Acropora. The mapping effort also found significant loss in sea grass beds off of Lower Base, as well as nearshore sand distribution (**Figure 27**, presented by Steve Mckagan, 2017). This decline was documented in detail by Camacho (2016) in a study on the spatial and temporal changes in seagrass and macroalgal assemblages. He suggests watershed management resources should focus on areas recently trending towards increased macroalgal cover, which include the Tanapag area, and suggests that restoration efforts in these regions could result in more ecological benefits for less cost and with less social conflict.

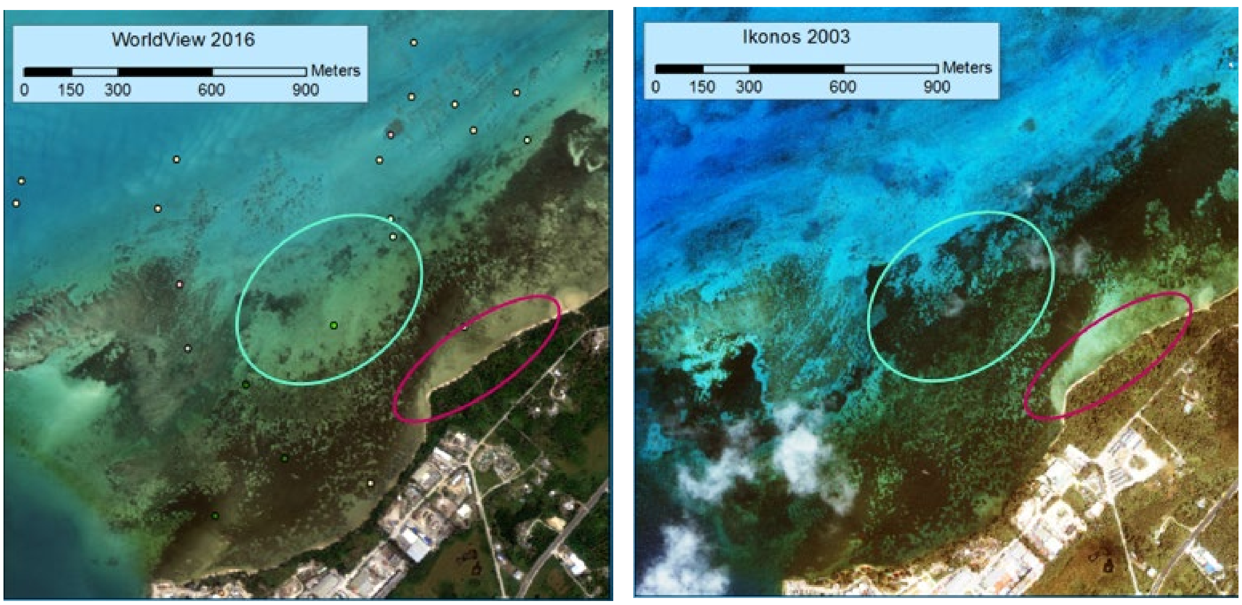

Figure 27. Comparison of seagrass coverage (blue) and shoreline extent (pink) between 2003 and 2016 imagery.

In 2017, Lyza Johnston presented preliminary results from 25 long-term, marine habitat monitoring sites in Saipan Lagoon from 2015-2016. Several of sites are in the Achugao watershed between Tanapag and the Kensington Hotel. **Figure 28** shows the cover and habitat diversity scoring for seagrass and coral at these sites. The seagrass beds (without consideration of invertebrates) rates fair to good in quality; coral ranks poor with better quality (some of the best in the lagoon) for sites associated with PauPau in the As Matuis watershed.

The Wildlife Action Plan for the CNMI 2015-2025 doesn't directly identify critical habitats or species located in the Achugao watershed. It does mention that the only mangrove forest in CNMI is between Memorial Park and Tanapag and that fragmentation of undeveloped areas increases opportunities for invasives. More information is needed on the quality of freshwater wetland habitats, terrestrial ecology, the presence of invasive species, and species of the greatest conservation need (SGCN), such as the Mariana Fruit Bat and Swiftlets. Locations of high and low quality habitats (e.g., limestone forest and *Tangantangan* stands, respectively) would be helpful for identifying conservation and restoration priorities.

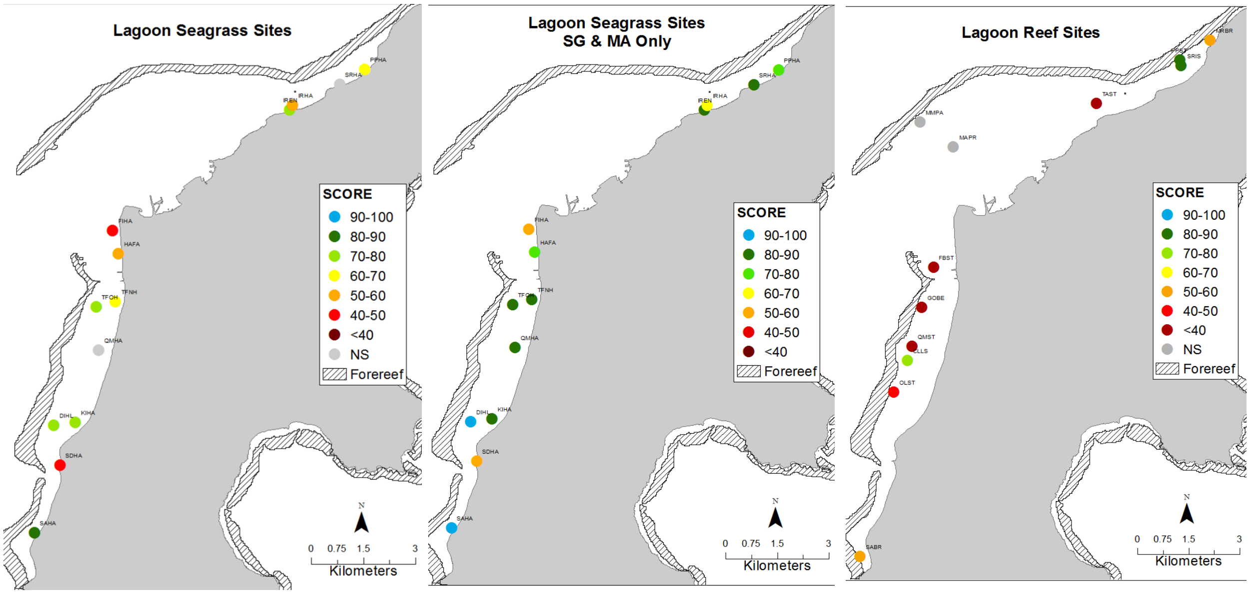

Figure 28. Status of seagrass and coral habitats in Saipan Lagoon 2015-2016 (Johnston presentation, 2017), where a) is seagrass habitat scores including invertebrate assemblage parameter; b) is seagrass habitat looking at seagrass and macroalgae cover and diversity only; and c) is reef habitat (coral abundance, richness, etc.).

A coral economic valuation study for the CNMI estimated that across several ecosystem services, coral reefs in CNMI generated over $104.5M annually (ERG, 2019). The reefs in Saipan lagoon contribute to infrastructure protection, tourism, recreation, fishing, and biodiversity revenue. Economic value is increased when reefs are close to shore and accessible (**Figure 29**). The reefs and seagrasses in the Achugao watershed are within 100m to shore and protect significant infrastructure (villages, roads, hotels, sewer lines, etc.).

Given the socio-economic importance of the Lagoon to users, and the remaining acreage of undeveloped public and private lands in the watershed, additional information on the following topics would be helpful for better addressing the ecological aspects in watershed management planning:

1. A better understanding of where high value habitats and what SGCN generally are located in the watershed;
2. What goals and strategies of the 2015 SWAP are the most relevant to watershed management?
3. Are there forest, invasive species, bat, and bird monitoring (or other) activities that are taking place or are planned. For example, is there data on density of invasive vine coverage?
4. Vegetative succession data for areas impacted by wildfires;
5. Understanding of DPL priorities for undeveloped public lands or any pending lease expirations;
6. Data derived from stream assessments in the watershed;
7. Habitat and functional evaluations of freshwater wetland complexes; and
8. Any information relating discharge characteristics of the four major streams on seagrass and coral habitats (such as sediment accumulation).

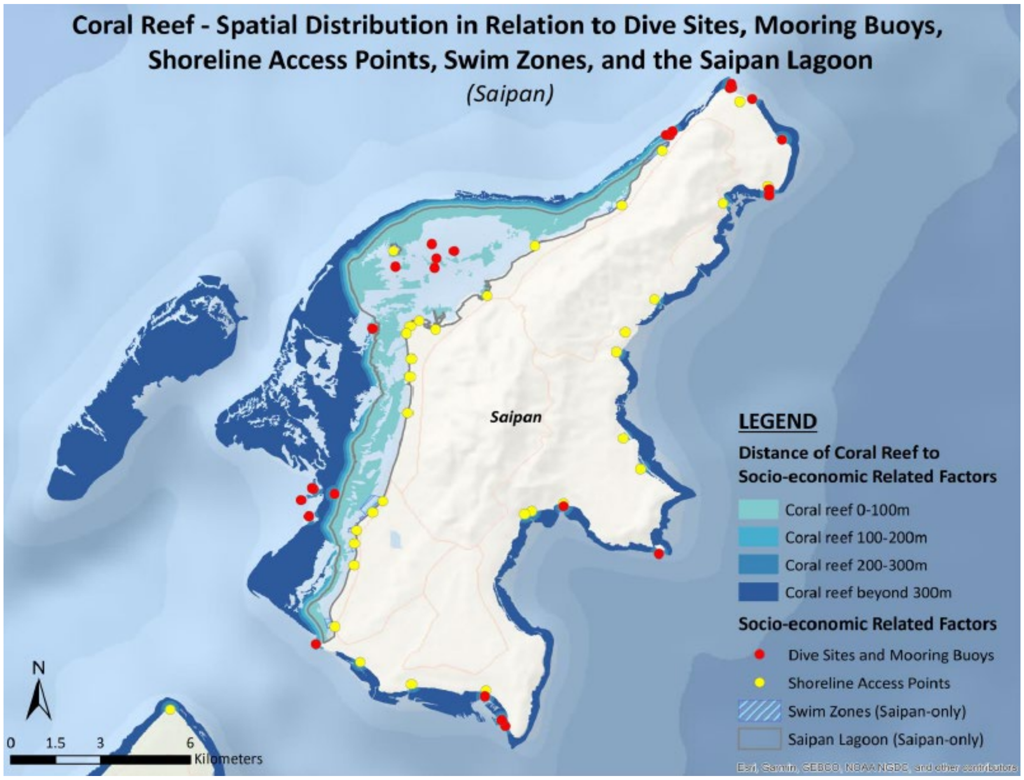

Figure 29. Distance to reefs (ERG, 2019)

Water Quality

The draft 2020 305(b) and 303(d) Integrated Waters Report identifies several impairments for Achugao waters, including poor habitat, low dissolved oxygen, high enterococcus bacteria counts, lead (Pb) in bivalves, and elevated orthophosphate. All coastal waters in Achugao are class AA, with the exception of the Class A industrial waters off of Lower Base, which span from the Agatan stream outlet southward to Smiling Cove Marina.

Figure 30 is a map of the assessment units and monitoring locations in the Achugao watershed. Achugao South has three BEACH monitoring sites (two in the industrial Class A waters—the sea plane ramp and central repair shop—and one near the Tanapag Meeting House). The 2020 Integrate Report includes four long term BEACH monitoring sites at the hotels (Aqua, Plumeria, Saipan Globe/San Roque School, and Kensington). Figure 30 does not show two different stations at Aqua Resort and Plumeria and may be utilizing outdated mapping data. The sea plane ramp site is also not shown since we are considering it outside the Achugao watershed.

SWQAMP monitoring sites were identified at locations within the stream systems; however, no data from this stream sampling was provided and it is not clear if these monitoring stations are active. A stream assessment was also conducted in Achugao in 2014 on three stream systems that were impaired, The Achugao, Dogas and Agatan streams. Sanitary assessments of the streams revealed illicit discharges of kitchen greywater, waste from animal pens, and failing sewer lines and connections. No locations of severe stream erosion, buffer encroachment, culvert replacement or other restoration opportunities were explicitly identified. Visual stream assessments and mapping were conducted by BECQ in 2020 for the Agatan, Dogas, and Achugao streams using the new CNMI SVAP method.

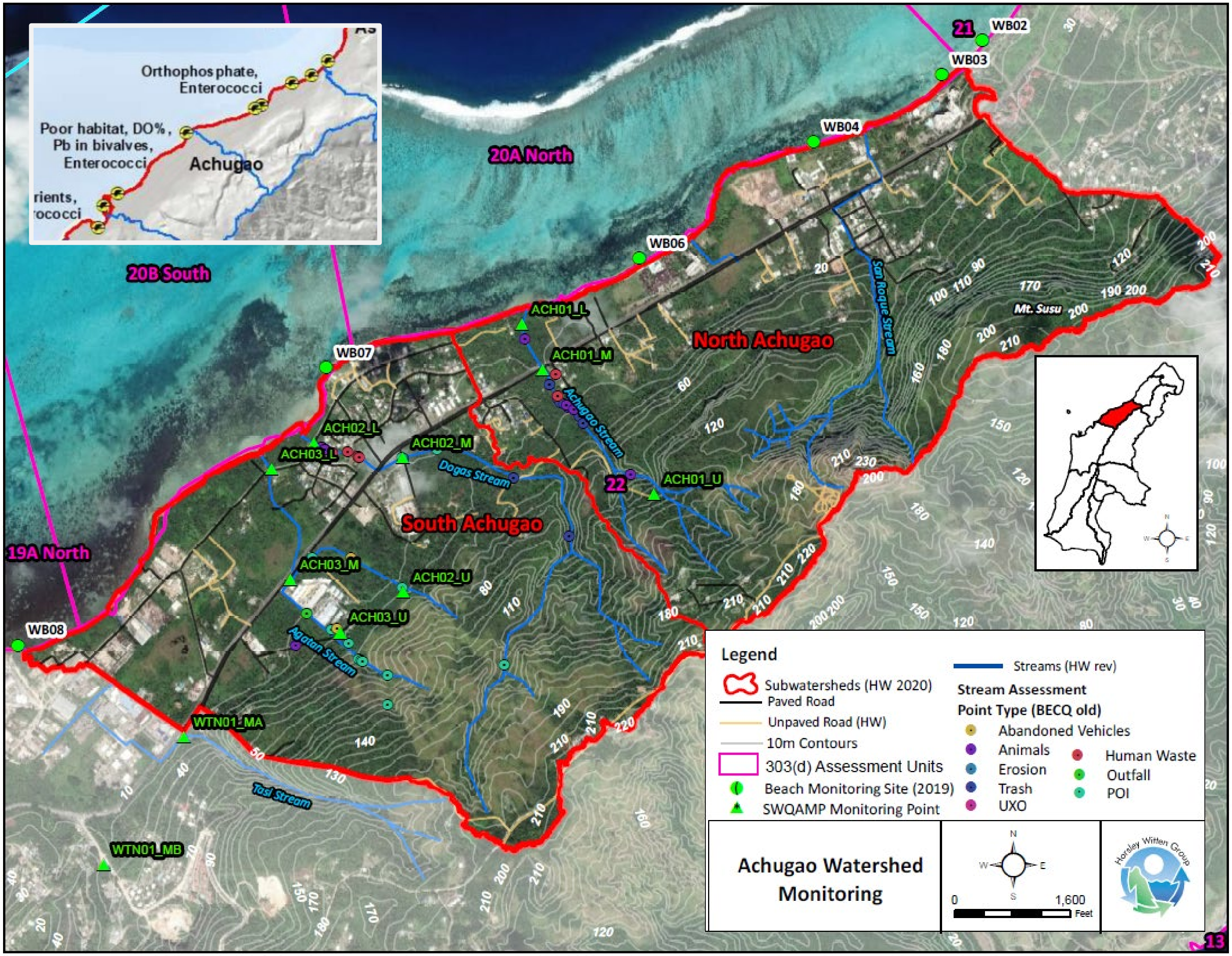

Figure 30. Monitoring locations and 303(d) assessment units

Table 9a summarizes the 2020 listings for each assessment unit in the watershed; **Table 9b** summarizes attainment status for each designated use category. While Enterococci is listed less frequently, this is because of the completion of the 2017 TMDL for bacteria rather than there being an actual decrease in WQS violations. Additionally, there has been an increase in waterbodies 303(d) listed as impaired for heavy metals based on recent studies by Denton, et.al. (2010, 2014, and 2018), that indicate that heavy metals are transported into sediment and biota from nearby WWII debris dumpsites. In fact, South Achugao's coastal waters do not support Fish and Shellfish Consumption designated usage die to elevated heavy metals.

Table 9a. 303(d) Impairment listings from the draft 2020 Integrated Report*

Seg ID	Segment Name	Size	Cause Name	Source	Cycle First Listed	Comments
20 A	Achugao (North)	1.9 miles	DO% (205)	Roads, Infrastructure New Construction	2010	
			Phosphate (340)	Source Unknown	2020	New data.
20 B	Achugao (South)	2.4 miles	DO% (205)	Grazing in Riparian or Shoreline zones	2010	
				On-site Treatment Systems Septic	2010	
				Sanitary Sewer Overflows	2010	
				Urban Runoff/Storm Sewers	2010	
			lead (267)	NPS Pollution from Military (Other than	2018	
20STRB	Achugao (South) Stream	6.5 miles	lead (267)	NPS Pollution from Military (Other than	2018	
			Enterococci (215)	Grazing in Riparian or Shoreline zones	2018	
				On-site Treatment Systems Septic	2018	
				Sanitary Sewer Overflows	2018	
				Urban Runoff/Storm Sewers	2018	

* Enterococci not listed due to 2017 TMDL completion

Table 9b. Designated Use Summary (2018 305(b) and 303(d) WQ Assessment Integrated Report)

Designated Use	Water Body Segment					
	20 (B) Achugao South			20 (A) Achugao North		
	Coastal WB9-7 (sea plane to Tanapag Meeting House)	**Streams** ACH03-02 (Agatan, Dogas)	**Wetlands**	**Coastal** WB6-3 (Aqua to Kensington)	**Stream** ACH01 (Achugao Stream)	**Wetlands**
Aquatic Life	Poor Habitat, DO% low	Native habitat, visual field good	Not attaining	Fair Habitat, DO% low, Orthophosphate exceedance	Native habitat, visual field good	Not attaining
Fish Consumption	Lead in bivalves	HG, Pb in bivalves	--	Fully Supportive	Insufficient information	--
Recreation	Enterococcus Exceeded*	Enterococcus Exceeded*	--	Enterococcus Exceeded*	Insufficient information	--
Aesthetic enjoyment	Fully Supportive	Fully Supportive	--	Fully Supportive	Fully Supportive	--
CALM Category	5	5	4c	5	2	4c

**Bacteria TMDL (2017) adopted*

Table 10 provides the number of bacteria (STV) at each station. North Achugao was listed for bacteria in 2016, reportedly due to sanitary sewer overflows and an increased sewage flows during peak hours attributed to increased number of workers during hotel renovations. Sewer upgrades and pump replacements since then have been credited with improved water quality. Similarly, Achugao South experienced multiple sewage overflows and system failures, specifically associated with worker's barracks (converted garment factories). Several instances of raw sewage overflow into wetlands were observed in 2017 and violations issued. In addition, piggeries at homesteads in the upper watershed have been cited as bacteria sources. Stormwater runoff and feral animals have also been identified as likely sources of bacteria; however dry weather flows (at least in Achugao south) seem to be the predominant issue (**Figure 31**).

Table 10a. Percentage of annual bacteria and dissolved oxygen exceedances (draft 2020 Integrated Report)

Enterococci % Violations																		
Sample Station ID	Sampling Station Name	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Segment Class
	SEGMENT 20A: ACHUGAO (NORTH)																	
WB 03	Kensington Hotel (Nikko Hotel)	21	8	6	19	4	6	0	10	8	8	7	16	0	0	6	0	AA
WB 04	San Roque School	35	14	13	17	14	10	4	8	6	10	18	14	4	2	4	2	AA
WB 05	Plumeria Hotel	10	12	6	13	4	0	4	19	4	2	18	12	4	6	8	4	AA
WB 06	Aqua Resort Hotel	8	14	12	13	2	4	6	8	2	4	28	12	2	4	7	4	AA
	SEGMENT 20B: ACHUGAO (SOUTH)																	
WB 07	Tanapag Meeting Hall	44	35	50	32	36	38	37	35	26	40	44	42	15	31	20	20	AA
WB 08	Central Repair Shop	33	35	35	34	34	56	23	38	39	37	26	39	6	23	29	35	A
WB 09	Sea Plane Ramp	0	4	2	15	0	0	0	2	2	2	3	2	4	6	8	2	A

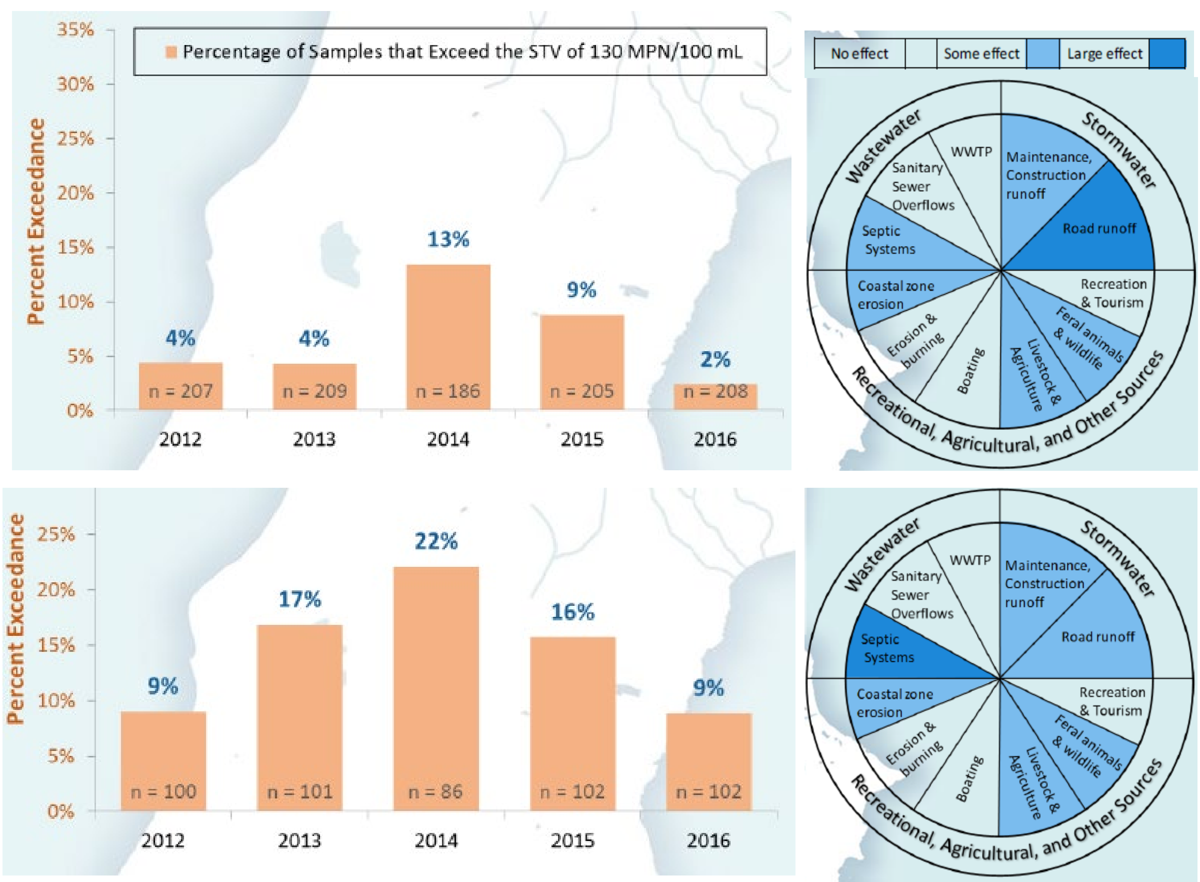

Figure 31. STV exceedances for Enterococcus between 2012-2016 and presumed sources in Achugao North (top) and South (bottom) subwatersheds (from 2017 Bacteria TMDL fact sheet).

A coastal waters bacteria TMDL was completed in 2017 by Paradigm Environmental establishing several reduction targets for Achugao based on rainfall season and duration curves (**Tables 10b-c**). Implementation recommendations for the watershed (presuming wastewater infrastructure improvements have been completed) include addressing new development projects that are key sources of sediment delivery and *Enterococcus* to the waterbodies. The TMDL recommends EPA focus on the following actions:

- Engage NRCS and consider USEPA NPS implementation funds for supporting small-scale water quality projects
- Engage CNMI government in planning for population growth from both migratory and immigration pathways
- Support regular site reviews of local piggeries and other local farm sites
- Support continued outreach and capacity building work with farmers and local managers to comply with WQS (to receive NRCS funding)
- Support ongoing watershed efforts in reducing fires and engagement in replanting or restoration projects.

Table 10b. Summary of *Enterococcus* TMDL load reductions for Achugao North (Segment 20A)

	Count	Exceedances	WQS	% Reduction				
				Duration Curve Zone				
				Dry (0 - 10%)	Low - Mid (10 - 40 %)	Mid (40 - 60 %)	Mid - High (60 - 90 %)	High (90 - 100%)
DRY SEASON								
STV	678	30	130	0%	0%	0%	0%	71%
Geomean	678	53	35	0%	0%	0%	0%	0%
WET SEASON								
STV	337	30	130	0%	0%	0%	38%	0%
Geomean	337	53	35	0%	0%	0%	0%	2%

Table 10c. Summary of *Enterococcus* TMDL load reductions for Achugao South (Segment 20B)

	Count	Exceedances	WQS	% Reduction				
				Duration Curve Zone				
				Dry (0 - 10%)	Low - Mid (10 - 40 %)	Mid (40 - 60 %)	Mid - High (60 - 90 %)	High (90 - 100%)
DRY SEASON								
STV	335	39	130	40%	0%	0%	40%	85%
Geomean	335	133	35	2%	0%	4%	8%	52%
WET SEASON								
STV	156	41	130	0%	0%	38%	63%	77%
Geomean	156	81	35	0%	38%	20%	88%	72%

Enterococci monitoring can be useful for identifying water quality "hot spots," but doesn't necessarily inform managers of where microbial contamination is generated. In 2018, molecular microbial source tracking for fecal indicating bacteria (FIB) was conducted at over 60 sites around Saipan to determine if sources were human, pig, cow, seabird, or dog (**Figure 32**). Several of these sites were within or near the Achugao watershed: WB07 (Tanapag Meeting House), WB08 (Central Repair Shop), and shoreline samples S04-S10. Sinigalliano et al (2020) reports that high levels of dog FIB was found at the Tanapag Meeting House (WB07) and S09 stations. Most shoreline samples returned insignificant counts of human FIB, with the exception of S09 in March 2018 and WB07 in July 2018. They recommended:

- BECQ gain a better understanding of the temporal and spatial contributions of dog fecal contribution to regional water quality
- Further investigation of potential contamination of stormwater runoff in the Tanapag area.

Figure 32. MST and nutrient study sites in and around Achugao (from Sinigalliano et al 2020 and Kim, 2019).

Nutrient contributions from groundwater is a concern in the CNMI and our understanding of groundwater transport of nutrients is evolving. Research on Guam has been conducted looking at nitrogen isotopes in seagrass to evaluate the impact of anthropogenic sources of nutrient loading (Pinkerton et. al 2015). This effort has expanded into recent studies by Dr. Kiho Kim and others to understand the source of nutrients and the spatial and temporal variations of nutrient-enriched groundwater discharges into the Saipan Lagoon. They collected benthic algae and seagrasses for isotope analysis as well as water quality samples for nutrient and radon analysis at several monitoring stations used for the microbial study mentioned previously (S04-S10 in the Achugao watershed). Results have not been widely distributed; however, initial findings indicate shoreline station S08:

- Is one of three nitrogen “hotspots” from sewage derived-nitrogen in Saipan Lagoon;
- Groundwater nitrogen concentrations are an order of magnitude higher than surface waters; and
- Wastewater system improvements may go further than stormwater retrofitting to improve nutrient dynamics.

Table 11 provides the percentage of bacteria (STV) and dissolved oxygen exceedances recorded at each monitoring station in Achugao.

Table 11. Percentage of annual dissolved oxygen exceedances (draft 2020 Integrated Report)

% DO Exceedences														
Sampling Station ID	Sampling Station Name	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Segment Class
	SEGMENT 20A: ACHUGAO (NORTH)													
WB 03	Kensington Hotel (Nikko Hotel)	2	12	2	4	12	4	8	4	19	21	6	9	AA
WB 04	San Roque School Beach	2	6	8	4	10	2	6	2	13	8	9	0	AA
WB 05	Plumeria Hotel	10	8	6	2	6	0	0	4	4	4	7	0	AA
WB 06	Aqua Resort Hotel	2	6	4	4	8	0	0	2	4	8	7	0	AA
	SEGMENT 20B: ACHUGAO (SOUTH)													
WB 07	Tanapag Meeting Hall	2	8	8	10	6	0	4	8	15	10	9	5	AA
WB 08	Central Repair Shop	4	16	13	21	19	16	10	16	16	27	13	7	A
WB 09	Sea Plane Ramp	2	8	6	4	4	0	3	2	4	0	2	5	A

To better understand current trends in water quality as they relate to watershed management goals and conservation targets, we need to:

1. Connect with Kathy Yuknavage on 303(d) listings and any water quality monitoring that may have been conducted in the stream network or freshwater wetlands. Confirm whether SWQAMP sites have been established and samples collected. If yes, where is the data?
2. Ask BECQ about the San Roque stream system and why it is not part of monitoring efforts.
3. Check back in with Kiho Kim on site ID#S08 results from the nitrogen studies to better understand how results can be interpreted along with MST data.
4. Confirm completion of wastewater improvements with CUC.
5. Collect SVAP data from Larry Maurin and add important stream corridor restoration projects to our watershed opportunities list.
6. Reconsider opportunities for reducing the impact of dog feces.

References

Carruth, R. 2003. Ground-Water Resources of Saipan, Commonwealth of the Northern Mariana Islands. U.S. Geological Survey Water-Resources Investigations Report 03-4178. 4 pp

Eastern Resources Group. 2019. Value of Ecosystem Services from Coral Reef and Seagrass Habitats in CNMI. Prepared for Bureau of Environmental and Coastal Quality's Division of Coastal Resources Management (BECQ-DCRM). 75 pp

Greene, R. and R. Skeele. (2014). *Climate Change Vulnerability Assessment for the Island of Saipan.* Prepared for CNMI Office of the Governor - Division of Coastal Resources Management. Saipan: Commonwealth of the Northern Mariana Islands. 102p.

Horsley Witten Group and Hofschneider Engineering Corporation. 2017. Saipan Lagoon Use Management Plan Update. 409 pp.

Kendall, M., B. Costa, S. McKagan, L. Johnston, and D. Okano. 2017. Benthic habitats of Saipan Lagoon 2001 - 2016. NOAA Technical Memorandum NOS NCCOS 229. Silver Spring, MD. https://maps.coastalscience.noaa.gov/biomapper/biomapper.html?id=saipan

Kiho, K. 2019. Identifying Hotspots of Nitrogen Pollution in Saipan. Final Report by American University for NOAA CRCP award NA17NOS4820082 to the NOAA Coral Reef Conservation Program, NOS Office for Coastal Management (OCM). 4 pp.

Liske-Clarke, Jill. 2015. Wildlife Action Plan for the Commonwealth of the Northern Marina Islands 2015-2025. 292 pp.

Sea Engineering, Inc. 2019. HYDRODYNAMIC STUDY OF SAIPAN'S WESTERN LAGOON. Prepared for CNMI Bureau of Environmental and Coastal Quality. 127 pp.

Skeele, R. and Okano, D. 2014. *Public knowledge and perceptions of climate change in the Northern Mariana Islands*. CNMI Division of Coastal Resources Management, Bureau of Environmental and Coastal Quality.

Sinigalliano,C., Bautista, C., K. Yuknavage, D. Palacois, Kim K., K Knee, M. Gidley. 2020. Molecular Microbial Source Tracking of LBSP-Associated Fecal Indicating Bacteria in Saipan Coastal Waters for September 2017, March 2018, and August 2018.

Yuknavage, K., J. Arriola, D. Benavente, R. Camacho, D. Chambers, E. Derrington, J. Kaipat, M. Johnson, R. Greene. 2020. Commonwealth of the Northern Mariana Islands 305(b) and 303(d), Water Quality Assessment Integrated Report. CNMI Bureau of Environmental and Coastal Quality, Saipan, 327 pp.

3.0 Field Inventory of Potential Restoration Projects

HW engineers and scientists, KOA Consulting, and knowledgeable staff from BECQ and NOAA conducted a rapid watershed field assessment the week of January 20, 2020 in the Achugao and Laolao Bay watersheds. The purpose of the assessment was to map drainage infrastructure, identify problem areas (pollution sources, flooding, damage, etc.), and identify potential restoration project opportunities. **Table 12** provides a generalized list of the types of watershed projects field crews were considering during field inventories, the data collected at each site, and the watershed benefits presented by each opportunity.

Table 13 summarizes each of the sites identified as a candidate project site. **Figure 33** shows the locations of potential project sites. **Appendix A** contains the field sheets from each potential restoration site, including concept sketches, where applicable. Depending on stakeholder input, there will be a few of these projects that rise to the top for further conceptual designing and implementation planning.

An online map showing the locations of these sites with photos can be accessed at https://www.arcgis.com/home/webmap/viewer.html?webmap=ddf0e4fd056b4211a5b6f53ca83425f8&extent=145.6635,15.1289,145.9171,15.2707.

Table 12. Inventory of Watershed Opportunities

Project type	Info Collected	Opportunities Considered
Drainage Infrastructure Repair	Type of structure (e.g., culvert, outfall); Dimensions & materials; Critical elevations; Type and severity of damage; Access limitations	Reduced flooding; Public health & safety; Infrastructure protection; Improved resiliency; Reduced erosion or resource impacts; Water quality improvement; Fish/aquatic insect passage
Stormwater Retrofits	Contributing drainage area; Type of practice; Pollutants of concern and description of land use; Conveyance mechanism and pretreatment; Constraints: soils, groundwater, utilities, etc.; Space available/footprint of practice; Public vs. private—who will do O&M; Access and visibility	Upgrade existing BMP; Improve water quality or flood control using new BMP; Encourage GI; Add trees or provide other co-benefits; Education opportunity
Unpaved Road Stabilization	Length of segment; Type and location of erosion (surface, ditch); Is there offsite drainage; Shoulder and road dimensions; Slope (flat-steep) and pitch (crowned, inside, outside) of segment; Are there places to discharge? Traffic volume; Public or private road	Diversions, cross drains, water bars, dips, turnouts, traps, slope stabilization, resurfacing
Shoreline Stabilization	Length/height of eroded area; High or low wave energy area; Substrate and surrounding vegetation; Access; Upland land use; infrastructure threat?	Living shoreline; Replanting/vegetate upland; Infrastructure protection; Hard structure or combo; Repair existing feature; Retreat?
Stream/Wetland Restoration	Cross-section dimensions & impacted length; Rate bank erosion/bed scour; Channelization; Trash/debris; Invasives; Buffer impacts; Access and other constraints; Cause of problem?	Habitat restoration; Infrastructure protection; Reduced erosion, bank stabilization; Link to upland volume controls; Improve buffer; Invasives removal; Replant vs natural revegetation; Reconnect to floodplain
Upland Revegetation/ restore	Description of area & Cause of problem; Ownership info; Estimated size; Access limitations	Invasives removal; Replant vs natural revegetation; education
Wastewater improvement	Surrounding land use; Dry or Wet weather, Smell, Color, Suds; Discharge point; Source, if known; Type: Violation (intentional dumping) or accident (unintended spill)	WQ improvement; Health and safety; SSO or pump repair; Upgrade or repair OSDS; IDDE and monitoring; Behavior change/education (dumping washwater); Connect to sewer; WWTP upgrade or package system
Construction Site ESC	Site name/location; Contractor; Permit #; Describe BMPs in use/failures; downstream/offsite impacts	Propose BMP installation or maintenance recommendations; Report problems
Pollution Prevention/site remediation (commercial/industrial hotspot)	Land use/description of activities at site; Observed pollutants; Violations? Storm drains on-site; Nearby wetlands/water resources?; Do they have a SWPP or NPDES permit?	Structural and non-structural; Monitoring; Trash cleanups/Dumpster cover; Spill prevention; Outdoor material storage; Landscaping; Vehicle maintenance/washwater-dedicated areas; Animal waste management; Buffer encroachment/restoration
Residential Stewardship	Neighborhood/area delineation; Project contact (HOA)/advocate; Community gathering place? Confirm sewer/septic; Curb/gutter? SW BMPs? Vehicle washing; dogs and chickens? lawn maintenance level	Lawn care; Pet waste; Connect to sewer; Downspouts or driveway disconnection; Buffer enhancement; Vehicle maintenance; Trash management; Common space management
Watershed Education/Signage	Describe location; Who is target audience? ; What is the message?; Describe activity or signage?	Improve watershed awareness; Build community support; Incorporate into E&O plan
Conservation	Public vs. Private; Surrounding Land Use; Replanting vs Natural Regeneration; Use (park vs. natural); Goal (e.g., education, expand buffer, flood control, habitat)	Habitat protection; Preserving hydrologic functions; Improved resiliency

Table 13. Potential Project Opportunities in Achugao

ID	Description of Condition & *Potential Solution*	Relative Severity[1]	Priority[2]	Cost[3]	Stormwater Retrofit/	Habitat Restoration	Road Stabilization	Shoreline/Bank Stabilization	Non-Structural	Education
Achugao North										
AN300	Grassed area along road shoulder between unpaved driveway and gravel parking lot @ Latte Stone. Loose aggregate driveways contributing sediment to street. High visibility opportunity to provide water quality treatment and reduce sedimentation onto public road. Existing infrastructure in road make overflow connection relatively easy. *Divert drainage into forebay; 15'W x 100' long between sidewalk and UT poles. Divert parking lot and two driveways' runoff into rain garden with sediment forebays on either side. Overflow into inlet in the road. Unpaved driveways may need stabilization.*	2	H	$	●		●			
AN303	Edge of road between sidewalk and utility poles approximately 25'Wx1000' owned by municipality. Dual box culverts as outlet. *Improve aesthetics and performance of existing swale with plantings. Extend detention time with check dams and reshaping. Simple depression no more than 12" to maintain invert elevations for flow. Trash rack and sediment forebay are optional. Significant amount of road runoff - thermal pollution and trash.*	3	H	$$	●				●	●
Aqua Resort AN307	Aqua Resort overflow grass/gravel lot - *access lane could be stabilized with grass pave (or similar) to improve runoff quality and reduce volume. Maintain/improve porosity and reduce channelized flow. Help to meet Sustainable Hotel objectives.*	2	M	$$$	●				●	●
San Roque Elementary School AN313	Existing trench drain at school drains to infiltration basin and overflow backs up/ponds at access road and discharges into deep wooded basin. *Educational opportunity at school for bioretention. Overgrowth could be thinned, invasive species removed, and native species planted. Highly visible educational opportunity. Same capacity with more appreciation.*	4	M	$	●	●				●
AN315	Natural channel turns to concrete channel on Diablo. Path on the side of the road leads to a gorge, which is a stream during the wet season. *Investigate further to determine if bank stabilization/stream restoration is warranted or if this is an opportunity for land conservation.*	3	M	?				●	●	
Achugao Stream AN318	Channel width 17' at outlet on shoreline. Channel showing hairline root exposure/erosion. Mild sheen on open water pockets - minimal trash. *Restoration and bank stabilization. Investigate opportunities upstream for volume reduction from developed lands.*	3	M	$		●		●		

ID	Description of Condition & *Potential Solution*	Relative Severity[1]	Priority[2]	Cost[3]	Stormwater Retrofit/	Habitat Restoration	Road Stabilization	Shoreline/Bank Stabilization	Non-Structural	Education
AN319	Tank leaking through hole. Looks like it hasn't been used in a while. Standing water around tank. *Fix leak*	1	L	$					●	
San Roque Market AN328	Runoff from parking lot goes to concrete swale at edge of Route 30. Minimal pitch in either direction. Sediment accumulation observed in channel along road. Vacant/wooded lot to north offers *potential location for stormwater practice, such as a sand filter*. Gas station also in the contributing drainage area, so could be an opportunity to remove PAHs from runoff.	3	M	$$	●					
AN330	Across from shell gas station near new condo construction, sediment accumulates on street because it is so flat. Direct road runoff to *vegetated bioretention or bioswale in ROW.*	3	L	$	●					
Magazine Drive (La Fiesta Mall) AN344	Where unpaved road turns and meets back of the mall (Magazine Drive). Gulling and wash out/sediment accumulation observed at the low point. Road also seems much wider than needed. *Road stabilization recommended, including paving section to top of turn/construction site, installing water bars or cross drains, and adding drainage swale with check dams and turnout.*	4	M	$			●			
AN346	Large residential drainage area to single inlet and culvert that is clogged and broken. Natural stream is channelized into concrete channel. *Clean out leaves and repair concrete structure. Reduce existing road widths within San Roque and install linear bioswales to collect and treat road runoff. This would be a great place to study and design "CNMI Green Streets" for water quality and impervious cover reduction.*	2	M	$$$	●					●
AN350	Channel and culvert full of trash, overgrown vegetation, and stagnant water. Neighbors report having problems with trash and mosquitoes and complained about needing to clean up. Flood issues in past. Open channel is fenced off on drive entrance to school. Poor visibility due to vegetation. *Need to clean out vegetation and remove trash. Reevaluate channel to determine if stream/buffer restoration is appropriate. Important to re-establish positive drainage at this site to avoid mosquito breeding conditions. Could be opportunity to beautify area and provide education for school on drainage. Further investigate opportunities upstream for retrofits.*	4	H	$-$$$		●			●	●

ID	Description of Condition & *Potential Solution*	Relative Severity[1]	Priority[2]	Cost[3]	Stormwater Retrofit/	Habitat Restoration	Road Stabilization	Shoreline/Bank Stabilization	Non-Structural	Education
Kensington AN501, AN601	Pond system draining hotel. *Clean out algae/jellyfish/organic debris at outlet structure, possibly retrofit ponds to improve water quality treatment by creating more wetland features (micro topography, floating wetland treatment cells, etc.). Need to confirm drainage at hotel, review plans. Opportunity to educate visitors and meet water quality objectives of CNMI Sustainable Hotels.* In addition, runoff from the parking lot goes either to an existing wetland or is discharged to pond system. *If it is going to the wetland, it would be good to treat runoff first using green infrastructure techniques. More investigation needed to confirm existing flow paths.*	4	H	$-$$$	●	●			●	●
Beverly Cnst. AN502	New construction site and clearing; hard to see if perimeter controls have been properly installed. *Needs to get out for inspection.*	2	M	$					●	
Global Saipan AN504, AN510	Walled off section of existing wetland to be used as stormwater practice for resort and convention center. Does not appear to be sized to manage full site. *Revisit permit to ensure compliance with stormwater standards. Require mitigation or make them restore wetland and redesign stormwater plan.* Zachary identified Bonsai Mangrove growing in shoreline karst (potentially). *This should be confirmed and, if present, be protected. There may be pending applications for boardwalk or bringing in sand to provide access for resort. Need to review beach access plans to ensure protection of mangrove.*	4	H	$	●				●	
San Roque Stream outlet AN602	Channel outlet appears to have been recently reopened with heavy equipment. Gabion baskets being undermined and there is trash and debris. *Investigate drainage paths further and consider options for habitat restoration and bank stabilization in channel, removal or repair of gabions.*	3	M	?		●		●	●	
Achugao South Subwatershed										
Lower base AS128 and AS168	Concrete swale along road. Collapsed culvert. Old WWII era tidal gate. Swales full of sediment. Industrial areas don't control their sed runoff. *Formalize inlet and add sediment forebay. For industrial businesses nearby--implement individual BMPs to control sediment. Replace culvert & restore side slopes. Clean swale. Require BMPs in contributing industrial area at each site. May be opportunities to install BMPs to control sediment in the ROW.*	5	H	$$	●				●	
AS132 & AS134	Agatan Stream has base flow and has been rerouted as part of development. Stream runs freely across the road and then along gutter line into wetland. Constant flow to another channel through clogged culvert. *PRIORITY PROJECT. Restore and reestablish stream to reduce flow of water and erosion of road edge. Fix culvert (AS133). Restore stream along Middle Road.*	5	H	$$	●		●			●

ID	Description of Condition & *Potential Solution*	Relative Severity[1]	Priority[2]	Cost[3]	Stormwater Retrofit/	Habitat Restoration	Road Stabilization	Shoreline/Bank Stabilization	Non-Structural	Education
Tanapag Park AS137 (entrance)	Paved roads drain to unpaved road in park. Road runoff appears to pond and scour. *Add waterbar or cross drain to direct runoff from Tanapag Ave (paved) to forebay and bio/rain garden in park. May have to be a wet swale. Education opportunity in park.*	3	H	$$	●		●			●
Tanapag Park AS138	Boat ramp and several roads with unorganized vehicular traffic causing minor erosion and sedimentation. Overall park is in good condition except lots of trash. *Eliminate some roads by reorganizing circulation and re-vegetating. Add signage for litter.*	2	L	$			●		●	●
Tanapag Park AS139	Roof runoff discharges directly to park through downpipes. *Rain garden to capture runoff from building roof, eliminate access road. (See AS138)*	2	H	$	●					●
Tanapag MS AS140	Road has little/no drainage infrastructure, so runoff goes into grass. *Stormwater practice in grass area (NW corner of school).*	1	M	$	●					
Tanapag MS AS142	Paved parking lot drains to swale and weep holes in school wall drain to infiltration trench with pipe overflow. Water from paved swale discharges to lawn w/ erosion and then crosses road. *Drainage/vegetated swale along road and tie into infiltration trench overflow near the school yard wall. Possible combination with AS140.*	1	M	$	●					●
Tanapag MS AS147	Informal swale draining runoff from end of dirt road and school yard that discharges off site. Eroded swale. Runoff goes between tanks and pump house. *Fix dirt road grades and direct to basin (AS149) on site.*	2	L	$$	●		●			
Tanapag MS AS149	Large basin in the NW corner of school site. Takes roof, walkway and field runoff. Vegetation is overgrown and should be cleared/cut and maintained. Standing water observed. Water overtops in the SW corner of basin and contributes to drainage issues at AS142. Basin is 4-6' deep, varies in width; up to 20'. *Clean basin. Explore possibility of expanding capacity and address overflow issue?*	3	H	$$$	●				●	●
Tanapag MS AS150	Roof runoff and overland flow uncontrolled in courtyard at school. Does not appear to be a problem but could be an opportunity to integrate stormwater into curriculum. Spoke with principal, who thought students and faculty would like that. *Stormwater BMP to manage roof runoff. Great possible outreach (cool project) but not big impact.*	1	H	$	●					●

ID	Description of Condition & *Potential Solution*	Relative Severity[1]	Priority[2]	Cost[3]	Stormwater Retrofit/	Habitat Restoration	Road Stabilization	Shoreline/Bank Stabilization	Non-Structural	Education
Tanapag MS AS151	Existing planters at school with downspouts directed to them. Downspouts may not actually discharge into planters (may go underneath). No plants. Spoke to principal: they have tried to grow plants but have issues with watering. *Convert planters into stormwater planters. Low hanging fruit and great education opportunity!*	2	H	$	●				●	●
Tanapag MS AS152	Wet/mushy soils./Determine cause-- leaking pipe? Stormwater? other?	3	M	?					●	
Tanapag MS AS153	Parking lot drainage directed to existing swale. Two inlets and one outlet. Inlets clogged- too small. Runoff may not actually be entering swale. Drainage area is parking lot of school and runoff overflow via concrete swales. *Add inlets to allow for better drainage/more inflow. Fix existing inverts and outlets to ensure flow. Clean swale and replant.*	2	M	$	●					●
Tanapag MS AS176	Clogged inlet of rain garden at Tanapag Middle School (see AS145). May contribute to flooding of building. *Clean inlet. Widen and clean outlet spillway. Maintain positive drainage from outlet to road.*	5	H	$	●					●
Tanapag MS AS177	Existing culvert clogged and unclear where it goes (off school property?). *Unclog culvert and consider a stormwater BMP at the downstream inlet.*	3	M	$	●					●
AS154	Water on road. *Confirm water source. Eliminate water from road.*	2	M	?	●					
Imperial Casha AS159, AS502	Gravel drive to main road. Runoff from inactive site discharges to road at construction entrance without erosion controls. *Erosion control on site at entrance. Stabilize site if construction is inactive, owner must enforce.*	4	H	$	●		●			
	Site to be stabilized with vegetation, mulch, or other cover— it's been left exposed for >2 yrs. Significant stream buffer encroachment; sedimentation is evident in stream bed. Existing sediment basins in need of maintenance and removal of accumulated sediment. Site is in clear violation of regulations. *Site stabilization and restoration/protection of stream. Use money from fines or bond to intervene on behalf of delinquent owner. Start with replanting vegetation in the buffer; add a perimeter berm to divert flows away from stream into additional sediment traps; clean out existing sediment basins; hydroseed remaining site. Confirm condition of small, isolated wetland on site. Remove billboards to increase visibility.*	5	H	$$$ (funded from fines)	●				●	
Dogas Stream Outlet AS174	LOTS of trash, including human waste (diapers). *Remove trash and discourage future dumping (signs, community education). Focus location for MINA*	5	H	$					●	●

ID	Description of Condition & *Potential Solution*	Relative Severity[1]	Priority[2]	Cost[3]	Stormwater Retrofit/	Habitat Restoration	Road Stabilization	Shoreline/Bank Stabilization	Non-Structural	Education
Mt Susu AN603	Informal dirt bike recreational area. Erosion issues. *Develop a plan for formalizing and stabilizing trail system, possibly as part of outdoor recreational grant opportunity. Needs better sediment collection system and could be good location for vegetative management and native species planting. Great spot for watershed education signage given the view.*	2	L	$$		●	●			●
Tasi Stream Catchment										
AS102	Ditch on uphill side of road, crosses road in 90 deg culvert to headwall. *Maintenance: clean. Repair trash rack, increase swale and pipe size. Reduce angles of 90 degree turn, add sediment forebay.*	2	M	$	●					
AS105	Catch basin & inlet to dry swale. Flow goes through culvert to drainage ditch with standing water (recently cleared by DPW Roads & Grounds). *Install a sediment forebay at inlet to wet swale for enhanced water quality treatment and reduced maintenance. Possibility for educational signage.*	2	H	$	●					●
Municipal transfer station. AS106, 109	Two leaking water main bubbling up in road, picking up trash and dumpster juice. Discharging to historic wetland. May be for fire suppressant. *Fix water line leaks.* Transfer station drainage network clogged. Unclear where runoff is discharged. *Build swale along landscape strip between wetland, fence, and roadway.*	5	H	$-$$	●				●	
AS170	Concrete swale with sump box is clogged with sediment. Culvert discharges to wetland. Sedimentation observed in wetland. Evidence of past cleaning and removal of sediment from wetland. *Clean box sump. Unclog pipe. Remove sediment from wetland. BMPs needed for all the sites in this area to manage disturbed surfaces with no stabilization. Make box sump easier to clean.*	4	H	$$	●	●			●	
AS171	Open space in front of DFW building. Appears that road runoff drains there now. *Great spot for a bioretention facility near DFW sign to treat small amount of road runoff from crowned road. Small drainage area but highly visible. Would like to get DFW involved as educational/public opportunity.*	2	M	$$	●					●

[1] Relative severity (or condition) indicates how critical it is to address this site, based on professional judgement on a scale of 0-5, where 5 is high.

[2] Implementation Priority (preliminary) is based on professional judgement of importance, feasibility, visibility, etc. H=high, M=medium, and L=Low. This has not gone through a formal ranking or stakeholder input process.

[3] Relative cost is a placeholder for additional development, where $$$>$50,000, $$=$25-50k, $<$25k. Don't hold us to this.

● Indicates type of project.

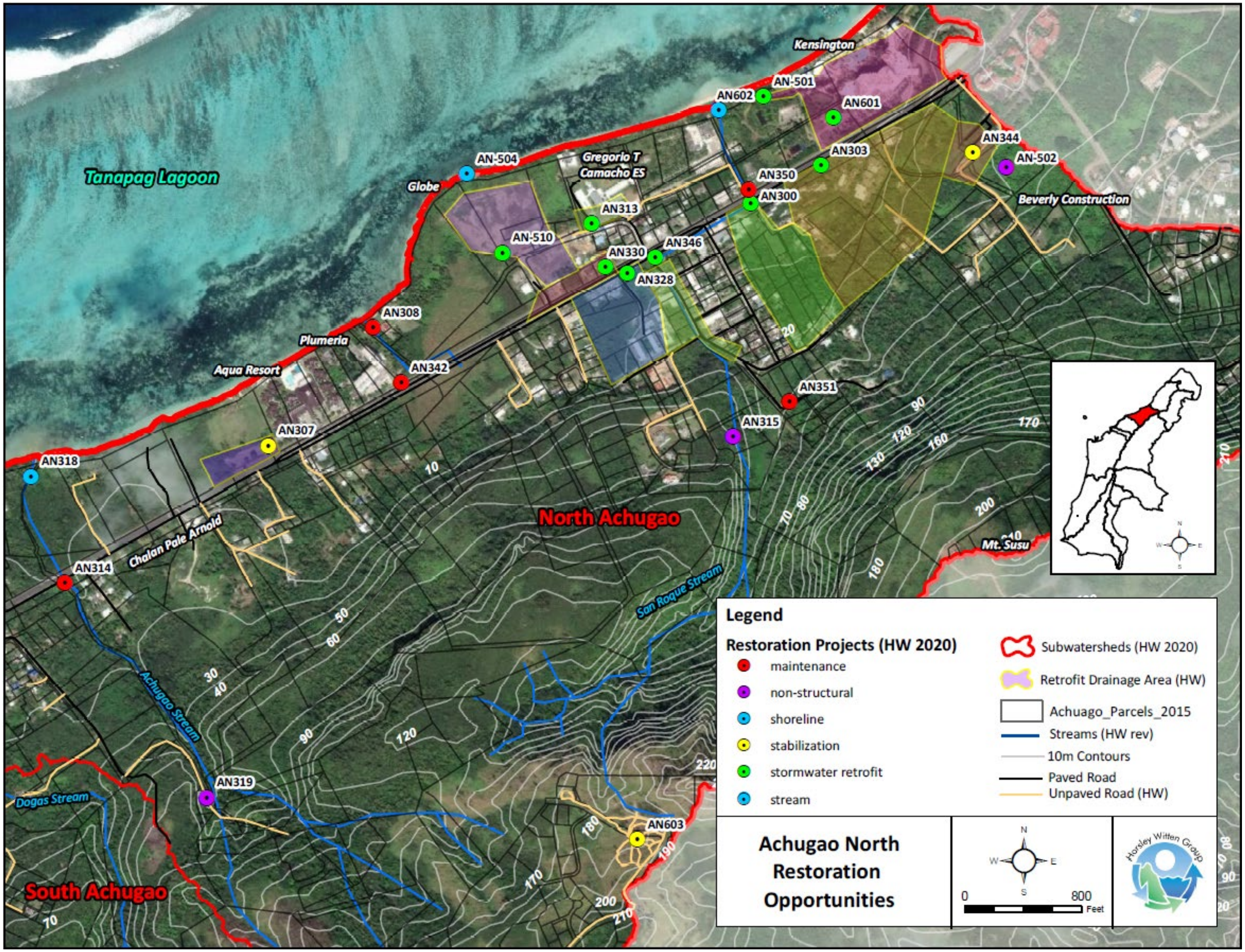

Figure 33a. Potential restoration opportunities identified in Achugao North by HW field crews, January 2020

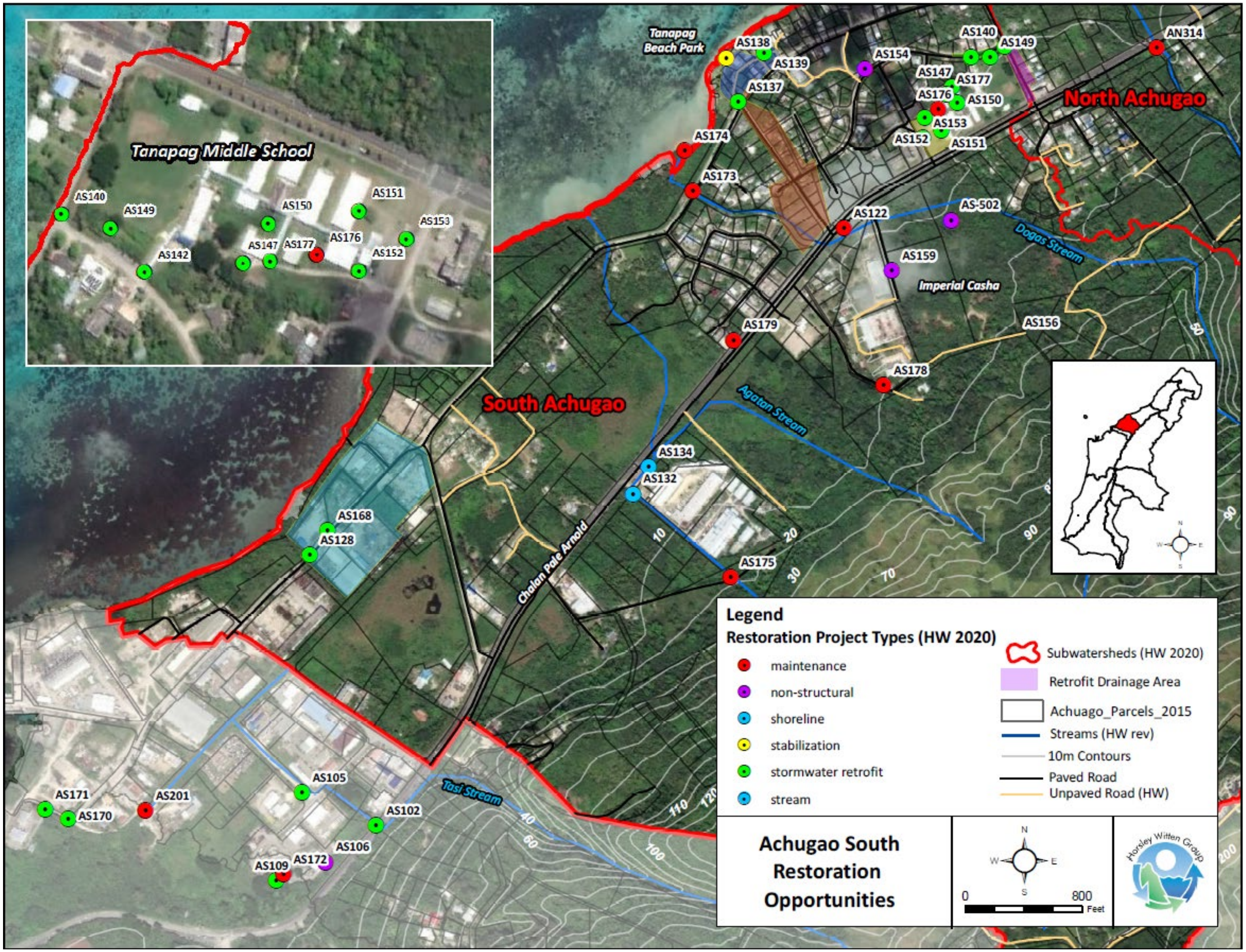

Figure 33b. Potential restoration opportunities identified in Achugao South by HW field crews, January 2020

General observations made by field crews in the Achugao watershed include the following (in no particular order):

1. Infrastructure resiliency is an issue in this watershed—there is significant infrastructure along the shoreline that is vulnerable to sea level rise and flooding (roads, electric, water/sewer, large hotels, schools, etc.). Also, many homesteads along Dogas stream given out without consideration of FEMA flood maps.

2. The water quality of Tanapag Lagoon is partially protected by the extensive freshwater wetland complexes spanning the coastal plain in the watershed. These wetlands, however, have likely taken a hydrologic beating from decades of alteration, pollution, water level fluctuations, habitat loss, etc. Man-made drainage ditches connect intermittent wetland pockets.

3. The commercial/industrial area in Lower Base is an obvious sediment source with very little exiting runoff management. The area is low-lying, but road shoulders and private properties offer a lot of opportunity to treat stormwater. The power plant, numerous manufacturing facilities, warehouses, and storage units are all highly visible from Route 30 and reinforce the working waterfront feel. Drainage from Route 30 and up-gradient drain into the industrial park system. Flooding at the recycling/transfer station does occur. Heavy metals and miscellaneous debris from post-hurricane are vulnerable to seeping and or washing away entirely.

4. Two very large construction sites offer insight into the potential development plan for this area, but also at the lack of environmental care afforded during the construction process. Both sites impacted wetlands and the years of exposed soils at the Sinopan property (a clear violation of ESC regulations) has resulted in a highly impacted stream system and contributed to clogging of downstream drainage infrastructure.

5. Economic activities in the area include tourism expansion, hotel development, extension of power/CUC service to the north of the island. There is a strong community (Tanapag) and "sense of place" and this conflicts with land use planning. They want growth, but not like Garapan. There are large areas of public land in the upper watershed. Development/Objectives may include: Clean water, Community fisheries, Disturbance response and terrestrial aquatic restoration, Compatible development (small B&B not massive hotels), Residential areas and piggeries on top of watershed, and dune buggies.

6. A majority of the stormwater infrastructure found throughout the Achugao Watershed is mostly closed pipe conveyance systems.

7. Fires are reportedly a big issue, exposing soils to erosion and increasing invasive species, loss of native vegetation and habitat

8. The watershed includes historic sites, several cemeteries, a fishing community, some hunting, medicinal plant gathering in the upper watershed.

9. Achugao (South) – *Driving north on the Route 30 corridor*--Dense development is nearly continuous on the west (seaward) side of Middle Road. The east side of the road contains intermittent development between steep slopes and areas with less favorable conditions for cost-effective land development. The terrain west of Route 30 is low-lying and extremely flat. The road design is curb

and gutter with concrete culvert crossings under Route 30. Past the industrial park, an abandoned textile plant remains standing east of Route 30. Current use or potential retrofit opportunities are unknown at this time.

10. A drainage divide exists at the Tanapag Elementary School. Ample open space and flat conditions provide an opportunity for green stormwater infrastructure. Tanapag Park, boat ramp, and meeting hall within the neighborhoods behind the Elementary School is a notable public asset. Any management plan needs to incorporate an activity here and to engage the community.

11. Achugao (North) – *Driving north on the Route 30 corridor*--Beyond the Mobil gas station, the road design changes to concrete shoulder-channels and uncontrolled, country drainage in places. Route 30 remains flat and development shifts to the east side. Minimal development exists along the seaward (West side) of Route 30 for the better part of a mile. The road remains flat to San Roque village, where the drainage collection system changes to curb, gutter, structures, and closed pipes. Stormwater management appears to be an after-thought. San Roque development contains hard edge concrete box culverts which in areas exceed 6 feet deep. A substantial volume is conveyed through this storm drain system and outlets across from ____ Coffee Shop.

12. Two hotel resorts are the next large developments present along the west side of Route 30. One being Aqua and the other, Plumeria, is abandoned. The watershed terminates at the Kensington Hotel and abandoned Mall site. Numerous infill and redevelopment opportunities exist near Kensington Hotel.

13. An extensive wetland system exists just north of these two resorts, it is bisected by Route 30 and abuts the Saipan Globe development. A 10'-wide culvert crossing connects the two eco-systems. Phragmites has invaded and colonized a majority of the landscape. The beach is most pristine towards the northern extends of Achugao North.

14. Small-scale agriculture, including piggeries, have been identified along the offshoot road neighborhoods east of Route 30.

4.0 Pollutant Load Modeling

One element of EPA's watershed planning criteria is to estimate existing and future watershed pollutant loads to help prioritize management actions. To this end, we used the Watershed Treatment Model (WTM), Version 3.0 (Caraco, 2013)--a public-domain, Microsoft Excel-based spreadsheet model used to estimate annual watershed pollutant loads for total nitrogen (TN), total phosphorus (TP), total suspended solids (TSS), fecal coliform bacteria (FC), and runoff volume. The WTM was applied to four major stream catchments within the Achugao Watershed (As Agatan, Saddok Dogas, Achugao, and San Roque) as illustrated in **Figure 34**. It is worth noting that these catchments include areas of direct drainage to Tanapag Lagoon (not strictly delineated to each stream outlet).

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

WTM Inputs and Assumptions

Tables 14-17 and **Tables 18-20** summarize key data input assumptions used to generate existing and future loads, respectively. These can (and should) be adjusted as more information is collected, particularly if numerical loads are considered important. The model inputs are based on a combination of available mapping information and our observations of watershed conditions, existing management measures, and potential opportunities for restoration. It should be noted that:

- Not all input parameters were fully vetted during field investigations (e.g., livestock). Some of the GIS data used may not accurately reflect conditions (e.g., impervious cover mapping). No model calibration or validation was conducted using water quality data.
- The model does not account for routing, attenuation, or subsurface flows in the watershed. The smaller the watershed area modeled the better.
- Stream erosion and shoreline stabilization is not well accounted for in the model, although the user can provide a broad estimate of the contribution of stream erosion to TSS loading.
- The model estimates load to groundwater from infiltration practices and septic systems but does not include those loads in the total surface loads to the receiving waters. Groundwater loads are reported separately.
- Surface loads to receiving waters includes both coastal waters and the freshwater wetland complexes in Achugao. Separate loads to the existing wetlands could be estimated, and amount of treatment offered by those wetlands, could be estimated by modeling contributing drainage areas to the wetlands first and then treating the wetlands as BMPs prior to coastal discharge.

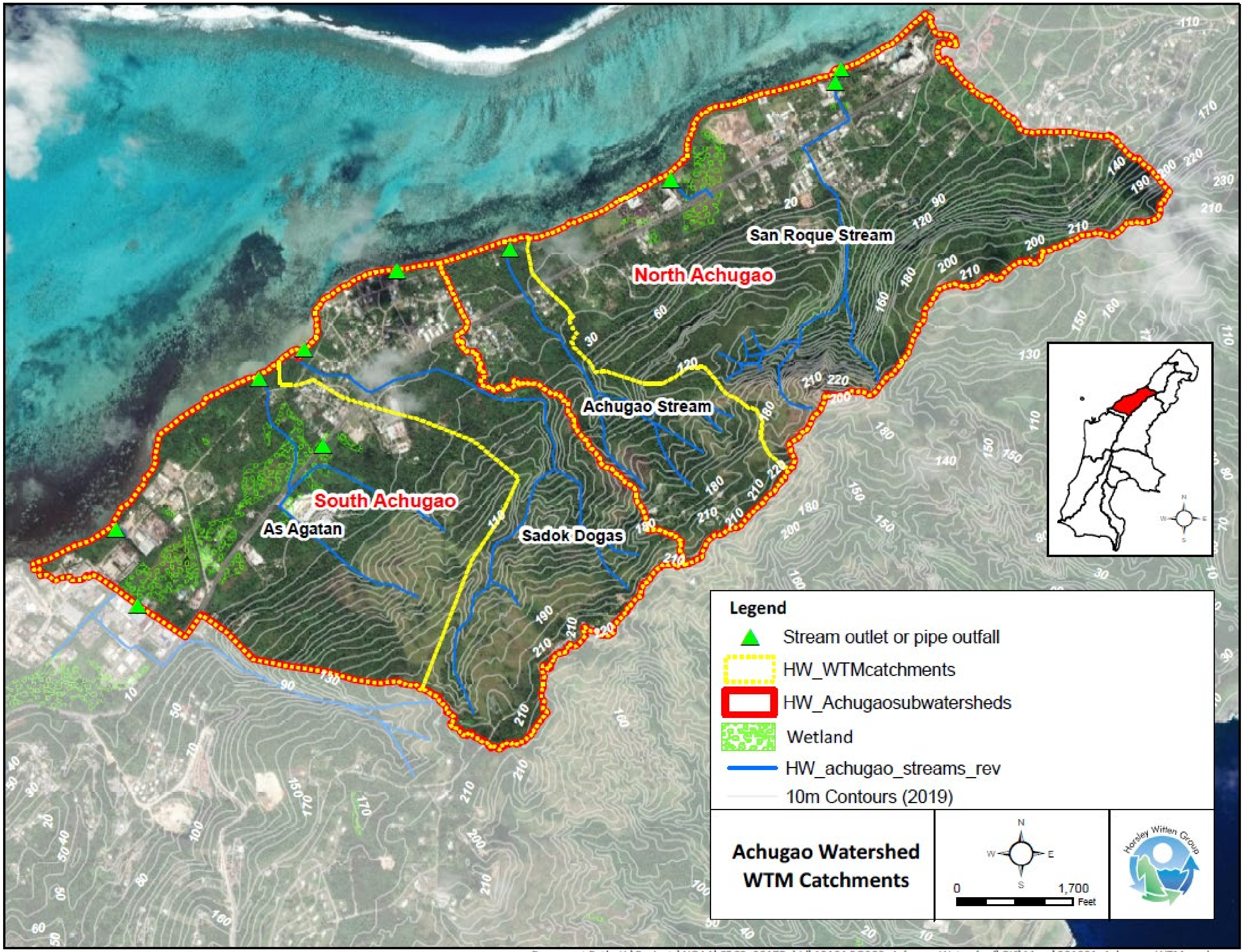

Figure 34. Four stream catchments included in the WTM model runs

Table 14. Input Data Used to Estimate Existing Loads

<table>
<tr><th rowspan="2">Input Parameter</th><th colspan="4">Value</th><th rowspan="2">Description</th></tr>
<tr><th>As Agatan</th><th>Dogas</th><th>Achugao</th><th>San Roque</th></tr>
<tr><td colspan="6">PRIMARY SOURCES</td></tr>
<tr><td>Avg annual rainfall</td><td colspan="4">85 inches</td><td>Interpolation from 2009 CNMI Stormwater Manual.</td></tr>
<tr><td>Watershed Area (acres)</td><td>436</td><td>336</td><td>190</td><td>645</td><td>Reduced watershed area by consensus during watershed meetings in January 2020 to exclude Tasi stream catchment that drains to DFW beach. Remaining boundary based on 2017 LIDAR-derived basin mapping from NOAA/CRM.</td></tr>
<tr><td>Land Use</td><td colspan="5">See Table 15. DCRM/NOAA provided the most current landuse GIS layer, which was incomplete and did not distinguish between L-H density residential. HW updated residential areas based on observations, aerial imagery and the USFS Vegetation Classification, and by selecting all parcels with buildings or were classified as urban land. HW reclassified Open Space area using the USFS Vegetation Classification to find more accurate estimates for agricultural land, beach/recreation area and forested area. We did not adjust for commercial areas or multifamily residential. The land use data contains a transportation class, which we classified as paved or unpaved.</td></tr>
<tr><td>Impervious Cover (acres/% watershed using GIS layer or by acres/% using coefficients in WTM)</td><td>NOAA: 54 acres (12%)

or

WTM: 75 acres (17%)</td><td>NOAA: 34 acres (10%)

or

WTM: 51 acres (15%)</td><td>NOAA: 15 acres (8%)

or

WTM: 18 acres (9.5%)</td><td>NOAA: 66 acres (10%)

or

WTM: 105 acres (17%)</td><td>IC is used in model to estimate runoff volume. There are two options for deriving IC: 1) use NOAA 2005 IC layer; or 2) use default impervious coefficients for land use categories. We used option 2 in the model but adjusted residential default values using 2019 LandSat satellite imagery from USGS to calculate the Normalized Difference Vegetation Index to estimate non-vegetated land cover for each residential category. An analysis of average impervious cover by other land use types was outside the scope of this effort.</td></tr>
<tr><td>Pollutant Event Mean Concentrations (EMCs)</td><td colspan="5">See Table 16. EMCs and loading rates from various land uses are typically based on values from the National Stormwater Quality Database (NSQD), which is a summary of stormwater data from over 200 jurisdictions across the US (Pitt et. al., 2003). Land uses with impervious cover are assigned an EMC. Land uses without impervious cover use an assigned loading rate. We have adjusted the default values for sediment using data from the USVI/PR, but they should be adjusted for CNMI as data becomes available.</td></tr>
<tr><td>Hydrologic Soil Groups (% of watershed)</td><td>22% HSG A;
2% HSG B;
10% HSG B/D;
29% HSG C;
37% HSG D</td><td>33% HSG A;
28% HSG B;
202% HSG C;
71% HSG D</td><td>3% HSG A;
17% HSG B;
36% HSG C;
43% HSG D</td><td>9% HSG A;
16% HSG B;
2% HSG B/D;
10% HSG C;
63% HSG D</td><td>Based on NRCS mapping. The HSGs are used to estimate surface conditions for infiltration potential, with A soils generally having a high permeability rate (e.g., sandy soils) and D soils generally having a low permeability rate (e.g., clay soils).</td></tr>
<tr><td>Depth to Groundwater (% of watershed)</td><td>12% <3 ft;
16% 3-5f;
72% >5 ft</td><td>2% <3 ft;
8% 3-5ft;
90% >5 ft</td><td>2% <3 ft;
8% 3-5ft;
90% >5 ft</td><td>4% <3 ft;
6% 3-5ft;
90% >5 ft</td><td>Based on NRCS soil mapping (depth to groundwater estimates) plus an adjustment of 2% for shoreline and up to 8% for transition zone when NRCS maps say 100% >5ft. Shallow depths to groundwater (e.g., <24”) can signify a higher potential for nutrients to enter groundwater, while deeper depths (e.g., > 48”) can provide better pollutant removal.</td></tr>
<tr><td>Stream length (miles)</td><td>1.4</td><td>2.5</td><td>1.7</td><td>2.2</td><td>DCRM/NOAA hydrography shapefile, modified by HW. Need to update with DCRM 2020 stream walk mapping and/or IR data layer.</td></tr>
</table>

Input Parameter	Value				Description
	As Agatan	Dogas	Achugao	San Roque	
SECONDARY SOURCES					
Sanitary Sewer Overflows (SSO) (pipe network miles/#overflows)	1.3 miles # SSOs:3.25	2.1 # SSOs:5.25	0.6 # SSOs:1.5	2.6 # SSOs:6.5	Most of the developed watershed is sewered (see CUC's Sadog Tasi sewershed boundaries). Length of sewer lines are from CUC dataset, and include gravitational sewer line, pressurized sewer line and lateral lines. We assume 2.5 sewer overflows per mile (this could be low).
Onsite Disposal Systems (OSDS) (#dwellings total/# with OSDS/%OSDS within 100' of stream)	150/68/15% within 100' of stream Includes 1/3 worker barrack units 50% OSDS failure rate due to known issues	170/8/50% within 100' of stream 40% failure rate of OSDS	43/7/30% within 100' of waterway Standard 30% OSDS failure rate	333/55/2% within 100' of stream Aqua and Kensington are on sewer Standard 30% OSDS failure rate	Sewage impacts are estimated from # dwellings, standard nutrient and bacteria concentrations of raw sewage, and default assumptions of volume generated per dwelling. # of dwellings is estimated from building footprint GIS, land use, and aerial photos. If a building is outside of CUC mapped sewer service area, it is counted as having OSDS. Dwellings include # of residential buildings plus 1/3 of commercial buildings and 1/3 the # of hotel rooms or units in worker barracks (see **Table 17**). We assumed <u>all</u> OSDS are conventional design (i.e., not enhanced for nutrient removal) with default concentrations and removal efficiencies.
Illicit discharge into the storm drain or stream (fraction illicitly connected)	10% of residents and businesses (of 33 total businesses)	10% (of 15 total businesses)	5% (of 25 total businesses)	10% (of 30total businesses)	This is non-stormwater runoff discharge into storm drain or stream. Not based on any CUC data, just best professional guess. Model default values used for concentrations in sewage and washwater. # of businesses derived from estimate based on # of buildings in commercial land.
Livestock	100 pigs and 300 chickens	75 pigs and 100 chickens	50 pigs and 150 chickens	150 pigs and 400 chickens	Not based on any data. This is probably low by an order of magnitude. It doesn't account for dogs…
Stream Channel Erosion	Low. 25% of total sediment load				Not based on any field data. Selected default method 1 in the model that back calculates a % for channel erosion based on total sediment load and miles of stream. Stream visual assessments did not indicate level of erosion, however new assessments are anticipated to do so.
EXISTING MANAGEMENT PRACTICES					
Structural stormwater BMPs (post-construction)	**See Table 16**. We included several BMPs we were aware of in the model that currently provide some level of stormwater management. There are likely more that BECQ and DPW are aware of. We used default pollutant removal rates for each type of practice, assumed 50% capture rate for target volume (90th percentile storm of 1.5 inch), estimated area managed by field observations, and assumed maintenance of facilities was low.				
Erosion and Sediment Control	50% program efficiency	25% program efficiency	50% program efficiency	50% program efficiency	CNMI has a relatively strong ESC inspection program. Program efficiency factors could probably be higher. Low points for Imperial Casha
Catch basin cleaning	none	none	none	none	This could be refined based on DCRM, DPW, and CUC guidance.
Riparian Buffers (% impacted/OK miles)	43%; 0.8 miles OK	45%; 1.4 miles OK	11%; 1.5 miles OK	22%; 1.7 miles OK	Assumes 50 ft buffer width X length of stream, with 0.4 regulatory protection factor.

Table 15. Area, % cover, and EMCs for each land use category

LU Category	Area (Acres)				% Cover		Event Mean Concentrations			
	Agatan	Dogas	Achugao	San Roque	Imper.	Turf	TN* (mg/l)	TP (mg/l)	TSS (mg/l)	FC (MPN/ 100 ml)
LDR > 1 ac	21.2	10.3	22.1	98.2	20%	16%	1	0.2	102	20300
MDR 0.25-1 ac	6.6	25.3	12.0	25.9	40%	12%	1	0.2	102	20300
HDR <0.25 ac	18.4	14.4	4.4	18.0	65%	7%	1	0.2	102	20300
Municipal/Inst.	6.7	10.2	0	4.0	72%	6%	1.2	0.22	49	20000
Recreational/Beach	22.9	4.1	0	0.1	10%	72%	1.2	0.22	49	20000
Commercial	1.0	4.0	0	43.2	72%	6%	1.2	0.39	56	20000
Roadway -Paved	23.0	15.0	3.0	21.7	100%	0%	1.2	0.16	36	13700
Roadway -Unpaved	4.0	4.4	3.2	8.4	90%	2%	1.2	0.24	2895	13700
Active Construction	4.0	2.2	0	16.2			1	0.2	680	0
Industrial	40.1	0	0.3	1.4	53%	9%	2.2	0.22	81	20000
	Area (Acres)				**% Cover**		**Annual Loading Rate**			
	Agatan	**Dogas**	**Achugao**	**San Roque**	**Imper.**	**Turf**	TN (lb/yr)	TP (lb/yr)	TSS (lb/yr)	FC (# billion)
Forest/Park or Open	234.0	226	145	388.4	0%	0%	1.8	0.25	147	12
Ag	11.2	0	0	5.8	0%	0%	5.3	1.2	147	39
Open Water/wetland	43	0.2	0.1	13.7	--	--	12.8	0.5	155	--
Total Acres	**436**	**336**	**190**	**645**			--			

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

Table 16. Existing stormwater manager practices and applied pollutant removal rates

BMP	**Contributing Drainage Area** (estimated acres)								% Removal *			
	As Agatan		Dogas		Achugao		San Roque		TN	TP	TSS	FC
	Total	*IC*	*Total*	*IC*	*Total*	*IC*	*Total*	*IC*				
Coral road BMPs & sediment traps					1	0.7			0%	60%	80%	50%
Vegetated swale			3.2	1.0					30%	25%	60%	0%
Dry detention basin									10%	15%	55%	0%
Ponding basin (wet)			3.7	1			10	8	30%	50%	80%	70%
Constructed wetland									25%	50%	75%	80%
Bioretention/rain garden			0.5	0.4					65%	55%	85%	90%
Infiltration (various)			0.2	0.2			3.5	3	55%	65%	95%	85%
Rooftop disconnection									25%	25%	85%	0%
Rain tanks and cisterns									40%	40%	40%	0%
Total Acres			**7.6**	**2.6**	**1.0**	**0.7**	**13.5**	**11.0**				

*removal rates when functioning properly. Should be updated per the CNMI stormwater manual.

Table 17. Number of dwelling units and rooms for hotels

Name	# rooms/units	Name	# rooms/units
Worker barracks- As Agatan	100	Villora condotel (not constructed)	150
Kensington- San Roque	313	New Century Hotel--redevelopment	48
Aqua-San Roque	91	Globe- San Roque, under construction	536
Plumeria- San Roque (closed)	100	Casha Imperial- Dogas, under construction	1184

*room estimates based on BECQ permit database and internet research

Table 18. Future management measures applied in the model

Input Parameter	As Agatan	Dogas	Achugao	San Roque
Septic System education, repair, upgrade	• Education program reaches 30% of population • 25% systems inspected • 100% willing to repair/upgrade			
Remove Illicit Connection	• 30% of system surveyed • 100% of repairs made			
SSO repair and abatement	• Goal of 100% reduction • 50% complete			
Stormwater retrofits (See **Table 19**)	15 additional acres managed (90% impervious)	13 additional acres managed (47% impervious)	none	69 acres managed, including retrofit of existing ponds at Kensington and completed BMP at Globe (51% impervious)
	• assumed 50% capture rate for target volume (1.5 inch) • low maintenance			
Impervious Cover Disconnection Program- Residential	• Program in place • 1200 sq ft typical roof size, 25% of land where applicable, • 8% of population reached and 10% willing to participate			
Redevelopment improvement	0.5 acres (New Century Hotel) reduces impervious and turf cover on site by 10%	none		5 acres (Plumeria) reduces impervious and turf cover on site by 10%
Erosion and Sediment Control	Increase from 50% to 80% program efficiency	Increase from 25% to 80% program efficiency	Increase from 50% to 80% program efficiency	
Catch basin cleaning	Semi-annual cleaning for 5 acre contributing drainage area		none	Semi-annual cleaning for 10 acre contributing drainage area
Street sweeping	Monthly sweeping of 10 total acres using mechanical sweeper	No street sweeping		
Riparian Buffers	Enhance 0.5 additional miles of stream buffer (100 ft width)	Replant additional 0.2 miles of stream (100 ft width)	No additional buffer enhancement	
	Implement specific buffer education, enforcement, and regulations			
Pet waste management	• Implement education program • 30% of households with dogs • 50% made aware and 25% will change behavior			Same except 5% of households with dogs (hotels account for a large % of households)

Table 19. Future stormwater management practices modeled

Stormwater BMP	Drainage Area Managed (Total acres/Impervious acres)			
	As Agatan	Dogas	Achugao	San Roque
Bioswales	15/14	7.3/5.2		24.7/11
Wet Pond		3.7/1.0		
Constructed Wetland				18.9/14.2
Permeable pavement				2/2
Sand filter				7.7/3.9
Bioretention (various, TBD)		2.3/1.0		13.8/5.7
Road stabilization			none	2.4/0.8
Total	**15/14**	**13.3/7.2**		**69.2/35.3**

Table 20. Future land use changes and new development assumptions

As Agatan	Dogas	Achugao	San Roque
• 4 acres of active current construction becomes commercial land • 10 acres of currently undeveloped land is converted to 5 commercial acres and 5 medium density residential acres • Meet 80% TSS and bacteria, 40% nutrients, 50% runoff reduction target • 0.2 mile sewer connections • No new septic systems • No illicit discharges	• 22 acres of active current construction becomes commercial land • 10 acres of currently undeveloped land is converted to 10 commercial acres • Meet 80% TSS and bacteria, 40% nutrients, 50% runoff reduction target • 0.2 mile sewer connections • No illicit discharges	• 10 acres of currently undeveloped land is converted to 10 low-density residential acres • Meet 80% TSS and bacteria, 40% nutrients, 50% runoff reduction target • 5 new conventional septic systems	• 16.2 acres of active current construction becomes commercial land • Meet 80% TSS and bacteria, 40% nutrients, 50% runoff reduction target • 0.2 mile sewer connections to connect Beverly • No illicit discharges

Results

While the WTM can be used to generate qualitative nutrient, TSS, and bacteria loads, it is better for comparing relative contributions between subwatersheds and management scenarios. At this time, we have only run a preliminary model to estimate existing and predict future pollutant loads based on an initial assessment of conditions and restoration opportunities. These estimates will be revisited as part of the watershed plan with a focus quantifying the potential load reduction benefits of priority implementation projects.

Table 21 summarizes model results for existing conditions, future management options/watershed treatment, and with future development. Quantification of the numeric annual load, while useful, is highly dependent on specific data inputs, such as runoff concentrations, number of pigs, volume of sewer overflows, etc. We don't recommend putting much stock in these numbers until more refined input data can be obtained and the model compared with findings from the water quality monitoring program.

Figure 35 illustrates which watershed sources (urban land, sanitary sewer overflows, construction sites, etc.) are the most significant.

Table 21. Loads to Surface Waters

Subwatershed Scenario	TN (lb/year)	TP (lb/year)	TSS (lb/year)	Fecal Coliform (billion/year)	Runoff Volume (acre-feet/year)
As Agatan					
existing	4,078	570	423,319	435,813	591
w future BMPs	3,680	506	372,620	334,401	552
%reduction	**10%**	**11%**	**12%**	**23%**	7%
w future development	3,829	549	380,312	344,627	599
Dogas					
existing	2,228	383	474,018	410,702	421
w future BMPs	1,904	323	377,866	300,199	409
%reduction	**15%**	**16%**	**20%**	**27%**	3%
w future development	2,287	447	393,973	326,527	532

Subwatershed Scenario	TN (lb/year)	TP (lb/year)	TSS (lb/year)	Fecal Coliform (billion/year)	Runoff Volume (acre-feet/year)
Achugao					
existing	786	132	156,244	74,738	126
w future BMPs	760	126	156,034	58,890	126
%reduction	3%	5%	0%	**21%**	0%
w future development	843	142	161,457	62,989	142
San Roque					
existing	4,675	863	791,397	818,292	835
w future BMPs	3,902	707	660,234	472,362	789
%reduction	**17%**	**18%**	**17%**	**42%**	6%
w future development	4,088	769	666,986	485,791	853

Figure 35 illustrates which of the catchments and sources are identified by the model as the biggest contributors of annual pollutant loads to Tanapag Lagoon from the Achugao watershed.

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

1. The model identifies San Roque as the largest total contributor of annual pollutants of the four catchments, which is not unexpected since it is the most developed. As Agatan, however, contributes a similar level of nutrients to Tanapag Lagoon likely due to the heavily developed Lower Base and issues with onsite wastewater systems. Dogas and Agatan contribute only half of the sediment and bacteria loads as San Roque. Achugao is the smallest and least developed catchment and is predicted to generate the lowest pollutant loads. Retrofit and stabilization efforts may be the most effective in San Roque and As Agatan.
2. Under the treatment scenarios modeled, the most effective treatment options to reduce nutrients in the watershed are illicit discharge removal, stormwater retrofitting, riparian buffer improvements, and erosion control. Understanding the influence of illicit discharges will be critical to refining a management approach. Excessive nutrient loading can lead to reduced dissolved oxygen, which Achugoa area is currently impaired for. To reduce TSS, erosion and sediment control at construction sites and stormwater retrofits (including unpaved road improvements) are likely to have the most impact.
3. While DCRM's water quality monitoring program tracks different indicator bacteria, initial results for load reductions ranging from 21%-42% for Fecal Coliform are encouraging. The 2017 bacteria TMDL establishes a wet weather geomean reduction range of 20-88%. The largest reductions seen in the model are gained through illicit discharge disconnections, retrofits, SSO repairs, and riparian buffers. MST data shows that most of bacteria in water quality samples are from dogs. More information is needed to accurately model the impact of livestock and dogs on watershed loads and better evaluate the real influence of sanitary overflows and illicit connections on the system.

4. There is a lot of room to achieve load reduction in the watershed, even if sanitary sewer improvements have mostly been completed. There is currently very little area being captured by stormwater management practices and enforcement of erosion control at construction sites could be improved.
5. Future development could quickly undue the gains earned through retrofitting and other watershed restoration actions.

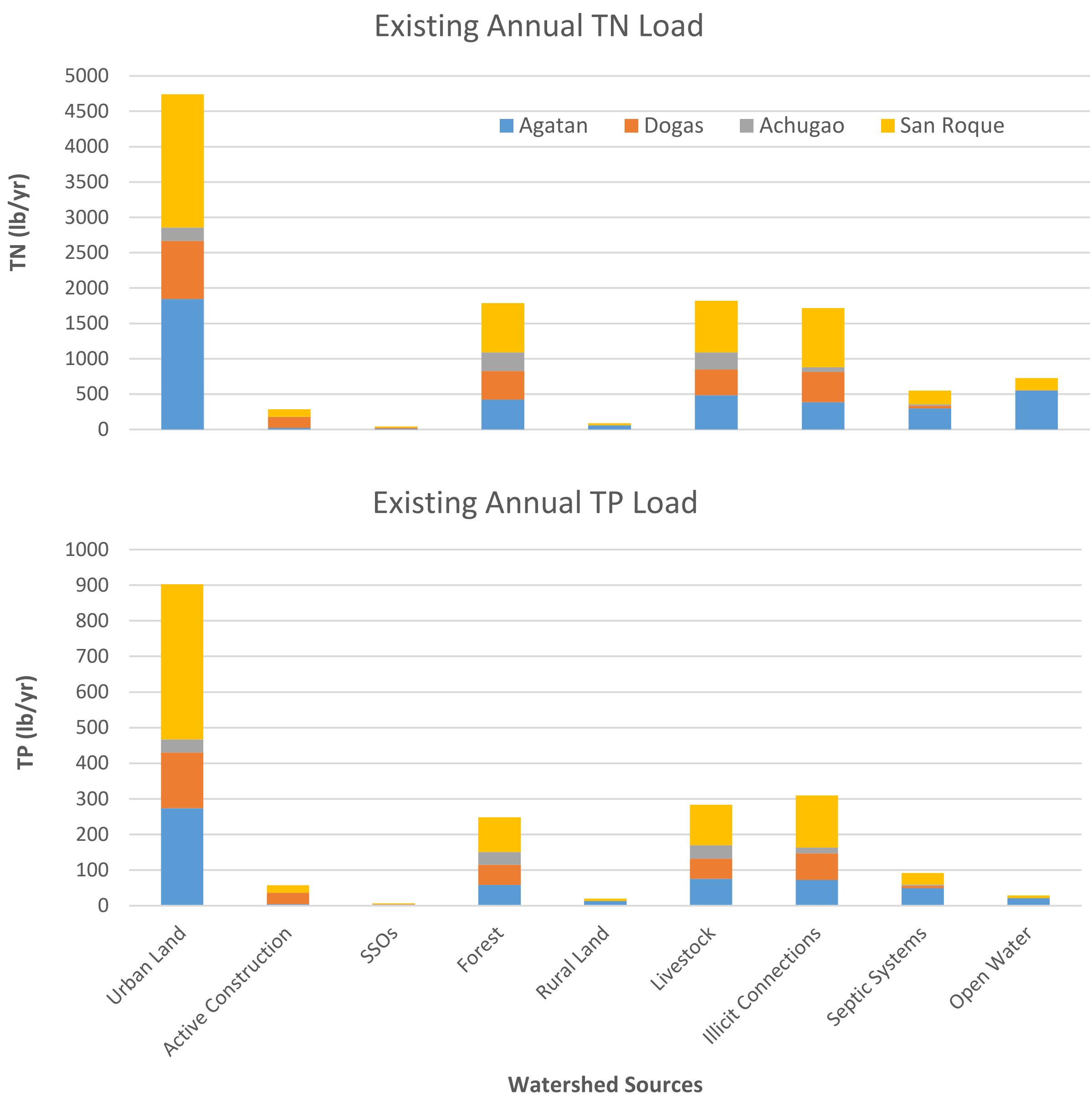

Figure 35a. Sources of nutrient loads to surface waters by subwatershed

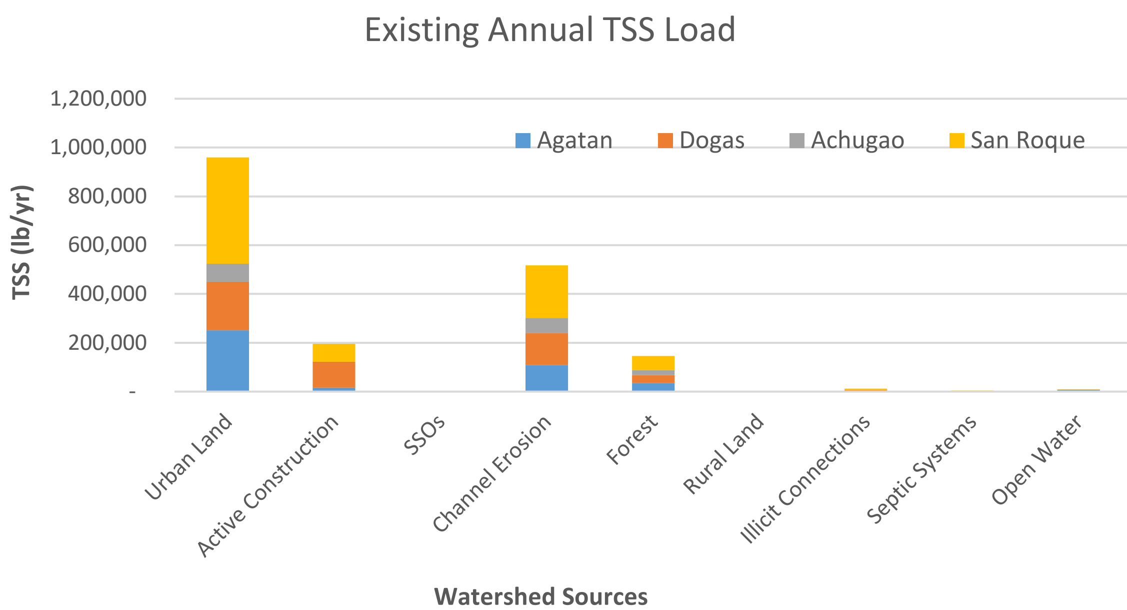

Figure 35b. Sources of sediment loading to surface water by subwatershed

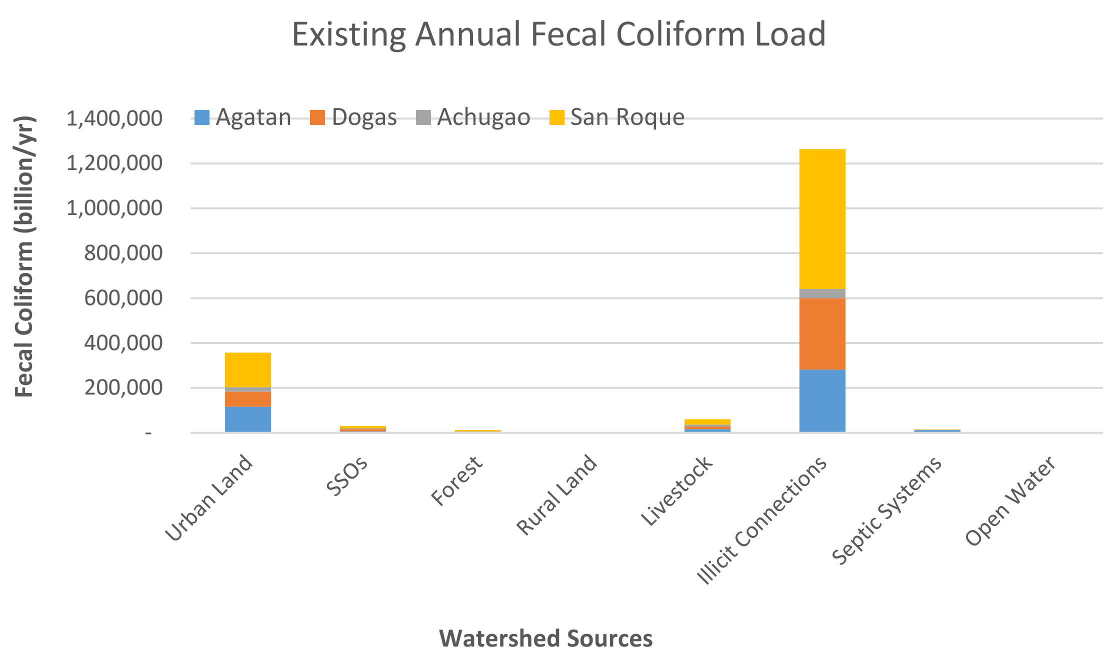

Figure 35c. Sources of bacteria loading to surface water by subwatershed

Next Steps

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

1. Consider how these model results fit into the priority strategies identified during the watershed workshops and if specific restoration actions in the watershed plan update are adequately reflected here. If there are a few projects that need to be put into the model so their benefits can be quantified, let us know and we can insert them.
2. Review water quality data for the watershed and broadly evaluate how representative you think the model results are at this stage.
3. Refine input variables where assumptions are wrong and data is readily available to correct input, such as primary land use acres, and secondary sources that other agencies have better insight on (e.g., # of SSOs, # of septic systems, livestock estimates).
4. Research and review completed field assessments to better evaluate stream erosion and estimate island appropriate EMCs for runoff.
5. Compare Achugao model results with Garapan and Laolao Bay watersheds.
6. Use the model to predict the load reduction benefit of priority restoration practices.

5.0 Stakeholder Engagement

This watershed has a stream restoration success story that could be used to rekindle community interest in watershed planning, as well as a strong community presence. The Tanapag community has come out on a number of occasions regarding development projects (e.g., Sinopan, New Century Hotel). They have also been the beneficiaries of DCRM's Stream Team Village Assistance Forum, which was an assistance program started in 2014 to help homeowners apply for financial aid from various local and federal government programs for watershed restoration activities, such as sewer hookup, energy - efficiency, improved piggeries, etc.

Stakeholder Engagement Plan

COVID19 has derailed the public engagement components of the Laolao and Achugao watershed planning projects. Our plan moving forward to engage stakeholders may include the following elements:

1. Updates and input from agency staff as part of the monthly Watershed Working Group - Becky Skeele is participating; this forum could be used specifically to:
    a. Help fill any remaining data gaps described in previous sections of this report
    b. Solicit input on goals and objectives
    c. Provide input on selection of priority watershed projects
    d. Provide a forum for review and comment on draft WMP
2. Reach out to watershed residents through one of more of the following:

a. a shared engagement process with OPD as part of their comprehensive planning communications
b. One or more socially distanced meetings targeting Tanapag Village and then San Roque. residents (hosted by Kodep, Sheila Babuta, or Vinnie Sablan). Schools, meeting hall, hotel
c. Host 3-4 online meetings to: (1) review background on WMP objective and existing conditions; (2) solicit input on goals and priorities; (3) to review draft plan; and (4) to present final watershed plan.
d. Becky to go on the radio show that we did for SCORP to gin up interest in taking an online survey to prioritize Laolao management priorities.

3. Reach out to hotels through HAMNI to see how they are doing with sustainability programs and to see any interest in retrofitting parking lots or existing stormwater facilities. Kensington and Aqua both have great retrofit opportunities.

4. Reach out to Department of Education to connect with the two schools. Watershed contest and onsite rain garden (maybe fix one at Tanapag MS).

5. Host a watershed hike.

6. Consider conducting a public survey to be distributed online via social media.

7. Need to reach out to DFW to get understanding of invasives management planning, sensitive species and high-quality habitats, as well as wetland assessments. A priority of the WMP should be to reduce direct stormwater discharges to natural wetland without pretreatment.

8. Populate the story map/project website with updated watershed information and engagement opportunities. https://horsleywitten.com/cnmiwatersheds/

Watershed Workshop

From January 21–24, 2020 over 40 stakeholders from CNMI government agencies and NGO's came together to discuss and complete watershed management planning activities for the three priority watersheds of Garapan, Laolao, and Achugao. The facilitation team was a collaboration of technical partners hired to develop the different watershed plans that consisted of The Nature Conservancy, Sea Change Consulting, Koa Consulting, and Horsley Witten Group. To reduce stakeholder fatigue, utilize different technical skills from each consultant group, and enable discussions that compare and contrast watersheds, planning for all three watersheds was carried out over one week. During the workshop, participants reviewed required components of watershed management plans to meet EPA standards including identifying watershed benefits, causes of impairments based on monitoring and other data, and strategies to reduce impairments and pollutant loads. The group updated core components (e.g. goals, objectives, actions) of the Garapan and Laolao Bay CAPs to reflect successes, lessons learned, existing efforts, updated modeling and monitoring results, and developed the core components of the Achugao Watershed Management Plan.

Additional input was provided on financial and technical assistance needed, outreach required to support strategies, implementation schedules, and monitoring and evaluation approaches after the workshop through the CNMI Watershed Working Group and meetings with key implementation partners in the plan. Several presentations were made on island-wide comprehensive planning, monitoring program updates, public outreach, infrastructure planning, and climate change. Each presenter included specific information relevant to the Achugao area. These items need to be revisited to ensure that they are adequately documented in this characterization report.

Notes from the workshop are presented below:

Vision

A preliminary vision that came from the workshop revolved around several themes:

- controlled development in keeping with the current sense of place
- sustainability and climate resilience
- healthy natural resources

Watershed Services

There are a number of ways this watershed benefits people, communities and local economies, freshwater, water purification, erosion prevention, and habitat were ranked as the top services. Benefits include some of the following:

- Several wells in this area that directly benefit community
- Great community center and activism in protecting resources, fishing, boating
- Parks bring community together, seagrass provides fish habitat
- 2nd strongest flowing streams, natural flow eels and freshwater shrimp
- Lovely, diverse wetland – habitat /WQ
- Provides medicinal plants
- Water quality at beaches
- Mangroves
- Springs that could be used to provide people water with surface water treatment plant
- Helps control increase erosion due to fires.
- Aquaculture?

Watershed Service	**Rank**
Food	8
Raw Material	0
1 - Freshwater	19
Medicinal Resources	2
Carbon Sequestration	1
Lessening of Extreme Events	2
3- Water purification and waste treatment	11
2 - Erosion Prevention/ Maintenance of Soil Fertility	18
Recreation	0
Aesthetic Value	2

Spiritual, Religious, Cultural Value	3
1 - Habitat value	19
Nutrient cycling	1

Causes of Watershed Impairments

The box below summarizes a brainstorming session used to identify the key causes of watershed impairment.

Trends	Root Causes/Threats /Drivers	Strategies

Fires	• Climate Change, agricultural clearing (time of year)
	• Trash burning→ lack of transport to dump
	• Hunting
	• Green waste
		• have advisory signs
		• Targeted campaign to rebrand "wildfires" to ensure people know that it's human caused
		  ○ What to do/not to do (in dry conditions)
		  ○ Improve understanding of what plants can help with restoration, etc. (Ilan working on this)
		  ○ Implement air quality regulation/permitting for agricultural burning
		  ○ Reveg burned areas with fire risk in mind
		  ○ Interagency cooperation with fire department

Development	• Increase in tourism investors → Chinese visa waiver program,
	• relaxed permitting
	• MVA encouraging investment
		• Sedimentation -follow up with CRM about buffers
		• Political will
		• Lack of long term planning
		• Lack of follow through with developers that don't follow plans
		  ○ Need performance bonds
		• Foreign investors → cultural differences not used to cheap land and no infrastructure (so think infrastructure is there)
		  ○ need consistency; think infrastructure first in pre-permit process/pre-applications process; language barrier/need interpreters
		• modify leasing to limit the number of years a lot can be with no activity before lease is lost (but consider how to protect landowners from having to deal with abandoned construction/degraded lands)
		• zoning to protect wetlands--regulations are not clear and are very vague – need more clarity and more specific categories and to include more small scale tourism zoning
		  ○ needs political will → community engagement; education of decision makers and landowners ; showing the economic value of resources /watershed services (eg. Wetlands)
		  ○ explore changes to how leasing occurs
		• More enforcement → lack of manpower; Lack of priority to enforce this watershed; Lack of communication/coordination between permitting agencies/processes
		  ○ Develop new MOU for one-start permitting
		  ○ Smaller developments tend to be overlooked by permitting and need to be considered
		  ○ Fine is not standardized → different for different developments
		  ○ Cost of compliance is more than cost of fine
		• Update stormwater/wastewater manual
		• Amount of SW/WW is not proportional to development investment; Make redevelopment improve conditions as well

		• Permitting – use adaptive management so when things don't go as planned they know what to do and have resources to do it → build compensatory mitigation into application process (In progress at CRM)
		• Need more communication between agencies on zoning waivers
		  ○ Create a checklist of zoing of other agencies that are needed to provide clearances
		  ○ Create flow chart for developers of different agency permits
		  ○ Some things should not be allowed to be waived (e.g. parking)
		• Follow through on permitting incentives for better buildings → regulatory update (In progress at CRM)

Invasive species	• Typhoon knocking down trees, • Lack of understanding on how to manage • Import of materials (toxic chemicals, invasives)	

Pollution	• Land development →lack of BMPs
	• Dogs
	• FUD sites/cemetery leaching
	• Illegal dumping
	• Fertilizer/ agriculture/ pig → lack of education to farmers
		• Agriculture → NRCS outreach and skills development of sustainable practices for the on the ground workers (not just land owners)
		• Non-point sources of runoff – renewal of MS4 permits – cover public roads and outfalls. Pair with SW/WW manual
		• Dogs – bacterial pollution → build new ASPA facility
		• Piggeries → lower priority
		• Solid Waste (trash/illegal dumping)– mayors office has disposal pick up → trash services for low income
		  ○ Outreach to community -- More community events (clean ups), Schools
		  ○ Behavior change campaign

Septic Systems	• Increasing population/development
	• Lack of maintenance
	• Old pipes
		• Septic/sewer overflows → Tanapag is a priority area – only place where there **are** back ups. Storm event – flooding/Mitigation –
		  ○ raising manholes/replacement
		  ○ Empty septics regularly especially before rainy season
		  ○ Stormwater improvements
		  ○ Sinopan Hotel - needs upgrade → being built up – need to get in front of build out
		• Work with CUC to finalize/priorities list of upgrades

Sedimentation	• Typhoon, development, • wildfires, heavy rain/CC, • lack of BMPs and enforcement	
Community Actions		• Open dialogue with community about the low lying cemetery • Relocation? • Stop use? • Develop community stewardship program • Adopt a stream • Community engagement for managed retreat • Create strong community district to be included in decision making on development
Other Nature Based Strategies:		• Seagrass restoration → provides nursery and cc adaptation • Protect/enhance living shoreline • Id areas for wetland migration to maintain for the future

Goals Development

Several strategies and goals discussed by workshop participants are summarized below and grouped into long-term and short-term goals. These priorities will be used as the basis for establishing watershed goals and objectives, but will first be refined then further vetted through a broader public input process.

GOAL DEVELOPMENT

- Sustainable resilient development
- Development impact taxes
- Development strategy - Incentivize re-development – may need technical guidance
- Loose animals/pets and not necessarily stray animals seen around

OBJECTIVES DEVELOPMENT

- BY 2025 ALL DEVELOPMENT PROJECTS INCORPORATES SMART SAFE GROWTH PRINCIPLES. HOTELS SELF-ASSESS FOR SUSTAINABILITY SCORE
- BY 2023 ZONING IS INTEGRATED IN MAJOR SITING PERMITTING PROCESS
- BY 2025 A CENTRAL GIS PORTAL FOR PUBLIC SPATIAL DATA IS ESTABLISHED AND IMPLEMENTED

Appendix A

Restoration Opportunities
Field Data Collection Sheets