

Watershed Management Plan

Manell and Geus Watersheds, Guam

HYDROLOGIC UNIT CODE (HUC)

MANELL 20100003-000-019

GEUS 20100003-000-020



MARCH 2014

Author: Romina King, M.Sc, M.A.

Advisors: Christine Camacho (Bureau of Statistics and Plans Guam Coastal Management Program) and Evangeline Lujan (Bureau of Statistics and Plans Guam Coastal Management Program)

Recommended Citation:

King, R. (2014) Watershed Management Plan for Manell-Geus – DRAFT.

Cover: Photo of Manell-Geus provided by Dave Burdick.

This report was funded by NOAA CRIGU10.

Table of Contents

Table of Contents

Table of Contents	3
List of Tables	5
List of Figures.....	7
Acronyms.....	9
ABSTRACT	10
Guam	12
Watershed Profile	12
Location.....	12
Physical Description.....	15
Geologic history	15
Geology.....	16
Topography	17
Climate.....	20
Soils.....	21
Land Cover	23
Benthic habitat.....	26
Water Resources	30
Surface Water	30
Groundwater.....	31
Flood zones.....	31
Socioeconomic Description.....	32
History	32
Land ownership	33
Historical Sites.....	34
Land Use Zones	35
Conservation Areas	36
Water Utilities Infrastructure	37
Current Projects	38
Future Projects	38
Monitoring Programs	39
Community Values, Attitudes, and Perceptions.....	39
Perceptions.....	40
Conservation Action Plan.....	40
Management Strategies	43
Recommendations.....	46
Partners	49
Next steps	Error! Bookmark not defined.

References..... 51

Appendices..... 53

List of Tables

Table 1: Reprinted from King (2014) and used with permission. Characteristics of the Manell and Geus Watersheds, located in Guam. Area, mean elevation, maximum elevation, mean slope, landcover distribution, and forested areas were calculated using 2007 LIDAR data. Mean annual precipitation was calculated using data from local rain gauges. High priority area for fuels treatment and highest priority treatment areas were calculated using GIS overlays of the vegetation map (derived from the LIDAR). The highest priority treatment areas identifies the acres where one would get the most benefit for the cost of treatment – the highest priority areas that will meet multiple objectives. These acres combine risks to meet multiple objectives by being within 300 ft of a forest edge, delivering sediment to streams, and having moderate - extreme fire behavior risk. Ownership was calculated from a land ownership distribution data provided by the Government of Guam. Estimated delivered sediment yield, delivered sediment yield (tons/acre/year) were calculated using the N-SPECT model All data was compiled from the Guam Statewide Forest Resource Assessment and Resource Strategy 2010 – 2015.	14
Table 2: Geology of Geus Watershed. Reprinted from King (2014) and used with permission.	16
Table 3: Geology of the Manell watershed. Reprinted from King (2014) and used with permission.	16
Table 4: Soils found within the Geus watershed. Reprinted from King (2014) and used with permission.	21
Table 5: Soils found within the Manell watershed. Reprinted from King (2014) and used with permission.	22
Table 6: Reprinted from King (2014). Total length of perennial and intermittent streams located within the Manell and Geus watershed. Data was compiled from Table 7 of the Guam Statewide Forest Resource Assessment and Resource Strategy 2010 – 2015.	30
Table 7: List of government officials who attended the Conservation Action Planning Workshop for Manell and Geus watersheds	41
Table 8: Revised Goals and Objectives for the Manell and Geus watersheds. Based on the second CAP workshop held from 29-30 August 2013.	44

Table 9: Reprinted from Parsons (2010). Cost-estimate of high-priority projects
located in Merizo..... 47

List of Figures

Figure 1: General Location Map of the Manell and Geus watersheds depicting rivers and streams, municipal boundaries, watershed boundaries, and the marine preserve. Reprinted from King (2014) and used with permission.	13
Figure 2: Geology of the Manell and Geus watersheds. Reprinted from King (2014) and used with permission.	16
Figure 3: Topographical Relief Map of Guam using 2007 LiDAR data. Reprinted from King (2014) and used with permission.....	17
Figure 4: Elevation contour (30 m) map of the Manell and Geus Watersheds. Reprinted from King (2014) and used with permission.	18
Figure 5: Digital Elevation Model of the Manell and Geus Watersheds derived from 2007 LiDAR (Bare Earth). Reprinted from King (2014) and used with permission.....	19
Figure 6: Slopes (derived from 2007 LiDAR data) of the Manell and Geus watersheds. Reprinted from King (2014) and used with permission. ...	20
Figure 7: Soils found within the Manell and Geus Watersheds. Reprinted from King (2014) and used with permission.....	21
Figure 8: Land cover of the Manell and Geus Watersheds. Reprinted from King (2014) and used with permission.....	23
Figure 9: Location of grasslands (savanna complex) within the Manell and Geus watersheds. Reprinted from King (2014) and used with permission. ...	25
Figure 10: Location of badlands within the Manell and Geus watersheds. Reprinted from King (2014) and used with permission.....	26
Figure 11: Benthic cover of marine areas surrounding the Manell and Geus watershed. Reprinted from King 2014 and used with permission.	27
Figure 12: Location of mangroves and wetlands within the Manell and Geus watersheds. Reprinted from King (2014) and used with permission. ...	29
Figure 13: Map depicting the rivers of Manell and Geus watersheds. This river dataset is in the process of being updated by WERI in conjunction with	

USGS. The version used in this geospatial analysis lacked river names. Reprinted from King (2014) and used with permission.	30
Figure 14: Flood zone map of the Manell and Geus watersheds. Reprinted from King 2014 and used with permission.	31
Figure 15: Land parcels within the Manell and Geus Watersheds	33
Figure 16: Location of historical sites within the Manell and Geus watersheds. Reprinted from King (2014) and used with permission.	34
Figure 17: Land Use Map of the Manell and Geus watersheds. Reprinted from King (2014) and used with permission.....	35
Figure 18: Terrestrial conservation areas within the Manell and Geus watershed. Reprinted from King (2014) and used with permission.	36
Figure 19: Water Utilities Infrastructure with the Manell and Geus watersheds. Reprinted from King (2014) and used with permission.	37
Figure 20: Conceptual diagram created at the 2010 CAP workshop.....	41
Figure 21: Revised threat matrix, based on community feedback from a 27 August 2013 village meeting held in Merizo.....	42
Figure 22: Comparison of perceptions of conservation target between government officials and the village of Merizo.....	43

Acronyms

BSP	Bureau of Statistics and Plans
CAP	Conservation Action Plan
CRI	Coral Reef Initiative
CWP	Center for Watershed Protection
DAWR	Division of Aquatics and Wildlife Resources
DLM	Department of Land Management
DAG	Department of Agriculture
DOE	Department of Education
DOI	Department of the Interior
DPR	Department of Parks and Recreation
DPW	Department of Public Works
EEC	Environmental Education Committee
FHWA	Federal Highway Administration
GCC	Guam Community College
GCMP	Guam Coastal Management Program
GCWCS	Guam Comprehensive Wildlife Conservation Strategy
GEPA	Guam Environmental Protection Agency
GIS	Geographic Information Science/System
GFD	Guam Fire Department
GovGuam	Government of Guam
NOAA	National Oceanic Atmospheric Administration
NPS	National Parks Service
NRCS	Natural Resources Conservation Service
OCRM	Office of Ocean and Coastal Resource Management
RC&D	Resource Conservation and Development
TNC	The Nature Conservancy
UOG	University of Guam
UOGML	University of Guam Marine Laboratory
USCB	United States Census Bureau
USDA	US Department of Agriculture
USFWS	US Fish and Wildlife Service
USGS	US Geologic Survey
WERI	Water Energy Research Institute

ABSTRACT

As a response to President Clinton's Clean Water Initiative, an interagency group was formed on Guam in order to categorize Guam's 20 watersheds based on water quality (Government of Guam, 1998). The watersheds were assigned a unique hydrologic code and classified as Category I (watersheds needing restoration); Category II (watersheds needing preventive action to sustain water quality and aquatic ecosystems); Category III (pristine or sensitive watersheds on public lands needing extra protection); or Category IV (watersheds with insufficient data to make an assessment) (Government of Guam, 1998). The Geus Watershed (HUC 20100003-000-020) was classified as Category I and tentatively scheduled for restoration during FY 2001-2005 (Government of Guam, 1998). The Manell Watershed (HUC 20100003-000-019) was classified as Category IV (Government of Guam, 1998).

After considerable input from the Land-based Sources of Pollution (LBSP) Local Action Strategy (LAS) Group formed under the Guam Coral Reef Initiative (GCRI), the Bureau of Statistics and Plans (BSP) Guam Coastal Management Program (GCMP) identified the Geus and Manell Watersheds as priority areas due to the presence of a relatively pristine freshwater ecosystem (Geus River), an adjacent marine protected area (Achang Marine Preserve), fringing reefs, a lagoon, mangroves, and a small homogenous community. The LBSP felt that of all Guam's reefs, the ones within the Geus and Manell Watersheds would be the most resilient and have the best chance of survival with regard to natural stressors. Thus, the GCMP secured funding through NOAA CRIGU 10 to hire a contractor (Romina King) via the Research Corporation of Hawaii (RCUH) to draft a preliminary watershed management plan for the Geus and Manell Watersheds.

One of the primary objectives of this plan was to compile, analyze, and present geospatial data specific to the Geus and Manell watersheds. The second objective was to garner input from the community residing in these watersheds through a household survey that measured attitudes, perceptions, knowledge, and behaviors (King 2014). The third objective was to catalog past, present, and future projects occurring within the Geus and Manell watersheds. The final objective is to provide management recommendations based on a Conservation Action Plan (CAP).

The 2014 version of this document was updated in 2018 in order to illustrate and track the management priorities and strategies that have been accomplished in the interim years. A *Goals Reached* section was added to the document to directly address the management recommendations provided by the original 2014 document.

Guam

Guam is an organized, unincorporated territory of the United States in the Pacific Ocean that lies between 13.2°N and 13.7°N and between 144.6°E and 145.0°E, has an area of approximately 212 square miles (549 km²), has a maximum elevation of approximately 405 m and a total shoreline length of 244 km. Guam is the largest, most populated and southernmost of the Mariana Islands and is also the largest and most populated island in Micronesia. The island of Guam is 30 miles (48 km) long and 4 mi (6 km) to 12 mi (19 km) wide.

The relatively flat northern half of the island, which is primarily composed of uplifted limestone, is the site of the Northern Guam Lens, the island's principle aquifer and main source of drinking water. In contrast, the southern half of the island is comprised mainly of volcanic rock and is mountainous, with areas with high erosion potential. The hilly topography on the southern half of the island creates approximately 14 general watersheds (Water and Environmental Research Institute of the Western Pacific, n.d.).

Watershed Profile

Location

The Manell watershed is located Southern Guam (see Figure 1). It has an approximate drainage area of 4.55 mi² or 11.784 km² (Water and Environmental Research Institute of the Western Pacific, n.d.). The Geus Watershed is adjacent to the Manell Watershed and has a drainage area of 1.73 mi² or 4.480 km² (Water and Environmental Research Institute of the Western Pacific, n.d.). Both watersheds drain into Cocos Lagoon. On the western side of Cocos Lagoon is the Philippine Sea and on the eastern side is the Pacific Ocean. However, it appears that water draining from the Geus watershed into Cocos Lagoon exits out through the western channel. Water draining from the Manell watershed into Cocos Lagoon exits out the eastern channels into the Pacific Ocean. Cocos Lagoon may be identified by the light blue water in Figure 1). Table 1 presents an overview of some of the characteristics of the Manell and Geus watersheds.

Manell-Geus Watershed Map

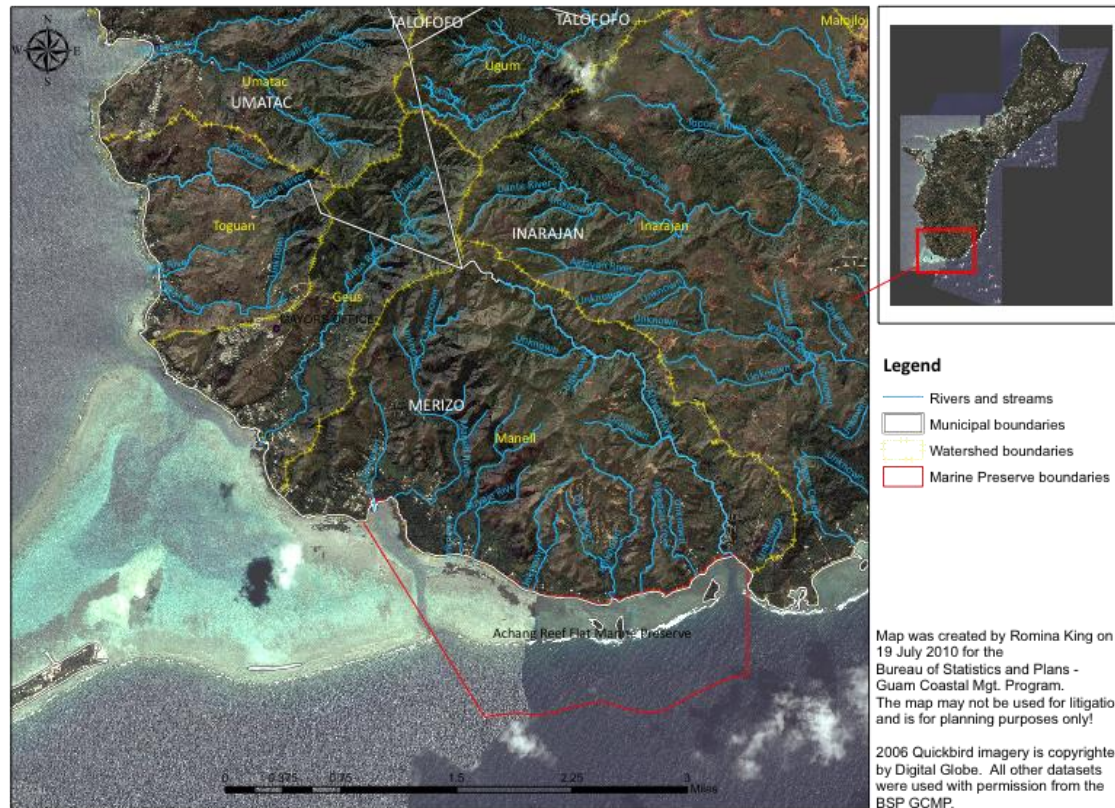


Figure 1: General Location Map of the Manell and Geus watersheds depicting rivers and streams, municipal boundaries, watershed boundaries, and the marine preserve. Reprinted from King (2014) and used with permission.

Table 1: Reprinted from King (2014) and used with permission. Characteristics of the Manell and Geus Watersheds, located in Guam. Area, mean elevation, maximum elevation, mean slope, landcover distribution, and forested areas were calculated using 2007 LIDAR data. Mean annual precipitation was calculated using data from local rain gauges. High priority area for fuels treatment and highest priority treatment areas were calculated using GIS overlays of the vegetation map (derived from the LIDAR). The highest priority treatment areas identifies the acres where one would get the most benefit for the cost of treatment – the highest priority areas that will meet multiple objectives. These acres combine risks to meet multiple objectives by being within 300 ft of a forest edge, delivering sediment to streams, and having moderate - extreme fire behavior risk. Ownership was calculated from a land ownership distribution data provided by the Government of Guam. Estimated delivered sediment yield, delivered sediment yield (tons/acre/year) were calculated using the N-SPECT model All data was compiled from the Guam Statewide Forest Resource Assessment and Resource Strategy 2010 – 2015.

Watershed	Area			Mean Elevation		Maximum elevation	Mean slope	Mean annual precipitation			Land cover distribution					Ownership		Estimated Delivered Sediment Yield (average tons/year)	Delivered Sediment Yield (tons/acre /year)	Forested Acres/Total Acres	High Priority area for Fuels Treatment to Protect Forests (Fire Risk rated Moderate to Extreme) in Acres	Highest Priority Treatment Areas - Multiple Objectives (acres)
	acres	sqmi	sqkm	ft	m	ft	m	%	in	cm	Bare Ground	Developed	Forest	Non-Forest	Other	GovGuam	Private					
Manell	3,107	4.9	12.6	226	69	1106	337	27	96	244	14%	3%	32%	51%	0%	43%	57%	63,147	20.3	988/3,107	977	689
Geus	1,120	1.7	4.5	331	101	1122	342	33	100	253	5%	10%	44%	41%	0%	75%	25%	8,822	7.9	493/1,120	341	206

Physical Description

Geologic history

According to Tracey et al., (1964), the formation of Guam happened in the mid-Eocene Epoch, along the Palau-Kyushu Ridge, as a result of the Pacific plate subducting under the Philippine plate. The emerging magma slowly formed an underwater volcano that became the volcanic basement bedrock of Guam. The rocks of this event are part of the Facpi formation and are not only the oldest rocks on Guam, but may be characterized as submarine lava flows in the form of pillow basalt. The Facpi formation formed over the course of 3-4 million years (from 43-39 Ma) (Tracey et al., 1964).

This gentle volcanism transitioned to a more violent volcanism involving explosive underwater pyroclastic eruptions forming what is now known as the Alutom formation (from 32-29 Ma) (Tracey et al., 1964). At the end of the Alutom period, the underwater volcano split from its location along the Palau Kyushu Ridge and migrated farther east in the direction of the Pacific plate and began its third and final episode of major volcanic construction along the West Mariana Ridge (Tracey et al., 1964). This final volcanic explosion resulted in the Umatac formation. Volcanism then ceased and Guam began rifting away from the West Mariana Ridge to its present location (Tracey et al., 1964).

By the end of the major volcanic episodes, the top of the volcano was near the ocean surface and there was a period of sedimentary limestone deposition.

Around 1-2Ma, Guam experienced tectonic uplift, so the ancient corals are now 100-200 m above sea level (Tracey et al., 1964).

The geological make-up of the Geus watershed is summarized in Table 2 and may be visualized in Figure 2.

The geological make-up of the Manell watershed is summarized in Table 3 and may be visualized in Figure 2.

Geology

Manell-Geus Watershed - Geology



2011 WorldView-2 imagery is copyrighted by DigitalGlobe and provided by the Bureau of Statistics and Plans Guam Coastal Management Program. All other datasets were provided by the University of Guam (UoG) Water Energy Research Institute (WERI) and Island Research & Education Initiative (IREI) and downloaded via www.hydroguam.net.

Map was created by Romina King on 11 March 2014 for her doctoral dissertation.

Figure 2: Geology of the Manell and Geus watersheds. Reprinted from King (2014) and used with permission.

Table 2: Geology of Geus Watershed. Reprinted from King (2014) and used with permission.

GEOABR	Area (sq m)	Area (sq km)
Tuf	2788845.784	2.788845784
Tub	1032196.509	1.032196509
Tum	13923.499	0.013923499
Qal	6847.713361	0.006847713
Tum	14821.60447	0.014821604
Tum	129741.8575	0.129741857
Qal	481720.526	0.481720526

Table 3: Geology of the Manell watershed. Reprinted from King (2014) and used with permission.

GEOABR	Area (sq.m.)	Area (sq.km.)
Tuf	2579821.798	2.579821798
Tub	7733863.839	7.733863839
Qal	68794.53037	0.06879453
Tud	25946.94852	0.025946949
Qal	1072396.126	1.072396126
Qrb	5318.242089	0.005318242
Qal	184528.746	0.184528746
Qtma	48168.06802	0.048168068
Qal	63739.54148	0.063739541

Topography

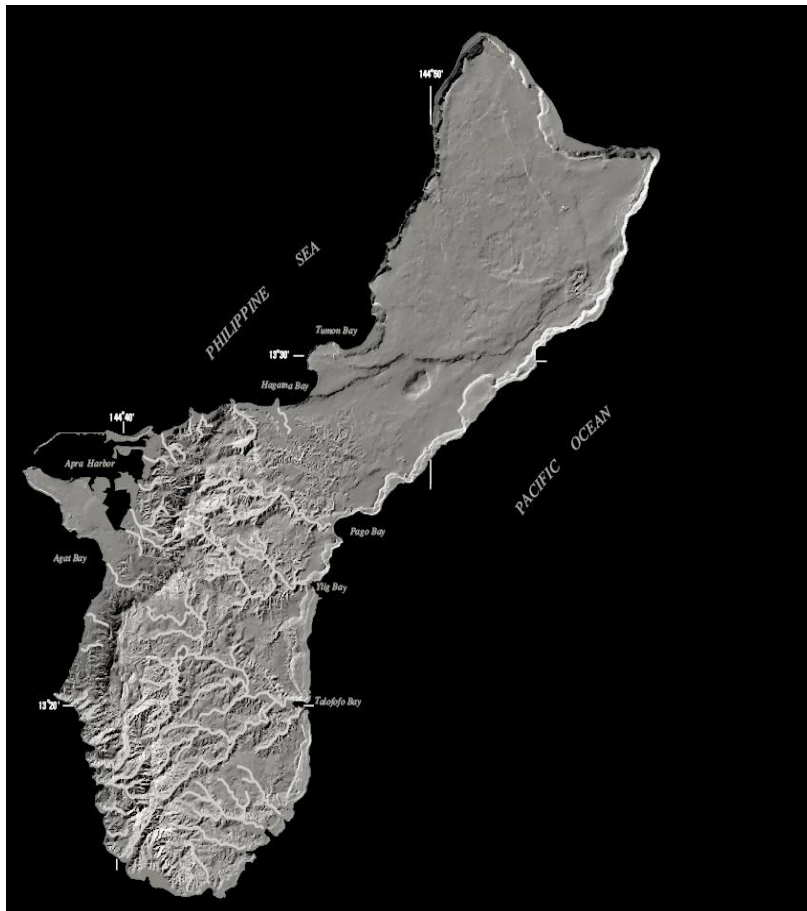


Figure 3: Topographical Relief Map of Guam using 2007 LiDAR data. Reprinted from King (2014) and used with permission.

The 2007 Joint Airborne LiDAR Bathymetry Technical Center of Expertise (JALBTCX) Topobathy LiDAR data was collected using the Compact Hydrographic Airborne Rapid Total Survey (CHARTS) system for the Government of Guam Department of Public Works and the Office of Homeland Security from February 18 through May 20, 2007. This 2007 LiDAR dataset was collected to produce 2-foot contours (see Figure 3 and Figure 3).

Manell-Geus Watershed - Elevation Contour Map

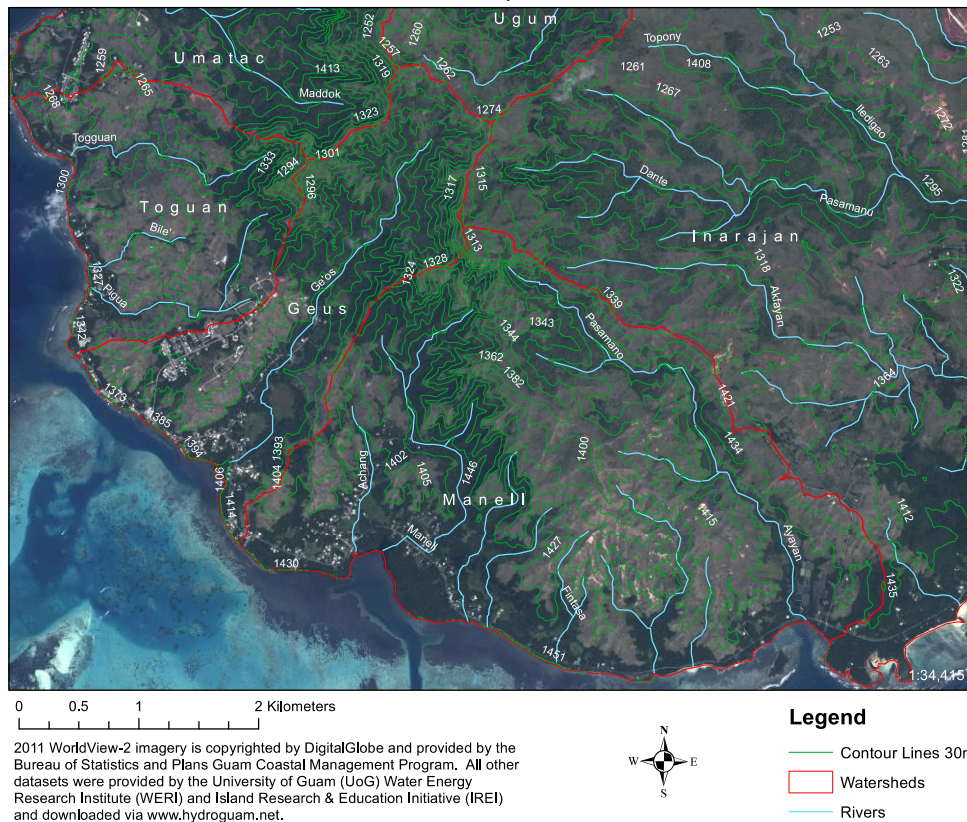
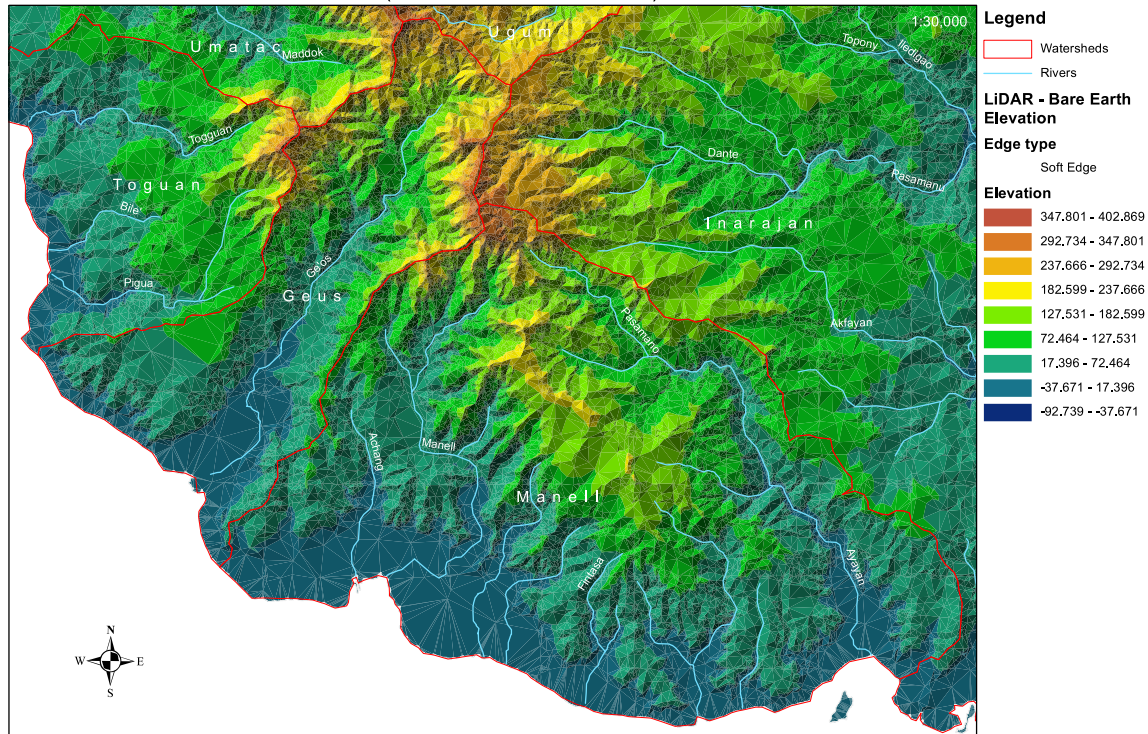


Figure 4: Elevation contour (30 m) map of the Manell and Geus Watersheds. Reprinted from King (2014) and used with permission.

Figure 4 provides 30-meter elevation contours for the Manell and Geus watersheds. Data for 6-meter elevation contours is also available. It is recommended for use for in a large-scale elevation contour map of the Manell and Geus watersheds that could be used to help determine best areas for vegetation (in conjunction with Figure 9 and Figure 10) and best possible access routes to those areas.

Manell-Geus Watershed - Elevation (From LiDAR - Bare Earth)



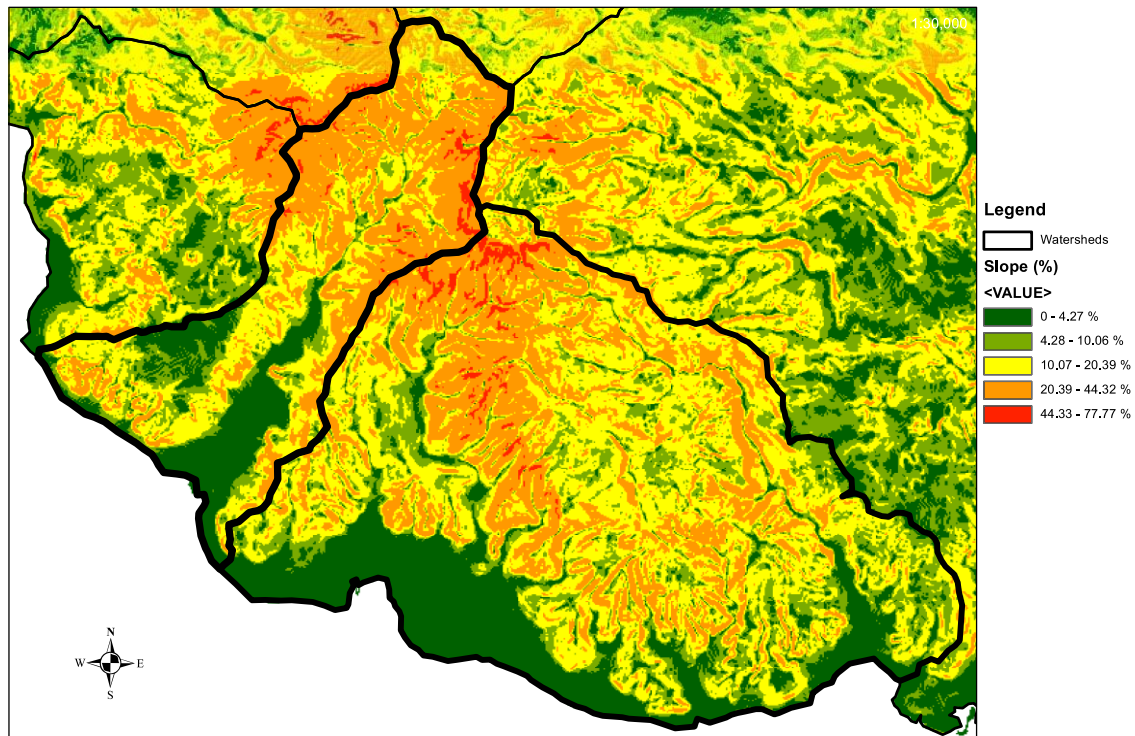
LiDAR dataset was provided by the Bureau of Statistics and Plans Guam Coastal Management Program. Watershed and River datasets were provided by the University of Guam (UoG) Water Energy Research Institute (WERI) and Island Research & Education Initiative (IREI) and downloaded via www.hydroguam.net.

Map was created by Romina King on 11 March 2014 for her doctoral dissertation.

Figure 5: Digital Elevation Model of the Manell and Geus Watersheds derived from 2007 LiDAR (Bare Earth). Reprinted from King (2014) and used with permission.

The highest elevation is approximately 1122 feet (342 meters) in the northern most point of Manell Watershed (Water and Environmental Research Institute of the Western Pacific, n.d.). Within the Geus watershed, the highest elevation is approximately 833 feet (254 meters) (Water and Environmental Research Institute of the Western Pacific, n.d.). These elevation figures correspond with Figure 5.

Manell-Geus Watershed - Slope



LiDAR dataset was provided by the Bureau of Statistics and Plans Guam Coastal Management Program. Watershed and River datasets were provided by the University of Guam (UoG) Water Energy Research Institute (WERI) and Island Research & Education Initiative (IREI) and downloaded via www.hydroguam.net.

Map was created by Romina King on 11 March 2014 for her doctoral dissertation.

Figure 6: Slopes (derived from 2007 LiDAR data) of the Manell and Geus watersheds. Reprinted from King (2014) and used with permission.

Figure 6 shows the slopes within the Manell and Geus watersheds; the steepest slopes are depicted in red.

Climate

The climate of Guam is characterized by a dry season that runs from December through June, and a wet season from July through November. Annual rainfall is high, averaging 90 to 110 inches of precipitation. Temperatures average 81 °F annually, with the coolest and least humid period being December through February. Guam is in “Typhoon Alley”, and has been impacted by sixteen typhoons since 1970 and was devastated by four typhoons since 1960.

Soils

Manell-Geus Watershed - Soil

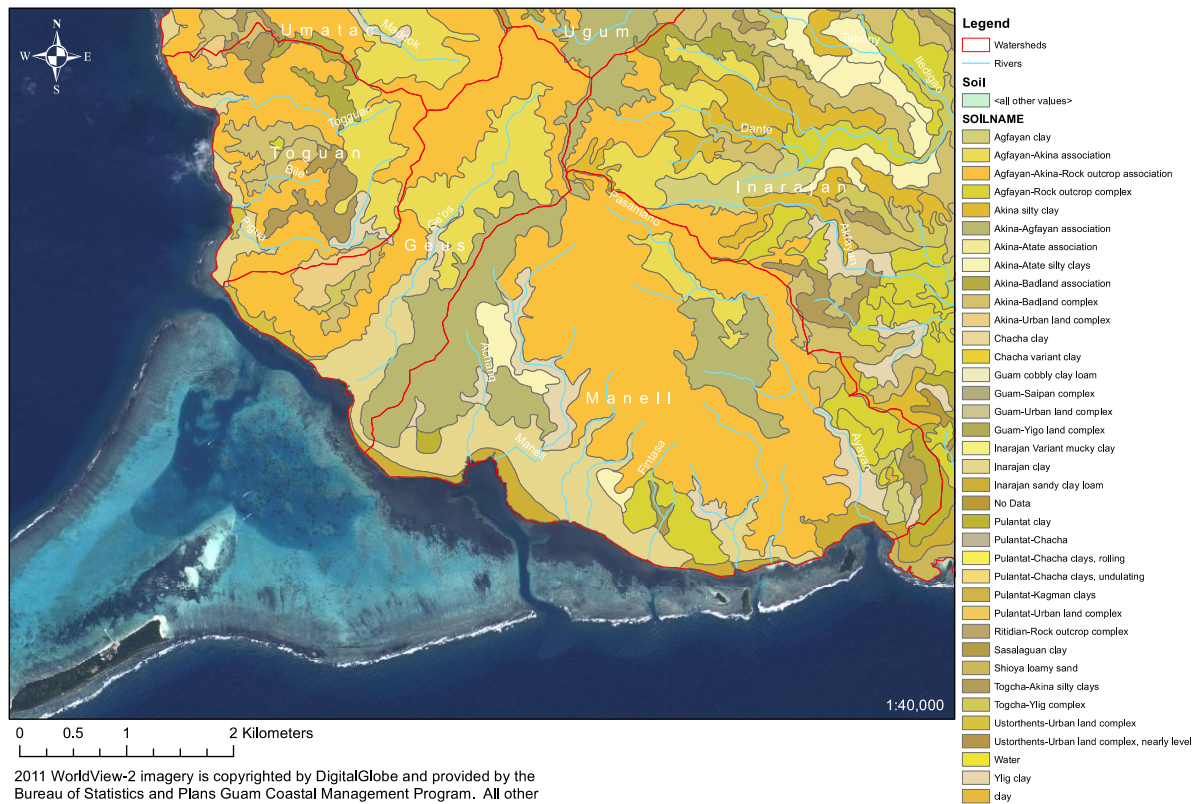


Figure 7: Soils found within the Manell and Geus Watersheds. Reprinted from King (2014) and used with permission.

Within the Geus Watershed, the soils found include Akina-Agfayan , Agfayan-Akina-Rock and urban rock complex, Inarajan clay, Inarajan sandy clay loam, Togcha-Ylig complex, Urban land complex, and Ylig clay (see Figure 7 and Table 4).

Within the Manell watershed, the soils found include Ylig clay, Akina silty clay, Akina-Atate silty clays, Sasalaguan clay, Pulantat clay, Lulantat-Kagman clays, Inarajan clay, Togcha-Akina silty clay, badland, Agfayan clay, Shioya loamy sand, rock and urban land complex (Water and Environmental Research Institute of the Western Pacific, n.d.) (see Figure 7 and Table 5).

Table 4: Soils found within the Geus watershed. Reprinted from King (2014) and used with permission.

Soil Type	Area (m)	Total Area (sq. m)	Total Area (sq.km.)
Agfayan-Akina association, extremely steep	1028983.507		
Agfayan-Akina-Rock outcrop association, extremely	28.19796772		
Agfayan-Akina-Rock outcrop association, extremely	40.04385406	2783896.478	2.783896478
Agfayan-Akina-Rock outcrop association, extremely	740.324985		

Agfayan-Akina-Rock outcrop association, extremely	740403.1615		
Agfayan-Akina-Rock outcrop association, extremely	1013701.243		
Akina-Agfayan association, steep	128.5285842		
Akina-Agfayan association, steep	617.7297565		
Akina-Agfayan association, steep	1654.046669	637580.3597	0.63758036
Akina-Agfayan association, steep	51652.41302		
Akina-Agfayan association, steep	582320.8085		
Akina-Badland association, steep	1206.833203	1206.833203	0.001206833
Akina-Badland complex, 7% to 15% slopes	113910.5275	113910.5275	0.113910528
Akina-Urban land complex, 0% to 7% slopes	176433.1568	176433.1568	0.176433157
Inarajan clay, 0% to 4% slopes	45.29048245		
Inarajan clay, 0% to 4% slopes	562365.1084	562410.3988	0.562410399
Inarajan sandy clay loam, 0% to 3% slopes	38.09793608		
Inarajan sandy clay loam, 0% to 3% slopes	15894.83699	15932.93493	0.015932935
Togcha-Ylig complex, 3% to 7% slopes	47987.84026	47987.84026	0.04798784
Urban land complex, nearly level	88196.04898	88196.04898	0.088196049
Ylig clay, 3% to 7% slopes	3468.384212		
Ylig clay, 3% to 7% slopes	50926.64032	54395.02453	0.054395025

Table 5: Soils found within the Manell watershed. Reprinted from King (2014) and used with permission.

Soil type	Area (sq.m)	Area (sq. km)
Agfayan-Akina-Rock outcrop association, extremely	5379224.672	5.379224672
Akina-Agfayan association, steep	20428.34412	0.020428344
Agfayan-Akina association, extremely steep	155.7987073	0.000155799
Akina silty clay, 15% to 30% slopes	21441.57643	0.021441576
Akina-Agfayan association, steep	1243557.03	1.24355703
Agfayan-Rock outcrop complex, 15% to 30% slopes	5976.34164	0.005976342
Agfayan-Akina association, extremely steep	277808.5396	0.27780854
Inarajan clay, 0% to 4% slopes	1227261.439	1.227261439
Akina-Badland complex, 30% to 60% slopes	33393.35333	0.033393353
Ylig clay, 3% to 7% slopes	317656.4768	0.317656477
Akina-Agfayan association, steep	644510.036	0.644510036
Akina-Atate silty clays, 15% to 30% slopes	211955.8239	0.211955824
Akina-Badland complex, 7% to 15% slopes	30083.89127	0.030083891
Akina silty clay, 7% to 15% slopes	56827.61204	0.056827612
Akina-Badland complex, 15% to 30% slopes	69926.46086	0.069926461
Ylig clay, 3% to 7% slopes	44132.71759	0.044132718
Inarajan sandy clay loam, 0% to 3% slopes	157704.0815	0.157704081
Shioya loamy sand, 0% to 5% slopes	4730.199685	0.0047302
Agfayan-Rock outcrop complex, 30% to 60% slopes	194435.7965	0.194435797
Ylig clay, 3% to 7% slopes	17781.43744	0.017781437
Inarajan sandy clay loam, 0% to 3% slopes	72820.10243	0.072820102
Ylig clay, 3% to 7% slopes	202909.6977	0.202909698
Agfayan-Rock outcrop complex, 15% to 30% slopes	112549.2661	0.112549266
Agfayan-Rock outcrop complex, 30% to 60% slopes	235.135896	0.000235136
Pulantat clay, 30% to 60% slopes	133483.8265	0.133483827
Pulantat clay, 7% to 15% slopes	42169.71667	0.042169717
Togcha-Akina silty clays, 7% to 15% slopes	73822.65908	0.073822659
Agfayan-Rock outcrop complex, 15% to 30% slopes	144.87647	0.000144876

Agfayan clay, 15% to 30% slopes	8346.094063	0.008346094
Togcha-Ylig complex, 7% to 15% slopes	29260.38419	0.029260384
Inarajan sandy clay loam, 0% to 3% slopes	150255.0831	0.150255083
Agfayan-Rock outcrop complex, 15% to 30% slopes	22515.76095	0.022515761
Akina silty clay, 7% to 15% slopes	10501.06218	0.010501062
Agfayan-Rock outcrop complex, 30% to 60% slopes	369014.0522	0.369014052
Akina-Atate silty clays, 15% to 30% slopes	61657.88959	0.06165789
Ylig clay, 3% to 7% slopes	70134.19695	0.070134197
Agfayan clay, 30% to 60% slopes	57761.87642	0.057761876
Agfayan clay, 15% to 30% slopes	33805.0439	0.033805044
Sasalaguan clay, 7% to 15% slopes	45006.88131	0.045006881
Ylig clay, 3% to 7% slopes	20893.84089	0.020893841
Inarajan clay, 0% to 4% slopes	183747.5393	0.183747539
Inarajan sandy clay loam, 0% to 3% slopes	70226.76783	0.070226783
Agfayan-Akina-Rock outcrop association, extremely	40.04385406	4.00439E-05
Akina-Agfayan association, steep	128.5285842	0.000128529
Inarajan clay, 0% to 4% slopes	45.29048245	4.52905E-05
Inarajan sandy clay loam, 0% to 3% slopes	38.09793608	3.80979E-05

Land Cover

Manell-Geus Watershed - Land Cover

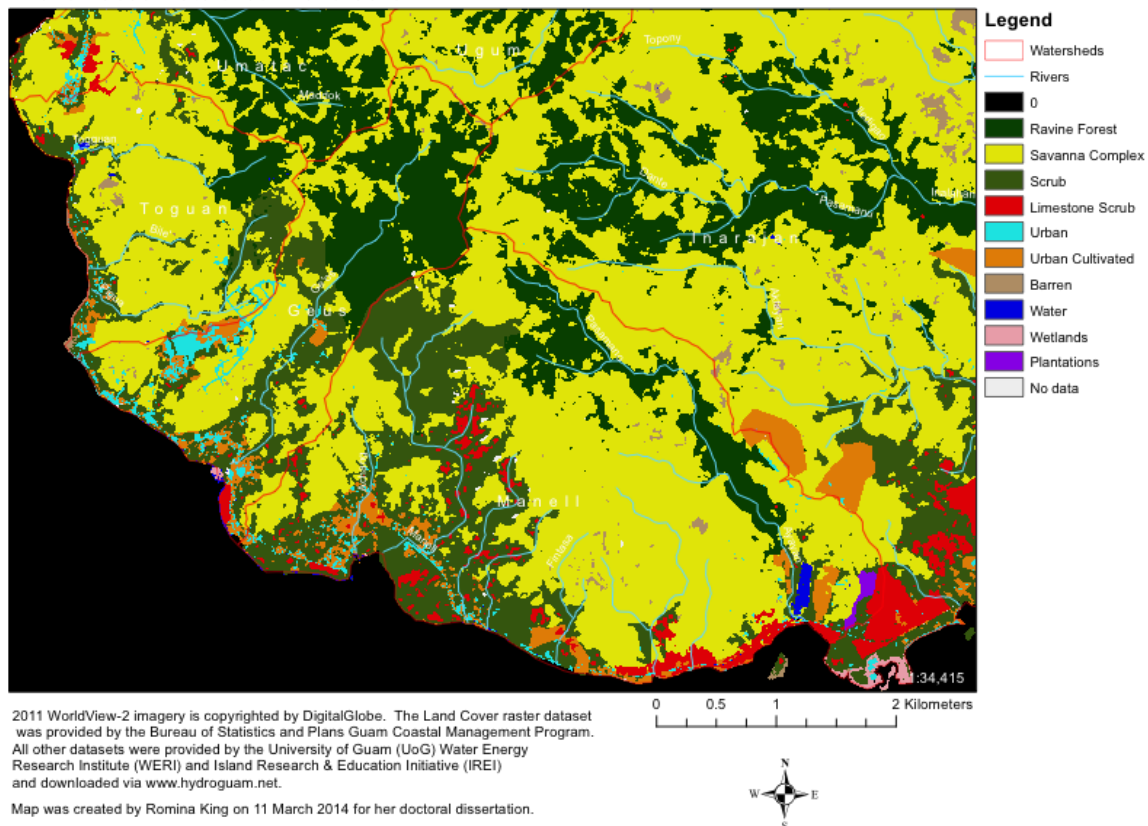


Figure 8: Land cover of the Manell and Geus Watersheds. Reprinted from King (2014) and used with permission.

There is very little urban area within either the Manell or Geus Watershed (see Figure 8). The majority of both watersheds appear to be vegetated (see Figure 8).

The primary type of vegetation found within the Manell Watershed appears to be savanna complex (see Figure 8). It also appears that there is ravine forest found along the Ajayen River (the eastern-most river of the Manell Watershed); scrub forest found along the Manell River; and intermittent patches of limestone scrub (see Figure 8).

It appears that the northern half of the Geus Watershed is composed of ravine forest, surrounded by savanna complex (see Figure 8). The southern half of the Geus Watershed appears to be predominantly savanna complex with the exception of scrub forest surrounded the Geus River (see Figure 8).

Southern Guam has very distinct forests: limestone forest, scrub forest, ravine forest, broken forest, and strand forest. Limestone forests include species of trees such as *Ficus sp.*, *Intsia bijuga*, *Artocarpus marianensis*, *Elaeocarpus joga*, etc. Scrub forests are degraded, but still diverse limestone forests. Ravine forest usually occurs in river valleys and other topographic depressions and may include native species such as *Ficus prolixa*, *Glochidion mariannensis*, *Hibiscus tiliaceus*, *Pandanus tectorius*, and *Premna serratifolia*. *Bambusa vulgaris* can also be found extensively throughout the Manell-Geus watersheds. This invasive species of clumping bamboo often fall into the riparian corridor, creating dams that contribute to flooding conditions during periods of heavy precipitation.

In 1973 the 45.2% of Geus watershed was covered by forest (REF). In 2001, the forest cover has increased by 0.36% (REF). The forest system in Geus has remained relatively stable in the past 30 years as compared to the Manell watershed (REF). In 1973, only 28.46% of the Manell watershed was covered by forest (REF). In 2001, 9.4% of the forest has been converted to urban area and 13.8% to grassland.

Grasslands

Manell-Geus Watershed - Grasslands

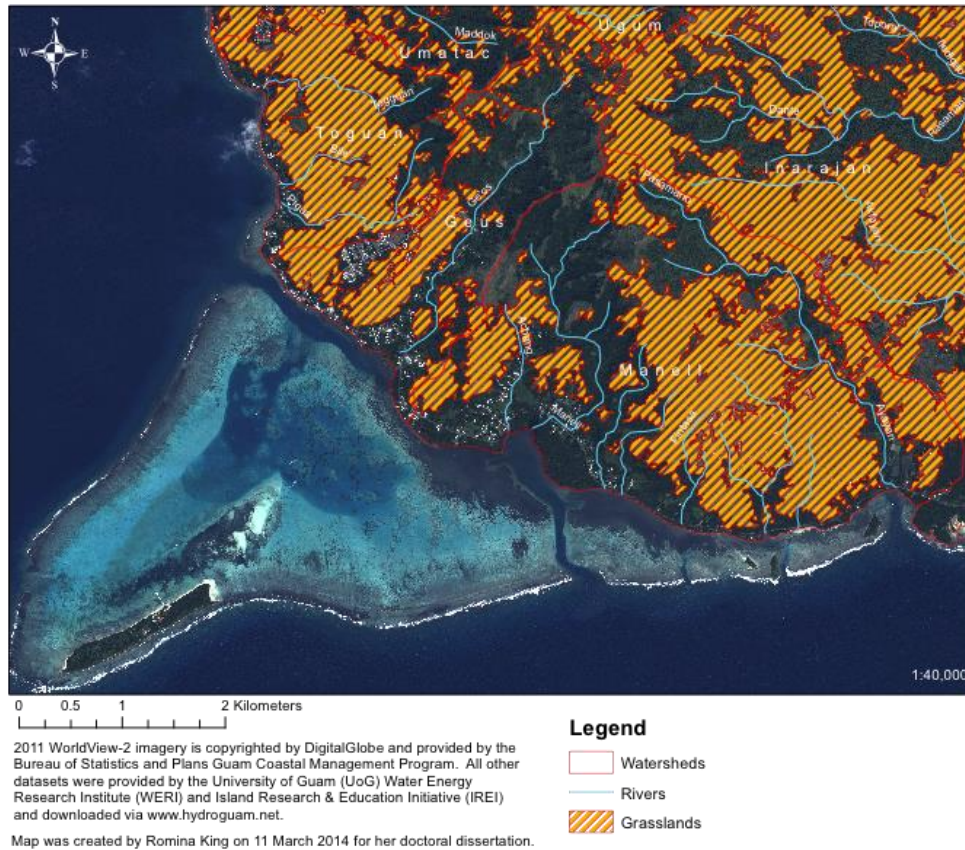


Figure 9: Location of grasslands (savanna complex) within the Manell and Geus watersheds. Reprinted from King (2014) and used with permission.

Figure 9 depicts the location of grassland in the Manell and Geus watersheds. There is substantive amount of grasslands in both watersheds.

Badlands

Badlands are areas of bare, nutrient poor soil. Figure 10 depicts the location of badlands within the Manell and Geus watersheds.

Manell-Geus Watershed - Badlands

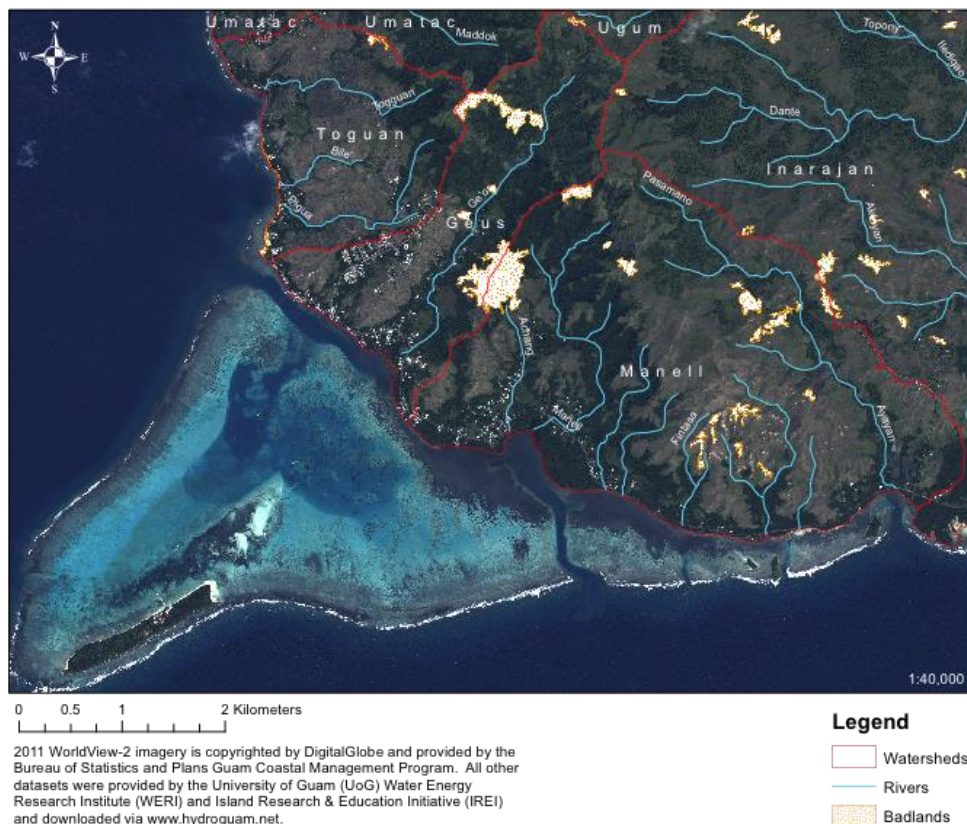


Figure 10: Location of badlands within the Manell and Geus watersheds. Reprinted from King (2014) and used with permission.

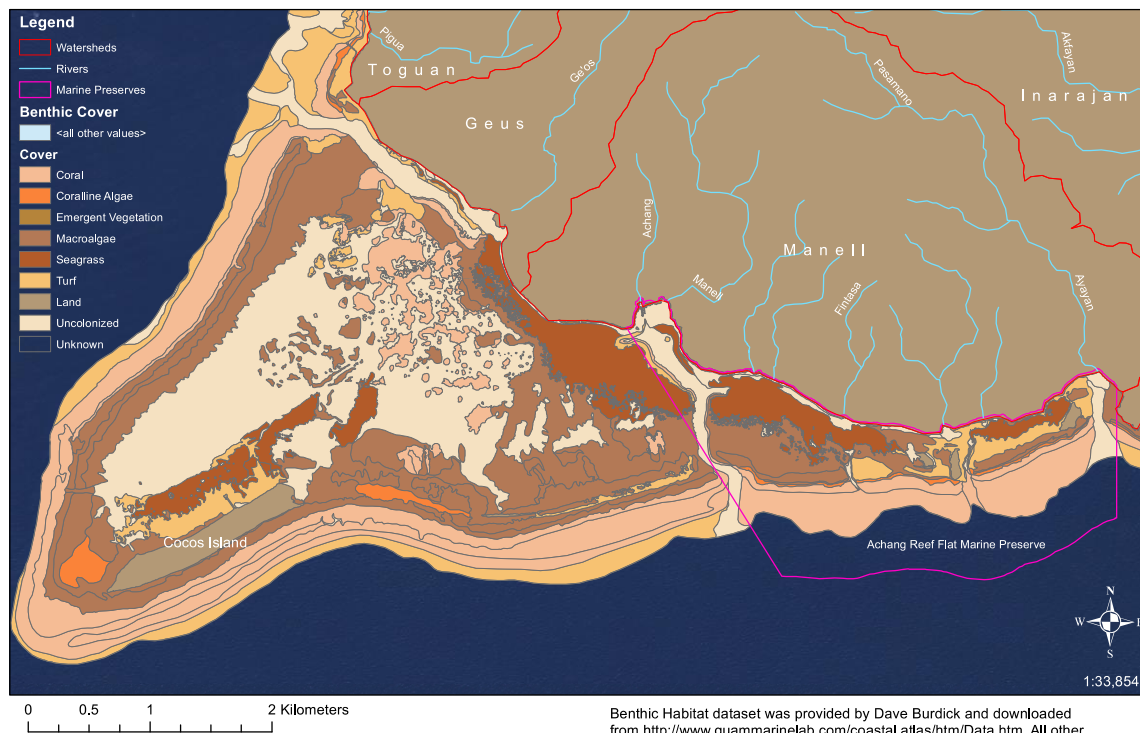
Badlands are susceptible to erosion. Increased sedimentation associated with runoff from coastal development and other causes of soil erosion are growing universal threats to coral reefs. Freshwater runoff from landscape altering or clearing activities, such as the construction of houses, hotels, resorts, golf courses, marinas, other recreational facilities, piers, roads, bridges, and waste treatment plants has taken a terrible toll on some close-to-shore-reef areas. Sediment runoff may settle on coral reefs, smothering them or increasing the turbidity of the water, which reduces both the amount of light reaching corals and the level of photosynthetic activity by corals' zooxanthellae. This, in turn, can cause diminished coral productivity and growth, enhanced macroalgal growth, and, ultimately, a communal shift on the reef from corals to macroalgae.

Benthic habitat

Guam is surrounded by offshore banks; fringing, patch, submerged, and barrier reefs. The coral reef lagoon area encompasses approximately 108 km² in nearshore waters (between 0 and 3 nautical miles) (Burdick et al. 2008). There are currently more than 1000 species of reef fish and more than 400 species of corals (Porter et al. 2005, Burdick et al. 2008). Some models and emission scenarios suggest that

coral reefs located in Micronesia, may be particularly vulnerable to climate change (Donner et al., 2005).

Manell-Geus Watershed - Benthic Cover



Benthic Habitat dataset was provided by Dave Burdick and downloaded from <http://www.guammarinelab.com/coastalAtlas/html/Data.htm>. All other datasets were provided by the University of Guam (UoG) Water Energy Research Institute (WERI) and Island Research & Education Initiative (IREI) and downloaded via www.hydroguam.net.

Map was created by Romina King on 11 March 2014 for her doctoral dissertation.

Figure 11: Benthic cover of marine areas surrounding the Manell and Geus watershed. Reprinted from King 2014 and used with permission.

The benthic habitat dataset (Burdick, n.d.) also provides additional information such as structure. However, upon discussions with Mr. Burdick, it was deemed that benthic cover would be the most appropriate data for the intended audience (natural resource managers).

Achang Marine Preserve

The Manell watershed drains into the Achang Reef Flat Marine Preserve (See Figure 11). No fishing, collecting, or harvesting of organisms is permitted in this preserve. However, fishing for seasonal fish (i.e., manahak, atulai, and achemson) is authorized by special permit from the Department of Agriculture Division of Aquatics and Wildlife Resources. This marine preserve is not actively enforced by DAWR, much to the ire of the residents (King, 2014).

The Achang Reef Flat Preserve (4.8 km²) is adjacent to the Manell Watershed. It includes a wide variety of habitats including mangroves (see Figure 12), seagrass (see Figure 11), sand (see Figure 11), coral (see Figure 11), and channels (see Figure 11). The seagrass, mangrove, and estuarine areas of this preserve are important

nursery areas for a number of fish species. Manell channel, the largest channel included in the preserve, is an important congregation site for green sea turtles as the surrounding areas include rich foraging habitat including dense sea grass beds. Only three species of seagrasses occur in Guam waters: *Enhalus acoroides*, *Halophila minor*, and *Halodule uninervis*. The largest species, *Enhalus acoroides*, inhabits the sandy-silt areas near the mouths of rivers in the southern half of Guam. *Halodule uninervis* is abundant in Cocos Lagoon; a few patches can also be found on the shallow sandy reef flats near shore in the southern bays. *Halophila minor* can be found in shallow sandy reef flats and deeper lagoon environments.

The Cocos Lagoon also adjacent to Manell and Geus watersheds, has a predominantly sand bottom with numerous small patch reefs scattered throughout (see Figure 11). This sheltered area has delicate staghorn coral communities that provide safe refuge for Convention of International Trade of Endangered Species (CITES) listed juvenile humphead wrasse (*Cheilinus undulatus*) and other reef fish species of concern. The lagoon is also home to soft coral stands that provide unique habitat found in few locations.

There seems to be great support for the Achang Marine Preserve. According to King (2014), approximately 41% of respondents (all residents of Manell and Geus watershed) support Achang Marine Preserve; 19% oppose it; and 30% do not know whether they support or oppose the preserve.

Reef Fish and Edible Invertebrates

Of the fisheries catch in the coastal waters, crustaceans make up a large portion of non-fish catch. There are several hundred species of crustaceans on Guam's coral reefs, but only about nine species of crab are targeted, including land and marine crabs. *Carpilius maculatus* (the "7-11 crab") and *Etisus splendidus* (the splendid pebble crab) are well fished. Spiny lobsters (*Panulirus pencillatus* and other species) and slipper lobsters (*Scyllarides squamosus* and *Parribacus antarcticus*) catches are also highly prized. Mantis shrimp and freshwater shrimp (*Macrobrachium rosenbergii*) are also harvested.

Echinoderms harvested include two species of sea urchins, the priest-hat urchin or hairy pincushion urchin (*Tripneustes gratilla*) and the Rock boring or math sea urchin (*Echinometra mathaei*), as well as two species of sea cucumbers, the warty Selenka's sea cucumber (*Stichopus horrens*) and the black sea cucumber or lolly fish (*Holothuria atra*). The introduced marine gastropod, Trochus or top shell (*Trochus niloticus*), is one of the larger edible shellfish that can be found on Guam's fringing reefs and reef flats. Species of octopus, including the common reef octopus (*Octopus cyanea*) and the Hawaiian night octopus (*Octopus ornatus*) are also popular mollusk food items.

Shore-based finfish harvesting is by cast nets, surround nets, spear-fishing, hook and line, hooks and gaffs, and gill netting. The principal fishes caught by these

methods are surgeonfishes, jacks, rabbitfishes, goatfishes, snappers, emperors, and rudderfishes. Barracudas and mackerels are caught via boat.

Turtles

Three of the seven species of the world's marine turtles have been reported from the coral reefs of the Mariana Archipelago: the green turtle (*Chelonia mydas*), hawksbill turtle (*Eretmochelys imbricate*), and leatherback turtle (*Dermochelys coriacea*). Harvesting of sea turtles for food was legal on Guam until 1976. However, sea turtle populations decreased to the point that the government intervened and placed a ban on sea turtle harvest. Yet, even with a ban in place, poaching remains a significant problem in Guam and continues to contribute to the decline of turtle populations in this region.

Mangroves and Wetlands

Though Guam does have mangroves, the already small footprint on which they exist is steadily shrinking. Of these species, the most dominant species of mangroves on include *Rhizophora mucronata*, *Rhizophora apiculata*, and *Avicenna marina* var. *alba*.

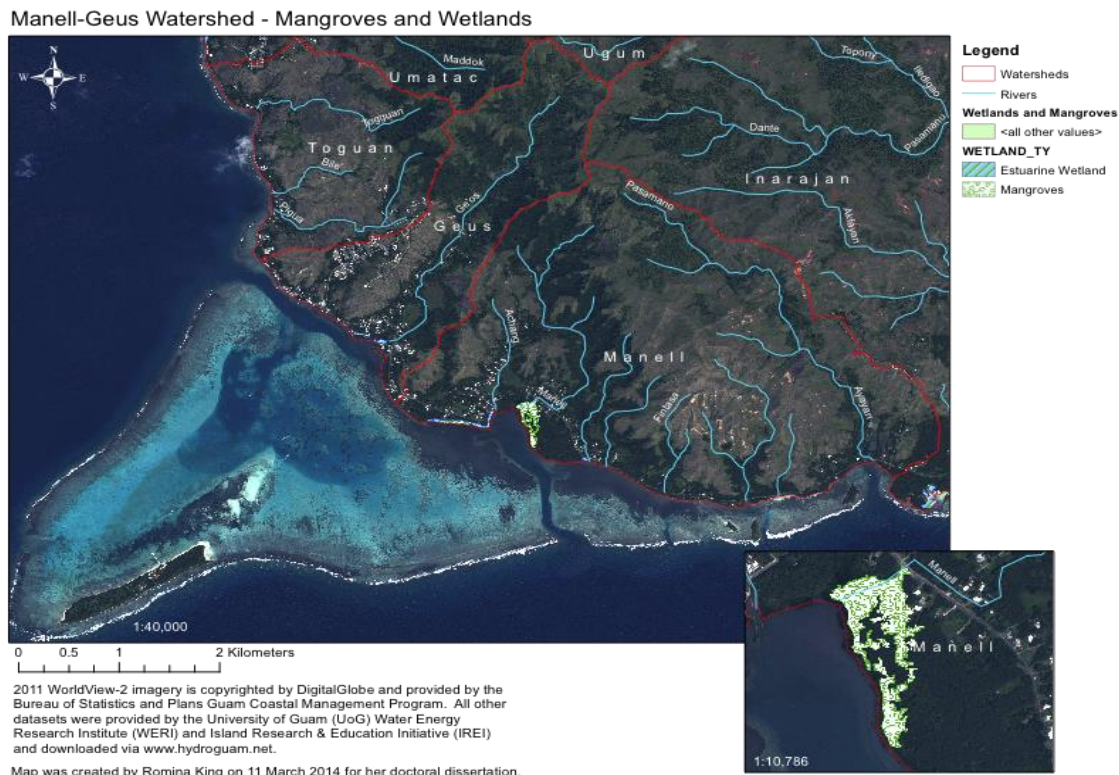


Figure 12: Location of mangroves and wetlands within the Manell and Geus watersheds. Reprinted from King (2014) and used with permission.

Water Resources

Surface Water

Manell-Geus Watershed - Rivers

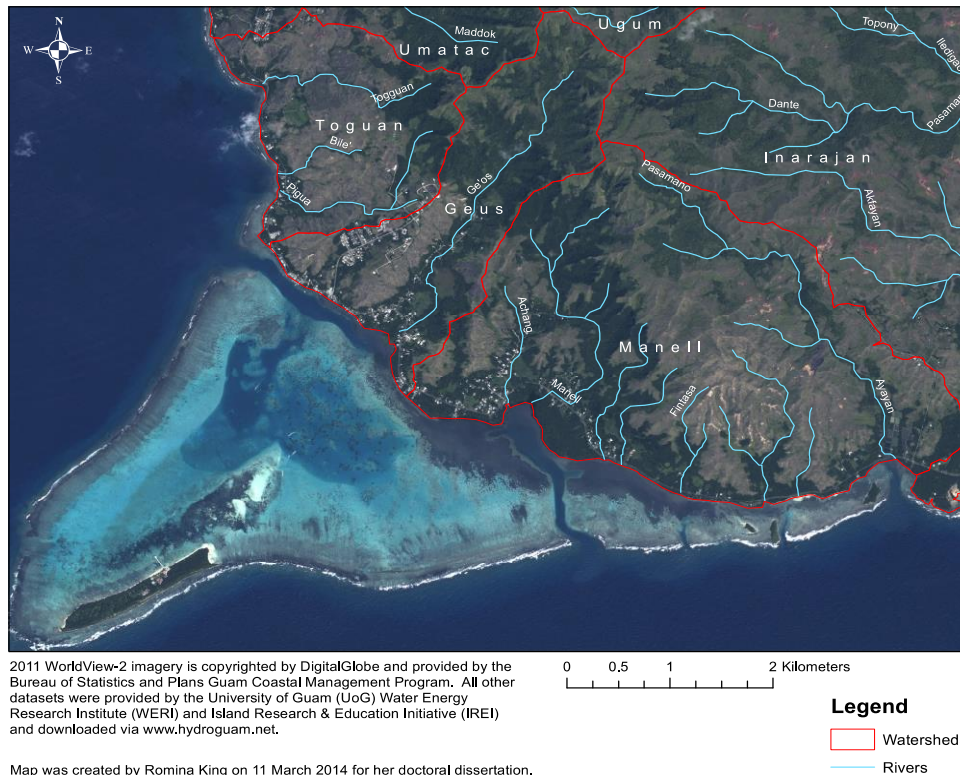


Figure 13: Map depicting the rivers of Manell and Geus watersheds. This river dataset is in the process of being updated by WERI in conjunction with USGS. The version used in this geospatial analysis lacked river names. Reprinted from King (2014) and used with permission.

The main rivers in the Manell watershed include Ajan River (2.91 mi), Nelansa River (2.01 mi.), Laolao River (.98 mi.), Fintasa River (.77 mi.), Liyog River (.72 mi.) and Ajan Creek (0.5 mi) (Water and Environmental Research Institute of the Western Pacific, n.d.). The main river in the Geus watershed is the Geus River (2.71 mi) (Water and Environmental Research Institute of the Western Pacific, n.d.). It is regarded as one of the most pristine river ecosystems on Guam (personal interview with Brent Tibbatts, biologist at DAWR).

Table 6: Reprinted from King (2014). Total length of perennial and intermittent streams located within the Manell and Geus watershed. Data was compiled from Table 7 of the Guam Statewide Forest Resource Assessment and Resource Strategy 2010 – 2015.

Watershed	Length of Streams					
	Perennial		Intermittent		Total	
	mi	km	mi	km	mi	km
Manell	12.7	20.5	3.6	5.8	16.3	26.3
Geus	3.3	5.3	0	0	3.3	5.3

Groundwater

There is little to no groundwater in this area due to the geologic make-up of Southern Guam. The majority of Guam's drinking water comes from the freshwater lens located in the limestone rich, northern region of Guam.

Flood zones

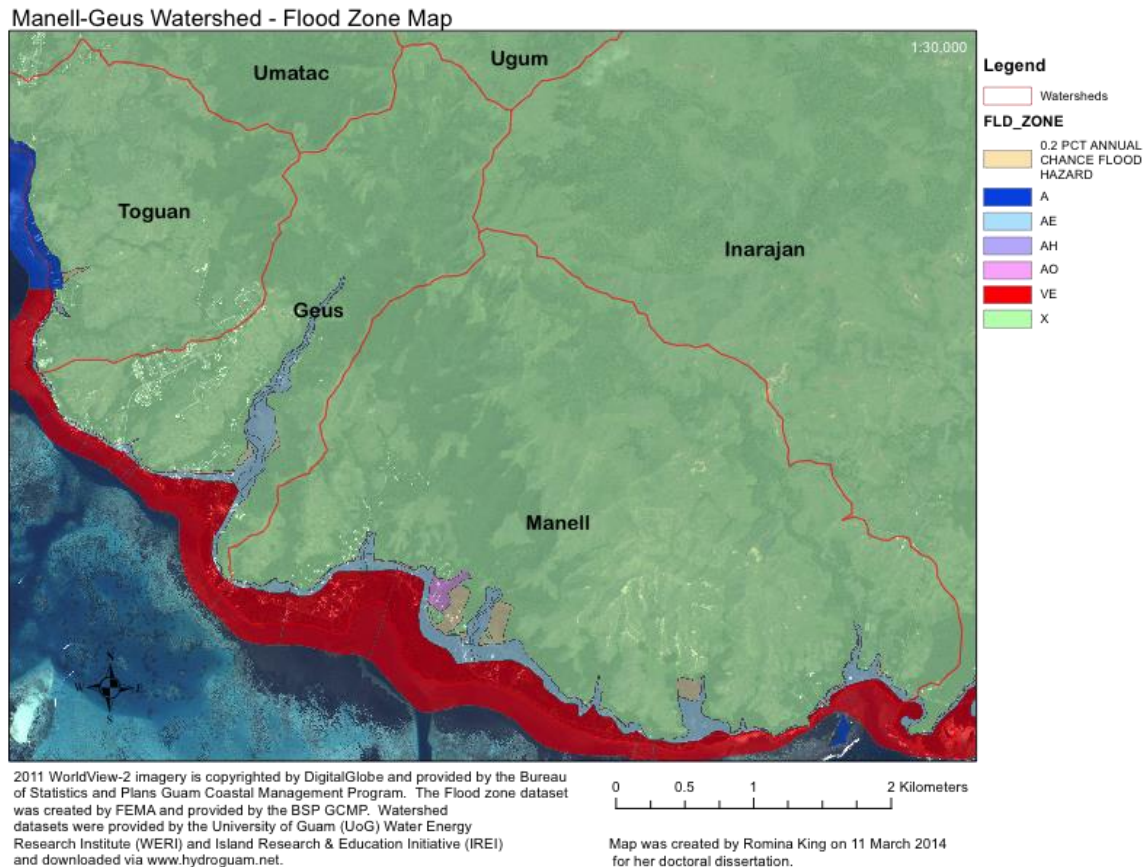


Figure 14: Flood zone map of the Manell and Geus watersheds. Reprinted from King 2014 and used with permission.

The most recent Flood Insurance Rate Map (FIRM) update for Guam became effective September 28, 2007; this incorporated a hydrology and hydraulic study for the Agana River; modified several transects along the southern coast as part of the revised typhoon analysis; and decreased the effective floodway along the Geus River (Federal Emergency Management Agency, 2012). Figure 14 was created using the 2007 FIRM dataset. The areas in red (see Figure 14), have a very high risk of flooding.

Heavy rains coupled with the steep hill topography have created conditions that contribute to regular flooding within these two watersheds. The invasive species of bamboo, *Bambusa vulgaris*, are also responsible for exacerbating the existing flood

conditions. These stands of clumping bamboo are prone to falling in the riparian corridors, creating dams that are swept away by fast moving waters during periods of heavy rainfall. These fast moving debris block drainage pathways, especially along the Barcinas culvert, damaging existing infrastructure, and making access along the only thru-road impossible.

Socioeconomic Description

The village of Merizo is a homogenous community. The majority of people identify themselves as Chamorro, Catholic, and speak Chamorro within their homes. According to the 2000 U.S. Census, the majority of the population (approximately 44% of the population) has attained a high school diploma, the highest level of educational attainment. Also, the mean family income, according to the 2000 Census, was approximately 49,187 USD (Bureau of Statistics and Plans, 2002).

Currently, there are approximately 1850 people residing in the village of Merizo (United States Census Bureau, 2011), a decrease from the 2,163 people counted in the 2000 Census (U.S. Census Bureau, 2001). Unfortunately, the 2010 Census is not broken down by village yet.

History

Plate, (2009) provides a brief synopsis of the history of Merizo or *Malessso*, the traditional Chamorro name, as it parallels the history of Guam.

Land ownership

Manell-Geus Watershed - Land Parcels

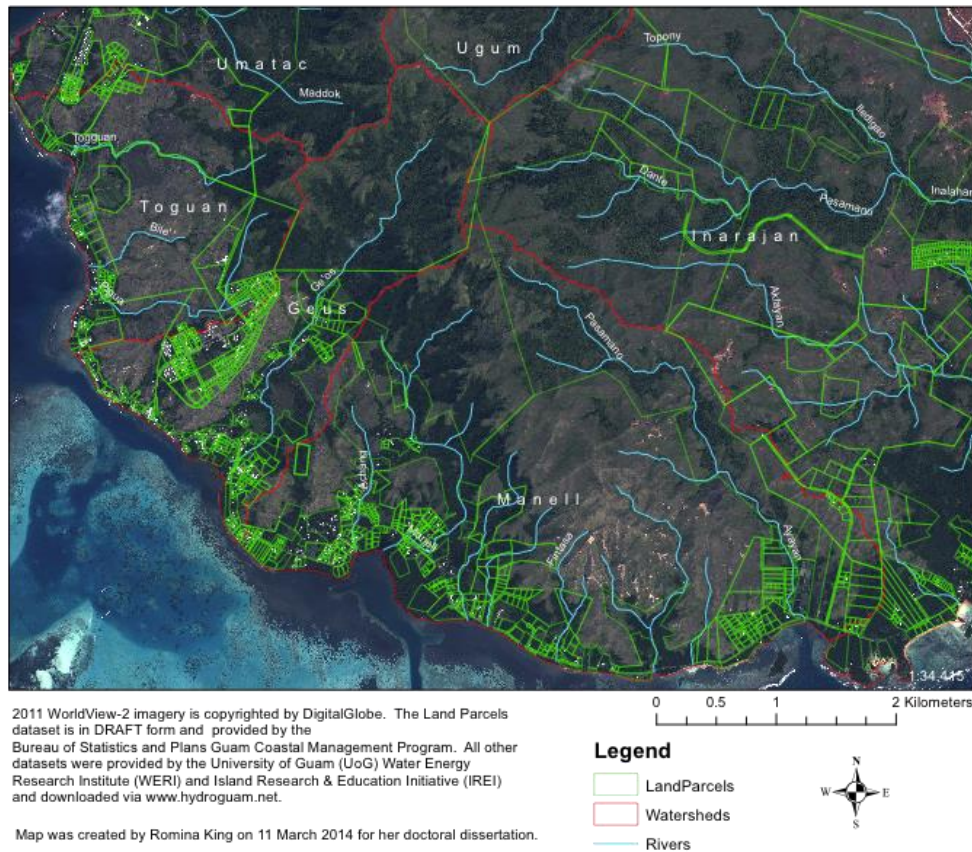


Figure 15: Land parcels within the Manell and Geus Watersheds

Historical Sites

Manell-Geus Watershed - Historical Sites

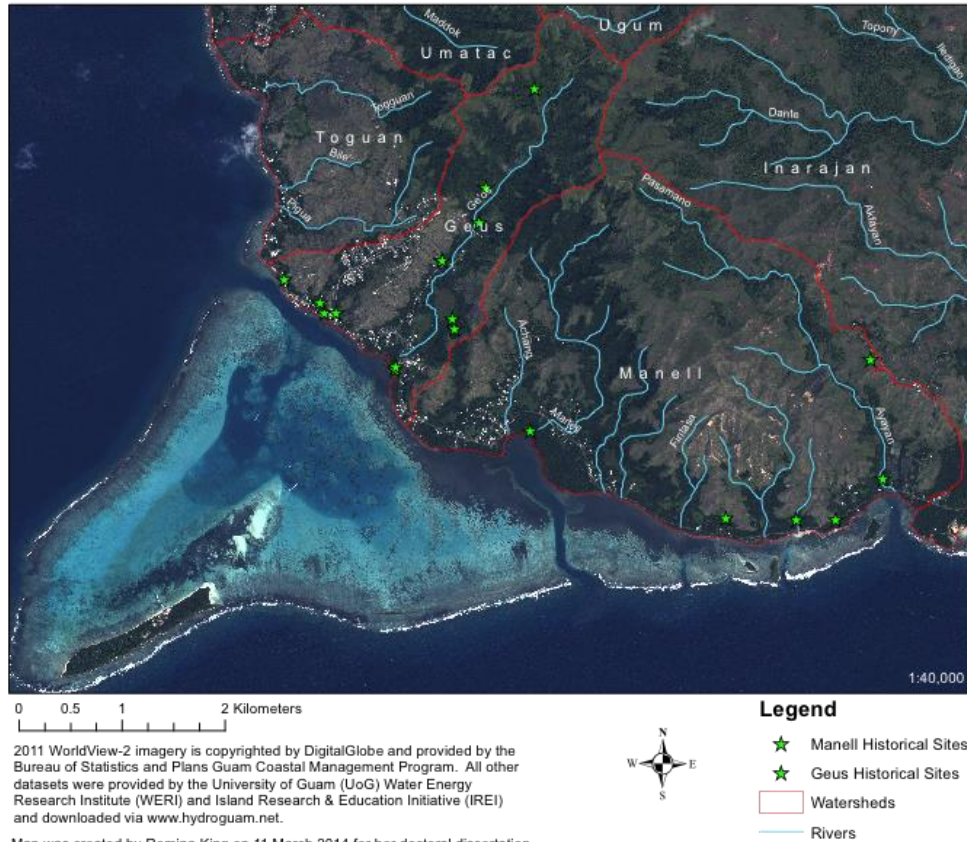


Figure 16: Location of historical sites within the Manell and Geus watersheds. Reprinted from King (2014) and used with permission.

There are approximately six historical sites located within the Manell watershed and there are twelve historical sites located within the Geus watershed (see Figure 16). The State Historical Preservation Office (SHPO) does not approved of disclosing specific locations of sites in fear of looting. For revegetation projects, it is required to obtain approval from SHPO to avoid disturbing prehistorical and historical sites.

Land Use Zones

Manell-Geus Watershed - Land Use Map

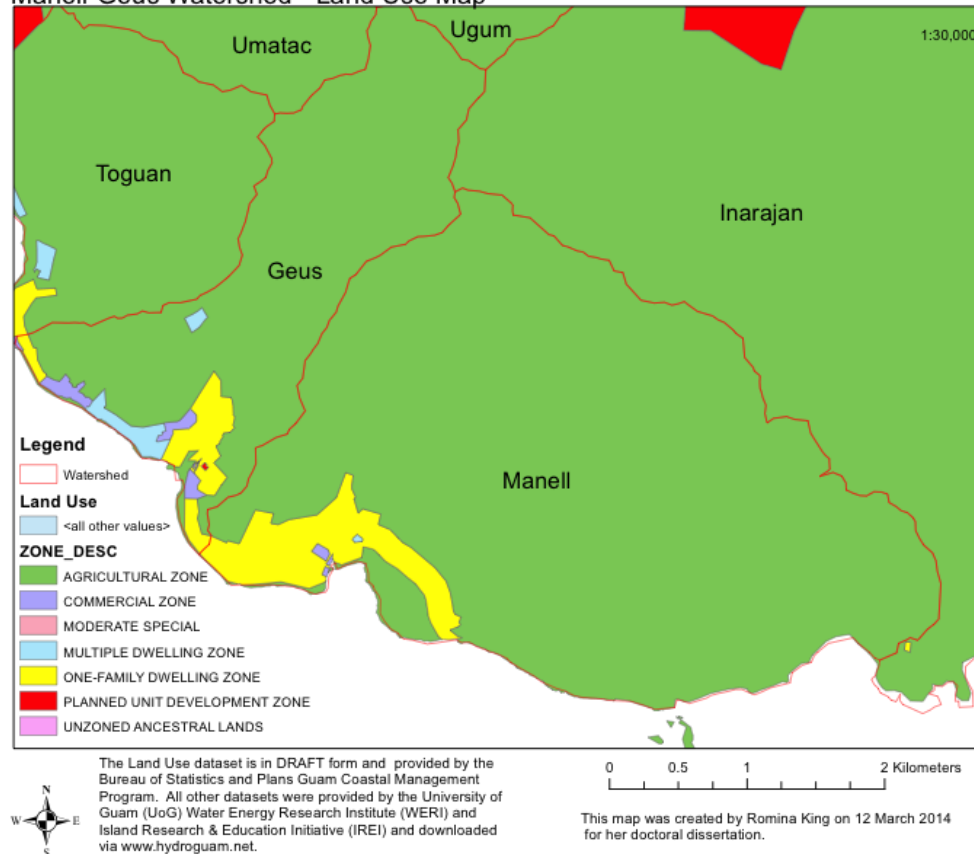


Figure 17: Land Use Map of the Manell and Geus watersheds. Reprinted from King (2014) and used with permission.

The majority of the Manell and Geus watersheds are zoned “agriculture” (see Figure 17). The areas depicting ‘one-family and multiple dwelling zones make up the village of Merizo (see Figure 17). There are very little commercially zoned areas (see Figure 17).

Conservation Areas

Manell-Geus Watershed - Bolanos Conservation Area

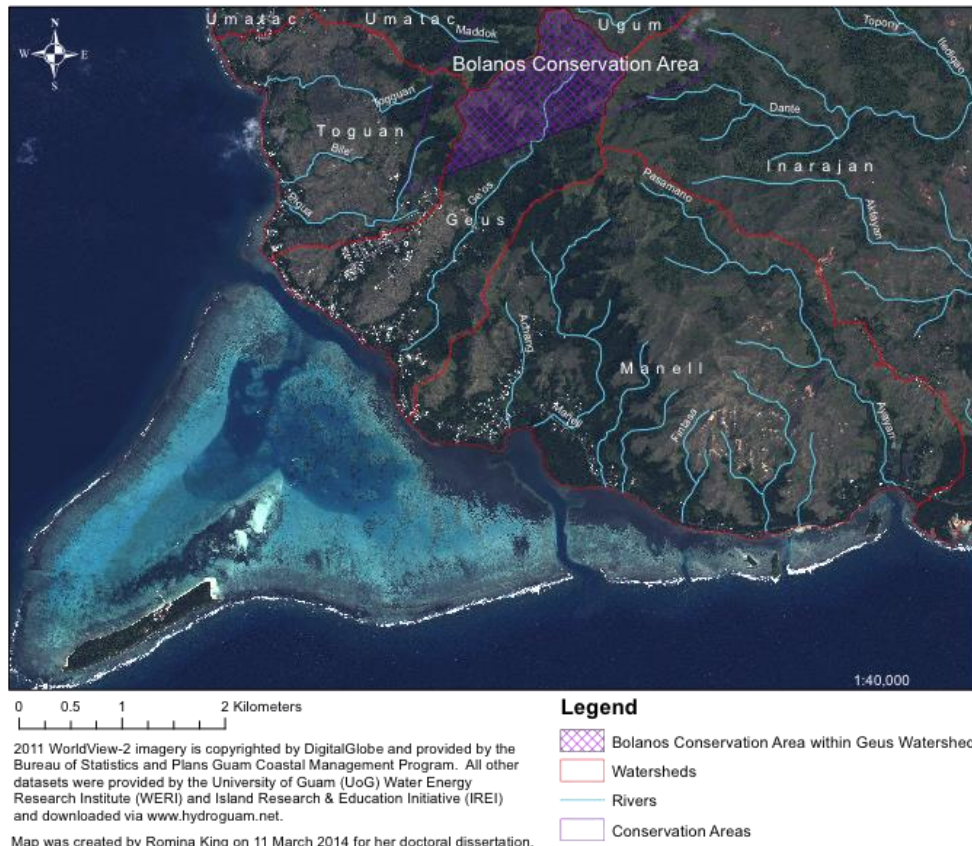


Figure 18: Terrestrial conservation areas within the Manell and Geus watershed. Reprinted from King (2014) and used with permission.

A portion of the Bolanos Conservation Area is within the northern part of the Geus watershed (see Figure 18). There are no terrestrial conservation areas within the Manell watershed.

According to Sablan Environmental, Inc. (2008), approximately 22% of Guam's land has been designate as local or federal conservation lands. The Bolanos Conservation Area is one of the three conservation areas (Anao and Cotal are the other two) under the administrative oversight of the Department of Agriculture (Sablan Environmental, Inc., 2008). These conservation areas contain habitats that are critical to native species (Guam Department of Agriculture Division of Aquatics and Wildlife Resources, 2005).

Water Utilities Infrastructure

Manell-Geus Watershed - Water Utilities Infrastructure

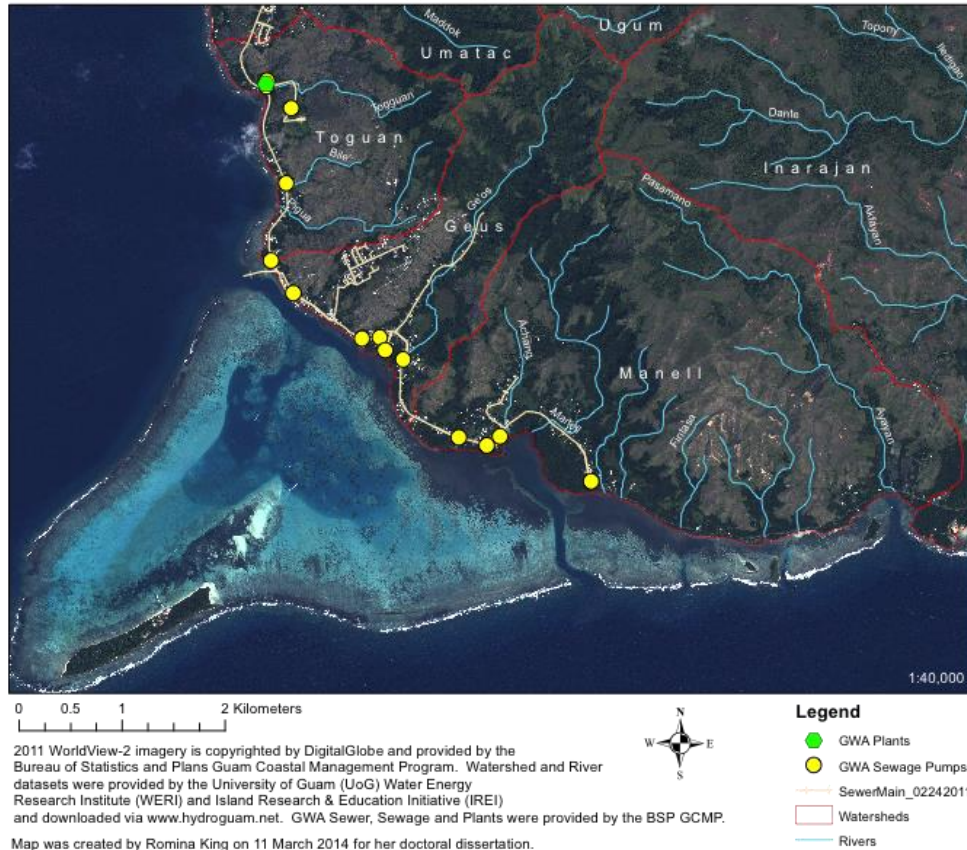


Figure 19: Water Utilities Infrastructure with the Manell and Geus watersheds. Reprinted from King (2014) and used with permission.

Approximately 72% of the population disposes of their sewage via public sewer, while 25% have a septic tank or cesspool (Bureau of Statistics and Plans, 2002).

When it floods in the Manell and Geus watersheds, the sewers get backed up. This becomes a public health concern.

Past Projects

These are some of the previous projects that were implemented in the Manell and Geus watersheds:

- Water quality sampling along Cocos Lagoon for PCBs with EPA and Coast Guard
- Pilot Bamboo Removal project implemented by previous watershed coordinator, Anna Simeon

- Reforestation of 17 acres of Quinene Hill with *Acacia auriculiformis* and interspersed natives
- NOAA's environmental contractors, EA, performed erosion mitigation and native plant propagation in multiple areas of the Manell watershed

Current Projects

These are some of the projects occurring in the Manell and Geus watersheds:

- Coral Reef Conservation Program via NMFS/PIRO – Stream assessment and pilot watershed restoration sites
- Western Pacific Regional Fisheries Management Council – Community Development Program
- DAWR Annual Pig Derby
- BSP-GCMP International Coastal Cleanup
- Invasive Bamboo Removal
- Department of Agriculture Forestry and Soil Resources Division Forest Stewardship Program
- Fire prevention and safety education and outreach
- Firebreak Maintenance
- Community Coral Reef Monitoring Program
- Native seed dispersal projects
- TNC's marine and terrestrial outreach via community coordinator, Farron Taijeron
- Coral Bleaching Surveys

Patrick Keeler from BSP-CRCP is currently the watershed coordinator for the Manell and Geus watersheds and does active environmental outreach with regard to fire education, reforestation efforts, and green infrastructure development.

Future Projects

There are some future projects planned for the Manell and Geus watersheds:

- Community gardens with Center for Island Sustainability (UOG)
- Southern Roots outreach and Education program run by GCMP
- Targeted outreach and feral pig removal by USDA-NRCS for private landowners
- Coral ambassador program
- Coral nursery within the Cocos Lagoon
- Landscape Scale Restoration (LSR) project run through Guam Forestry with partners at BSP and NOAA

- ACOE and GCMP are coordinating work to address flooding issues along the Barcinas Culvert
- Expansion of ongoing bamboo removal projects
- Rain Garden and green infrastructure workshop

Monitoring Programs

There is an island-wide coral reef monitoring program under the direction of Dave Burdick. Achang Marine Preserve is one of the sites to be monitored.

The Guam Environmental Protection Agency is monitoring the streams and water quality of the beaches within the Manell and Geus watersheds.

GEPA is also sampling fish caught within Cocos Lagoon for contaminants.

DAWR is mandated to be collecting, analyzing, and reporting fish catch data. However, due to internal issues, this has not been done in quite some time.

There is active work being done with the Koko bird at Cocos Island.

There is a WERI led project funded under NOAA CRI GU 12 that is examining stream flow and turbidity of the Geus River.

Marybelle Quinata runs the Community Coral Reef Monitoring Program which teaches a targeted audience how to perform benthic surveys and properly report their results.

Eyes of the Reef, run by Val Brown, trains the public on how to identify and report coral disease and bleaching.

Community Values, Attitudes, and Perceptions

A community household survey was conducted during the summer of 2010 by Romina King that attempted to measure attitudes, perceptions, beliefs, and land/marine use patterns in the Manell/Geus (King, 2014). Approximately 350 surveys were returned and tabulated. Data was analyzed using SPSS. Of the 350 respondents, approximately 58% perceived threats to the Manell/Geus watershed; 38% did not think there were any threats to the watershed; and 4% declined to answer (King, 2014). Of the 58% of respondents (203) who perceived threats to Manell/Geus watershed, 57% 'strongly agreed' and 22% 'agreed' that flooding was 'threat' to the watershed (King, 2014). Other highly perceived threats include coastal erosion, pollution, and land clearing (King, 2014).

With regard to what the community wants, results from the survey indicate that respondents are most desirous of

1. stopping floods;
2. fixing the roads and bridges;
3. increasing the number of community functions and activities for kids; and
4. fixing the schools (King, 2014).

Of the 350 respondents, approximately 52% were not familiar with the term “watershed”; 40% felt they could not define the term ‘watershed’; 46% did not know the term “Ridge to Reef” (King, 2014). Only 20% of respondents participated in watershed projects in 2009. This is an important finding and indicates that environmental education and outreach needs to continue and address the unfamiliarity with this term. However, while many respondents were unfamiliar with the term and there were few who participated in watershed projects in 2009, 57% of respondents want to participate in future watershed projects (King, 2014).

Perceptions

Of the 350 respondents, 44% believed that “the forests are filled with native vegetation”; 60% believed that “there is erosion”; 35% believe that “native animals are abundant”; 44% do not believe that “the rivers are clean”; 45% believe that “there are many wildland fires”; and 56% believe that “there are more non-native animals than native animals” (King 2014).

Another more recent household survey was conducted by NOAA in April and May of 2016. The goal of the survey was to measure residents’ perceptions on existing threats to ecological and human health. The results of this study are set to be released in the latter part of 2018.

Conservation Action Plan

The Conservation Action Plan is a tool developed by The Nature Conservancy (TNC) to assist governments with the conservation of natural resources. BSP GCMP decided to use this tool to assist in the development of the Manell and Geus watershed plans.

In September 2010, the first iteration of the conservation action planning process was conducted with key government agency partners (Table 7) to define conservation targets, threats, and strategies for addressing them (King and Victor, 2013).

Table 7: List of government officials who attended the Conservation Action Planning Workshop for Manell and Geus watersheds

Attendees	Agency/Company	Email	Telephone
Romina King	GCMP	rominaking@gmail.com	929-6714
Dave Burdick	GCMP	burdickdr@hotmail.com	472-4201
Nathaniel Martin	Dept. of Ag/DAWR	nathanemartin@hotmail.com	735-3982
Trina Leberer	TNC	tleberer@tnc.org	789-2228
Elaina Todd	GCMP	elainatodd@gmail.com	475-4468
Justin Santos	Dept. of Ag/DAWR	j5anto5@yahoo.com	735-3949
Steven Victor	TNC	svictor@tnc.org	680-488-2017
Umiich Sengebau	TNC	fsengebau@tnc.org	
Peggy Denney	iRecycle	peggcp1@yahoo.com	483-9415
Tammy Jo Taft	GCMP	tammyjoanderson.taft@gmail.com	988-7582
Esther Taitague	GCMP	esther.taitague@bsp.guam.gov	475-9670
Vangie Lujan	GCMP	vangelujan@yahoo.com	475-9672
Margaret Aguilar	GEPA	margaret.aguilar@epa.guam.gov	
Jesse Cruz	GEPA	jesse.cruz@epa.guam.gov	
Brent Tibbatts	Dept. of Ag/DAWR	brent.tibbatts@gmail.com	

See Appendix A for a report and outcomes of this initial workshop.

One particular outcome is the conceptual diagram of the threats with regard to the various ecosystems found in the Manell and Geus watersheds (see Figure 20).

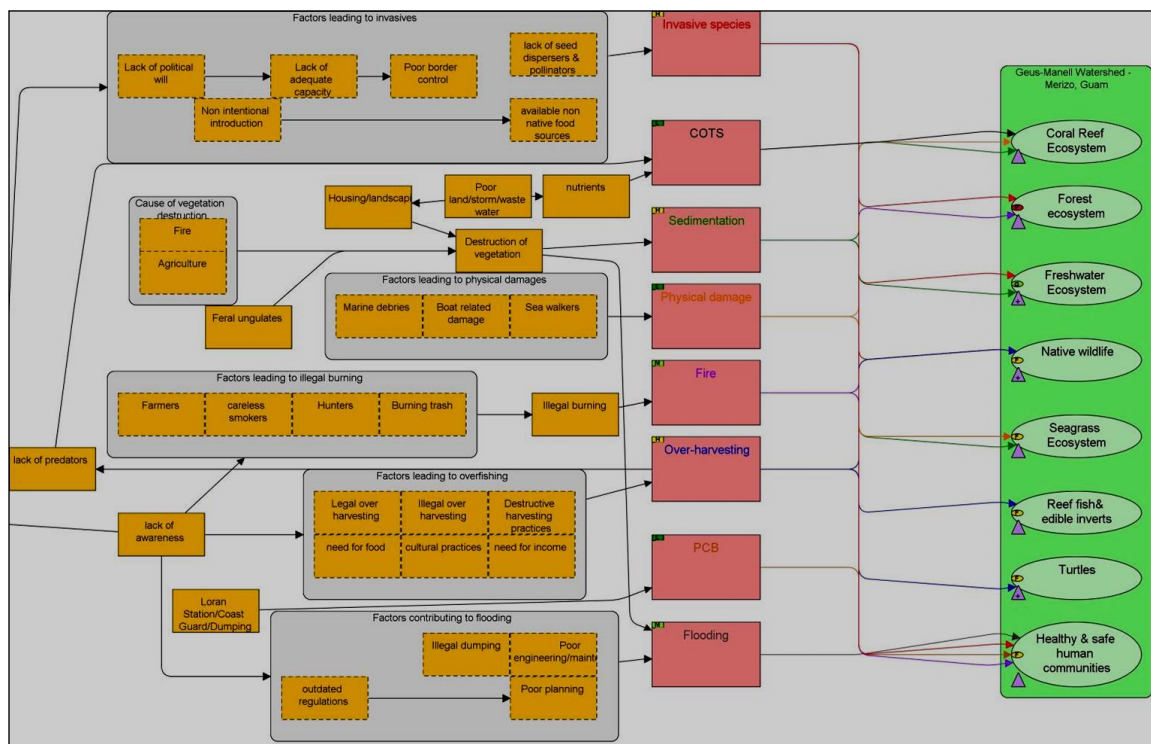


Figure 20: Conceptual diagram created at the 2010 CAP workshop.

In 2013, the CAP was revisited. The results from the 2010 CAP were presented to the community during a village meeting on 27 August 2013 in order to garner community feedback. There was very little change in the threat matrix (see Figure 21) and it also appears the community perceives the state of the conservation target in poorer condition than the government agencies (see Figure 22).

	CORAL REEF ECOSYSTEM	FOREST ECOSYSTEM	FRESHWATER ECOSYSTEM	HEALTHY & SAFE HUMAN COMMUNITIES	NATIVE WILDLIFE	REEF FISH & EDIBLE INVERTS	SEAGRASS ECOSYSTEM	TURTLES	MANGROVE ECOSYSTEM	SUMMARY THREAT RATING
OVER-HARVESTING	MEDIUM			LOW	MEDIUM	HIGH		VERY HIGH		HIGH
SEDIMENTATION	HIGH		HIGH	LOW			MEDIUM			HIGH
INVASIVE SPECIES		HIGH	LOW	MEDIUM	VERY HIGH					HIGH
EROSION		HIGH	HIGH	MEDIUM						HIGH
FIRE		HIGH		MEDIUM	LOW					MEDIUM
FLOODING	LOW		LOW	HIGH			LOW			MEDIUM
PCB				MEDIUM						LOW
CROWN OF THORNS STARFISH	MEDIUM									LOW
PHYSICAL DAMAGE	LOW	LOW	LOW				LOW		LOW	LOW
SUMMARY TARGET RATINGS:	MEDIUM	HIGH	HIGH	MEDIUM	HIGH	MEDIUM	LOW	HIGH	LOW	HIGH

Figure 21: Revised threat matrix, based on community feedback from a 27 August 2013 village meeting held in Merizo.

GEUS/MANELL CONSERVATION TARGETS	STATUS (GOV'T) 2010	STATUS (MERIZO) 2013
OVERALL TARGET RANKING	FAIR	
CORAL REEF ECOSYSTEM (CORAL COVER)	FAIR	POOR-FAIR
FOREST ECOSYSTEM (TREE CANOPY COVER)	POOR	POOR-FAIR
FRESHWATER ECOSYSTEM (PRESENCE/ABSENCE OF COMMON NATIVE SPECIES)	GOOD	POOR
HEALTHY & SAFE HUMAN COMMUNITIES (HAPPINESS INDEX)	FAIR	POOR
NATIVE CRABS (NUMBER OF ADULT CRABS)	GOOD	MIXED
REEF FISH& EDIBLE INVERTS (FOOD FISH BIOMASS)	FAIR	FAIR-GOOD
SEAGRASS ECOSYSTEM (AREAL EXTENT)	FAIR	POOR
TURTLES (NUMBER OF TURTLES NESTING/SEASON)	FAIR	FAIR

Figure 22: Comparison of perceptions of conservation target between government officials and the village of Merizo.

After the 27 August 2013 village meeting, government officials convened again from 29-30 August 2013 at the NRCS Conference Room, located in Tiyan, GU for the second round of CAP and to discuss the revised threat matrix (see Appendix 2 for Agenda and notes). The conceptual diagram (Figure 20) is currently being revised by Christine Camacho to reflect any changes that occurred at the second CAP workshop.

Management Strategies

One of the outcomes of the second CAP workshop was an updated “Goals and Objectives” for the Manell and Geus watersheds (see Table 8).

Table 8: Revised Goals and Objectives for the Manell and Geus watersheds. Based on the second CAP workshop held from 29-30 August 2013.

Item	Details
Wildfire	Reduce southern wildfires from 1670 average per year to 835/year by 2012. In 2011, only 23 (180 acres) reported fires- refer to SWARS; action: Grid Map for Mayors Office that can be used to track fires -Mulch/composting as alternative to burning -Stipends provided to community members to maintain firebreaks around reforestation site (2017-2018)
Best farming practices	By 2015, at least 50% of farmers in Merizo are implementing best farming practices. Action: Identify farmers in Merizo, who and where? Leads to creation of conservation plans (NRCS); - Department of Ag has some brochures to be distributed
Capacity to implement	By 2014, at least 80% of engineers and contractors (public & private) are trained in storm water management. -training held in 2012 -working with Senator Cruz to make it a requirement to have certified storm water personnel at construction site
Community watch	By 2013, a community program group has been established in Merizo to help reduce incidence of fires. - Community feels program will not be beneficial because of close knit community where they do not report on family members (change objective) - Graduate student working on a project in Merizo (STEM student) - Firewise program run by Guam Forestry has been established in Merizo
Erosion control	By 2015, at least 10% of bad land as identified in red areas in SWARS has either re-vegetation activity and or erosion control measure being implemented. - Forestry has propagate plants - Buffer strips, stream banks stabilization (short term goals)- storm water control - Land acquisition (federal highway) - EA, environmental contractor hired by NOAA, to address erosion and badland issues.

Item	Details
Trained officers	By 2015, at least 4 new conservation officers have been hired. -funding from CRM to DAWR, hired 2 officer but 4 have been lost (\$60,000) -historically, there have been 21 CO; needs to be locally funded -Reserve program, need to be established; could place 1 reservist in Achang -returned vets (VA Office)
Enforcement	By 2013, EPA has adequate capacity to enforce storm water regulations. -CRM has funded inspectors -provided cameras for inspectors - (take pictures and send to database using phones- use media)
Hydrology study	By mid-2012, hydrology study to determine vulnerability of Merizo community to flooding has been implemented. -Flood assessment performed by GCMP in 2016; identified the Barcinas area as a target for GCMP and ACOE to address
Rain gardens	By 2013, at least 5 pilot rain garden projects have been successfully implemented in Merizo. -2 pilot sites (check status) -could be done through Island Girl Power (will be establishing office in Merizo)
Storm water regs.	By end of 2011, EPA board have passed storm water regulations -in work plan for EPA – not moving, not a priority
Local champion	By 2011, at least 1 community liaison officer who is from Merizo based in Merizo. (community based liaison) -Community coordinator for Merizo, Farron Taijeron, has been hired by The Nature Conservancy.

Recommendations

It is strongly recommended that the issue of flooding is addressed. The Department of Public Works prioritized a list of infrastructure projects (see **Error! Reference source not found.**) for the village of Merizo (Parsons Transportation Group, Inc, 2010) that should help alleviate the flooding. Funding needs to be identified for the execution of these projects.

It is recommended that a strategy is developed to address the overgrowth of bamboo along the rivers, particularly the Manell River. During floods, bamboo is flushed down the river and forms a blockade in front of culverts, hindering the flow of water. By harvesting the bamboo regularly, it will minimize the debris and hopefully allow native species to take root and grow.

It is recommended that community monitoring programs be developed and implemented. The community desires more projects for youth and an excellent way of building capacity is engaging that youth in meaningful projects. Data is needed by government agencies, with regard to stream flow, precipitation, coral health and coverage, vegetation, erosion. The youth can be trained to collect data to assist the government agencies with their data gaps.

It is recommended that the strategies are developed to meet the objectives outlined in the 2nd CAP workshop.

It is recommended that enforcement is increased at the Achang Marine Preserve. Residents are upset over the lack of enforcement by DAWR (King 2014).

It is recommended that a working group meet regularly to discuss the progress of the projects scheduled for Manell and Geus. The community of Merizo should be updated on a regular basis.

Table 9: Reprinted from Parsons (2010). Cost-estimate of high-priority projects located in Merizo.

MERIZO VILLAGE								
LOCATION		COST ESTIMATE						
MAP DESIGNATION	STREET/ROUTE	RECOMMENDATIONS		QUANTITIES UNITS	COST / UNIT	COST	TOTAL COST	TOTAL COST W/ENGINEERING & CONTINGENCIES
ME-113 ME-119 ME-121 ME-122	Rt 4 & Juan Baubata St Rt 4 & SO Benny Espinoza Ave Rt 4 & NO Benny Espinoza Ave Rt 4 & Chalan Joseph A Cruz	1/4 AC DEBRIS REMOVAL	DEBRIS REMOVAL	0 AC	\$4,562.38 / CY	\$1,141	\$83,894	\$142,620
		3000 CF RIP RAP	RIP RAP	111.11 CY	\$744.79 / LF	\$82,754		
ME-101	Rt 4 & Asmaile Creek	1/2 AC DEBRIS REMOVAL	DEBRIS REMOVAL	0.5 AC	\$4,562.38 / AC	\$2,281	\$167,788	\$285,240
		6000 CF RIP RAP	RIP RAP	222.22 CY	\$744.79 / CY	\$165,507		
ME-124	Culvert at Mobil Station	100'x12'x6" RCB	REINFORCED CONCRETE BOX CULVERT	266.67 CY	\$1,103.85 / CY	\$294,364	\$398,258	\$677,038
		2 HEADWALL/WINGWALLS	HEADWALL W/WINGWALL	2 EA	\$10,000.00 / EA	\$20,000		
		1/4 Ac DEBRIS REMOVAL	DEBRIS REMOVAL	0.25 AC	\$4,562.38 / AC	\$1,141		
		3000 CF RIP RAP	RIP RAP	111.11 CY	\$744.79 / CY	\$82,754		
ME-130	Rt 4 & Ajayan River	1/4 AC DEBRIS REMOVAL	DEBRIS REMOVAL	0.25 AC	\$4,562.38 / AC	\$1,141	\$83,894	\$142,620
		3000 CF RIP RAP	RIP RAP	111.11 CY	\$744.79 / CY	\$82,754		
ME-111	Emma Juan Reyes Street	1/4 Ac DEBRIS REMOVAL	DEBRIS REMOVAL	0.25 AC	\$4,562.38 / AC	\$1,141	\$84,429	\$143,529
		3000 CF RIP RAP	RIP RAP	111.11 CY	\$744.79 / CY	\$82,754		
		3000 CF FILL	STRUCTURAL FILL	11.11 CY	\$48.14 / CY	\$535		
ME-114	Mannell Channel	4000 CY ROCK REMOVAL	ROCK REMOVAL	4000 CY	\$14.53 / CY	\$58,120	\$4,487,587	\$7,628,897
		1/4 AC DEBRIS REMOVAL	DEBRIS REMOVAL	0.25 AC	\$4,562.38 / AC	\$1,141		
		15000 CF RIP RAP	RIP RAP	555.56 CY	\$744.79 / CY	\$413,776		
		20 CY CUT	EXCAVATION	20 CY	\$27.53 / CY	\$551		
		4000 CY RETAINING WALL	RETAINING WALL	4,000 CY	\$1,003.50 / CY	\$4,014,000		
ME-115	North of Mannell Channel	1/4 AC DEBRIS REMOVAL	DEBRIS REMOVAL	0.25 AC	\$4,562.38 / AC	\$1,141	\$6,489	\$11,032
		3,000 CF RIP RAP	RIP RAP	111.11 CY	\$48.14 / CY	\$5,349		
ME-128	N O Bile River	2 HEADWALL W/WINGWALL	HEADWALL W/WINGWALL	2 EA	\$10,000.00 / EA	\$20,000	\$98,466	\$167,393
		600 CF RIP RAP	RIP RAP	22.22 CY	\$744.79 / CY	\$16,549		
		1/4 AC DEBRIS REMOVAL	DEBRIS REMOVAL	0.25 AC	\$4,562.38 / AC	\$1,141		
		100'x5'x3" RCB	RCB	54.56 CY	\$1,103.85 / CY	\$60,226		
		20 CY CUT	EXCAVATION	20 CY	\$27.53 / CY	\$551		
ME-117	N O Geus River	1/4 Ac DEBRIS REMOVAL	DEBRIS REMOVAL	0.25 AC	\$4,562.38 / AC	\$1,141	\$83,894	\$142,620
		3000 CF RIP RAP	RIP RAP	111.11 CY	\$744.79 / CY	\$82,754		
ME-116	Rte 4 and Achang River at Jesus R Quinene	1/4 Ac DEBRIS REMOVAL	DEBRIS REMOVAL	0.25 AC	\$4,562.38 / AC	\$1,141	\$9,415	\$16,006
		300 CF RIP RAP	RIP RAP	11.11 CY	\$744.79 / CY	\$8,275		

LOCATION		COST ESTIMATE						
MAP DESIGNATION	STREET/ROUTE	RECOMMENDATIONS		QUANTITIES UNITS	COST / UNIT	COST	TOTAL COST	TOTAL COST W/ENGINEERING & CONTINGENCIES
ME-120	Rte 4 & Benny Espinoza Ave	1/4 AC DEBRIS REMOVAL	DEBRIS REMOVAL	0.25 AC	\$4,562.38 / AC	\$1,141	\$1,141	\$1,939
ME-103	Rte 4 and Liyog River	100 CY CUT	EXCAVATION	100 CY	\$27.53 / CY	\$2,753	\$86,647	\$147,300
		3000 CF RIP RAP	RIP RAP	111.11 CY	\$744.79 / CY	\$82,754		
		1/4 Ac DEBRIS REMOVAL	DEBRIS REMOVAL	0.25 AC	\$4,562.38 / AC	\$1,141		
ME-126	Rte 4 and Pigua River	100 CY CUT	EXCAVATION	100 CY	\$27.53 / CY	\$2,753	\$319,653	\$543,410
		300 CF RIP RAP	RIP RAP	11.11 CY	\$744.79 / CY	\$8,275		
		100'x6'x12" RCB	RCB	266.67 CY	\$1,103.85 / CY	\$294,364		
		800 CF GABIONS	GABIONS	22.65 CY	\$629.66 / CY	\$14,262		
ME-106	Rte 4 and Sumay River	1/4 AC DEBRIS REMOVAL	DEBRIS REMOVAL	0.25 AC	\$4,562.00 / AC	\$1,141	\$83,894	\$142,620
		3000 CF RIP RAP	RIP RAP	111.11 CY	\$744.79 / AC	\$82,754		
ME-110	Rte 4 and Suyafe River	3000 CF RIP RAP	RIP RAP	111.11 CY	\$744.79 / CY	\$82,754	\$83,894	\$142,620
		1/4 Ac DEBRIS REMOVAL	DEBRIS REMOVAL	0.25 AC	\$4,562.38 / AC	\$1,141		
ME-118	Rte 4 and Geus River	1/2 AC DEBRIS REMOVAL	DEBRIS REMOVAL	0.5 AC	\$4,562.38 / AC	\$2,281	\$167,788	\$285,240
		6000 CF RIP RAP	RIP RAP	222.22 CY	\$744.79 / CY	\$165,507		
ME-104	Rte 4 Coastal Issues	1 Ac DEBRIS REMOVAL	DEBRIS REMOVAL	1 AC	\$4,562.38 / AC	\$4,562	\$418,338	\$711,174
ME-107		15000 CF RIP RAP	RIP RAP	555.56 CY	\$744.79 / CY	\$413,776		
ME-125	Rte 4 & NO Merizo Catholic Church	1/4 AC DEBRIS REMOVAL	DEBRIS REMOVAL	0.25 AC	\$4,562.38 / AC	\$1,141	\$9,513	\$16,172
		300 CF RIP RAP	RIP RAP	11.11 CY	\$744.79 / CY	\$8,275		
		100 SF APRON	CONCRETE (DITCH LINING)	0.1543 CY	\$633.32 / CY	\$98		
ME-112	Rte 4 S O Baubata	1/4 AC DEBRIS REMOVAL	DEBRIS REMOVAL	0.25 AC	\$4,562.38 / AC	\$1,141	\$83,894	\$142,620
		3000 SF RIP RAP	RIP RAP	111.11 CY	\$744.79 / LF	\$82,754		
ME-105	Rte 4 S O Sumay River	1/4 Ac DEBRIS REMOVAL	DEBRIS REMOVAL	0.25 AC	\$4,562.38 / AC	\$1,141	\$83,894	\$142,620
		3,000 CF RIP RAP	RIP RAP	111.11 CY	\$744.79 / CY	\$82,754		
ME-108	Rte 4 S O Suyafe River	1/2 AC DEBRIS REMOVAL	DEBRIS REMOVAL	0.5 AC	\$4,562.38 / AC	\$2,281	\$167,788	\$285,240
		6000 CF RIP RAP	RIP RAP	222.22 CY	\$744.79 / CY	\$165,507		
ME-129	Toguan River	1/4 Ac DEBRIS REMOVAL	DEBRIS REMOVAL	0.25 AC	\$4,562.38 / AC	\$1,141	\$115,411	\$196,199
		600 CF RIP RAP	RIP RAP	22.22 CY	\$744.79 / CY	\$16,549		
		10000 SF Ditch Lining	CONCRETE (DITCH LINING)	154.3 CY	\$633.32 / CY	\$97,721		

Goals Reached

Since the completion of the watershed plan's initial draft, many of the recommendations given have been addressed and implemented:

A flood assessment was completed by the Guam Coastal Management Program (GCMP) in 2016. Based on the findings of this report, GCMP has begun talks with the Army Corps of Engineers as well as the Department of Public Works in order to explore ways in which the issue can be addressed more effectively.

Bamboo removal has begun. Thanks to the pilot project designed and overseen by the Bureau of Statistics and Plans previous watershed coordinator, Anna Simeon, we have a working model and method on how to effectively, and permanently, remove bamboo. Multiple bamboo stands along the Manell channel, an area known for its flooding due to bamboo damming up existing waterways, have been removed and replaced with native vegetation.

A community coral reef monitoring program as well as Eyes of the Reef program have been created and successfully implemented. Marybelle Quinata is the community coral reef monitoring program coordinator and Val Brown, a NOAA fisheries biologist, is currently heading the Eyes of the Reef program.

An updated implementation plan was developed in July 2017 based off of a survey performed in April-May 2016. This plan contains a timeline with project goals and targets, and deadlines in order to address issues that villagers of the habitat blueprint area cited as ongoing problems and concerns for both ecological as well as human health.

A habitat blueprint working group has been created and is currently being overseen by NOAA employees Val Brown and Adrienne Loerzel. During these bi-weekly meetings partners that coordinate and manage projects within the Manell-Geus watersheds discuss strategies and progress

Partners

Below are a list of partners who have committed to doing projects and work within the Manell and Geus watersheds:

- NMFS
- NOS
- Guam Coastal Management Program
- Merizo Mayor's Office
- Guam Department of Agriculture Division of Aquatic and Wildlife Resources
- Guam Department of Agriculture Forestry and Soil Resources Division
- TNC
- Guam Environmental Protection Agency
- University of Guam
- UOG Water and Environmental Research Institute
- UOG Center for Island Sustainability
- UOG Marine Laboratory
- USDA Natural Resource Conservation Service
- Environmental Education Committee/ INA
- Humatak Community Foundation
- Humatak Project

Below are a list of potential partners that may be interested in doing work in the Manell and Geus watershed:

- UOG College of Natural and Applied Sciences
- NMFS PIFSC
- NMFS RC
- Guam Department of Public Works
- Federal Highway Administration
- Guam Community College
- TASI
- San Dimas Parish
- Marianas Research and Development Council
- Guam Environmental Education Partners, Inc.
- Ayuda Foundation
- Southern Soil and Water Conservation District
- Merizo business owners
- Cocos Lagoon marine operators
- Guam Visitors Bureau

References

- Burdick, D., n.d. The Guam Coastal Atlas (No. Multimedia Publication No. 4). Marine Laboratory University of Guam, Guam.
- Bureau of Statistics and Plans, 2002. 2000 Census of Population and Housing Profile - Guam.
- Donner, S.D., Skirving, W.J., Little, C.M., Oppenheimer, M., Hoegh-Guldberg, O., 2005. Global assessment of coral bleaching and required rates of adaptation under climate change. *Global Change Biology* 11, 2251–2265.
- Federal Emergency Management Agency, 2012. Discovery Report Guam Watershed, HUC8 30010000 Island of Guam (No. 01). Guam.
- Government of Guam, 1998. Clean Water Action Plan for Guam - Unified Watershed Assessment.
- Guam Department of Agriculture Division of Aquatics and Wildlife Resources, 2005. Guam Comprehensive Wildlife Strategy. Guam.
- King, R., 2014. Vulnerability of small island communities to climate change- A vulnerability assessment of the Manell an Geus watersheds on Guam with regard to freshwater resources (Ph.D Dissertation). University College Cork, Cork, Ireland.
- King, R., Victor, S., 2013. Manell and Geus Watershed Conservation Action Planning Workshop (September 2010)-Overview of Results. Guam.
- Parsons Transportation Group, Inc, 2010. Storm Water Drainage Master Plan 2010 (Master Plan No. PTG DPW FHWA-GU-NH-IPMS (002)). Department of Public Works, Guam.
- Plate, D., 2009. Merizo (Malesso'). Guampedia™.
- Sablan Environmental, Inc., 2008. Guam Natural Resources Strategy 2012. Prepared for the Bureau of Statistics and Plans and the Civilian Military Task Force. Guam.
- Tracey, J.I., Jr., Schlanger, S.O., Stark, J.T., Doan, D.B., May, H.G., 1964. General Geology of Guam: U.S. Geological Survey Professional Paper 403-A (U.S. Geological Survey Professional Paper No. 403-A). United States Geological Survey.
- U.S. Census Bureau, 2001. Census Bureau Releases Census 2000 Population Counts for Guam.

United States Census Bureau, 2011. 2010 Census of Population and Housing - Guam.

Water and Environmental Research Institute of the Western Pacific, n.d. Digital Atlas of Southern Guam [WWW Document]. URL <http://south.hydroguam.net/watersheds-manell.php> (accessed 3.13.14).

Appendices