FLOOD RISK ASSESSMENT IN POST ANTIAO RIVER CONTROL PROJECT IN CATBALOGAN CITY, PHILIPPINES

Ronald L. Orale
Samar State University, Philippines,
ronald_catb@yahoo.com

Abstract

Flooding in cities of developing countries is common, primarily due to poor planning and project designing and execution. Factors causing floods are due to increase population, outdated and non-functional drainage system, heavily silted and reduced river size, poor waste management, no erosion control measures, reduced vegetative cover and the unusually heavier precipitation. In response to this flood problem, the local government asked help from the Department of Public Works and Highways which in turn developed a Flood Management and Drainage System Master Plan wherein a River Control Project which includes desilting of an almost 2km stretch of the river, and the construction of river walls. Using a hydrologic modeling system (HEC-HMS) version 4, river discharge was calculated for at least four extreme events. Results have shown that the project will not solve the flooding problem due to extreme precipitation. The river walls are more needed upstream than the downstream portion of the river while the disiltation of the river is not enough to carry storm water. There is, therefore, an urgent need to construct river walls in the upstream as well as other interventions specified in the master plan to manage the flooding problems in Catbalogan.

Keywords: river flooding, rain-induced risk, flood mitigation, flood management, engineering solution

I. INTRODUCTION

The changing climate has increased the intensity of precipitation which has exceeded capacities of natural and human-made drainage systems (www.eoearth.org, 2014, www.apf,.info, 2012). The rapid growth in population and urbanization has forced communities to change land use. These changes in ground cover from vegetation to impervious layers like paved surfaces and buildings has reduced infiltration capacity and increased volume of run-off (www.epa.gov).

Natural disasters in the Philippines resulted into PHP 5B to PHP 15B direct damages which are about 9.5% of the country's Gross Domestic Product (GDP) and 972 casualties per year from 1970-2006 (Porcil, 2009). About 20 typhoons cross the Philippines yearly, 5 of which are destructive (ibid). Storms carry with them heavy precipitation swelling canals, streams and rivers. In September 2009, Metro Manila in the Philippines experienced a record-breaking flood due to a 448.5mm of rain in 12 hours placing the over 11 million citizens to a virtual standstill (Lagmay, undated). Catbalogan has a fair share of floods due to unusually heavy rain causing the river to overflow. In 2009, Tropical Storm Feria (Nanka) carried a total accumulated rain of about 324mm has submerged majority of Catbalogan City (Quirante, 2009). The extreme rainfall event was aggravated by the 75-80% denuded state of the watershed resulting in higher surface runoff eroding soil and deposited on the river bed (ibid). The siltation problem due to erosion, illegal structure along the river and poor waste management all contribute to reducing its carrying capacity (ibid). In December 2014, Category 5 Typhoon Ruby (Hagupit) and Tropical Storm Seniang (Jangmi) caused flooding in Catbalogan.

Many communities in the world have implemented several strategies in managing flood water from the swelling of rivers due to heavy rainfall in some cases aggravated by the flood surges up to rivers from the sea-caused by high tides among others. The main options for river defenses include; permanent solid walls and banks, demountable river barriers and glass floodwalls (www.floodcontrolinternational.com).

The Catbalogan City government requested the Department of Public Works and Highways for assistance in solving the sedimentation problem and the perennial flooding due to swelling of various sections of the Antiao River (www.pertconsult.com). The Master Plan and Feasibility Study of Flood Management and Drainage System of Catbalogan City includes structural measures such as river improvement works, soil erosion countermeasures, urban storm drainage as well as non-structural measures (ibid). These actions include the construction of river walls and disilting of the river bed. The Construction/Rehabilitation of Antiao River Control in Catbalogan City commenced last February 2014 and is about 55% completed as of February 28, 2015 (www.dpwh.com, 2015a).

In January 2015, during a five-day participatory rural appraisal workshop facilitated by the Samar State University, the people from Barangay San Andres claimed that the flooding in their community has worsened since the river control project was started, hence the study was conducted.

Using the physical characteristics of the watershed and the profile of the river including the river control project, a computer simulation of different scenarios were performed to determine flood risks due to swelling of the Antiao River.

II. METHODOLOGY

The methods used to answer the research question includes watershed profiling, characterization of precipitation in Catbalogan City, runoff and discharge analysis, river control project assessment and the flood risk calculation. Interviews, participatory rural appraisal, and observation were also conducted to validate data gathered in the study.

2.1 Watershed Profiling

The profile of Antiao watershed was determined with the aid of National Mapping and Resource Information Authority (NAMRIA) topographic maps. The said map was used to identify the boundaries of the watershed including the tributaries supplying water to the river. Soil classification was derived from the Bureau of Soils and Water Management (BSWM) geological and soil maps. The determination of ground cover of the Antiao Watershed was estimated using rasterized satellite images from www.bing.com. These maps were analyzed by overlaying it with the NAMRIA maps in AutoCAD environment.

2.2 Characterization of Precipitation in Catbalogan

Daily rainfall data came from the Catbalogan station of the Department of Science and Technology (DOST)-Philippine Atmospheric, Geographical and

ISSN 2449-4577 (online) 2408-283X (print)

Astronomical Services Administration (PAGASA). Thirty years of monthly data was used as a reference to normal precipitation volume. Five years of daily rainfall data were evaluated to determine extreme rainfall events. Some days with relatively continuous rains as well as the accumulated amount of rain was presented in a histogram.

2.3 Runoff and Discharge Analysis

The runoff and discharge analysis made use of the Hydrologic Modeling System (HEC-HMS) Version 4, developed by the US Army Corps of Engineers-Institute for Water Resources Hydrologic Engineering Center. Variables used are based on runoff curve number (CN) method proposed by the United States Department of Agriculture (USDA) Technical Release 55 (TR55) published in June 1986.

Simulation run using the HEC-HMS software was performed using daily rainfall data on selected months with extreme precipitation events. The simulation run is capable of estimating the behavior of the modeled watershed given hydrologic information.

2.4 Antiao River Control Project Assessment

The assessment includes an examination of the design and the as-built plan of the project. After which the responsiveness of the design was tested through the Antiao Watershed Model using HEC-HMS.

2.4.1 The Antiao River Control Project

The details of the project were taken from the feasibility study and plans from DPWH which was validated on site. A survey team examined the as-built structure as of January 2014. The project commenced on February 2014 and on January 2015, it was about 60% completed. The depth of river bed, the dimension of the river was estimated based on the survey data gathered.

2.4.2 Flood Risk Assessment

The Risk assessment was limited to the calculation whether the on-going and the post-construction scenario of the Antiao River Control Project will solve the currently identified risk or not. One major purpose of the project was to manage the flooding caused by the swelling of the river. In risk calculation, the volume of water from the watershed was calculated based on past events. The river discharge was then compared to the current river capacity before and after the full of construction. River capacity calculation used the Manning's Formula which considers cross sectional area, a wetted perimeter of the river bed, river bed slope and the coefficient of roughness.

III. RESULTS AND DISCUSSIONS

Flood risk calculation was performed using HEC-HMS Version 4 based on field data acquired through actual survey and secondary information from various government agencies such as Department of Agriculture and Department of Science and Technology.

3.1 Profile of Antiao River and its Watershed

The Antiao River is the only river in Catbalogan with a total length of about 4.08 km wherein about 3 km is gently sloping by about 0.06%. The mouth of the river has coordinates of 11^{o} 46’48.32” N and 124^{o} 52’42.6” E and traverses about N45^{o}E. Water flowing in the river comes from the Antiao watershed approximately about 1942.4 hectares.

3.1.1 The Antiao Watershed

The Antiao watershed is draining water from three sub-watershed denoted as Antiao Watershed – North (AW-N), the AW-South (AW-S) and AW-West (AW-W). The AW-N and AW-S watershed have a total area of 1206 and 443 hectares respectively wherein tributaries drop its water to the Barangay San Andres section of the Antiao River. On the other hand, the AW-W portion of the Antiao watershed drains water along the remaining 2.5 km stretch of the river.

The portion of the Antiao Watershed denoted as AW-N and AW-S are primarily covered by non-graze grasslands which sometimes are cultivated, and grass covers are often removed, sometimes through slash and burn or locally known as a kingpin. Trees in these zones are mostly coconut trees, and woods or forest trees are few. On the other hand, AW-W is mostly built up zones mostly made of residential houses.

The weathered limestone and shale are of clay type (Caroll and Hathaway, undated; Zagorzki, 2010) on the other hand shale and sandstone rocks when weathered produces clay loam

Table 1. Antiao Watershed Profile

Ground Cover	Area in Hectares					
	AW-N	%	AW-S	%	AW-W	%
Woods	244.9	20.3	36.4	8.2	57.6	19.6
Woods-grass (Coconuts)	351.2	29.1	79.0	17.8	53.7	18.3
Bare soil	102.9	8.5	54.9	12.4	3.8	1.3
Meadow-grass	491.6	40.8	234.1	52.8	32.8	11.2
Urban District	0	0	0	0	46.5	15.9
Residential Districts	14.6	1.2	38.6	8.7	89.2	30.5
Antiao River	0.8	0.1	0.6	0.1	9.3	3.2
Total	1,206.0	100.0	443.5	100.0	292.9	100.0
Grand Total			1942.4			

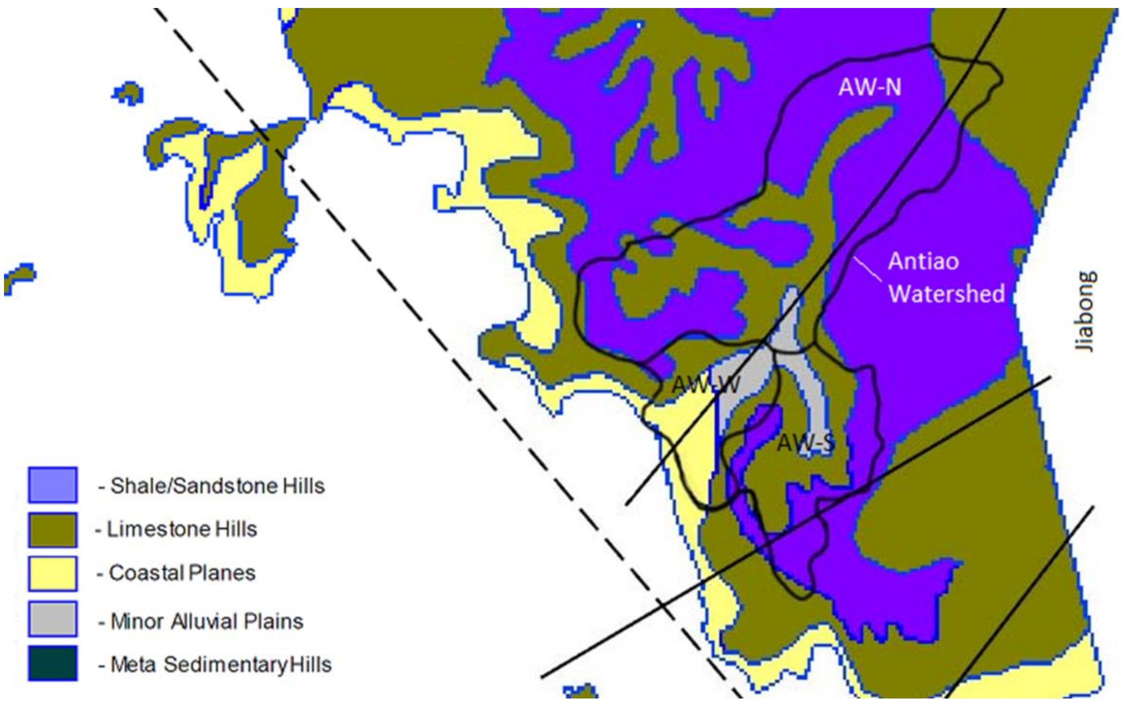


Figure 1.: Geologic Map in the Antiao Watershed

ISSN 2449-4577 (online) 2408-283X (print)

(www.claysandminerals.com). Clay and clay loam has a very low permeability (www.usgs.gov, JS Dagdu & Nimbalkar P., 2012) with infiltration rate for clay range from 1 to 5 mm/hr and 5 to 10 mm/hr for clay loam(www.fao.org). This means that surface runoff is heavier because infiltration is low. Infiltration rates of soils are affected by subsurface permeability including surface intake rates. Soils are classified into four Hydrologic Soil Groups (HSGs) according to their minimum infiltration rate which is obtained for bare soil after prolonged saturation (www.usda.gov). Figure 1 and Table 2 illustrates soil and bedrock characteristics of the Antiao watershed. The soil type in the watershed is of clay type while soil surrounding most of the stretch of the river are of a sand type.

3.1.2 The Antiao River

The Antiao River is approximately 4.08 km from the mouth to the first main tributary. Waters flowing in the river primarily come from precipitation drained from the Antiao watershed as well as several springs in the watershed. One major spring source is located in the Masacpasac sub-surface channel. However, almost all of its discharge is for Catbalogan water supply use (Gomba et.al, 2007). During prolonged dry spells, many of the headwaters relatively stop providing the river. The 4km stretch of the river is classified as alluvial while the rest of the river system is bedrock. Soil erosion in the upstream is severe mostly carried by surface runoff for about 53% of the watershed in the upstream is used for agricultural activities. These eroded soil are

Table 2. Geologic Soil Types

Geologic Type	Top Soil Type	HSG*	AW-N	AW-S	AW-W	Sub Total
Shale/Sandstone	Clay Loam	C	740.2	193.2	18.3	951.7
Limestone Hills	Faraon Clay	D	442.9	191.3	101.9	736.1
Coastal Planes	Sand	A	0.0	0.0	104.4	104.4
Minor Alluvial Plains	Fine Sand	B	22.9	59.0	68.3	150.2
Sub-Basin HSG	-	-	C	C	B	C
Total			1206.0	443.5	292.9	1942.4

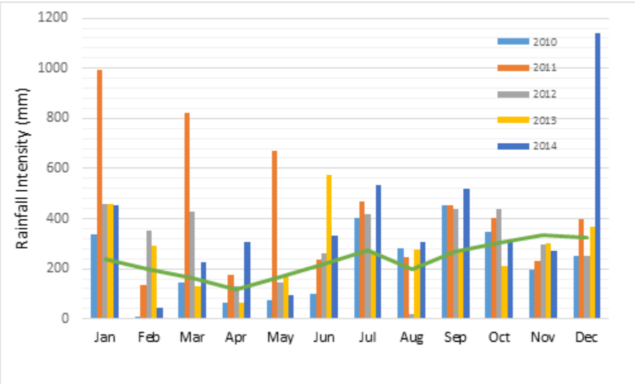
Legend: *Hydrologic Soil Group(HSG)
A -Sand, loamy sand, or sandy loam
B -Silt loam or loam
C -Sandy clay loam
D -Clay loam, silty clay loam, sandy clay, silty clay, or clay

Figure 3: Sand Bars after December 2014 Storms

deposited along the stretch of the Antiao River reducing its carrying capacity. Figure 3 is a photo taken after the December 2014 storms show the tremendous volume of sediments which was deposited in the river mouth.

3.2 Precipitation Characteristics in Catbalogan City (2010-2014)

Most of Samar Island weather is of type II, but Catbalogan is more of type IV, meaning that rainfall is evenly distributed over the year (PAGASA). Shown in figure 4 are rainfall intensity from 2010 to 2014 and compared to 30-year normalized rainfall intensity. Months of January, March and May 2011 exhibited more than 600mm of rain while December 2014 has the highest monthly rainfall totaling to about 1140mm of rain, 72% higher than normal. More than half of the months have total rain more than the 30-year average.



Source: PAGASA Catbalogan and www.pagasa.dost.gov.ph

Figure 4: Monthly Precipitation from 2010-2014

As shown in figure 5, about 42% of days from the year 2000 to 2014 has no rain. On the other hand, a little more than 1% has rainfall intensity between 100 and 200mm. There were two days having rainfall higher than 300mm rain; both occurred in December 2014 during a storm.

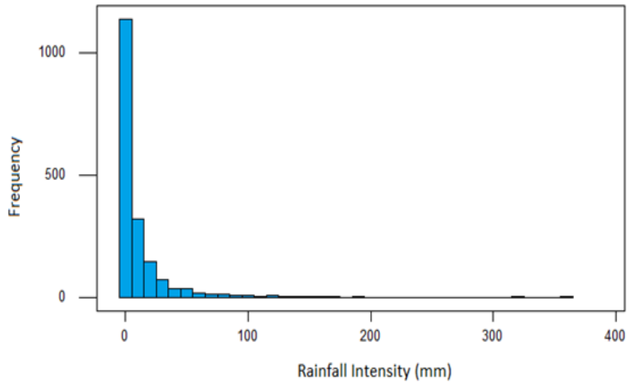


Figure 5: Frequency Distribution of Daily Precipitation from 2010-2014

The effect of continuous rainfall is catastrophic when the accumulated rain is so much that it saturate the soil and swells the river system. Figure 6 and 7 summarizes the frequency of rainy days and the total accumulated precipitation respectively from January 2010 to December 2014. In these years, the longest duration of rainy days was 23 which occurred on March 2011 having a total accumulated precipitation of 728.5mm. Twenty days of continuous rain in March 2011 has collected a total of 634mm of rain. There were two storms in December 2014 while March 2011 has none. The total accumulated rain in March 2011 is about 80% higher than normal, the largest deviation from the norm in the last five years.

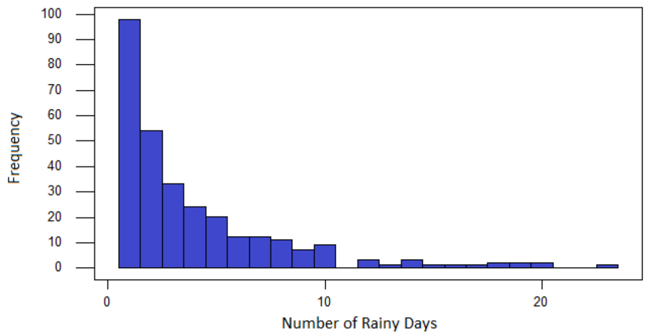


Figure 6: Frequency Distribution of Days with Rain (2010-2014)

ISSN 2449-4577 (online) 2408-283X (print)

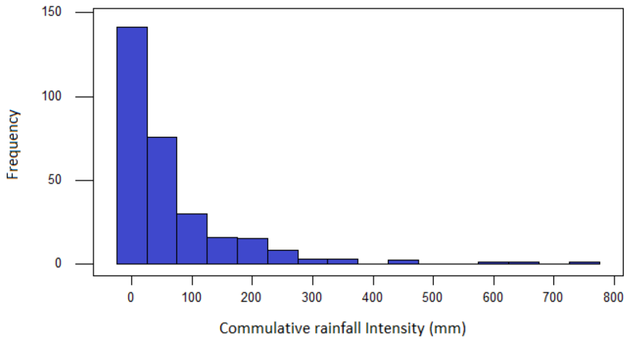


Figure 7: Cumulative Precipitation from Consecutive Days with Rain (2010-2014)

3.3 Runoff and River Discharge Characteristics

The runoff and river discharge were calculated using HEC-HMS version 4 software on selected months with high precipitation quantities between the years 2000 to 2014. The amount of runoff is affected by the HSG and the ground cover or land use. The combination of these two variables is used to determine the Curve Number (CN). Percent amount of impermeable layer (i.e., paved space/roads or buildings/covered zones) also reduces infiltration rate and increased runoff volume. Table 3 shows the varied parameters used in the calculation of runoff volume. The runoff water runs over the intermediate river or streams and is drained by the Antiao River after a period. The relatively flat slope on AW-W3 and AW-W4 sub-basins resulted into longer lag time. On the other hand, the AW-N and AW-S lag time are affected by the sub-basin size and length of the longest path.

The three sub-basins AW-N, AW-S, and AW-W, was transformed into the Antiao Watershed Model as shown in figure 8. Water from the AW-N watershed is converged in J1 and run through the first segment of the Antiao River denoted as Reach 3. Reach three discharge flow and the water coming from AW-S sub-basin and converged in J2. This portion of the river is located in the vicinity of Brgy San Andres. The water from J2 runs through J3 and water from AW-W1, and AW-W2 portion of the AW-W sub-basin converges here. This part of the river is where the Bliss Community is located. Discharge flow from J3 runs to J4 with water from AW-W3 converging. Discharge flow from J4 runs to J5, where water from the Antiao creek draining from the AW-W4 portion of the AW-W sub-basin converges. This part of the river is in the vicinity of Antiao Bridge where the river walls are being constructed. The discharge waters from J5 exits to the sea.

Table 3. Hydrologic-Characteristics of Antiao Watershed

Properties	AW-N		AW-S	AW-W			
	1	2		1	2	3	4
Area (Km2)	7.24	4.82	4.43	1.46	0.3	0.44	0.72
Hydrologic Soil Group [a]	C	C	C	C	C	B	B
Curve Number (CN) [a]	74	74	80	75	75	85	92
Average Slope (longest path in %)	4	5	2	6	4	0.5	0.5
Impermeable (%)	≈0	≈0	≈0	≈0	≈0	40	65
Lag Time (min) [b]	22	16	21	6	5	20	25

[a] *USDA TR-55*

[b] *Sub-basin lag-time according to the SCS formula*

Referring to figure 4, four months have exhibited a total accumulated rainfall of more than 600mm. These are the months of January, March and May 2011 and December 2014. Various parts of Catbalogan has experienced floods during these months. Using properties enumerated in Table 3 inputted to the Antiao Watershed Model through the HEC-HMS software as simulation run for the four selected months was performed.

The simulation run shows that the peak discharge in the past five years (2010-2014) was observed on December 28, 2014, during the height of Typhoon Seniang. A river discharge of about 53.1 m3/s near the mouth of Antiao River and 33.6 m3/s was observed.

There were two extreme events on December 2014 due to Tropical Storms (TS) Ruby (Hagupit) and Seniang (Jangmi). The total rainfall during TS Ruby on December 5, 2014, was larger; however, the peak

Table 4. Simulated Discharge During an Extreme Precipitation

Hydro-logic Element**	Drain-age Area (KM2)	Jan 2011		Mar 2011		May 2011		Dec 2014	
		Peak Discharge (M3/S)	Volume (MM)	Peak Discharge (M3/S)	Volume (MM)	Peak Discharge (M3/S)	Volume (MM)	Peak Discharge (M3/S)	Volume (MM)
AW-N 1	7.24	11.8	889.27	7.8	667.99	13.7	307.45	20.4	1034.77
Reach-1	7.24	11.6	889.26	7.7	667.24	13.5	307.39	20.2	1034.52
AW-N 2	4.82	7.8	889.27	5.2	667.99	9.1	307.45	13.6	1034.77
Reach-2	4.82	7.8	889.26	5.1	667.44	9.0	307.41	13.5	1034.59
J1	12.06	19.4	889.26	12.8	667.32	22.5	307.40	33.6	1034.54
Reach-3	12.06	19.3	889.25	12.8	666.84	22.3	307.36	33.3	1034.37
AW-S	4.43	7.3	916.52	4.9	694.29	8.9	330.35	12.6	1062.46
Reach-4	4.43	7.3	916.52	4.8	693.54	8.8	330.29	12.4	1062.20
J2	16.49	26.5	896.58	17.5	674.02	31.0	313.52	45.7	1041.85
Reach-5	16.49	26.4	896.58	17.5	673.68	30.8	313.49	45.4	1041.73
AW-W1	1.46	2.4	894.03	1.6	672.57	2.8	311.37	4.1	1039.62
Reach-7	1.46	2.4	894.03	1.6	672.29	2.8	311.34	4.1	1039.53
AW-W2	0.3	0.5	894.03	0.3	672.57	0.6	311.37	0.8	1039.62
Reach-6	0.3	0.5	894.03	0.3	672.40	0.6	311.35	0.8	1039.56
J3	18.25	29.2	896.33	19.3	673.54	34.2	313.28	50.4	1041.52
Reach-8	18.25	29.1	896.33	19.3	673.20	34.0	313.26	50.1	1041.39
AW-W3	0.44	0.7	957.75	0.5	734.78	0.9	368.07	1.3	1104.02
Reach-11	0.44	0.7	957.75	0.5	734.57	0.9	368.05	1.3	1103.95
J4	18.69	29.8	897.77	19.8	674.65	34.9	314.55	51.3	1042.86
Reach-9	18.69	29.7	897.77	19.7	674.48	34.8	314.53	51.2	1042.80
AW-W4	0.72	1.2	979.74	0.8	756.48	1.6	388.69	2.2	1126.13
Reach-10	0.72	1.2	979.74	0.8	756.14	1.6	388.67	2.2	1126.01
J5	19.41	30.9	900.81	20.5	677.51	36.3	317.28	53.2	1045.89
Reach-12	19.41	30.9	900.81	20.5	677.41	36.3	317.27	53.1	1045.85
Sea	19.41	30.9	900.81	20.5	677.41	36.3	317.27	53.1	1045.85

Please refer to figure 8

ISSN 2449-4577 (online) 2408-283X (print)

discharge was observed on December 28, 2014, during TS Seniang due to saturated grounds. Figure 10 shows sub-basin AW-N1 precipitation, soil infiltration, and outflow.

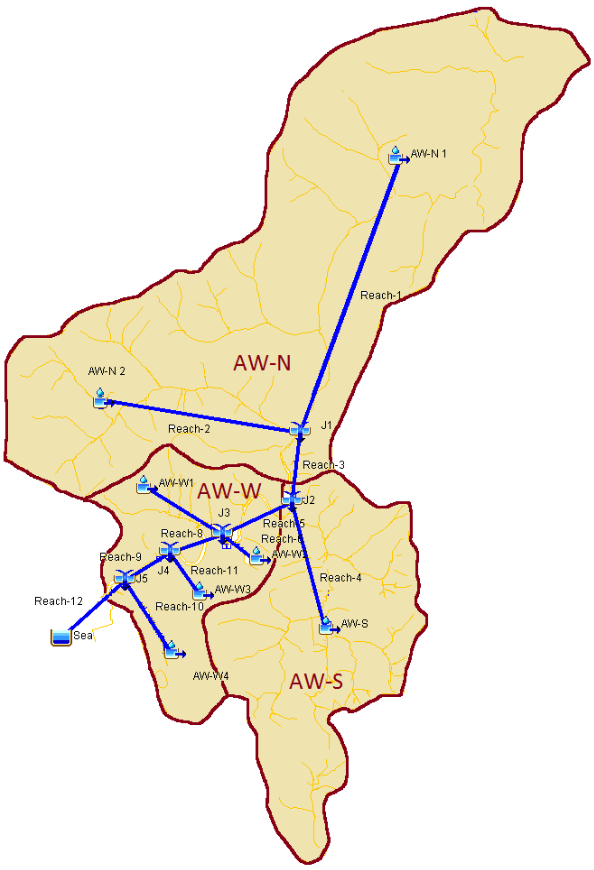


Figure 8: Antiao Watershed Model

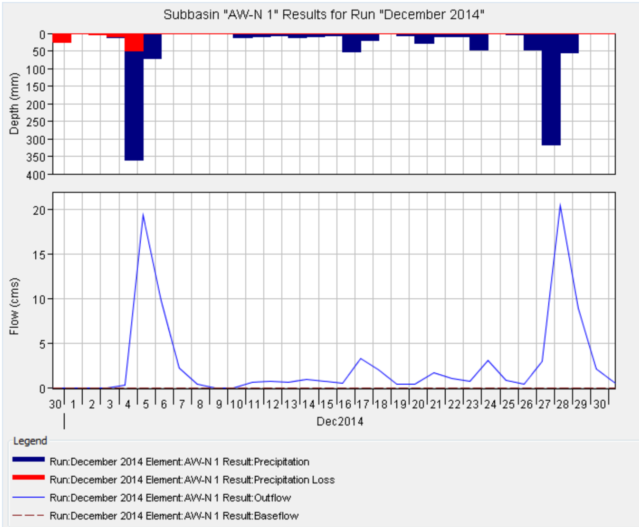


Figure 10: December 2014 HEC-HMS Simulation Run for AW-N Sub-Basin

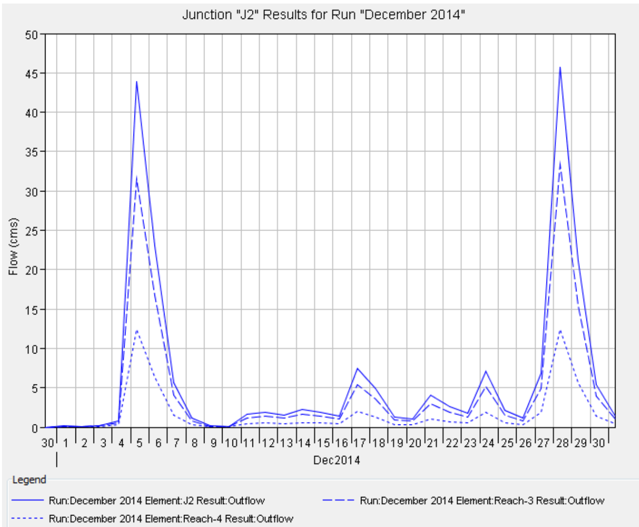


Figure 11: December 2014 HEC-HMS Simulation Run for the Antiao River in Brgy. San Andres

Figure 11 illustrates the outflow coming from Junction 2 (J2). J2 is a portion of the Antiao River in the vicinity of Brgy. San Andres. This junction receives water from AW-S and AW-N sub-basins carried by tributaries reach 3 and reach four respectively. Most water that runs in the Antiao River in the vicinity of Brgy San Andres is contributed by AW-N sub-basin of the Antiao watershed. Brgy San Andres is one of the several Barangays of Catbalogan easily flooded during events with extreme precipitation.

3.4 The Antiao River Control Project

The Antiao River Control Project is one of the components of the Master Plan and Feasibility Study of Flood Management and Drainage System of the City of Catbalogan. The flood management and drainage system was proposed to primarily assist Catbalogan to manage the sedimentation problem in the

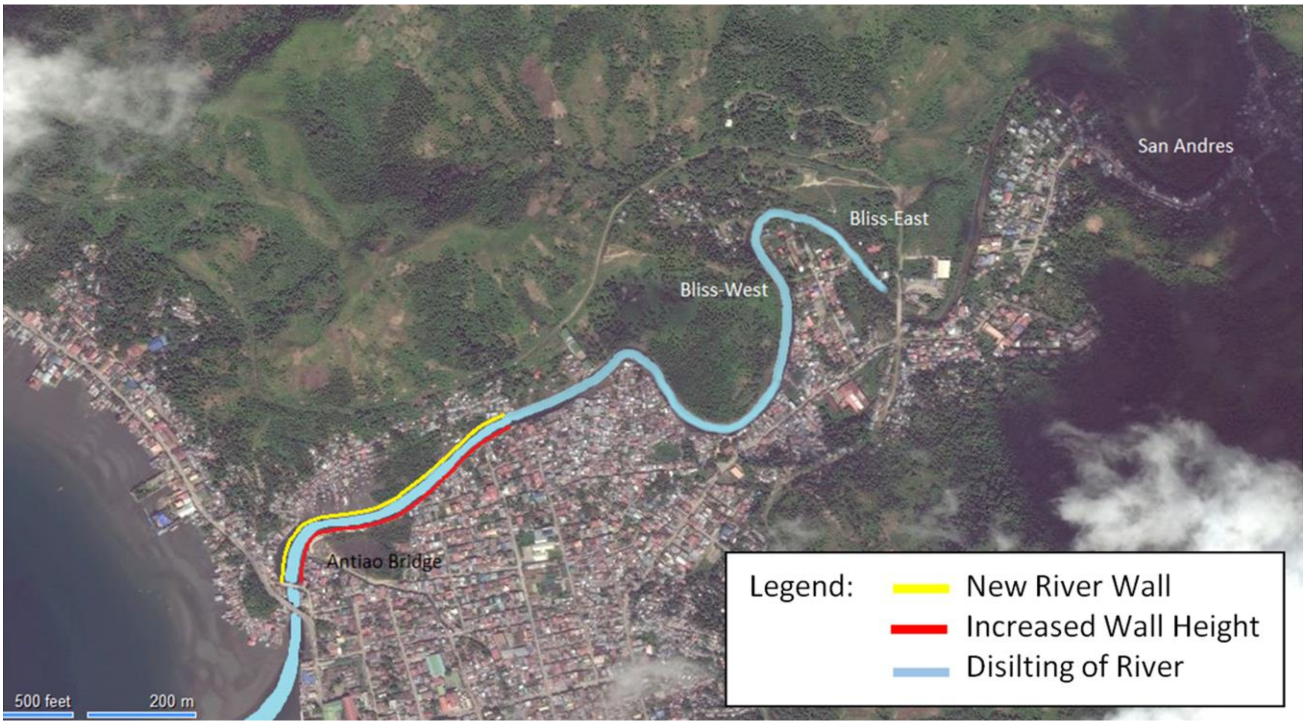


Figure 12. The Antiao River Control Project

upstream section of the river and the perennial flood at the mid and downstream section of the river floodplain as well as the perimeters of Antiao Creek (www.pertconsult.com.ph). On February 14, 2014, Hi-Tone Construction started construction of the project named Construction/Rehabilitation of Antiao River Control, Catbalogan City, Samar under the supervision of the Department of Public Works and Highways-Regional Office No. 8. It is a PHP 75 million project. It includes construction of 554 meters concrete revetment wall on concrete sheet pile foundation and disilting of 1,940 meters (380 m downstream, 1,560 m upstream) of the river (www.dpwh.com.ph). Figure 12 shows the location and the scope of the Antiao River Control Project.

3.5 Post Construction Risk Assessment of the flood control project.

The Antiao River Control Project was implemented to manage river swelling that leads to flooding and river bank erosion (www.pertconsult.com.ph). Flooding is the more destructive of the two was the subjected to risk analysis. Flooding occurred when the water usually from a heavy precipitation resulted in high surface runoff which exceeded river capacity. The risk assessment was based on the simulated discharge values from an extreme event which occurred in the past five years and compared it to the capacity of the river.

Table 1 summarizes the comparison of capacities before and after the project has been completed. The calculated capacity was then compared to the simulated volume of water due to an extreme event, specifically December 2014. Before the implementation of the river control project in February 2014, the river near the old Antiao Bridge can carry the discharge of about 72.49 m3/s while the construction of the river walls will increase its capacity to 226.57 m3/s which are 212% higher than without the project. The December 2014 extreme events produced about 53.1 m3/s which are 26.7% lower compared to the capacity of the

ISSN 2449-4577 (online) 2408-283X (print)

Table 5: River Flow Characteristics of Antiao River near Antiao Bridge (Coordinates)

River Flow Parameters	Before Flood Control Project	After Flood Control Project
Cross sectional area (m2)	57.24	117.68
Wetted Perimeter (m)	32.37	35.5
Slope (linear head loss)	0.0012	0.0012
Coefficient of roughness	0.04	0.04
Calculated River Capacity		
Flow Velocity (m/s)	1.26	1.93
Discharge (m3/s)	72.49	226.57
Simulated Discharge (December 2014 Scenario)		
Discharge (m3/s)	53.1	53.1
Percent difference	-26.7	-76.7

Table 6: Flow Characteristics of Antiao River in the Upstream

River Flow Parameters	East Side-Bliss		West Side-Bliss		Brgy San Andress
	Before Disilting	After Disilting	Before Disilting	After Disilting	(no disilting)
Cross sectional area (m2)	15.6	31.28	6.73	20.74	4.38
Wetted Perimeter (m)	25.7	25.9	19.15	19.9	12.45
Slope (linear head loss)	0.0009	0.0009	0.0009	0.0009	0.0006
Coefficient of roughness	0.04	0.04	0.04	0.04	0.04
Calculated River Capacity					
Flow Velocity (m/s)	1.26	0.85	0.37	0.77	0.31
Discharge (m3/s)	19.7	26.61	2.5	15.99	1.34
Simulated Discharge (December 2014 Scenario)					
Discharge (m3/s)	50.1	50.1	50.1	50.1	45.4
Percent difference	+154.3	+88.3	+1904	+213.3	+328.8

river. This means that even without the project, flooding due to the swelling of the river in this section from a hydrologic event similar to December 2014 will not happen. On the other hand when storm or events with violent precipitation increase flooding significantly increase (www.noaa.gov).

The Antiao River Control Project includes disilting activity almost 2km from the mouth of the River to the upstream section as shown in figure 12. River capacity in the vicinity of Bliss Community was analyzed with and without the disilting activity. Bliss community is bounded on the east and west by the Antiao River. The river in the vicinity of San Andress will not receive any intervention from this project. River capacity on the west side of the Bliss community and Barangay San Andres can only carry 19.7, 2.5 and 1.34 m3/s of flowing water. These values are way too low to carry events like those experienced in December 2014. The river along the west side of Bliss community is 1904% higher than what it can carry.

The river control project includes disilting almost 2 km of the Antiao River. This disiltaing activity is from the mouth of the river to the rear or west side of the Bliss Community. This disilting increased the carrying capacity of the river but is still not enough to carry flood waters from extreme events such as the December 2014 storms. Based on the model, flood height has reached between 1 to 2 meters from the river bank normal water level. Based on interviews conducted, water even was higher than 2m as it submerges several houses by more than 3m.

IV. CONCLUSIONS

Catbalogan Samar in the past decade has experienced perennial flooding primarily due to extreme rainfall events usually occurring during a storm. In the past five years, Catbalogan has experienced more than half of the total number of months having precipitation larger than the 30 years normal.

Based on the simulation, the river on the upstream part specifically along the vicinity of Bliss Community and San Andres in Catbalogan City cannot carry surface runoff from an extreme precipitation event. On the other hand, the river in its natural state near the Antiao Bridge is more than enough to carry precipitation as high as that which was experienced in December 2014.

The Antiao River Project near the Antiao Bridge has increased the capacity, but the same was not needed. On the other hand, disilting activity along Bliss Community will not solve the risk of flooding from extreme events. The walls constructed narrows the width of the river, therefore, an increase in water level is expected. This, in turn, may cause upstream water to increase. This possibility needs to be examined thoroughly.

Heavy siltation is expected during an extreme precipitation event which reduces river carrying capacity. The disilting activity must regularly be made, at least ever after every extreme precipitation events. Soil erosion in the watershed needs to be addressed to reduce siltation and avoid clogging of the river.

The river control project should have been implemented on the upstream side of the Antiao River and not near the mouth. To minimize the risk of flooding in the upstream side construction of river wall needs to be extended up to Barangay San Andres.

REFERENCES

Asian Disaster Preparedness Center (ADPC), Citizen-Based & Development-Oriented Disaster Response, http://www.adpc.net/pdr-sea/cbdo-dr/chapter1.html Accessed 2/5/14

Associated Program on Flood Management (2012), Integrated Flood Management Tools Series: Urban Flood Management in a Changing Climate, February 2012, http://www.apfm.info/publications/tools/APFM_Tool_14.pdf, Accessed 2/1/14

Congress of Soil Solutions for Chnaging World, Brisbane, Australia. http://www.ldd.go.th/swcst/Report/soil/symposium/pdf/0481.pdf Accessed 2/2/2015

Department of Public Works and Highways (DPWH a), Infrastructure Projects – Region 8, 2015, http://www.dpwh.gov.ph/infrastructure/pms/08.asp Accessed 3/11/15

Department of Public Works and Highways (DPWH b), Annual Procurement Plan CY 2014, http://www.dpwh.gov.ph/post/cw/pdf/cw/notice/14/july/Annual%20Procurement%20Plan%202014%20%2814IO0001%20-%2014IO0020%29.pdf, Accessed 2/14/2015.

ISSN 2449-4577 (online) 2408-283X (print)

Dorothy Carroll and John C. Hathaway, Clay Minerals in Limestone Profile, undated http://www.clays.org/journal/archive/volume%202/2-1-171.pdf Accessed 2/2/15

Flood Control International, River Flooding- Strategies for Flood Defences, http://www.floodcontrolinternational.com/CASE-STUDIES/river-flooding.html Accessed 3/1/2015

Food and Agriculture Organization of the United Nation (FAO), Soil Permeability, ftp://ftp.fao.org/fi/CDrom/FAO_Training/FAO_Training/General/x6706e/x6706e09.htm, Accessed 1/2/2015

Gomba F., R. Orale, R Uy (2007), Stochastic Process Applied to Catbalogan Water Supply Resource Planning, http://www.nscb.gov.ph/ncs/10thNCS/papers/invited%20papers/ips-13/ips13-01.pdf Accessed 1/2/2015

Jagdale Satyawan Dagdu & Nimbalkar P.T., (2012) Infiltration Studies of Different Soils Under Different Soil Conditions and Comparison of Infiltration Models with Field Data, International Journal of Advanced Engineering Technology Vol. 3 Issue 2.

Hydrologic Engineering Center-Hydrologic Modelling System (HEC-HMS), US Army Corps of Engineers, http://www.hec.usace.army.mil/software/hec-hms/ Accessed 12/30/14

Lagmay, Alfredo M, (undated) Lessons from Rescent Philippine Disasters. Leyte Samar Daily Express (2014), Over P1.6 billion worth of infra projects in EV delayed completion-DPWH, http://www.leytesamardailynews.com/over-p1-6-billion-worth-of-infra-projects-in-ev-delayed-completion-dpwh/ Accessed 1/2/2015

National Oceanic and Atmospheric Administration, Storm Surge and Coastal Inundation, http://www.stormsurge.noaa.gov/overview_causes.html, Accessed 2/2/15

Natural Resources Management and Environment Department, Food and Agriculture Organization (FAO), http://www.fao.org/docrep/r4082e/r4082e05.htm. Accessed 3/12/2014

Nick Wiltgen (2014), Tropical Storm Jangmi (Seniang) Brings Flooding, Landslides to Philippines; 54 Dead, 260,000 Affected By Storm, http://www.weather.com/storms/typhoon/news/tropical-storm-seniang-philippines-jangmi-flooding Accessed 2/10/2015

PERT Consult, Catbalogan Flood Management, http://pertconsult.com.ph/catbalogan-flood-management/ Accessed 3/31/2015.

Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAG-ASA). Climatological Normals. http://pagasa.dost.gov.ph/index.php/climate/climatological-normals Accessed 3/12/15

Porcil, Josefina T. (2009), The Philippine Disaster Management System, http://www.adrc.asia/aboutus/vrdata/countryreport/josefina2009_cr.pdf Accessed 2/12/2014

Quirante Nimfa F. (2009), Philippines: DENR bares causes of flashflood in Samar capital, seeks solutions with leaders, http://reliefweb.int/report/philippines/philippines-denr-bares-causes-flashflood-samar-capital-seeks-solutions-leaders Accessed 2/13/2014

The Encyclopedia of the Earth, Climate Change (November, 2014), http://www.eoearth.org/view/article/151215/ Accessed 2/1/14

The James Hutton Institute (JHI), Clay and Minerals – Shale http://www.claysandminerals.com/materials/shales, Accessed 2/2/2015

US Department of Agriculture (USDA), Urban Hydrology for Small Watershed, 1986, http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb1044171.pdf Accessed 1/12/2015

US Department of Transportation, Guide for Selecting Manning's Roughness Coefficients for Natural Channels and Flood Plains, United States Geological Survey Water supply Paper 2339 http://www.fhwa.dot.gov/BRIDGE/wsp2339.pdf Accessed 3/12/2015

US Environmental Protection Agency (EPA), Stormwater runoff & impervious surfaces, http://www.epa.gov/caddis/ssr_urb_is1.html Accessed 2/5/14 Accessed 1/2/2015

US Geological Survey (USGS), Porosity, Permeability and Groundwater, http://online.wr.usgs.gov/outreach/landpeople/students/cc_ppg.html Accessed 1/2/2015

Zbigniew Zagorski (2010), Clay minerals as indicators of the soil substrate origin of Rendzinas (Rendzic Leptosols) from the Małopolska Upland (S Poland), Paper presented during the 2010 19th World