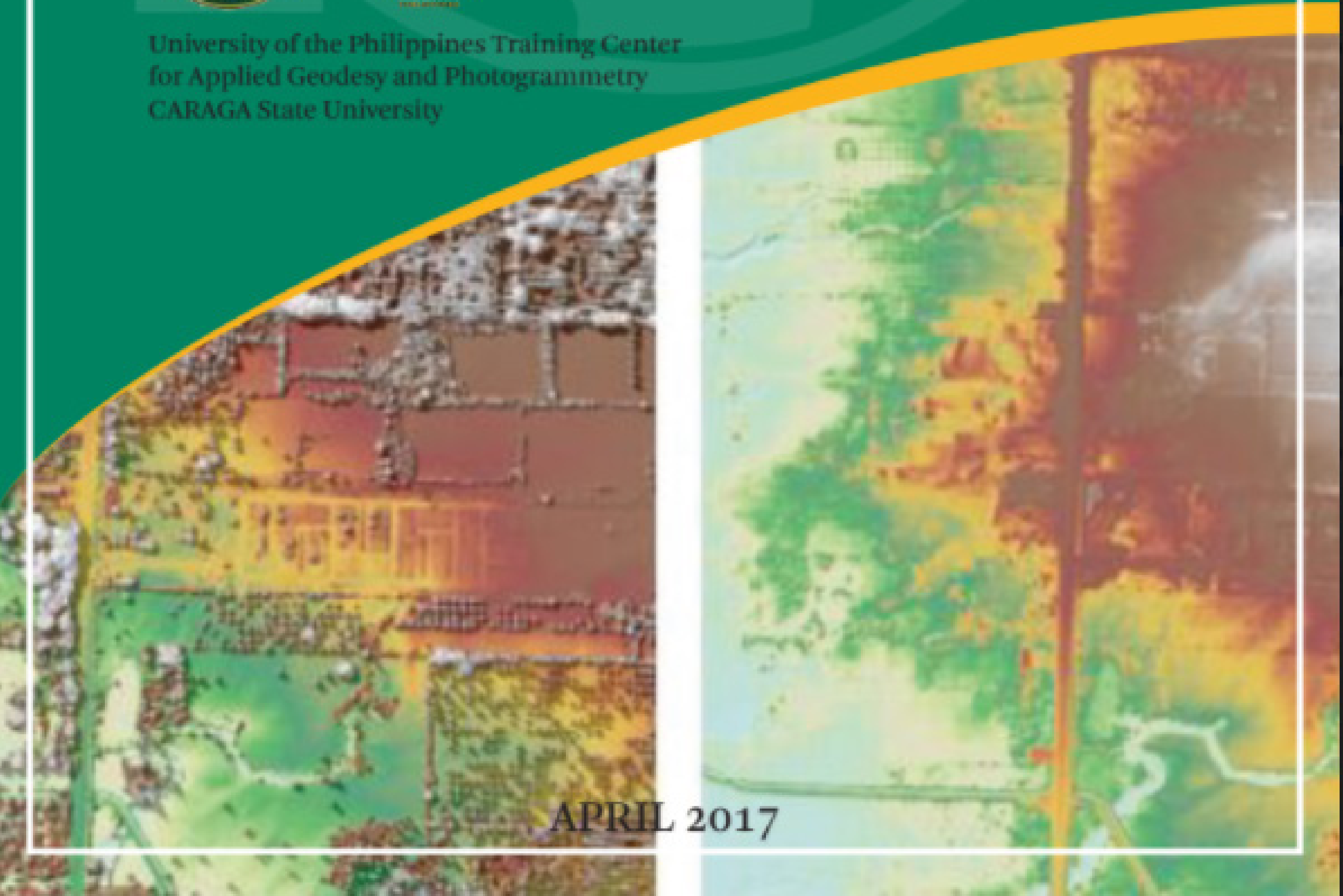
HAZARD MAPPING OF THE PHILIPPINES USING LIDAR (PHIL-LIDAR 1)

LiDAR Surveys and Flood Mapping of Mainit-Tubay River

University of the Philippines Training Center for Applied Geodesy and Photogrammetry
CARAGA State University



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LIST OF ACRONYMS AND ABBREVIATIONS

AAC	Asian Aerospace Corporation
Ab	abutment
ALTM	Airborne LiDAR Terrain Mapper
ARG	automatic rain gauge
ATQ	Antique
AWLS	Automated Water Level Sensor
BA	Bridge Approach
BM	benchmark
CAD	Computer-Aided Design
CN	Curve Number
CSRS	Chief Science Research Specialist
CSU	Caraga State University
DAC	Data Acquisition Component
DEM	Digital Elevation Model
DENR	Department of Environment and Natural Resources
DOST	Department of Science and Technology
DPPC	Data Pre-Processing Component
DREAM	Disaster Risk and Exposure Assessment for Mitigation [Program]
DRRM	Disaster Risk Reduction and Management
DSM	Digital Surface Model
DTM	Digital Terrain Model
DVBC	Data Validation and Bathymetry Component
FMC	Flood Modeling Component
FOV	Field of View
GiA	Grants-in-Aid
GCP	Ground Control Point
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
HEC-HMS	Hydrologic Engineering Center - Hydrologic Modeling System
HEC-RAS	Hydrologic Engineering Center - River Analysis System
HC	High Chord
IDW	Inverse Distance Weighted [interpolation method]
IMU	Inertial Measurement Unit
kts	knots
LAS	LiDAR Data Exchange File format
LC	Low Chord
LGU	local government unit
LiDAR	Light Detection and Ranging
LMS	LiDAR Mapping Suite
m AGL	meters Above Ground Level
MMS	Mobile Mapping Suite
MSL	mean sea level
NAMRIA	National Mapping and Resource Information Authority
NSTC	Northern Subtropical Convergence
PAF	Philippine Air Force
PAGASA	Philippine Atmospheric Geophysical and Astronomical Services Administration
PDOP	Positional Dilution of Precision
PPK	Post-Processed Kinematic [technique]
PRF	Pulse Repetition Frequency
PTM	Philippine Transverse Mercator
QC	Quality Check
QT	Quick Terrain [Modeler]
RA	Research Associate
RIDF	Rainfall-Intensity-Duration-Frequency
RMSE	Root Mean Square Error
SAR	Synthetic Aperture Radar
SCS	Soil Conservation Service
SRTM	Shuttle Radar Topography Mission
SRS	Science Research Specialist
SSG	Special Service Group
TBC	Thermal Barrier Coatings
VSU	Visayas State University
UP-TCAGP	University of the Philippines – Training Center for Applied Geodesy and Photogrammetry
UTM	Universal Transverse Mercator
WGS	World Geodetic System

CHAPTER 1: OVERVIEW OF THE PROGRAM AND MAINIT-TUBAY RIVER

Enrico C. Paringit, Dr. Eng. and Engr. Meriam M. Santillan

1.1 Background of the Phil-LiDAR 1 Program

The University of the Philippines Training Center for Applied Geodesy and Photogrammetry (UP-TCAGP) launched a research program entitled "Nationwide Hazard Mapping using LiDAR" or Phil-LiDAR 1, supported by the Department of Science and Technology (DOST) Grants-in-Aid (GiA) Program. The program was primarily aimed at acquiring a national elevation and resource dataset at sufficient resolution to produce information necessary to support the different phases of disaster management. Particularly, it targeted to operationalize the development of flood hazard models that would produce updated and detailed flood hazard maps for the major river systems in the country.

Also, the program was aimed at producing an up-to-date and detailed national elevation dataset suitable for 1:5,000 scale mapping, with 50 cm and 20 cm horizontal and vertical accuracies, respectively. These accuracies were achieved through the use of the state-of-the-art Light Detection and Ranging (LiDAR) airborne technology procured by the project through DOST.

The methods applied in this report are thoroughly described in a separate publication entitled "FLOOD MAPPING OF RIVERS IN THE PHILIPPINES USING AIRBORNE LiDAR: METHODS" (Paringit, et. Al. 2017).
The implementing partner university for the Phil-LiDAR 1 Program is the Caraga State University (CSU). CSU is in charge of processing LiDAR data and conducting data validation reconnaissance, cross section, bathymetric survey, validation, river flow measurements, flood height and extent data gathering, flood modeling, and flood map generation for the 11 river basins in the Caraga Region. The university is located in Butuan City in the province of Agusan del Norte.

1.2 Overview of the Mainit-Tubay River Basin

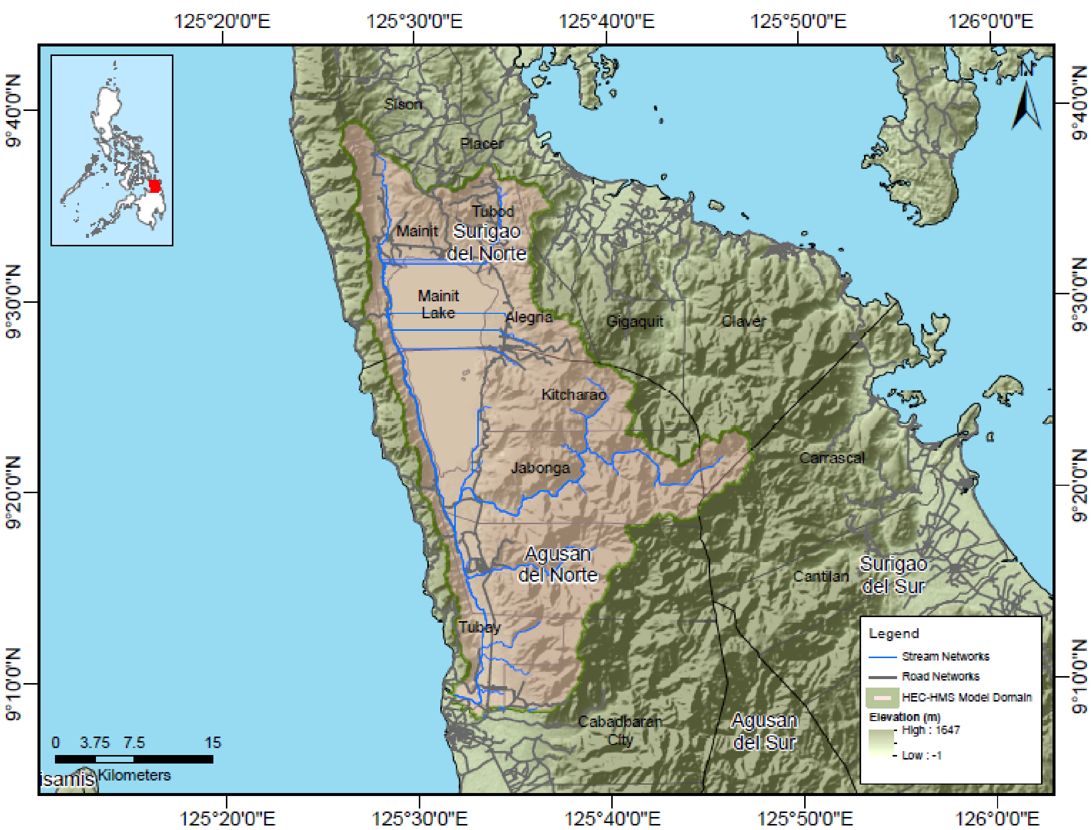

Figure 1. Map of the Mainit-Tubay River Basin (in brown)

Mainit-Tubay River Basin is located in Caraga Region, Mindanao. It covers the municipalities of Kitcharao, Jabonga, Santiago and Tubay of the province of Agusan del Norte and the municipalities of Mainit, Tubod and Alegria in Surigao del Norte. The basins location is between 125^{0}31' to 125^{0}46' East longitude and 9^{0}39' to 9^{0}7' North latitude. Mainit-Tubay river basins' estimated drainage area is 997 square kilometers and is approximately 59 kilometers long and about 34 kilometers in width.

The river basin includes Lake Mainit, the deepest lake in the Philippines, with an approximate surface area of 150 square kilometers[1] and an approximate maximum depth of 223 meters[2]. The lake served as a reservoir of the river basin. Kalinawan River is the principal drainageway of the basin. It originates at the outlet of Lake Mainit in Barangay Poblacion, Municipality of Jabonga, Agusan del Norte, which has three major tributary rivers, the Puyo, Asiga and Sta. Ana, all traced at the eastern portion of the basin, and intersects the northeast and southeast portion of the Kalinawan River. Puyo River meets Kalinawan River at a junction near Barangay Colorado, Municipality of Jabonga, just approximately 4.5 kilometers from the outlet of Lake Mainit. At about 5.7 kilometers from this junction, Asiga River intersects Kalinawan River at Barangay Curva, Municipality of Santiago and from this joint, the third junction can be observed at a distance of approximately 7.9 kilometers in Barangay Sta. Ana, Municipality of Tubay. The Kalinawan River discharges at Butuan Bay in Barangay Poblacion, Municipality of Tubay. Its whole river channel is wide and deep enough to be navigated by boat, though there is a portion of the river where rapid waters could be experienced.

Mainit-Tubay River Basin has a type II and IV climates. Type II is characterized by no dry season with a very pronounced maximum rain period from December to February and type IV is characterized by an evenly distribution of rainfall throughout the year and is very similar to the type II since it also has no definite dry season[3]. Since the basin is located in the Eastern Coast of the Agusan del Norte Province its climate is greatly affected by seasonal winds that pass through it.

The highest point within the basin is 1,823 meters above mean sea level and is located along the mountains of Barangay Libas, Municipality of Jabonga, Agusan del Norte[4]. Based on the Digital Soil Map of the Philippines published by the Bureau of Soil and Water Management-Department of Agriculture, silt-loam is the most abundant soil type within the basin which accounts for 73.6% of its land area. The land cover type that dominates the basin is brush land which covers an approximate area of 384 square kilometers or 38% of the basins' land area leaving only 0.27% to the built-up areas.

Covering a number of municipalities, the communities are consistently scattered throughout the basin. According to the Census of Population and Housing of Philippine Statistics Authority, the total population of the seven municipalities within the basin is 135, 295 with 22% of its people reside at every municipality's Poblacion or the towns' center of trade and industry[5]. The economic condition of the basin is anchored on agricultural and agro-industrial activities along with the people's sources of living such as crop, rice, coconut, mango, corn, palm oil, banana, prawns, milkfish, crabs and seaweeds production. The basin's economy is also affected by mining sectors which produces mineral deposits such as iron, gold, silver, nickel, chromite, manganese and copper[6], particularly in the municipalities of Santiago, Tubay and Jabonga[7]. The basin's proximity to major cities in the country makes it a favorable shipping socket for its products to and from the markets. The local language of Mainit-Tubay is Cebuano; however in some portions of Agusan del Norte and Surigao del Norte, the Mamanwa and Surigaonon dialects are also used[8].

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1 Tumanda, M. I., Jr., E. R., Gorospe, J. G., Daita, M. T., Dejarme, S. M., & Gaid, R. D. (2003). Limnological and Water Quality Assessment of Lake Mainit. Retrieved July 4, 2017, from http://lib.mainit.org/30/1/lake-mainit-project-terminal-report.pdf

2 Lewis, W. M., Jr. (1973). A limnological survey of Lake Mainit, Philippines. Internationale Revue der gesamtenHydrobiologie und Hydrographie, 58(6), 801-818. doi:10.1002/iroh.19730580603

3 Bareja, B. G. (2011, January). Climate Types, Rainfall and Typhoons in the Philippines. Retrieved June 29, 2017, from http://www.cropsreview.com/climate-types.html

4 NAMRIA. (n.d.). Retrieved June 29, 2017, from http://www.namria.gov.ph/topo50Index.aspx

5 Total Population by Province, City, Municipality and Barangay: as of May 1, 2010. (n.d.). Retrieved June 28, 2017, from https://psa.gov.ph/sites/default/files/attachments/hsd/pressrelease/Caraga.pdf

6 DTI Caraga. (n.d.). PROFILE OF CARAGA. Retrieved June 29, 2017, from http://www.dti.gov.ph/regions/caraga/caraga-profile-of-region

7 Hilario, B. (n.d.). Nature Exploitation and protection in Mindanao: Saving Biodiversity. Retrieved June 28, 2017, from http://www.socialwatch.org/sites/default/files/pdf/en/biodiversity2005_phi.pdf

8 Philippines. (n.d.). Retrieved June 29, 2017, from https://www.ethnologue.com/country/ph/languages

The basin has a vast diversity of ecosystem however it is threatened by the indiscriminate cutting of mangroves for firewood and clearing of fishponds and prawn farms in Tubay, Agusan del Norte and the dumping of mining wastes in the rivers of Surigao del Norte[5].

For the past years, the river basin suffered from consistent visits of storms and typhoons such as Typhoon “Ruby” in December 2014 that affected the municipalities of Jabonga, Kitcharao and Tubay in Agusan del Norte and Alegria, Mainit and Tubod in Surigao del Norte as it moves West Northwest at 10 kilometers per hour towards Eastern Samar[9] and just last January 2017, the river basin also experienced the tough effects of the Low Pressure Area and Tail-End of a Cold Front which brought light to moderate rains and isolated thunderstorms over the rest of Mindanao area[10].

9 NDRRMC Update, Final Report, re: Effects of Typhoon “Ruby” http://www.ndrrmc.gov.ph/attachments/article/1356/FINAL_REPORT_re_Effects_of_Typhoon_RUBY_(HAGUPIT)_04_-_10DEC2014.pdf

10 NDRRMC Update, Effects of Low Pressure and Tail-End of a Cold Front in Visayas and Mindanao including Southern Luzon http://www.ndrrmc.gov.ph/attachments/article/3001/Sitrep_No_07_re_effects_of_tail_end_of_a_cold_front_and_low_pressure_area_(LPA)_issued_on_22JAN2017_@0800AM.pdf

CHAPTER 2: LIDAR DATA ACQUISITION OF THE MAINIT-TUBAY FLOODPLAIN

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The methods applied in this Chapter were based on the DREAM methods manual (Sarmiento, et al., 2014) and further enhanced and updated in Paringit, et al. (2017).

2.1 Flight Plans

Plans were made to acquire LiDAR data within the delineated priority area for Mainit-Tubay (Asiga) floodplain in Surigao del Norte. Each flight mission has an average of 12 lines and ran for at most four and a half (4.5) hours including take-off, landing and turning time. The flight planning parameter for the LiDAR system is found in Table 1. Figure 2 shows the flight plan for Mainit-Tubay (Asiga) floodplain.

Table 1. Flight planning parameters for the Aquarius LiDAR system.

Block Name	Flying Height (m AGL)	Overlap (%)	Field of view (ø)	Pulse Repetition Frequency (PRF) (kHz)	Scan Frequency (Hz)	Average Speed (kts)	Average Turn Time (Minutes)
AGUS	600	30	18	50	45	130	5
AGU1A	600	30	18	50	45	130	5
AGU1B	600	30	18	50	45	130	5

Table 2. Flight planning parameters for the Gemini LiDAR system.

Block Name	Flying Height (m AGL)	Overlap (%)	Field of view (ø)	Pulse Repetition Frequency (PRF) (kHz)	Scan Frequency (Hz)	Average Speed (kts)	Average Turn Time (Minutes)
BLK59A	800	30	50	125	40	130	5
BLK59B	800	30	50	125	40	130	5
BLK59C	800	30	50	125	40	130	5
BLK59D	800	30	50	125	40	130	5
BLK60D	800	30	50	125	40	130	5

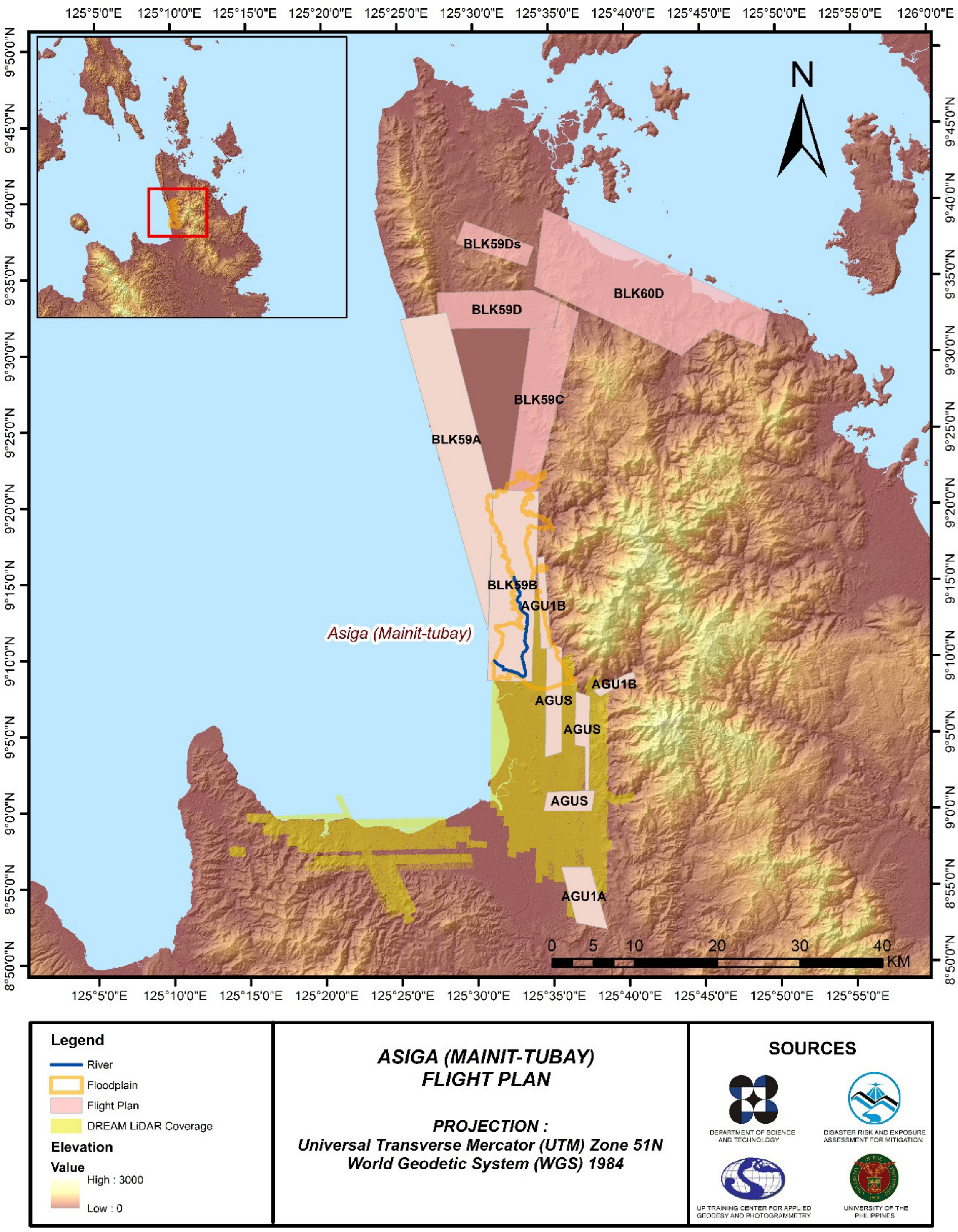

Figure 2. Flight plans used for Mainit-Tubay (Asiga) Floodplain Survey

2.2 Ground Base Stations

The project team was able to recover six (6) NAMRIA ground control points: SRN-119 and SRN-102, which are of second (2nd) order accuracy, and AGN-3026, AGN-3074, AGN-3075, and AGN-3740, which are of fourth (4th) order accuracy. Coordinates of AGN-3026 and AGN-3740 were re-processed to obtain first (1st) order GCPs. The certifications for the NAMRIA reference points are found in Annex 2 while the baseline processing reports are found in Annex 3. These were used as base stations during flight operations for the entire duration of the survey (June 2 to 8, 2014, and June 20 to 22, 2014). Base stations were observed using dual frequency GPS receivers, TRIMBLE SPS 882, SPS852, and SPS985. Flight plans and location of base stations used during the aerial LiDAR acquisition in Mainit-Tubay (Asiga) floodplain are shown in Figure 3.

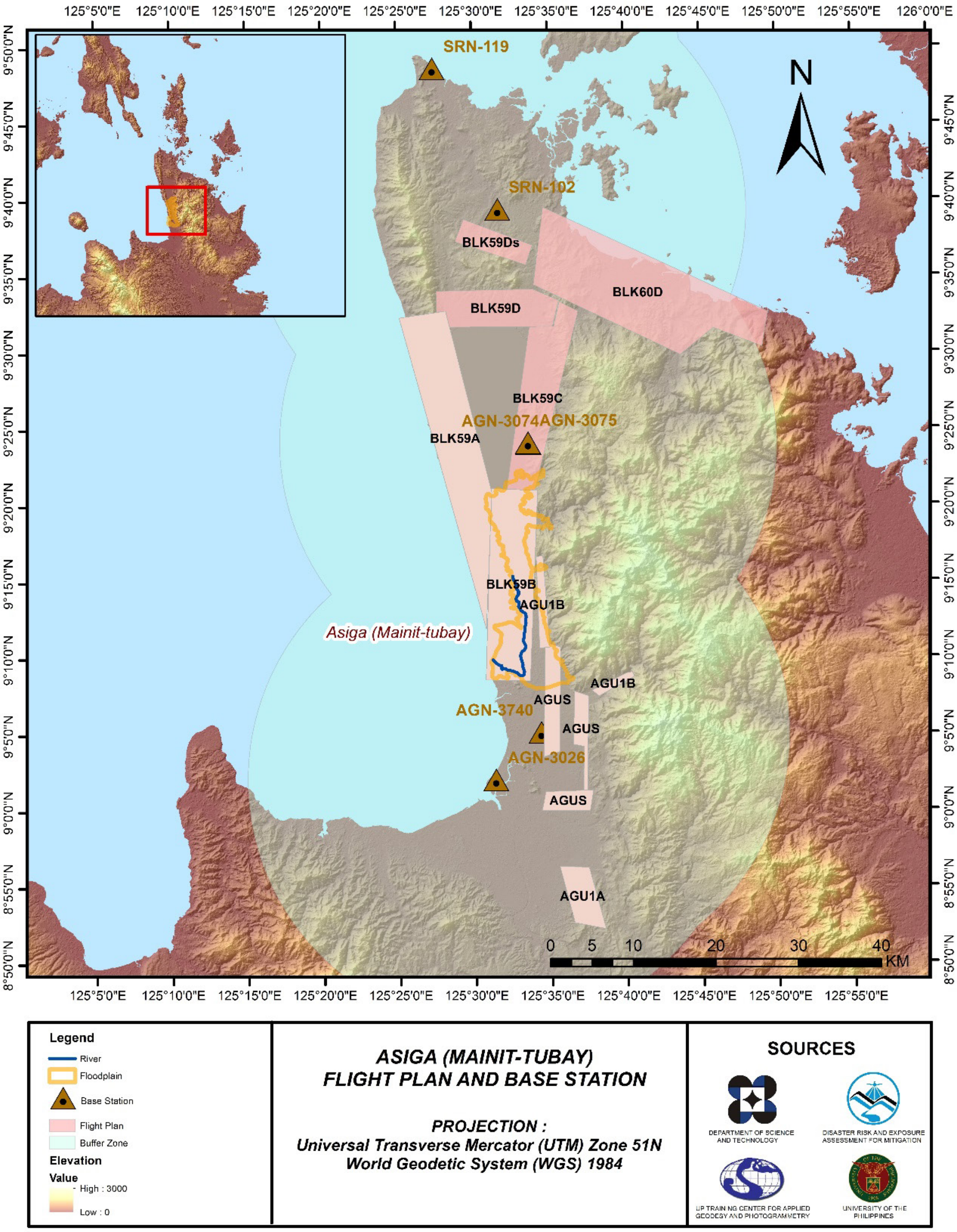

Figure 3. Flight plans and base stations for Mainit-Tubay (Asiga) floodplain

Figure 4 to 9 show the recovered NAMRIA reference points within the area. In addition, Table 3 to Table 8 show the details about the following NAMRIA control stations while Table 9 shows the list of all ground control points occupied during the acquisition together with the corresponding dates of utilization.

(a) (b)

Figure 4. GPS set-up over SRN-119 Kilometer Post 1114 along the National Highway at Surigao City, Surigao Del Norte (a) and NAMRIA reference point SRN-119 (b) as recovered by the field team

Table 3. Details of the recovered NAMRIA horizontal control point SRN-119 used as base station for the LiDAR acquisition

Station Name	**SRN-119**	
Order of Accuracy	**2nd**	
Relative Error (Horizontal positioning)	**1:50,000**	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude Longitude Ellipsoidal Height	9° 48' 39.52825" North 125° 27' 19.47825" East 26.179 meters
Grid Coordinates, Philippine Transverse Mercator Zone 5 (PTM Zone 5 PRS 92)	Easting Northing	549958.116 meters 1084859.315 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude Longitude Ellipsoidal Height	9° 48' 35.66803" North 125° 27' 24.75607" East 92.905 meters
Grid Coordinates, Philippine Transverse Mercator Zone 51 North (UTM 51N PRS 1992)	Easting Northing	769495.998 meters 1085380.264 meters

(a) (b)

Figure 5. GPS set-up over AGN-3074 near the entrance gate of Jaliobong National High School at Kitcharao, Surigao del Norte (a) and NAMRIA reference point AGN-3074 (b) as recovered by the field team

Table 4. Details of the recovered NAMRIA horizontal control point AGN-3074 used as base station for the LiDAR acquisition

Station Name	**AGN-3074**	
Order of Accuracy	**4TH**	
Relative Error (Horizontal positioning)	**1:10,000**	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude Longitude Ellipsoidal Height	9° 24’ 4.13108” North 125° 33’ 31.76634” East 39.759 meters
Grid Coordinates, Philippine Transverse Mercator Zone 5 (PTM Zone 5 PRS 92)	Easting Northing	561376.548 meters 1039549.784 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude Longitude Ellipsoidal Height	9°24 ’0.38679” North 125°33’37.07966” East 107.652 meters
Grid Coordinates, Philippine Transverse Mercator Zone 51 North (UTM 51N PRS 1992)	Easting Northing	781185.928 meters 1040114.043 meters

(a) (b)

Figure 6. GPS set-up over AGN-3075 near the flagpole of Jaliobong Elementary School at Kitcharao, Surigao del Norte (a) and NAMRIA reference point AGN-3075 (b) as recovered by the field team

Table 5. Details of the recovered NAMRIA horizontal control point AGN-3075 used as base station for the LiDAR acquisition

Station Name	AGN-3075	
Order of Accuracy	**4th**	
Relative Error (horizontal positioning)	**1:10,000**	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude Longitude Ellipsoidal Height	9° 24’ 7.19957” North 125° 33’ 29.91739” East 38.994 meters
Grid Coordinates, Philippine Transverse Mercator Zone 5 (PTM Zone 5 PRS 92)	Easting Northing	561319.987 meters 1039643.962 meters
Geographic Coordinates,4 World Geodetic System 1984 Datum (WGS 84)	Latitude Longitude Ellipsoidal Height	9°24 ’3.45501” North 125° 33’ 35.23064” East 106.884 meters
Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N PRS 1992)	Easting Northing	781128.795 meters 1040207.949 meters

(a)

(b)

Figure 7. GPS set-up over AGN-3026 infront of Buhang National High School, Municipality of Magallanes, Surigao del Norte (a) and NAMRIA reference point AGN-3026 (b) as recovered by the field team

Table 6. Details of the recovered NAMRIA horizontal control point AGN-3026 used as base station for the LiDAR acquisition with re-processed coordinates

Station Name	**AGN-3026**	
Order of Accuracy	**1st**	
Relative Error (horizontal positioning)	**1 in 100,000**	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude Longitude Ellipsoidal Height	9°02'02.05467" North 125°31'15.59370" East 0.915 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude Longitude Ellipsoidal Height	9°01'58.40327" North 125°31'20.94031" East 69.513 meters
Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N PRS 1992)	Easting Northing	777,155.999 meters 999,495.498 meters

(a)

(b)

Figure 8. GPS set-up over AGN-3740 on the bridge at Barangay Sanghan, Asiga (mainit-tubay), Surigao del Norte (a) and NAMRIA reference point AGN-3740 (b) as recovered by the field team

Table 7. Details of the recovered NAMRIA horizontal control point AGN-3740 used as base station for the LiDAR acquisition with re-processed coordinates

Station Name	**AGN-3740**	
Order of Accuracy	**1st**	
Relative Error (horizontal positioning)	**1 in 100,000**	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude Longitude Ellipsoidal Height	9°05’07.75605” North 125°34’15.27340” East 10.495 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude Longitude Ellipsoidal Height	9°05’04.09554” North 125°34’20.61487” East 79.105 meters
Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N PRS 1992)	Easting Northing	782606.301 meters 1005241.953 meters

(a) (b)

Figure 9. GPS set-up over SRN-102 at the first approach of Patag Bridge (right side) located at the Municipality of Sison, Surigao Del Norte (a) and NAMRIA reference point SRN-102 (b) as recovered by the field team

Table 8. Details of the recovered NAMRIA horizontal control point SRN-102 used as base station for the LiDAR acquisition

Station Name	**SRN-102**	
Order of Accuracy	**2nd**	
Relative Error (horizontal positioning)	**1:50,000**	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude Longitude Ellipsoidal Height	9° 39’ 24.81730” North 125° 31’ 40.71501” East 35.047 meters
Grid Coordinates, Philippine Transverse Mercator Zone 5 (PTM Zone 5 PRS 92)	Easting Northing	557783.962 meters 1067892.026 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude Longitude Ellipsoidal Height	9° 39’ 21.00341” North 125° 31’ 40.71501” East 102.294 meters
Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N PRS 1992)	Easting Northing	777426.956 meters 1068387.750 meters

Table 9. Ground control points used during LiDAR data acquisition

Date Surveyed	Flight Number	Mission Name	Ground Control Points
June 20, 2014	1604A	3AGUS171A	AGN-3026, AGN-3740
June 22, 2014	1612A	3AGU1AB173A	AGN-3026
June 2, 2014	7286GC	2BLK59CD153A	SRN-102
June 3, 2014	7288GC	2BLK59C + BLK60D154A	SRN-102
June 6, 2014	7294GC	2BLK59AB157A	AGN-3074, AGN-3075, SRN-119
June 8, 2014	7298GC	2BLK59AB157A	AGN-3074, AGN-3075, SRN-119

2.3 Flight Missions

Three (3) missions under DREAM program covered around forty six (46) square kilometers (Table 10) within Asiga floodplain. Six (6) missions were conducted to Mainit-Tubay (Asiga)floodplain, for a total of twenty four hours and fifty four minutes (24+54) of flying hours for RP-C9122 and RP-C9322. All missions are acquired using the Aquarius and Gemini LiDAR systems. Table 11 shows the total area of actual coverage and the corresponding flying hours per mission while Table 12 presents the actual parameters used during the LiDAR data acquisition.

Table 10. Flight missions under DREAM program which covers Mainit-Tubay floodplain

Flight Number	Mission Name	Area Surveyed within Floodplain (km^2)
203P	1ASN1A118A	19.84
209P	1ASD122A	4.94
211P	1ASN1S123A	21064
TOTAL		46.42

Table 11. Flight missions for LiDAR data acquisition in Mainit-Tubay (Asiga) floodplain

Date Surveyed	Flight Number	Flight Plan Area (km^2)	Surveyed Area (km^2)	Area Surveyed within the River Systems (km^2)	Area Surveyed Outside the River Systems (km^2)	No. of Images (Frames)	Flying Hours	
							Hr	Min
June 20, 2014	1604A	52.34	84.02	10.84	73.17	909	4	17
June 22, 2014	1612A	41.03	58.23	8.32	49.91	641	4	23
June 2, 2014	7286GC	158.99	126.34	2.87	123.46	NA	3	47
June 3, 2014	7288GC	328.25	209.13	8.31	200.81	NA	4	23
June 6, 2014	7294GC	289.61	231.06	86.50	144.56	NA	4	29
June 8, 2014	7298GC	163.08	133.52	3.52	130.01	NA	3	35
TOTAL		1033.3	842.3	120.36	721.92	1550	24	54

Table 12. Actual parameters used during LiDAR data acquisition

Flight Number	Flying Height (m AGL)	Overlap (%)	Field of View (θ)	Pulse Repetition Frequency (kHz)	Scan Frequency (Hz)	Average Speed (Kts)	Average Turn Time (Minutes)
1604A	600	30	36	50	45	130	5
1612A	600	40, 50	36	50	45	130	5
7286GC	800	30	50	125	50	130	5
7288GC	800	30	50	125	50	130	5
7294GC	1100	30	40	100	20	130	5
7298GC	1100	30	40	100	20	130	5

2.4 Survey Coverage

Mainit-Tubay (Asiga) floodplain is located in the province of Surigao del Norte. The list of municipalities and cities surveyed, with at least one (1) square kilometer coverage, is shown in Table 13. The actual coverage of the LiDAR acquisition for Mainit-Tubay (Asiga) floodplain is presented in Figure 10.

Table 13. List of municipalities and cities surveyed during Mainit-Tubay floodplain LiDAR survey

Province	Municipality/ City	Area of Municipality/City (km²)	Total Area Surveyed (km²)	Percentage of Area Surveyed
Surigao del Norte	Mainit	114.07	72.19	63%
	Tubod	37.53	22.50	60%
	Alegria	79.04	44.96	57%
	Malimono	107.68	33.77	31%
	Mainit Lake	72.60	19.25	27%
	Bacuag	63.68	15051	24%
	Placer	88.79	20.85	23%
	Gigaquit	119.02	12.84	11%
	Claver	337.34	31.21	9%
	Sison	68.78	1.77	3%
	Tagana-An	81.99	1.24	2%
	Surigao City	240.67	2.71	1%
Agusan del Norte	Tubay	107.14	80.98	76%
	Mainit Lake	69.28	29.48	43%
	Jabonga	269.89	99.06	37%
	Kitcharao	122.41	26.99	22%
	Santiago	218.28	42.29	19%
	Remedios T. Romualdez	56.92	9.44	17%
	Cabadbaran City	343.91	54.84	16%
	Butuan City	670.69	58.68	9%
Total		3269.81	680.56	20.81%

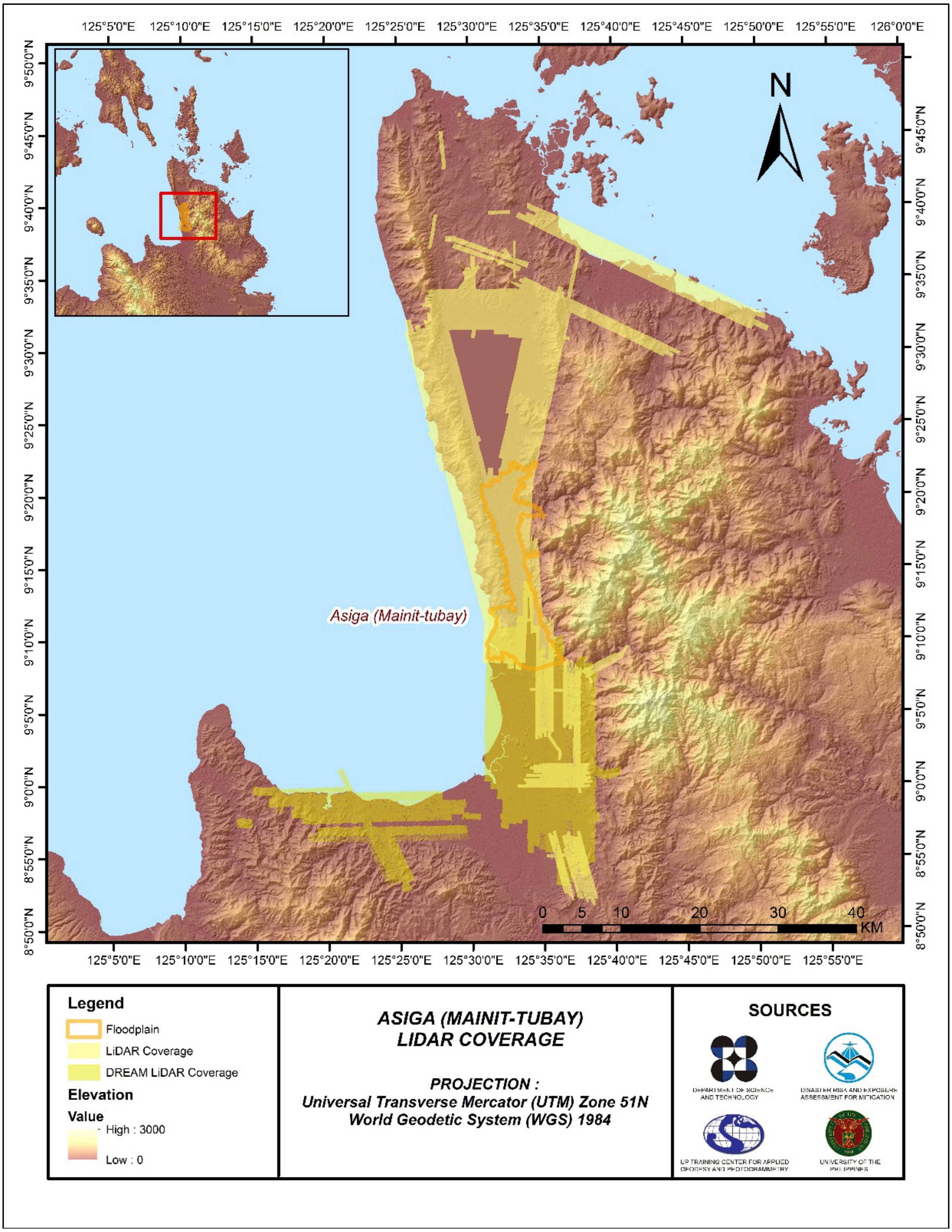

Figure 10. Actual LiDAR survey coverage for Mainit-Tubay (Asiga)floodplain

CHAPTER 3: LIDAR DATA PROCESSING FOR MAINIT-TUBAY FLOODPLAIN

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The methods applied in this Chapter were based on the DREAM methods manual (Sarmiento, et al., 2014) and further enhanced and updated in Paringit, et al. (2017).

3.1 Overview of the LiDAR Date Pre-Processing

The data transmitted by the Data Acquisition Component are checked for completeness based on the list of raw files required to proceed with the pre-processing of the LiDAR data. Upon acceptance of the LiDAR field data, georeferencing of the flight trajectory is done in order to obtain the exact location of the LiDAR sensor when the laser was shot. Point cloud georectification is performed to incorporate correct position and orientation for each point acquired. The georectified LiDAR point clouds are subject for quality checking to ensure that the required accuracies of the program, which are the minimum point density, vertical and horizontal accuracies, are met. The point clouds are then classified into various classes before generating Digital Elevation Models such as Digital Terrain Model and Digital Surface Model.

Using the elevation of points gathered in the field, the LiDAR-derived digital models are calibrated. Portions of the river that are barely penetrated by the LiDAR system are replaced by the actual river geometry measured from the field by the Data Validation and Bathymetry Component. LiDAR acquired temporally are then mosaicked to completely cover the target river systems in the Philippines. Orthorectification of images acquired simultaneously with the LiDAR data is done through the help of the georectified point clouds and the metadata containing the time the image was captured.

These processes are summarized in the flowchart shown in Figure 11.

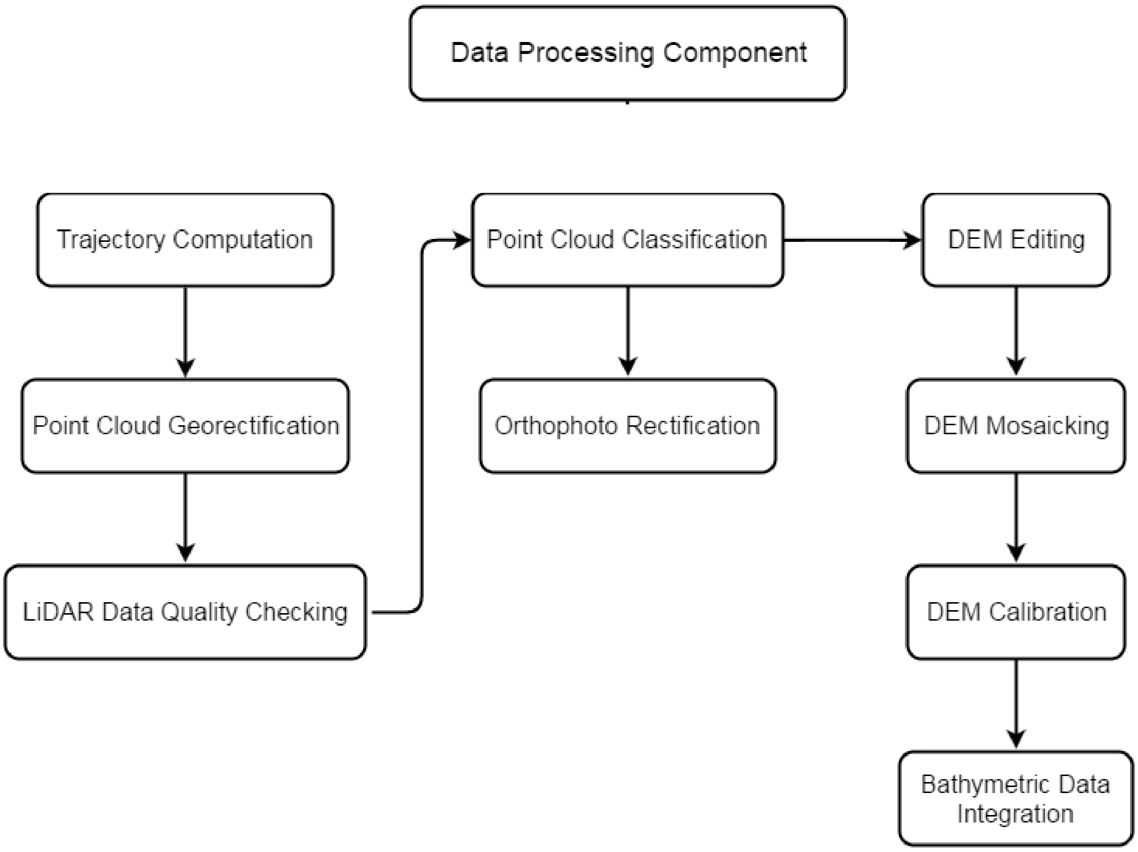


Figure 11.Schematic Diagram for Data Pre-Processing Component

3.2 Transmittal of Acquired LiDAR Data

Data transfer sheets for all the LiDAR missions for Mainit-Tubay floodplain can be found in Annex A-5. Missions flown during the first survey conducted on April 2013 used the Airborne LiDAR Terrain Mapper (ALTM™ Optech Inc.) Pegasus system while missions acquired during the second survey on May 2014 were flown using the Aquarius and Gemini system over Surigao and Agusan del Norte. The Data Acquisition Component (DAC) transferred a total of 172.18 Gigabytes of Range data, 2.41 Gigabytes of POS data, 157.49 Megabytes of GPS base station data, and 318.20 Gigabytes of raw image data to the data server on May 11, 2013 for the first survey and June 28, 2014 for the second survey. The Data Pre-processing Component (DPPC) verified the completeness of the transferred data. The whole dataset for Mainit-Tubay was fully transferred on July 3, 2014, as indicated on the Data Transfer Sheets for Mainit-Tubay floodplain.

3.3 Trajectory Computation

The Smoothed Performance Metric parameters of the computed trajectory for flight 1604A, one of the Mainit-Tubay flights, which is the North, East, and Down position RMSE values are shown in Figure 12. The x-axis corresponds to the time of flight, which is measured by the number of seconds from the midnight of the start of the GPS week, which on that week fell on June 20, 2014 00:00AM. The y-axis is the RMSE value for that particular position.

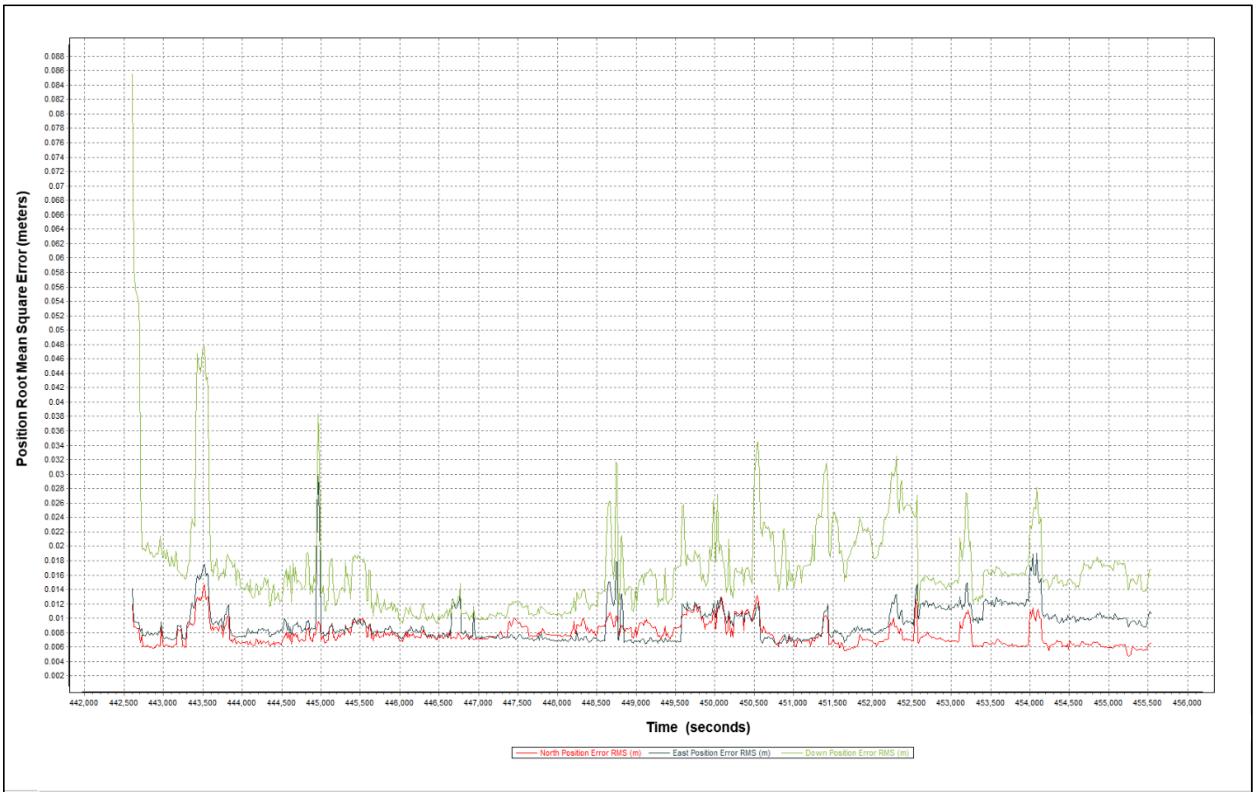


Figure 12. Smoothed Performance Metric Parameters of a Mainit-Tubay Flight 1604A

The time of flight was from 442,500 seconds to 455,500 seconds, which corresponds to morning of June 20, 2014. The initial spike that is seen on the data corresponds to the time that the aircraft was getting into position to start the acquisition, and the POS system starts computing for the position and orientation of the aircraft. Redundant measurements from the POS system quickly minimized the RMSE value of the positions. The periodic increase in RMSE values from an otherwise smoothly curving RMSE values correspond to the turn-around period of the aircraft, when the aircraft makes a turn to start a new flight line. Figure 12 shows that the North position RMSE peaks at 1.40 centimeters, the East position RMSE peaks at 3.00 centimeters, and the Down position RMSE peaks at 4.80 centimeters, which are within the prescribed accuracies described in the methodology.

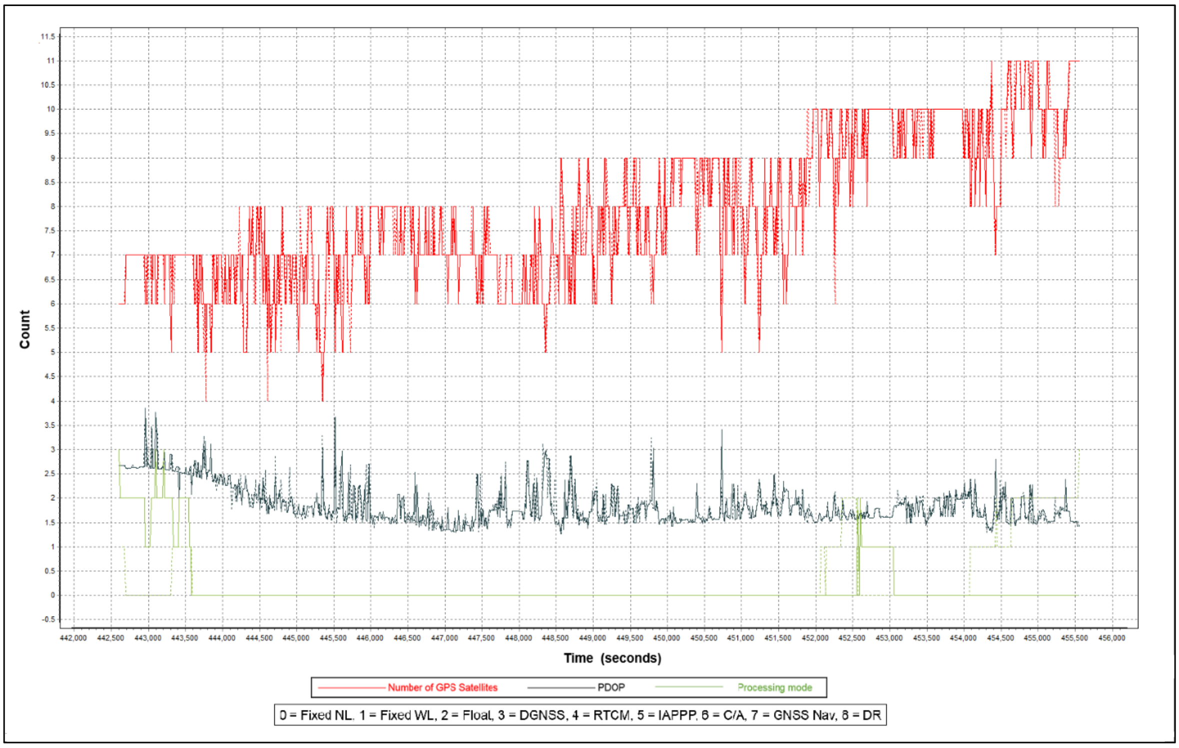


Figure 13. Solution Status Parameters of Mainit-Tubay Flight 1604A

The Solution Status parameters of flight 1604A, one of the Mainit-Tubay flights, which are the number of GPS satellites, Positional Dilution of Precision (PDOP), and the GPS processing mode used, are shown in Figure 13. The graphs indicate that the number of satellites during the acquisition did not go down to 6. Majority of the time, the number of satellites tracked was between 6 and 10. Majority of the PDOP value also did not go above the value of 3, which indicates optimal GPS geometry. The processing mode stayed at the value of 0 for majority of the survey with some peaks up to 1 attributed to the turns performed by the aircraft. The value of 0 corresponds to a Fixed, Narrow-Lane mode, which is the optimum carrier-cycle integer ambiguity resolution technique available for POSPAC MMS. All of the parameters adhered to the accuracy requirements for optimal trajectory solutions, as indicated in the methodology. The computed best estimated trajectory for all Mainit-Tubay flights is shown in Figure 14.

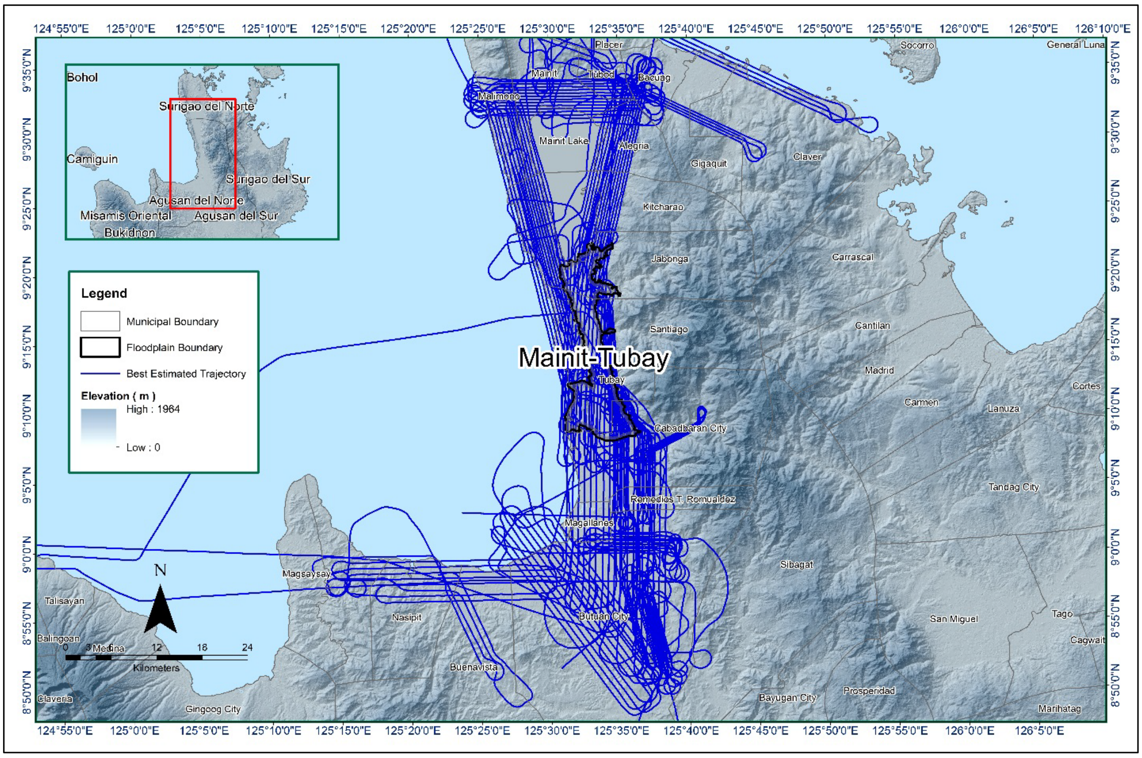


Figure 14. The best estimated trajectory of the LiDAR missions conducted over the Mainit-Tubay floodplain

3.4 LiDAR Point Cloud Computation

The produced LAS data contains 189 flight lines, with each flight line containing two channels for Pegasus system and one channel for both Gemini and Aquarius systems. The summary of the self-calibration results obtained from LiDAR processing in LiDAR Mapping Suite (LMS) software for all flights over Mainit-Tubay floodplain are given in Table 14.

Table 14. Self-Calibration Results values for Mainit-Tubay flights

Parameter	Acceptable Value	Value
Boresight Correction stdev)	<0.001degrees	0.000646
IMU Attitude Correction Roll and Pitch Correction stdev)	<0.001degrees	0.006175
GPS Position Z-correction stdev)	<0.01meters	0.0025

The optimum accuracy values for all Mainit-Tubay flights were calculated based on the computed standard deviations of the corrections of the orientation parameters. Standard deviation values for individual blocks are available in the Annex B-1. Mission Summary Reports. No mission summary report annexes.

3.5 LiDAR Data Quality Checking

The boundary of the processed LiDAR data on top of a SAR Elevation Data over Mainit-Tubay Floodplain is shown in Figure 15. The map shows gaps in the LiDAR coverage that are attributed to cloud coverage.

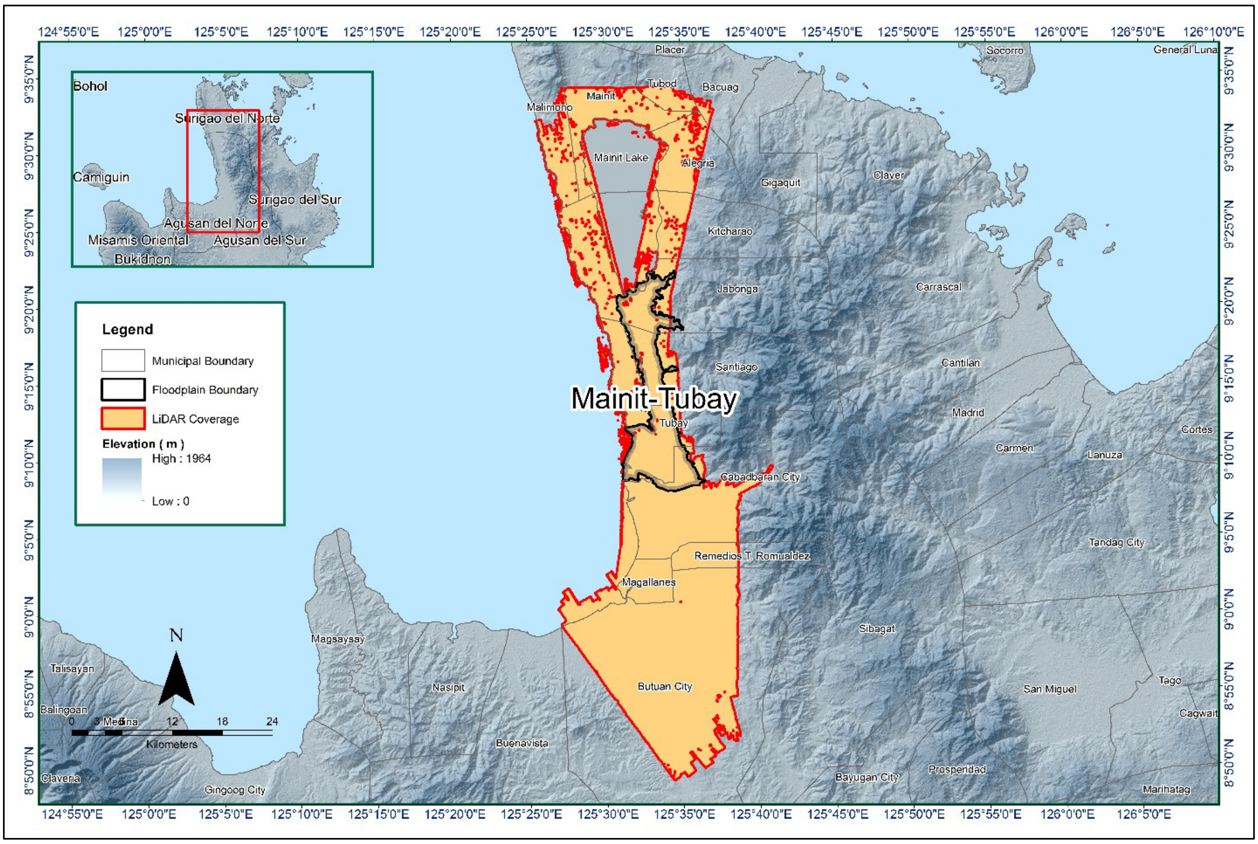


Figure 15. Boundary of the processed LiDAR data over Mainit-Tubay Floodplain

The total area covered by the Mainit-Tubay missions is 1,227.83 sq.km that is comprised of ten (10) flight acquisitions grouped and merged into ten (10) blocks as shown in Table 15.

Table 15. List of LiDAR blocks for Mainit-Tubay floodplain

LiDAR Blocks	Flight Numbers	Area (sq. km)
Butuan_Agusan_right	207P	509.96
	209P	
	211P	
Butuan_Agusan_203P	203P	131.31
Butuan_Agusan_fill	209P	3.02
	211P	
Butuan_AgusAB	1612A	55.05
Butuan_Agus	1604A	77.79
SurigaoDelNorte_Blk59B	7294GC	128.27
SurigaoDelNorte_Blk59C	7298GC	109.68
SurigaoDelNorte_Blk59D	7286GC	70.30
SurigaoDelNorte_Blk59D_additional	7298GC	3.40
SurigaodelNorte_Blk59A	7294GC	139.05
	7298GC	
TOTAL		**1,227.83 sq.km.**

The overlap data for the merged LiDAR blocks, showing the number of channels that pass through a particular location is shown in Figure 16. Since the Gemini system employs one channel, we would expect an average value of 1 (blue) for areas where there is limited overlap, and a value of 2 (yellow) or more (red) for areas with three or more overlapping flight lines. While for the Pegasus system which employs two channels, we would expect an average value of 2 (blue) for areas where there is limited overlap and a value of 3 (yellow) or more (red) for areas with three or more overlapping flight lines.

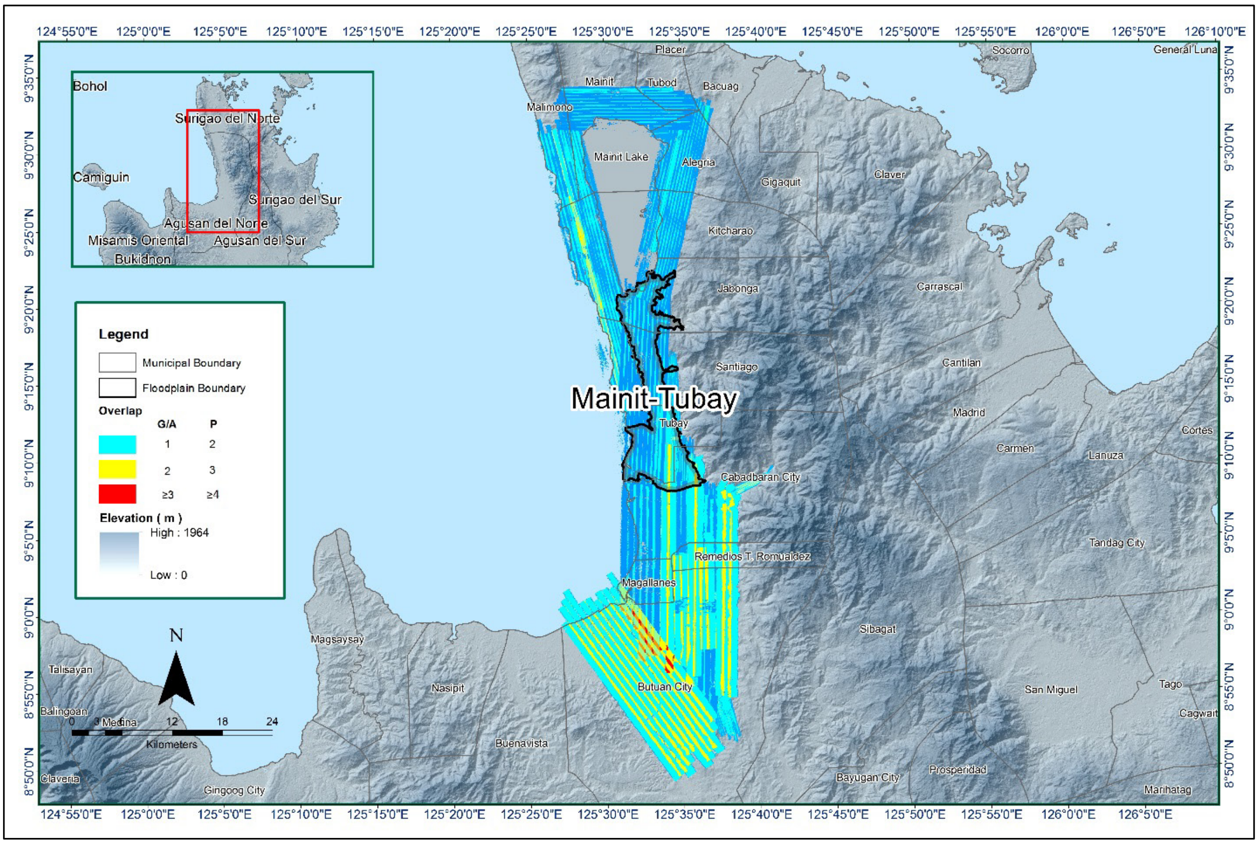


Figure 16. Image of data overlap for Mainit-Tubay floodplain

The overlap statistics per block for the Mainit-Tubay floodplain can be found in **Annex B-1**. One pixel corresponds to 25.0 square meters on the ground. For this area, the minimum and maximum percent overlaps are 24.19% and 52.81% respectively, which passed the 25% requirement.

The pulse density map for the merged LiDAR data, with the red parts showing the portions of the data that satisfy the 2 points per square meter criterion is shown in Figure 17. It was determined that all LiDAR data for Mainit-Tubay floodplain satisfy the point density requirement, and the average density for the entire survey area is 3.30 points per square meter.

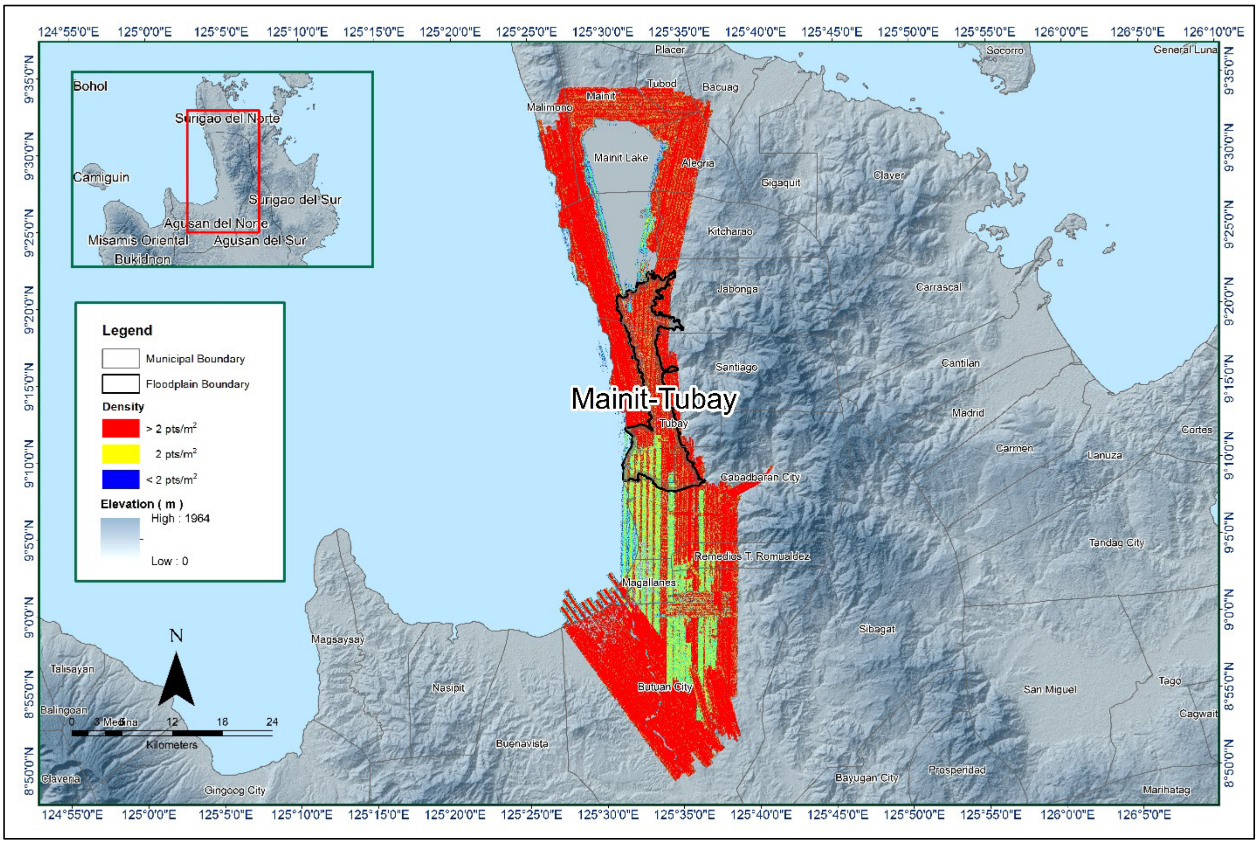


Figure 17. Pulse density map of merged LiDAR data for Mainit-Tubay floodplain

The elevation difference between overlaps of adjacent flight lines is shown in Figure 18. The default color range is from blue to red, where bright blue areas correspond to portions where elevations of a previous flight line, identified by its acquisition time, are higher by more than 0.20m relative to elevations of its adjacent flight line. Bright red areas indicate portions where elevations of a previous flight line are lower by more than 0.20m relative to elevations of its adjacent flight line. Areas with bright red or bright blue need to be investigated further using Quick Terrain Modeler software.

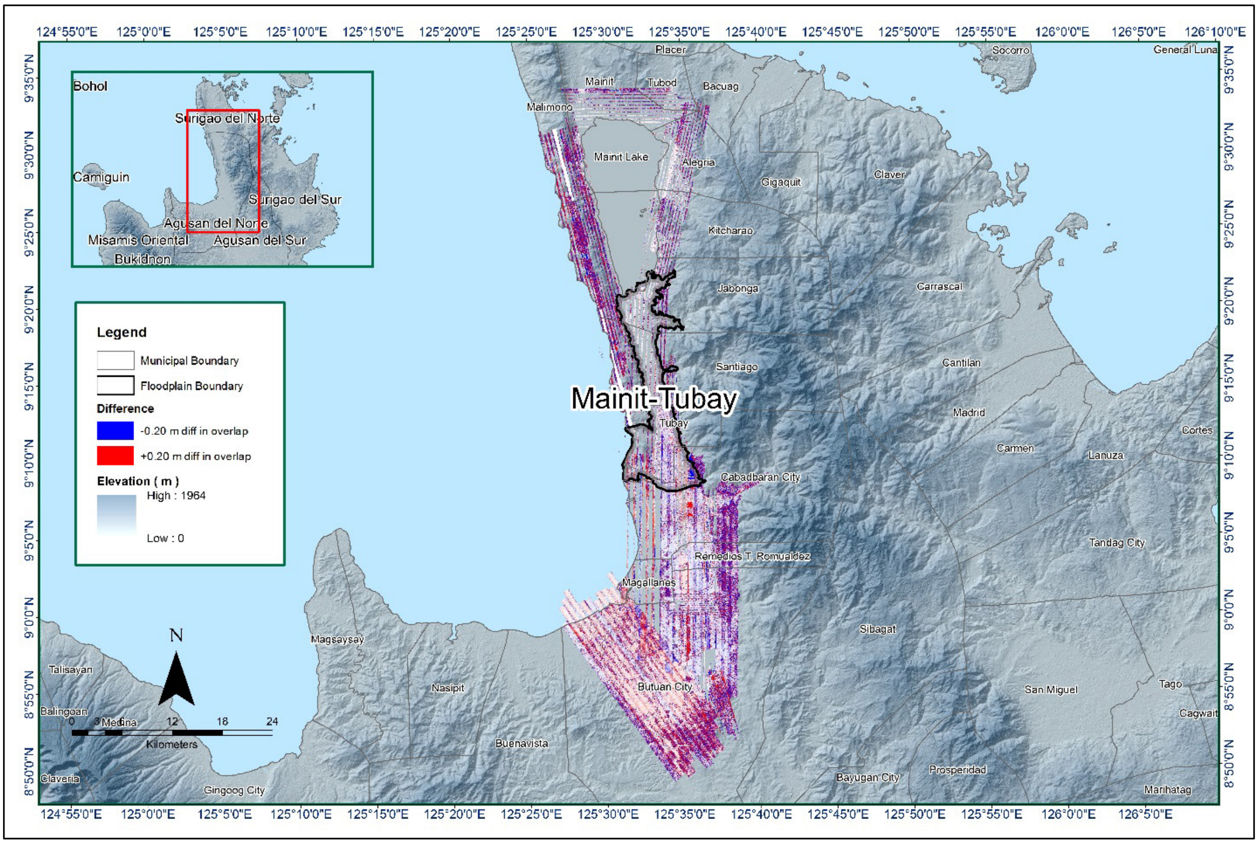


Figure 18. Elevation difference map between flight lines for Mainit-Tubay floodplain

A screen capture of the processed LAS data from a Mainit-Tubay flight 1604A loaded in QT Modeler is shown in Figure 19. The upper left image shows the elevations of the points from two overlapping flight strips traversed by the profile, illustrated by a dashed red line. The x-axis corresponds to the length of the profile. It is evident that there are differences in elevation, but the differences do not exceed the 20-centimeter mark. This profiling was repeated until the quality of the LiDAR data becomes satisfactory. No reprocessing was done for this LiDAR dataset.

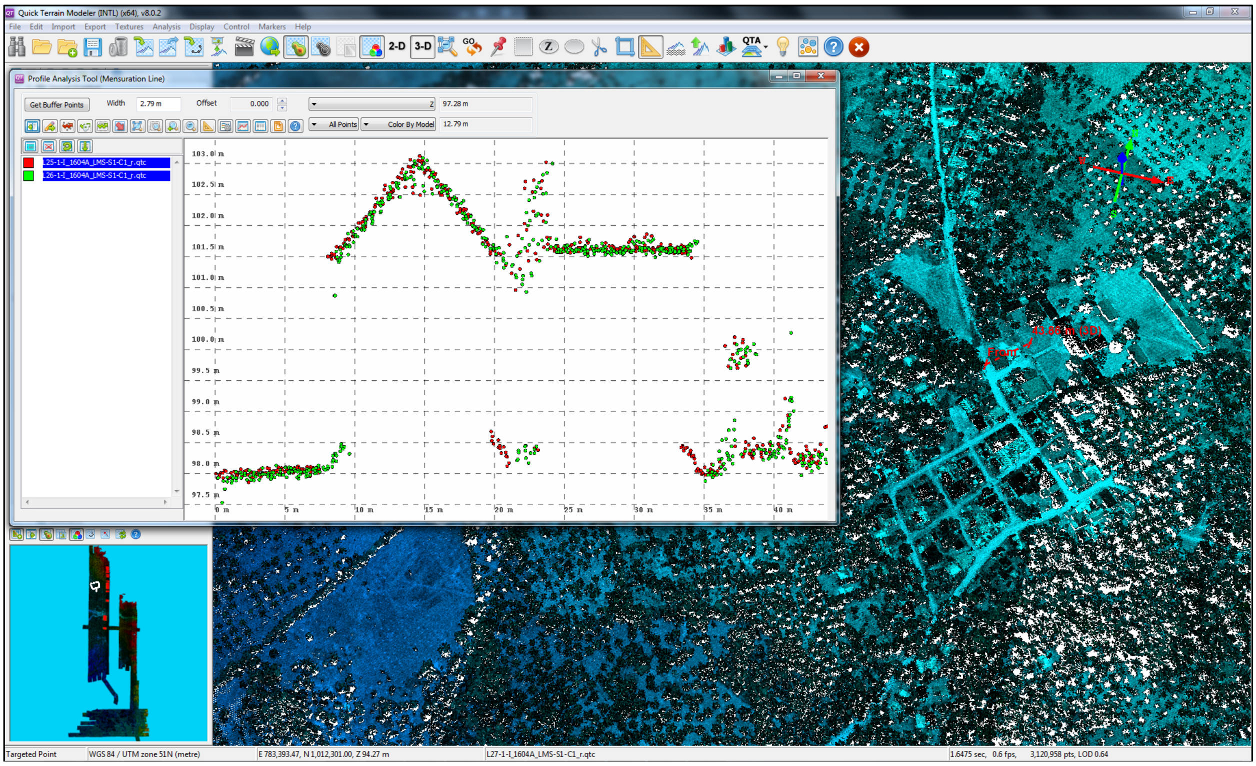


Figure 19. Quality checking for a Mainit-Tubay flight 1604A using the Profile Tool of QT Modeler

3.6 LiDAR Point Cloud Classification and Rasterization

Table 16. Mainit-Tubay classification results in TerraScan

Pertinent Class	Total Number of Points
Ground	612,492,879
Low Vegetation	518,172,870
Medium Vegetation	711,263,898
High Vegetation	1,373,811,952
Building	42,792,693

The tile system that TerraScan employed for the LiDAR data and the final classification image for a block in Mainit-Tubay floodplain is shown in Figure 20. A total of 1,784 1km by 1km tiles were produced. The number of points classified to the pertinent categories is illustrated in Table 16. The point cloud has a maximum and minimum height of 724.79 meters and 12.81 meters respectively.

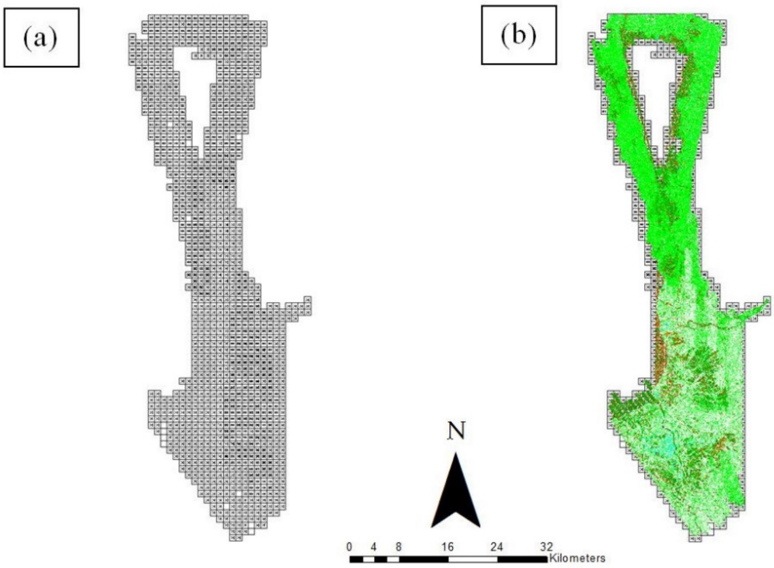


Figure 20. Tiles for Mainit-Tubay floodplain (a) and classification results (b) in TerraScan

An isometric view of an area before and after running the classification routines is shown in Figure 21. The ground points are in orange, the vegetation is in different shades of green, and the buildings are in cyan. It can be seen that residential structures adjacent or even below canopy are classified correctly, due to the density of the LiDAR data.

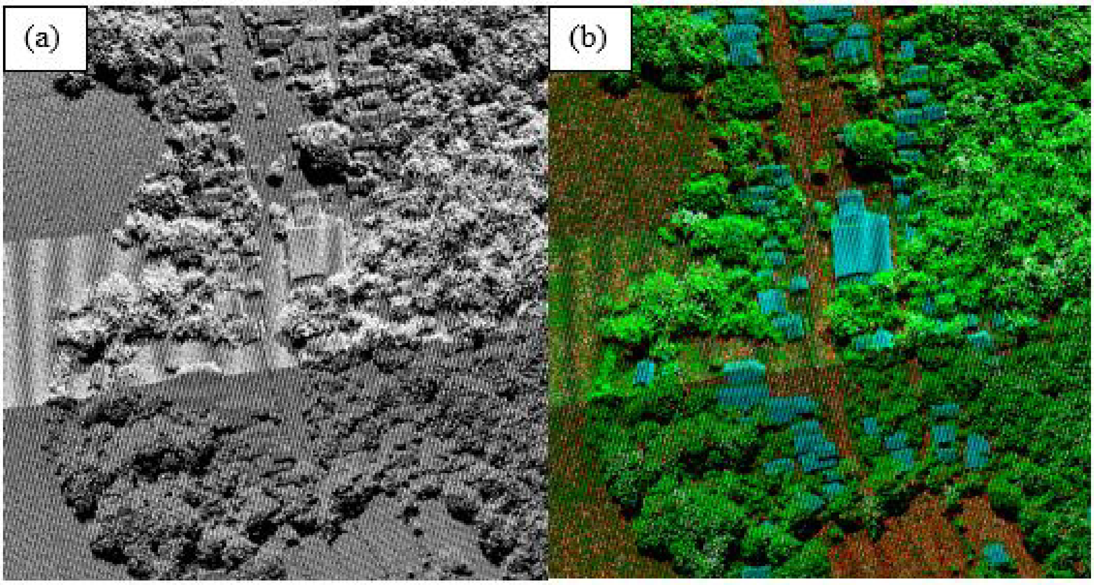


Figure 21. Point cloud before (a) and after (b) classification

The production of last return (V_ASCII) and the secondary (T_ ASCII) DTM, first (S_ ASCII) and last (D_ ASCII) return DSM of the area in top view display are shown in Figure 22. It shows that DTMs are the representation of the bare earth while on the DSMs, all features are present such as buildings and vegetation.

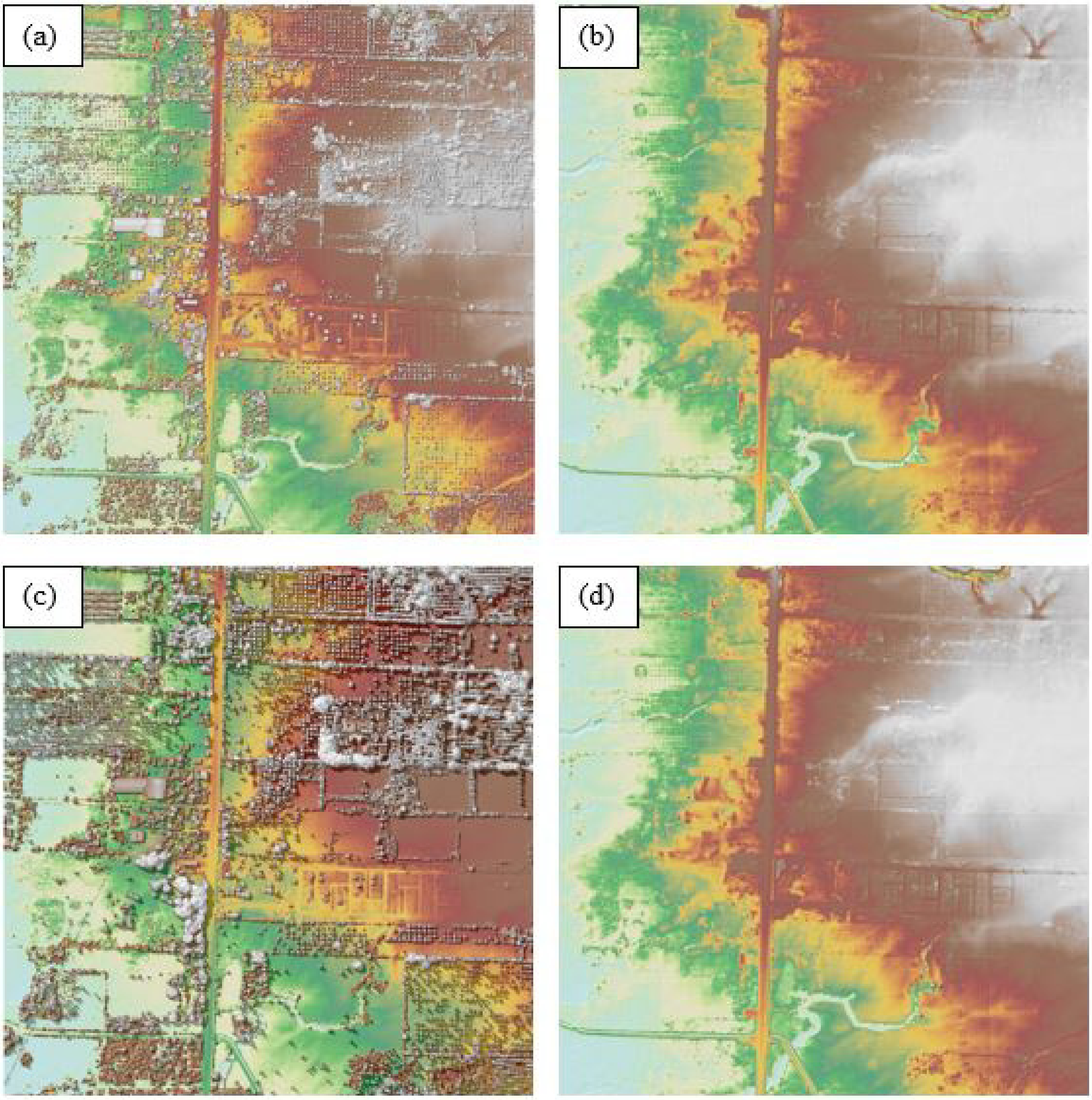


Figure 22. The production of last return DSM (a) and DTM (b), first return DSM (c) and secondary DTM (d) in some portion of Mainit-Tubay floodplain

3.7 LiDAR Image Processing and Orthophotograph Rectification

The 996 1km by 1km tiles area covered by Mainit-Tubay floodplain is shown in Figure 23. To fix photo misalignments, a tie point selection was done. Color points were added to smoothen out visual inconsistencies along the seamlines where photos overlap. The Mainit-Tubay floodplain survey attained a total of 576.59 km2 in orthophotogaph coverage, comprised of 2,900 images. A zoomed in version of sample orthophotographs named in reference to its tile number is shown in Figure 24.

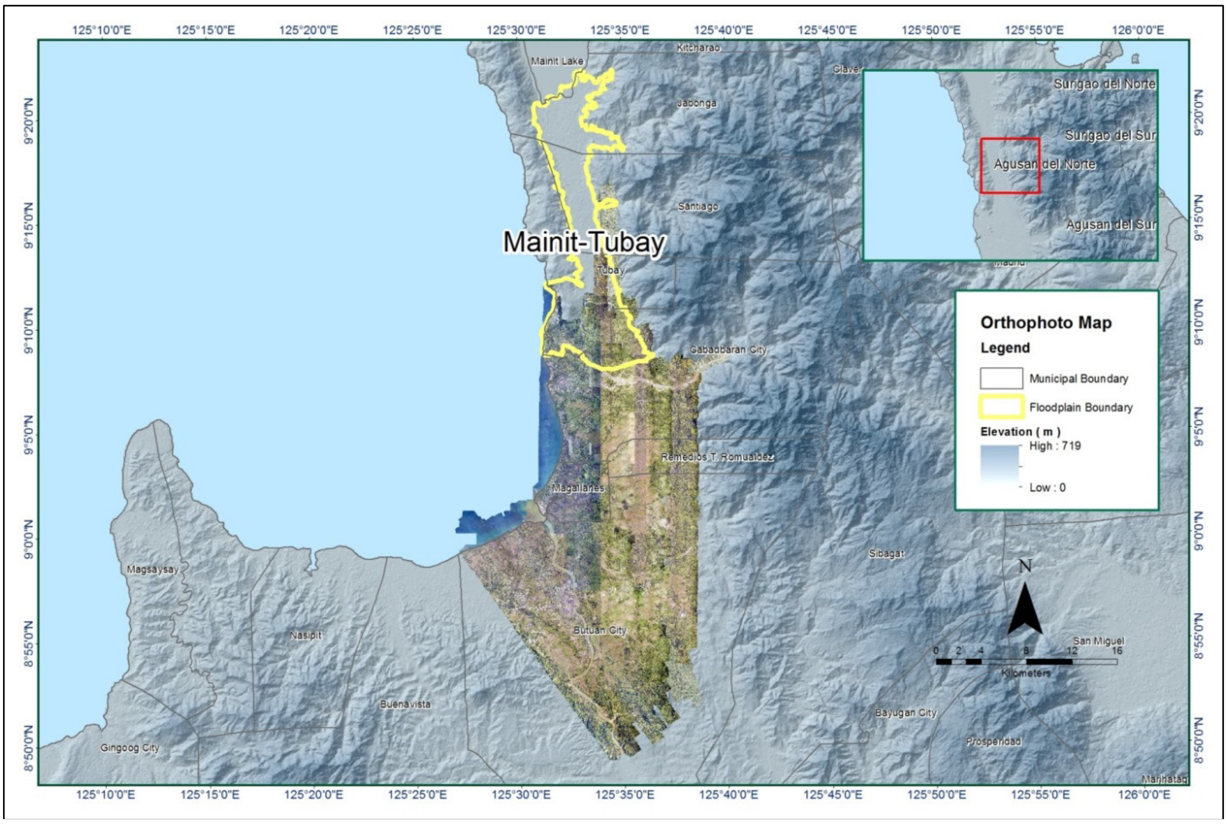


Figure 23. Mainit-Tubay floodplain with available orthophotographs

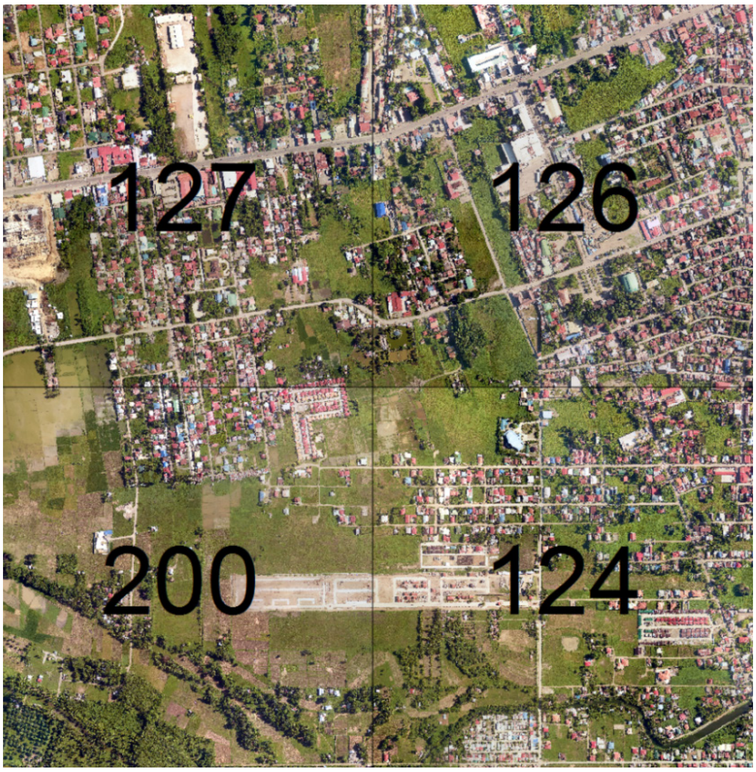


Figure 24. Sample orthophotograph tiles for Mainit-Tubay floodplain

3.8 DEM Editing and Hydro-Correction

Ten (10) mission blocks were processed for Mainit-Tubay flood plain. These blocks are composed of ButuanAgus and Surigao blocks with a total area of 1,227.83 square kilometers. Table 17 shows the name and corresponding area of each block in square kilometers.

Table 17. LiDAR blocks with its corresponding area

LiDAR Blocks	Area (sq.km)
Butuan_Agusan_right	509.96
Butuan_Agusan_203P	131.31
Butuan_Agusan_fill	3.02
Butuan_AgusAB	55.05
Butuan_Agus	77.79
SurigaoDelNorte_Blk59B	128.27
SurigaoDelNorte_Blk59C	109.68
SurigaoDelNorte_Blk59D	70.30
SurigaoDelNorte_Blk59D_additional	3.40
SurigaoDelNorte_Blk59A	139.05
TOTAL	**1,227.83 sq.km**

Portions of DTM before and after manual editing are shown in Figure B25. It shows that the river embankment has been misclassified and removed during classification process in (Figure 25a) and has to be retrieved to complete the surface as in (Figure 25b) to allow the correct flow of water. The bridge in (Figure 25c) would be an impedance to the flow of water along the river and was removed in order to hydrologically correct the river, as done in (Figure 25d).

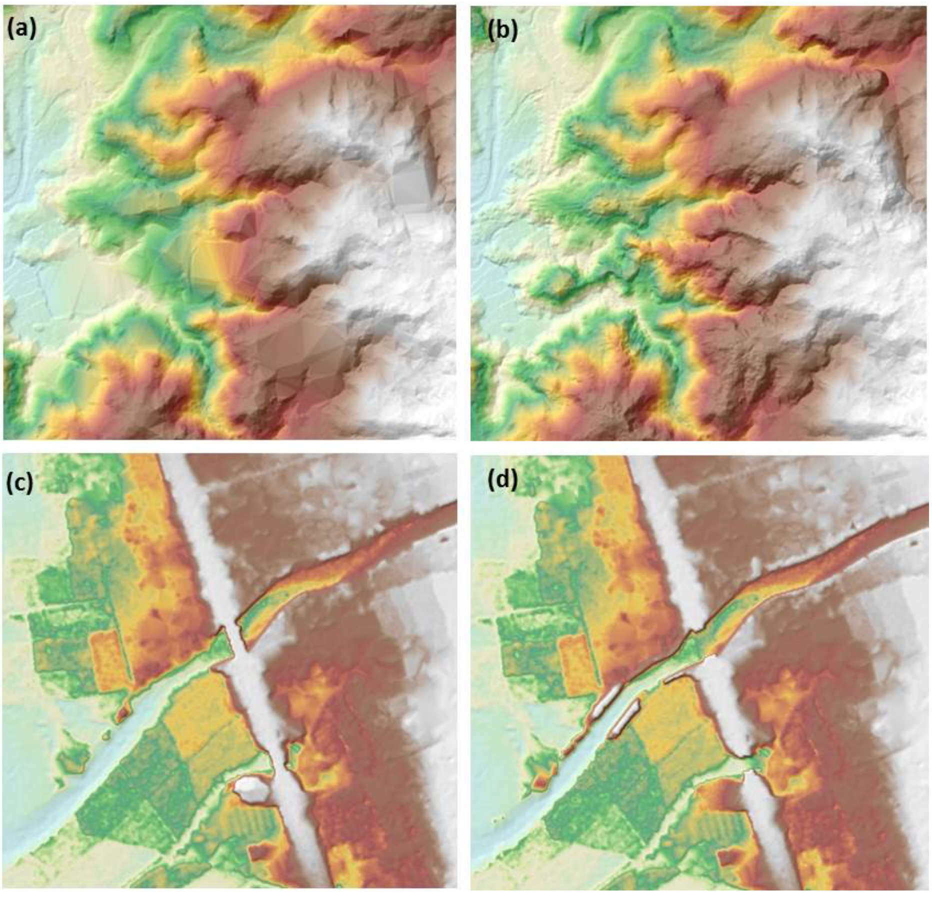


Figure 25. Portions in the DTM of Mainit-Tubay floodplain – a river embankment before (a) and and after (b) data retrieval and a bridge before (c) and after (d) manual editing

3.9 Mosaicking of Blocks

No assumed reference block was used in mosaicking because the identified reference for shifting was an existing calibrated Agusan DEM overlapping with the blocks to be mosaicked. Table 18 shows the shift values applied to each LiDAR block during mosaicking.

Mosaicked LiDAR DTM for Mainit-Tubay floodplain is shown in Figure 26. It can be seen that the entire Mainit-Tubay floodplain is 88.58% covered by LiDAR data.

Table 18. Shift Values of each LiDAR Block of Mainit-Tubay floodplain

Mission Blocks	Shift Values		
	x	y	z
Butuan_AgusAB	28.00	0.09	1.93
Butuan_Agus	27.00	0.09	-2.21
SurigaoDelNorte_Blk59B	27.00	0.09	5.78
SurigaoDelNorte_Blk59C	29.60	4.08	0.89
SurigaoDelNorte_Blk59D	28.99	0.09	-1.18
SurigaoDelNorte_Blk59D_additional	-1.61	0.01	5.85
SurigaoDelNorte_Blk59A	29.00	0.09	9.92
Butuan_Agusan_right	29.40	-0.50	0.00
Butuan_Agusan_fill	28.60	-0.90	0.00
Butuan_Agusan203P	28.20	-0.67	0.00

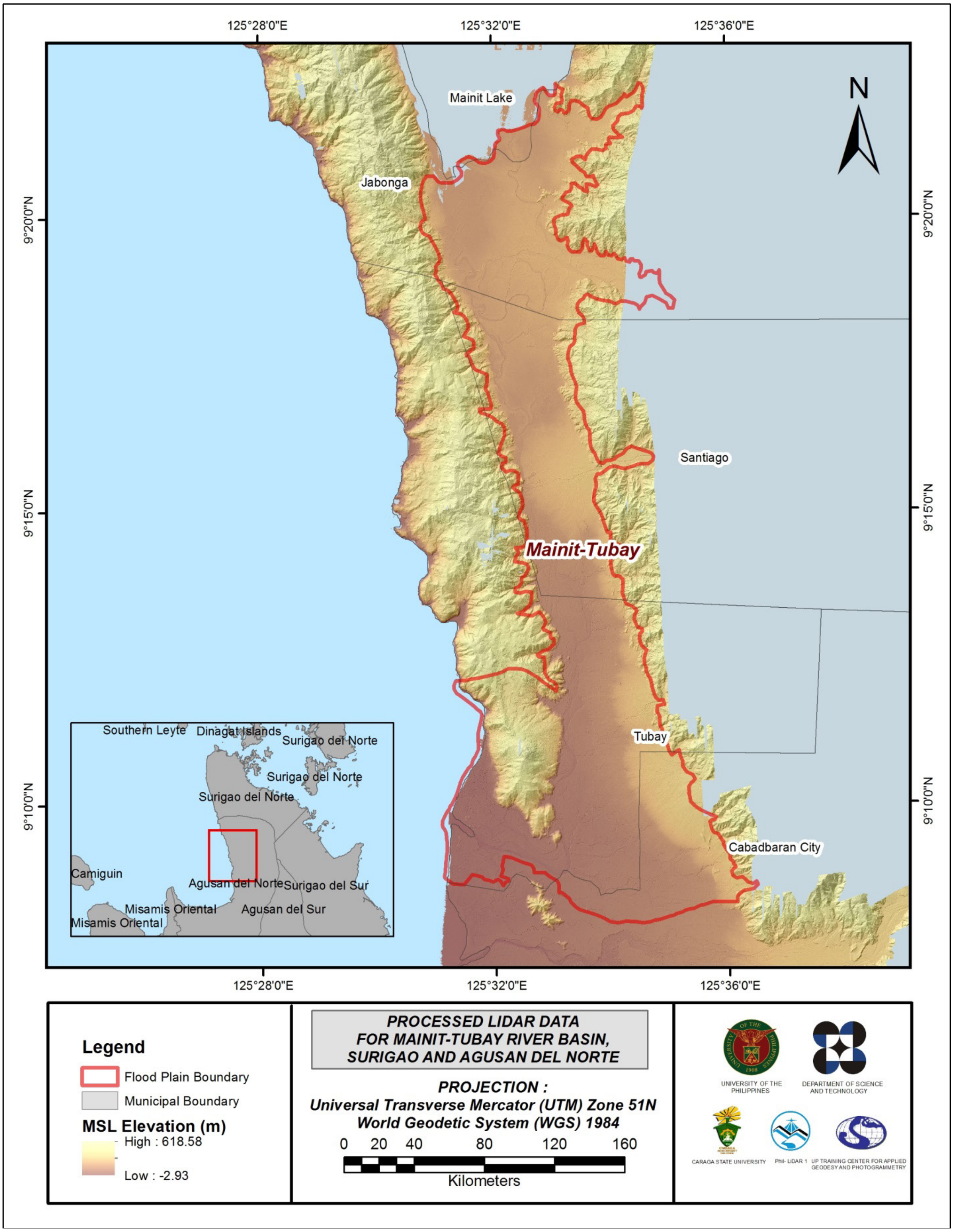


Figure 26. Map of Processed LiDAR Data for Mainit-Tubay Flood Plain

3.10 Calibration and Validation of Mosaicked LiDAR DEM

The extent of the validation survey done by the Data Validation and Bathymetry Component (DVBC) in Mainit-Tubay to collect points with which the LiDAR dataset is validated is shown in Figure 27. A total of 1,530 survey points were used for calibration and validation of Mainit-Tubay LiDAR data. However, the point dataset was not utilized because during the mosaicking process, each LiDAR block was already referred to the calibrated Agusan DEM. A good correlation between the uncalibrated Agusan LiDAR DTM and calibration elevation values is shown in Figure 28. Statistical values were computed from extracted LiDAR values using the selected points to assess the quality of data and obtain the value for vertical adjustment. The computed height difference between the LiDAR DTM and calibration elevation values is 0.12 meters with a standard deviation of 0.10 meters. Calibration of Mainit-Tubay LiDAR data was done by adding the height difference value, 0.12 meters, to Mainit-Tubay mosaicked LiDAR data. Table 19 shows the statistical values of the compared elevation values between LiDAR data and calibration data.

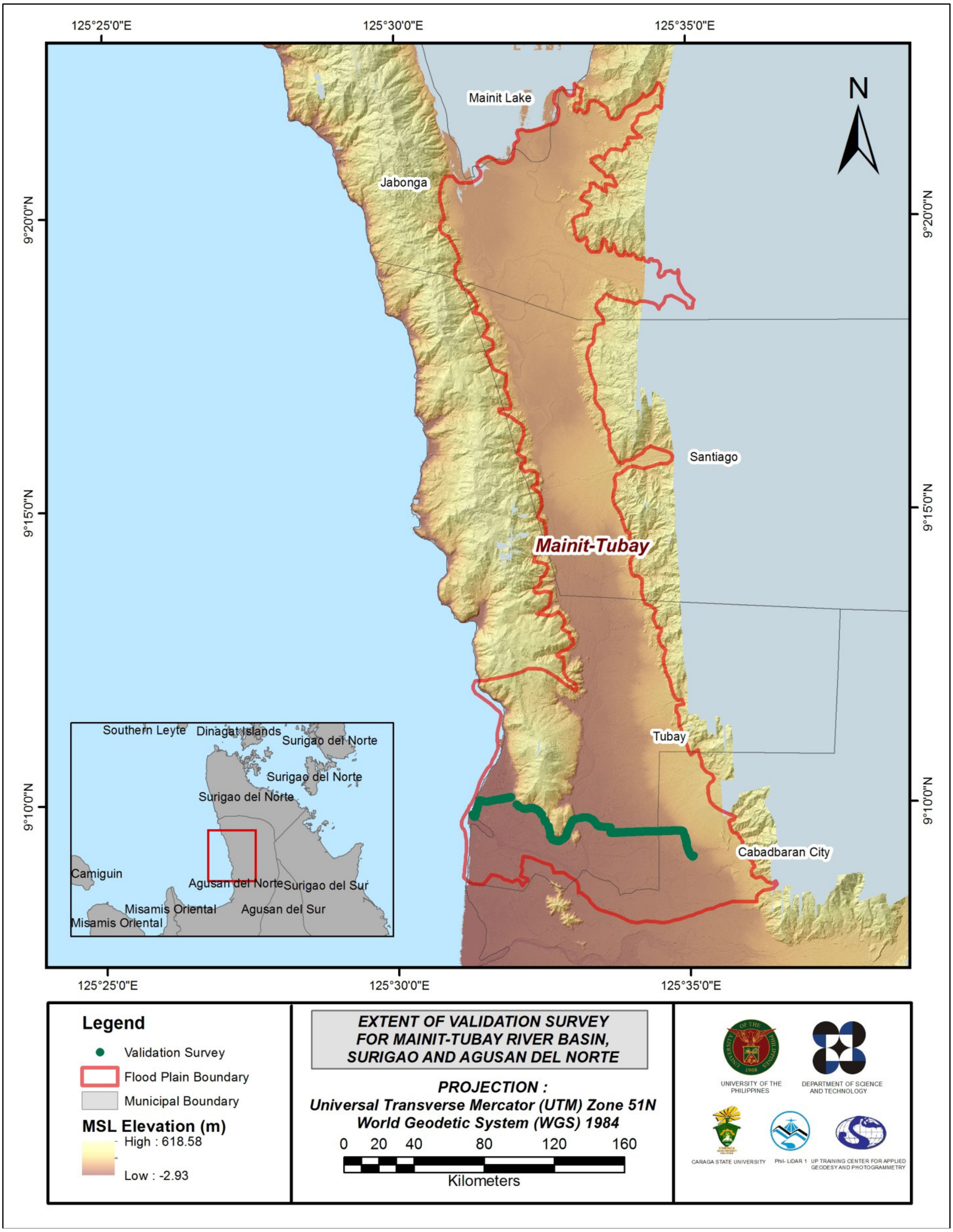


Figure 27. Map of Mainit-Tubay Flood Plain with validation survey points in green

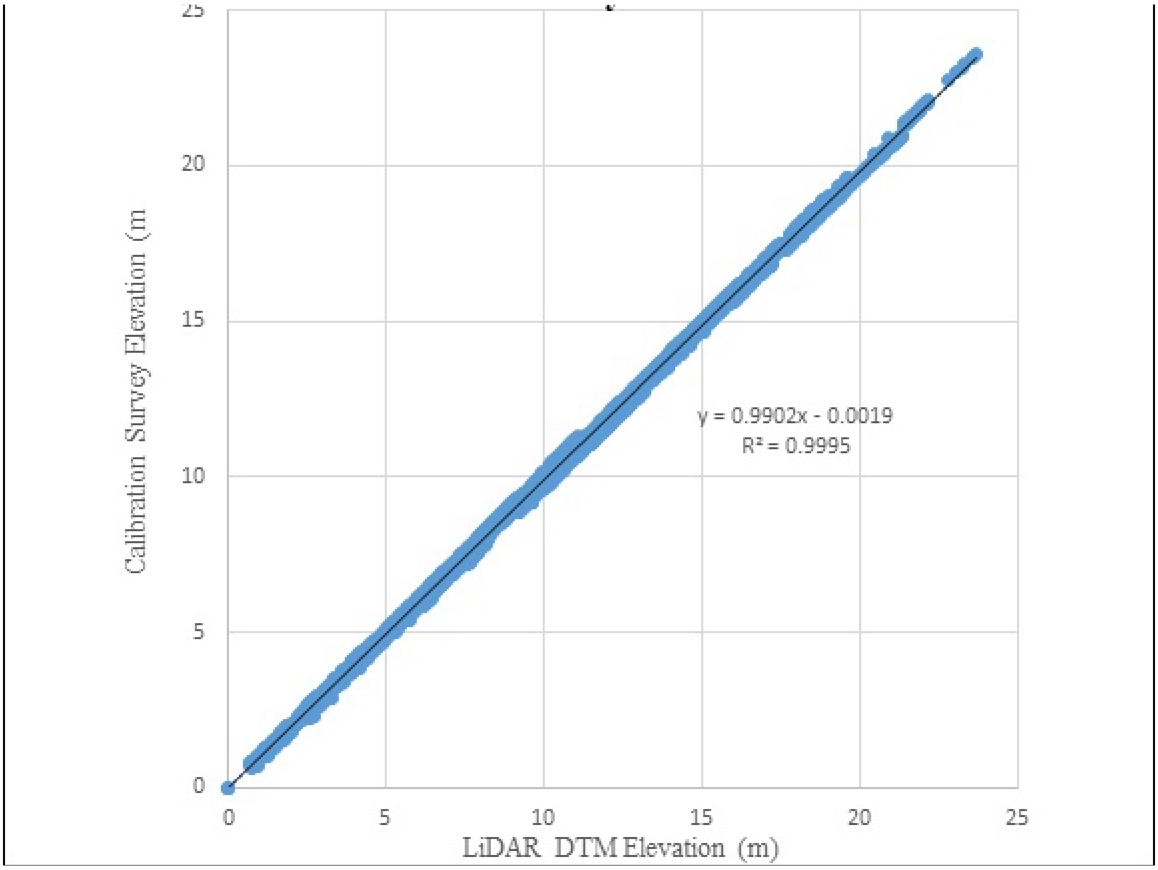


Figure 28. Correlation plot between calibration survey points and LiDAR data

Table 19. Calibration Statistical Measures

Calibration Statistical Measures	Value (meters)
Height Difference	0.12
Standard Deviation	0.11
Average	0.07
Minimum	-0.19
Maximum	0.41

The remaining 20% of the total survey points, resulting to 306 points, were used for the validation of calibrated Mainit-Tubay DTM. A good correlation between the calibrated mosaicked LiDAR elevation values and the ground survey elevation, which reflects the quality of the LiDAR DTM is shown in Figure 29. The computed RMSE between the calibrated LiDAR DTM and validation elevation values is 0.16 meters with a standard deviation of 0.09 meters, as shown in Table 20.

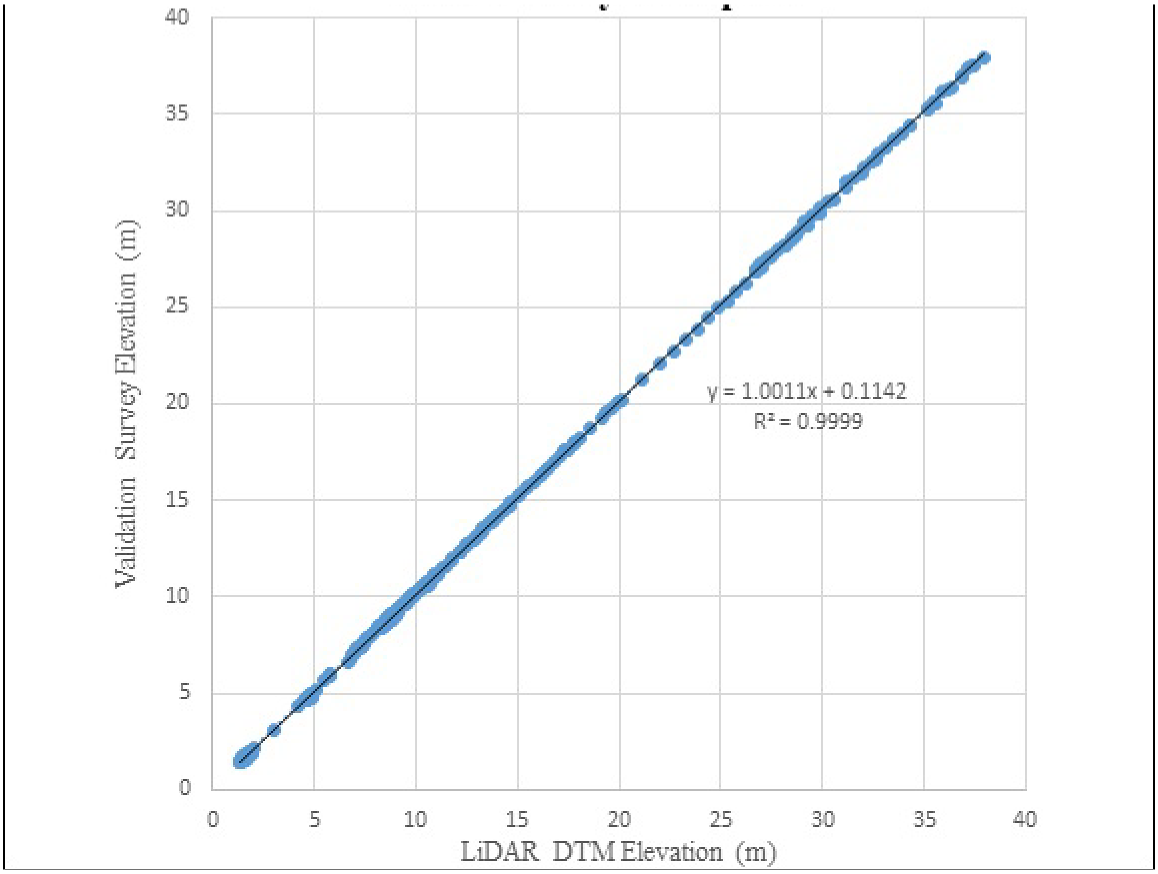


Figure 29. Correlation plot between validation survey points and LiDAR data

Table 20. Validation Statistical Measures

Validation Statistical Measures	Value (meters)
RMSE	0.16
Standard Deviation	0.09
Average	-0.13
Minimum	-0.36
Maximum	0.12

3.11 Integration of Bathymetric Data into the LiDAR Digital Terrain Model

For bathy integration, only centerline data was available for Mainit-Tubay with 8,744 bathymetric survey points. The resulting raster surface produced was done by Inverse Distance Weighted (IDW) interpolation method. After burning the bathymetric data to the calibrated DTM, assessment of the interpolated surface is represented by the computed RMSE value of 0.13 meters. The extent of the bathymetric survey done by the Data Validation and Bathymetry Component (DVBC) in Mainit-Tubay integrated with the processed LiDAR DEM is shown in Figure 30.

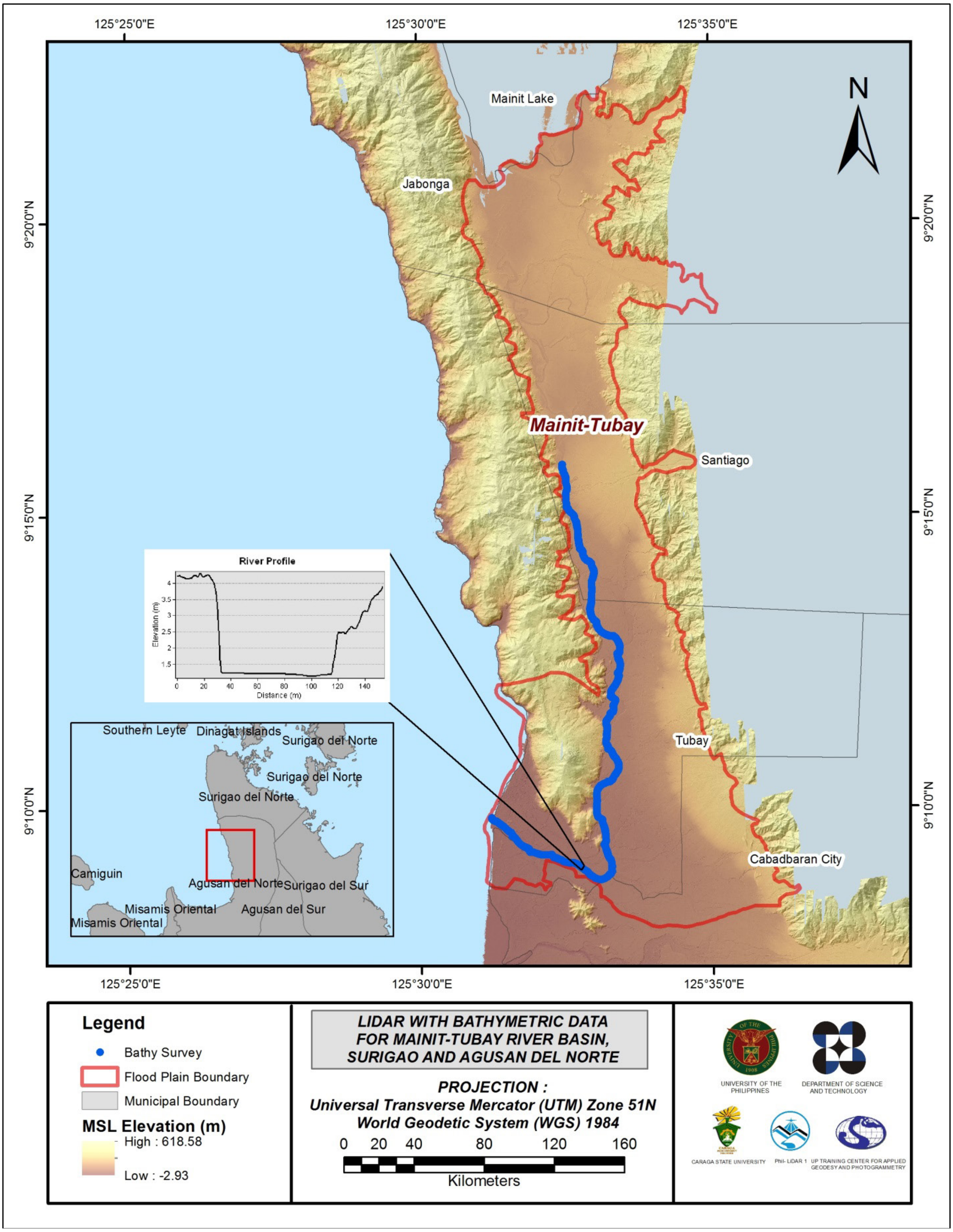


Figure 30. Map of Mainit-Tubay Flood Plain with bathymetric survey points shown in blue

3.12 Feature Extraction

The features salient in flood hazard exposure analysis include buildings, road networks, bridges and water bodies within the floodplain area with 200 m buffer zone. Mosaicked LiDAR DEM with 1 m resolution was used to delineate footprints of building features, which consist of residential buildings, government offices, medical facilities, religious institutions, and commercial establishments, among others. Road networks comprise of main thoroughfares such as highways and municipal and barangay roads essential for routing of disaster response efforts. These features are represented by a network of road centerlines.

3.12.1 Quality Checking of Digitized Features' Boundary

Mainit-Tubay floodplain, including its 200 m buffer, has a total area of 135.66 sq km. For this area, a total of 5.0 sq km, corresponding to a total of 1,273 building features, are considered for QC. Figure 31 shows the QC blocks for Mainit-Tubay floodplain.

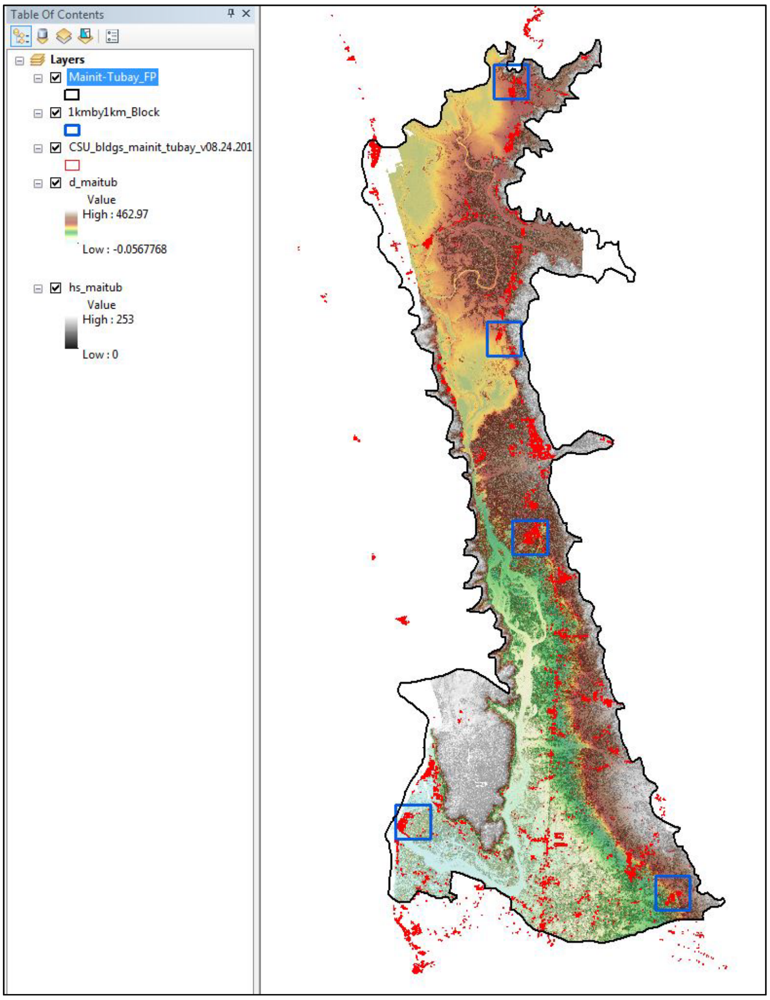


Figure 31. Blocks (in blue) of Mainit-Tubay building features that were subjected to QC

Quality checking of Mainit-Tubay building features resulted in the ratings shown in Table 21.

Table 21. Quality Checking Ratings for Mainit-Tubay Building Features

FLOODPLAIN	COMPLETENESS	CORRECTNESS	QUALITY	REMARKS
Mainit-Tubay	100.00	100.00	87.35	PASSED

3.12.2 Height Extraction

Height extraction was done for 27,817 building features in Mainit-Tubay floodplain. Of these building features, 963 were filtered out after height extraction, resulting to 26,854 buildings with height attributes. The lowest building height is at 2.00 m, while the highest building is at 5.52 m.

3.12.3 Feature Attribution

Field surveys, familiarity with the area, and free online web maps such as Wikimapia (http://wikimapia.org/) and Google Map (https://www.google.com/maps) were used to gather information such as name and type of the features within the river basin.

Table 22 summarizes the number of building features per type. On the other hand, Table 23 shows the total length of each road type, while Table 24 shows the number of water features extracted per type.

Table 22. Building Features Extracted for Mainit-Tubay Floodplain

Facility Type	No. of Features
Residential	26,343
School	354
Market	6
Agricultural/Agro-Industrial Facilities	13
Medical Institutions	1
Barangay Hall	14
Military Institution	0
Sports Center/Gymnasium/Covered Court	28
Telecommunication Facilities	0
Transport Terminal	0
Warehouse	0
Power Plant/Substation	0
NGO/CSO Offices	5
Police Station	3
Water Supply/Sewerage	0
Religious Institutions	40
Bank	1
Factory	0
Gas Station	7
Fire Station	1
Other Government Offices	12
Other Commercial Establishments	26
Total	**26,854**

Table 23. Total Length of Extracted Roads for Mainit-Tubay Floodplain

Floodplain	Road Network Length (km)					Total
	Barangay Road	City/ Municipal Road	Provincial Road	National Road	Others	
Mainit-Tubay	233.74	60.47	120.76	59.93	0.00	**474.90**

Table 24. Number of Extracted Water Bodies for Mainit-Tubay Floodplain

Floodplain	Water Body Type					Total
	Rivers/Streams	Lakes/Ponds	Sea	Dam	Fish Pen	
Mainit-Tubay	144	3	0	1	9	157

A total of 128 bridges and culverts over small channels that are part of the river network were also extracted for the floodplain.

3.12.4 Final Quality Checking of Extracted Features

All extracted ground features were completely given the required attributes. All these output features comprise the flood hazard exposure database for the floodplain. This completes the feature extraction phase of the project.

Figure 32 shows the Digital Surface Model (DSM) of Mainit-Tubay floodplain overlaid with its ground features.

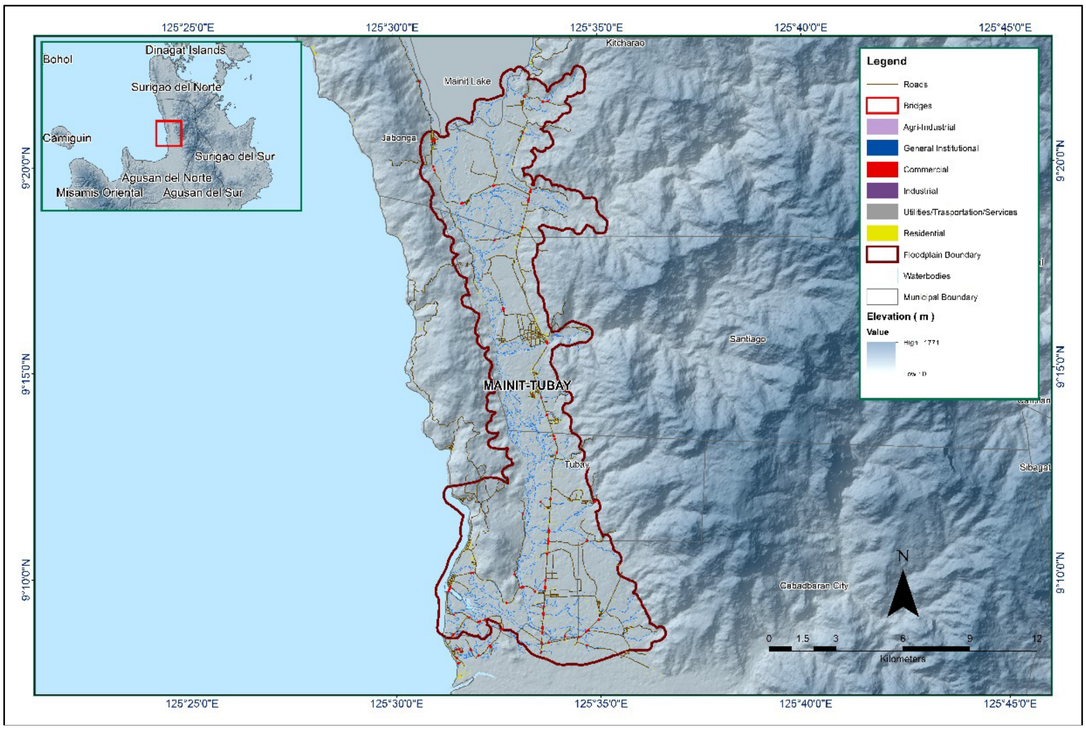


Figure 32. Extracted features for Mainit-Tubay floodplain

CHAPTER 4: LIDAR VALIDATION SURVEY AND MEASUREMENTS OF THE MAINIT-TUBAY RIVER BASIN

Engr. Louie P. Balicanta, Engr. Joemarie S. Caballero, Ms. Patrizcia Mae. P. dela Cruz, Engr. Dexter T. Lozano, For. Dona Rina Patricia C. Tajora, Elaine Bennet Salvador, For. Rodel C. Alberto

The methods applied in this Chapter were based on the DREAM methods manual (Balicanta, et al., 2014) and further enhanced and updated in Paringit, et al. (2017).

4.1 Summary of Activities

A field survey was conducted in Kalinawan river on February 15 to 26, 2015 with the following scope of work: reconnaissance; control survey for the establishment of a control point; cross-section, bridge as-built of Tubay Bridge in Brgy. Doña Rosario, Municipality of Tubay; ground validation data acquisition of about 19.4 km; and bathymetric survey from Brgy. La Paz in Santiago down to Poblacion 1 in the Municipality of Tubay, Agusan del Norte using Ohmex™ Single Beam Echo Sounder and GNSS PPK survey technique, as shown in Figure 33.

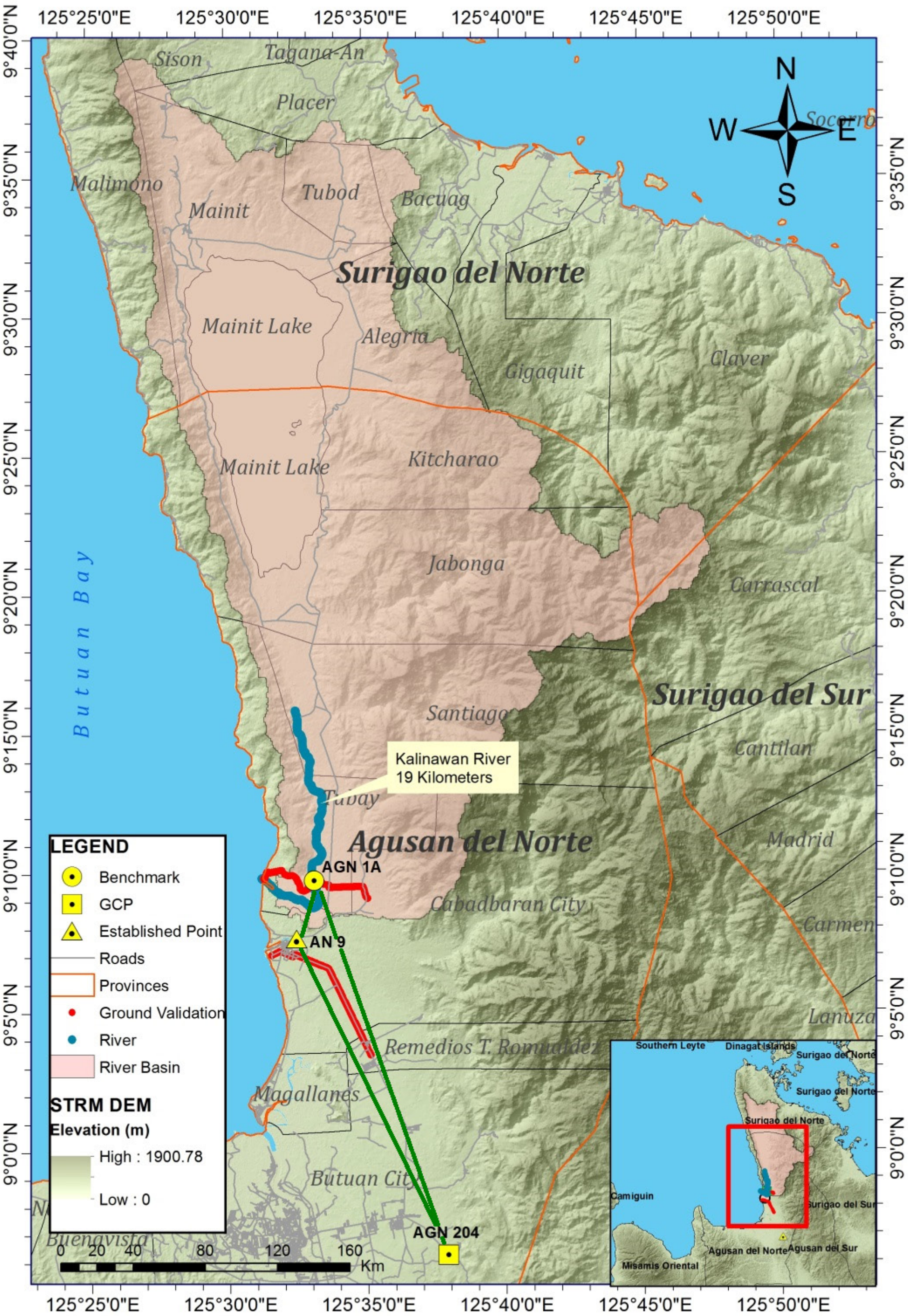


Figure 33. Extent of the bathymetric survey (in blue) in Mainit-Tubay River and the LiDAR data validation survey (in red)

4.2 Control Survey

The GNSS network used for Kalinawan River Basin is composed of a single loop established on February 19, 2015 occupying the following reference points: AGN-204, a second order GCP located in Brgy. Basag, Butuan City; and AGN-1A, a fixed control point from partner HEI, CSU levelling survey located in Brgy. Doña Rosario, Municipality of Tubay; both in Agusan Del Norte.

A NAMRIA established control point namely AN-9, located along the approach of Cabadbaran Bridge, in Brgy. Kauswagan, Cabadbaran City, Agusan Del Norte; was also occupied to use as marker for the survey.

The summary of reference and control points and its locations is shown in Table 26.

Table 25. Tabulation of elevation of levelling survey points from AN100 to AN1A from CSU

Established Control Point	Computed Elevation from the Mean Sea Level	Latitude	Longitude	Error of Closure (mm)	3rd order levelling Maximum allowable error of closure (mm)
AN-100	22.953	9.1274	125.541		
CP1	19.228	9.1288	125.5455	-1	5.37479
CP2	16.75801	9.1296	125.5508	-1	5.22268
CP3	14.15651	9.1347	125.5597	-1	5.3949
CP4	12.11901	9.1328	125.5646	0	5.29275
CP5	12.50251	9.1328	125.569	0	3.76582
CP6	9.20801	9.1336	125.5751	-2	5.39318
CP7	8.39151	9.1329	125.5789	2	5.35143
CP8	7.21951	9.1317	125.5823	-1	5.35032
CP9/AGN-1A	10.56801	9.1313	125.585	-3	5.40914

Table 26. List of Reference and Control Points used in Kalinawan River Survey (Source: NAMRIA, UP-TCAGP, CSU)

Control Point	Order of Accuracy	Geographic Coordinates (WGS84)				
		Latitude	Longitude	Ellipsoidal Height (m)	MSL Elevation (m)	Date established
AGN-204	2nd Order, GCP	8°56’16.03323”	125°37’53.34384”	96.791	-	2007
AGN-1A	Fixed, CSU Established	-	-	78.994	10.568	2010
AN-9	Used as marker	-	-	76.54	-	2007

The GNSS set up made in the location of the reference and control points are exhibited in Figure 34 to Figure 36.

Figure 34. Base set-up using Trimble® SPS 852 at AGN-204 located near the concrete fence of Taligaman Elementary School, in Brgy. Basag, Butuan City, Agusan Del Norte.

Figure 35. Base set-up using Trimble® SPS 882 at AGN-1A located along the approach of Tubay Bridge in Brgy. Doña Rosario, Municipality of Tubay, Agusan del Norte

Figure 36. Base set-up using Trimble® SPS 882 at AN-9 located at the approach of Cabadbaran Bridge, Brgy. Kauswagan, Cabadbaran City, Agusan Del Norte

4.3 Baseline Processing

The GNSS baselines were processed simultaneously in TBC by observing that all baselines have fixed solutions with horizontal and vertical precisions within +/- 20 cm and +/- 10 cm requirement, respectively. In cases where one or more baselines did not meet all of these criteria, masking is performed. Masking is done by removing/masking portions of these baseline data using the same processing software. It is repeatedly processed until all baseline requirements are met. If the reiteration yields out of the required accuracy, resurvey is initiated. Baseline processing result of control points generated by TBC software in Kalinawan River Basin is summarized in Table 27.

Table 27. Baseline Processing Report for Kalinawan River static survey

Observation	Date of Observation	Solution Type	H. Prec. (Meter)	V. Prec. (Meter)	Geodetic Az.	Ellipsoid Dist. (Meter)	ΔHeight (Meter)
AGN-1A – AGN-204	AGN-1A	Fixed	0.005	0.023	340°36’12”	26343.613	-17.798
AGN-1A – AN-9	AN-9	Fixed	0.003	0.012	17°17’35”	4050.187	2.450
AN-9-- AGN-204	AGN-1A	Fixed	0.004	0.025	334°37’12”	23222.966	-20.253

Three (3) control points were occupied at the same time. The point AGN-204 was held fixed and was used as a control for the network. Baseline AGN-1A to AGN-204 has a fixed solution type with horizontal and vertical accuracies of 0.4 cm and 2.3 cm, respectively. Baseline AN-9 to AGN-204 has horizontal and vertical accuracies of 0.4 cm and 1.9 cm, respectively, and AGN-1A to AN-9 has a horizontal precision of 0.3 cm and a vertical precision of 1 cm. The three (3) occupied control points are within the required precision of the program.

4.4 Network Adjustment

After the baseline processing procedure, network adjustment is performed using TBC. Looking at the Adjusted Grid Coordinates table of the TBC generated Network Adjustment Report, it is observed that the square root of the sum of the squares of x and y must be less than 20 cm and z less than 10 cm or in equation from:

$$\sqrt{((x_e)^2 + (y_e)^2)} < 20cm \text{ and } z_e < 10\ cm$$

Where:

xe is the Easting Error,
ye is the Northing Error, and
ze is the Elevation Error

for each control point. Table 28 to Table 31 show the complete details of the Network Adjustment.

The three (3) control points, AGN-204, AGN-1A and AN-9 were occupied and observed simultaneously to form a GNSS loop. Elevation value of AGN-1A and coordinates of point AGN-204 were held fixed during the processing of the control points as presented in Table 28.

Table 28. Constraints applied to the adjustments of the control points

Point ID	Type	East σ (Meter)	North σ (Meter)	Height σ (Meter)	Elevation σ (Meter)
AGN-204	Local	Fixed	Fixed		
AGN-1A	Grid				Fixed
Fixed = 0.000001(Meter)					

Table 29. Adjusted grid coordinates for the control points used in the Mainit-Tubay River floodplain survey

Point ID	Easting (Meter)	Easting Error (Meter)	Northing (Meter)	Northing Error (Meter)	Elevation (Meter)	Elevation Error (Meter)	Constraint
AGN-1A	780449.982	0.016	1013806.588	0.012	10.568	?	e
AGN-204	789383.684	?	989007.083	?	28.115	0.100	LL
AN-9	779272.654	0.015	1009928.879	0.012	8.302	0.063	

The network is fixed at reference point AGN-204 and AGN-1A for coordinates and elevation, respectively. With the mentioned equation, $\sqrt{((x_e)^2 + (y_e)^2)} < 20cm$ for horizontal and $z_e < 10\ cm$ for the vertical, the computations for the horizontal and vertical accuracy are as follows:

a. AGN-204
Horizontal accuracy = fixed
Vertical accuracy = 10 cm

b.AGN-1A
horizontal accuracy = √((1.6)² + (1.2)²
= √(2.56 + 1.44)
= 2 cm < 20 cm
vertical accuracy = fixed

c.AN-9
horizontal accuracy = √((1.5)² + (1.2)²
= √(2.25 + 1.44)
= 1.92 cm < 20 cm
vertical accuracy = 6.3 cm < 10 cm

Following the given formula, the horizontal and vertical accuracy result of the three (3) occupied control points are within the required precision.

Table 30. Adjusted geodetic coordinates for control points used in the Mainit-Tubay Floodplain validation

Point ID	Latitude	Longitude	Height (Meter)	Height Error (Meter)	Constraint
AGN-1A	N9°09’44.79823”	E125°33’06.77787”	78.994	?	e
AGN-204	N8°56’16.03323”	E125°37’53.34384”	96.791	0.100	LLh
AN-9	N9°07’38.92818”	E125°32’27.34268”	76.540	0.063	

Table 31. Reference and control points used and its location (Source: NAMRIA, UP-TCAGP, CSU)

Control Point	Order of Accuracy	Geographic Coordinates (WGS 84)			UTM ZONE 51 N		
		Latitude	Longitude	Ellipsoidal Height (m)	Northing (m)	Easting (m)	BM Ortho (m)
AGN-204	2nd order GCP	8°56'16.03323"	125°37’53.34384	96.791	989007.083	789383.684	28.115
AGN-1A	Fixed, CSU established	9°09’44.79823”	125°33’06.77787”	78.994	1013806.588	780449.982	10.568
AN-9	Used as marker	9°07’38.92818”	125°32’27.34268”	76.54	1009928.879	779272.654	8.302

4.5 Cross-section and Bridge As-Built survey, and Water Level Marking

Cross-section and as-built survey was done on February 19, 2015 along the upstream side of Tubay Bridge in Brgy. Doña Rosario using Trimble® SPS 882 in GNSS PPK survey technique and an Ohmex™ single beam echo sounder (Figure 37).

Figure 37. Gathering of cross-section points in Tubay Bridge using Trimble® SPS 882

The cross-sectional length of Tubay bridge is about 197 m with 19 cross-sectional points acquired using the control point AGN-1A as the GNSS base station. The location map, cross-section diagram, and bridge as-built form are shown in Figure 38 to Figure 40, respectively.

Caraga State University acquired the water surface elevation of Kalinawan River. The water surface elevation in MSL was marked along the piers of Tubay Bridge which will serve as reference for their flow data gathering and depth gauge deployment activities.

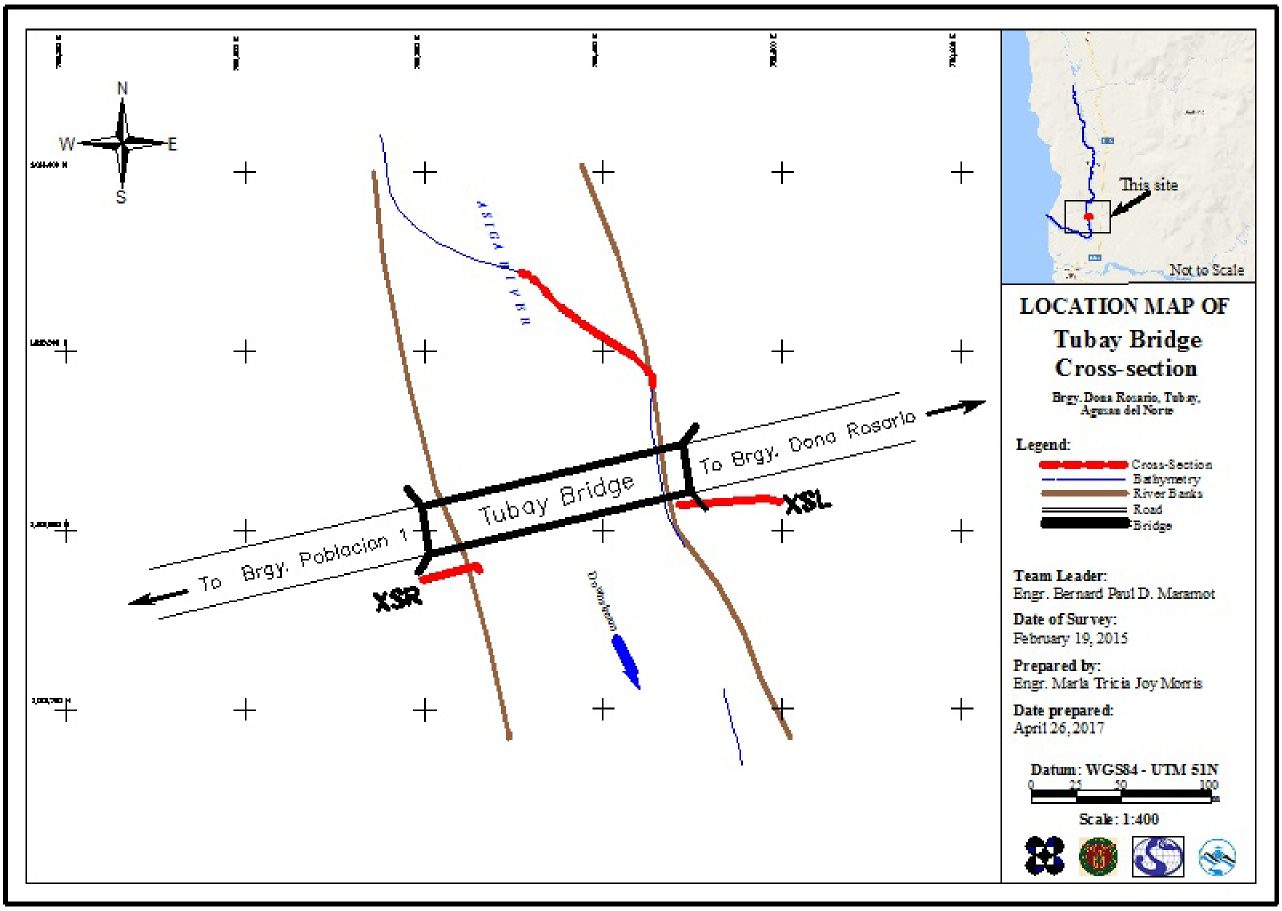


Figure 38. Tubay bridge cross-section location map

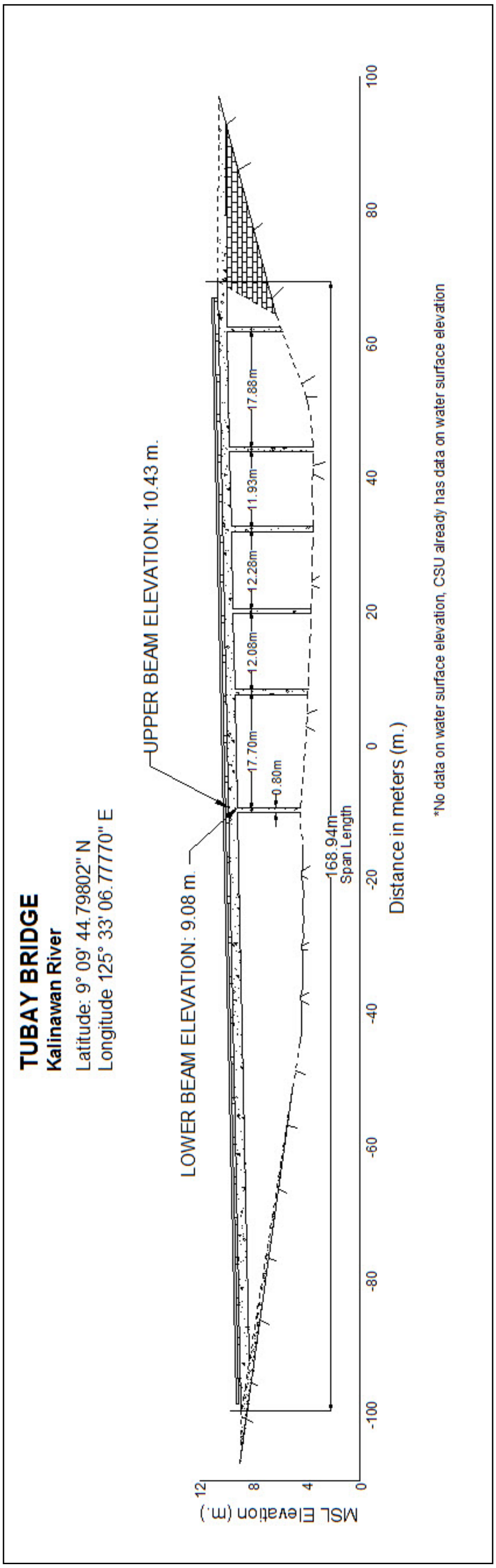
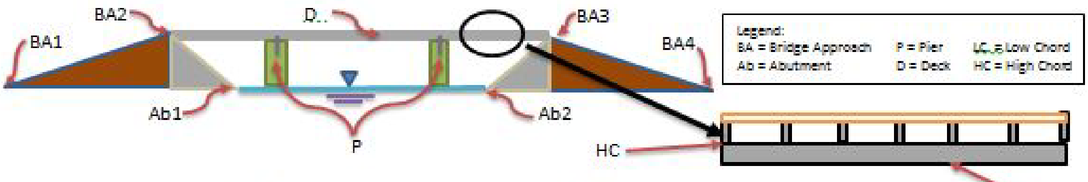


Figure 39. Tubay Bridge cross-section diagram

Bridge Data Form

Bridge Name: Tubay Bridge	**Date:** February 19, 2015
River Name: Kalinawan River	**Time:** 3:30 PM
Location (Brgy, City,Region): Bgy. Dona Rosario, Tubay, Agusan del Norte	
Survey Team: Mark Lester D. Rojas, Bernard Paul Maramot, Dona Rina Patricia Tajora, Edjie Abalos	
Flow condition: low ✓normal high	**Weather Condition:** ✓fair rainy
Latitude: 9°9'44.79802" N	**Longitude:** 125°33'6.77770" E



LC

Deck (Please start your measurement from the left side of the bank facing upstream)

Elevation: 10.43799 m. **Width:** 8.00 m. **Span (BA3-BA2):** 168.94 m.

	Station	High Chord Elevation	Low Chord Elevation
1	97.67319	10.73199	9.380831
2	115.3725	10.65399	9.302831
3	127.4493	10.64499	9.293831
4	139.7369	10.64799	9.296831
5	151.6582	10.63999	9.288831

Bridge Approach (Please start your measurement from the left side of the bank facing upstream)

	Station(Distance from BA1)	Elevation		Station(Distance from BA1)	Elevation
BA1	**0**	**6.4099**	**BA3**	**238.237**	**5.566**
BA2	**161.4708542**	**11.7029**	**BA4**	**346.826**	**9.369**

Abutment: Is the abutment sloping? ✓Yes No; If yes, fill in the following information:

	Station (Distance from BA1)	Elevation
Ab1	7.820188	5.08299
Ab2	171.7398	6.30199

Pier (Please start your measurement from the left side of the bank facing upstream)

Shape: Cylindrical Number of Piers: 6 Height of column footing: N/A

	Station (Distance from BA1)	Elevation	Pier Width
Pier 1	97.67319	10.73199	**approx. 0.8 m.**
Pier 2	115.3725	10.65399	**approx. 0.8 m.**
Pier 3	127.4493	10.64499	**approx. 0.8 m.**
Pier 4	139.7369	10.64799	**approx. 0.8 m.**
Pier 5	151.6582	10.63999	**approx. 0.8 m.**
Pier 6	169.5459	10.66099	**approx. 0.8 m.**

NOTE: Use the center of the pier as reference to its station

DREAM
Disaster Risk and Exposure Assessment for Mitigation

Figure 40. Tubay Bridge As-Built Data Form

4.6. Validation Points Acquisition Survey

Validation points acquisition survey was conducted on February 21, 2015 using a survey grade GNSS rover receiver, Trimble® SPS 882, mounted to a pole which was attached in front of a vehicle as shown in Figure 42. It was secured with a nylon rope to ensure that it was horizontally and vertically balanced. The height of instrument was measured from the ground up to the bottom of the notch of the receiver. It is about 1.522 m. The survey was conducted in PPK technique on a continuous topography mode with one (1) second logging time. Points were gathered along major concrete roads with vehicular speed of 20 to 40 kph, cutting across the flight strips of the DAC.

Figure 41. Setting up of GNSS rover receiver, Trimble® SPS882 in a vehicle

Figure 43 shows the lines covered in validation data gathering. It covered the municipalities of Tubay and Remedios T. Romualdez and Cabadbaran City, Agusan del Norte. The team gathered about 3,120 validation points with a length of approximately 20 km. Data gaps were present because of the presence of obstruction like canopy of trees which inhibited satellite signals.

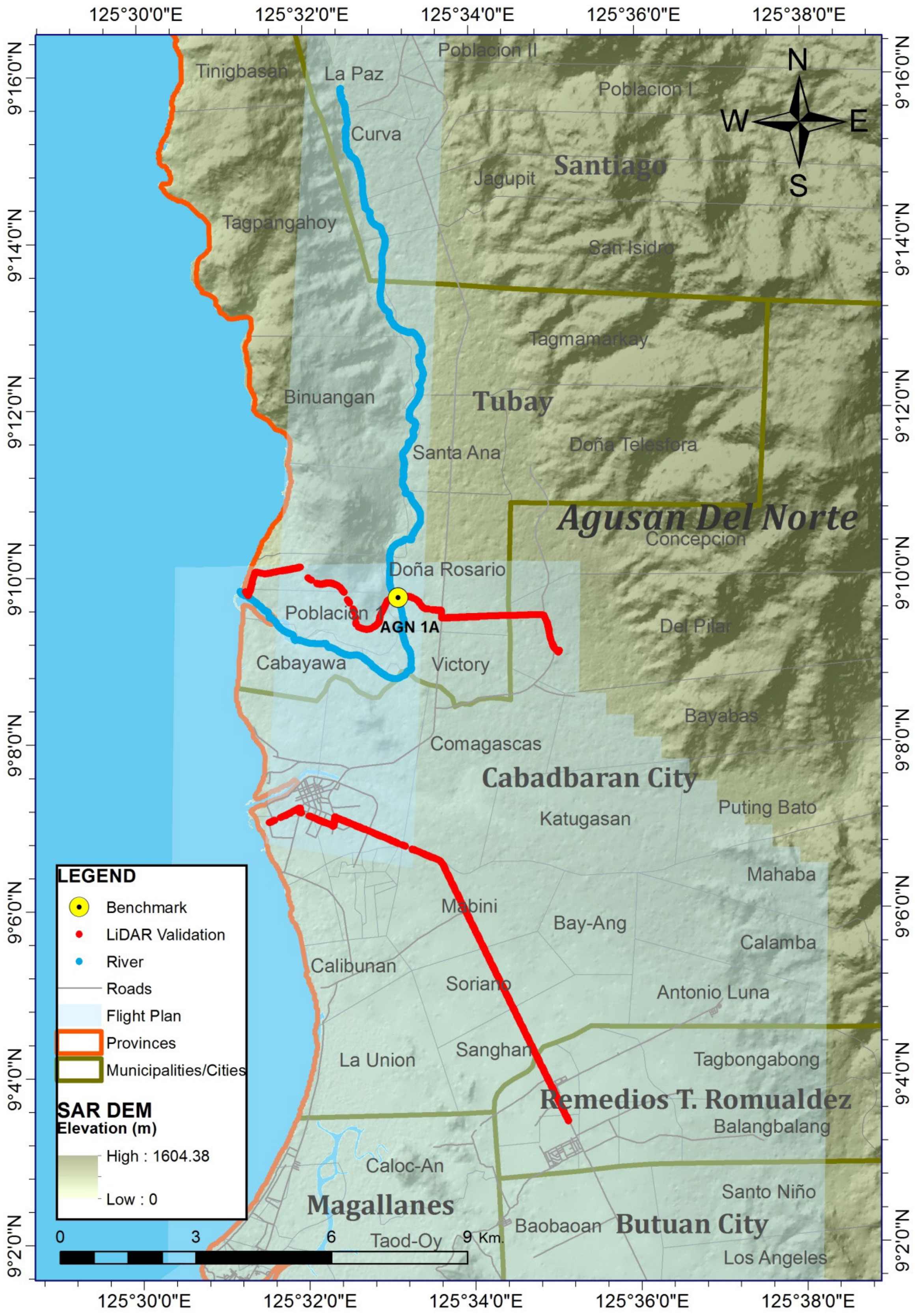


Figure 42. LiDAR ground validation survey along Agusan del Norte

4.7 River Bathymeric Survey

Bathymetric survey of Kalinawan River was executed on February 20, 2015 using Trimble® SPS 882 in GNSS PPK survey technique utilizing continuous topo mode and an Ohmex™ Single Beam Echo attached on a boat as shown in Figure 44. The survey started at the uppermost part of the river in Brgy. La Paz, Municipality of Santiago with coordinates 9°15'51.12203"N, 125°32'27.44218"E, and ended at the mouth of the river in Brgy. Poblacion, also in Municipality of Tubay with coordinates 9°09'47.60016"N, 125°31'13.39809"E. The control point AGN-1A was used as the GNSS base station all throughout the survey.

Figure 43. (a) Tying of the pole with transducer in one of the gunwales of the boat and (b) setup of bathymetric survey

The bathymetric survey gathered a total of 8,761 points covering an estimated length of 19 km of the river traversing nine barangays in Municipality of Tubay and four barangays in Municipality of Santiago, Agusan Del Norte as shown in Figure 45. A CAD drawing was also produced to illustrate the riverbed profile of Kalinawan River. As shown in Figure 46, the highest and lowest elevation has a 35-m difference. The highest elevation value gathered was 32.99 m in MSL located in Brgy. La Paz, Municipality of Santiago, Agusan Del Norte, while the lowest elevation value gathered was -3.65 m below MSL located in Brgy. Poblacion, Municipality of Tubay, Agusan del Norte.

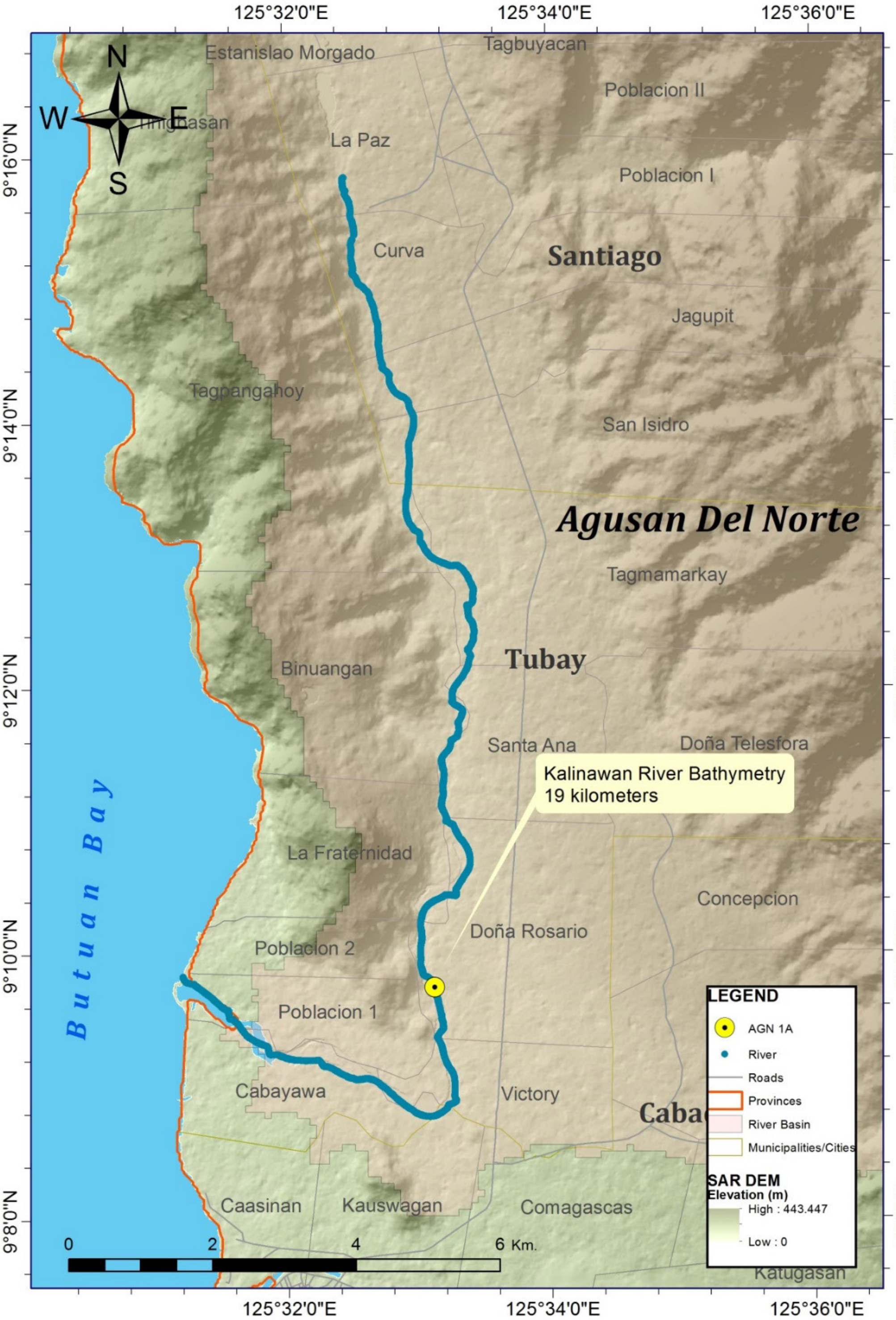


Figure 44. Bathymetric points gathered in Kalinawan River

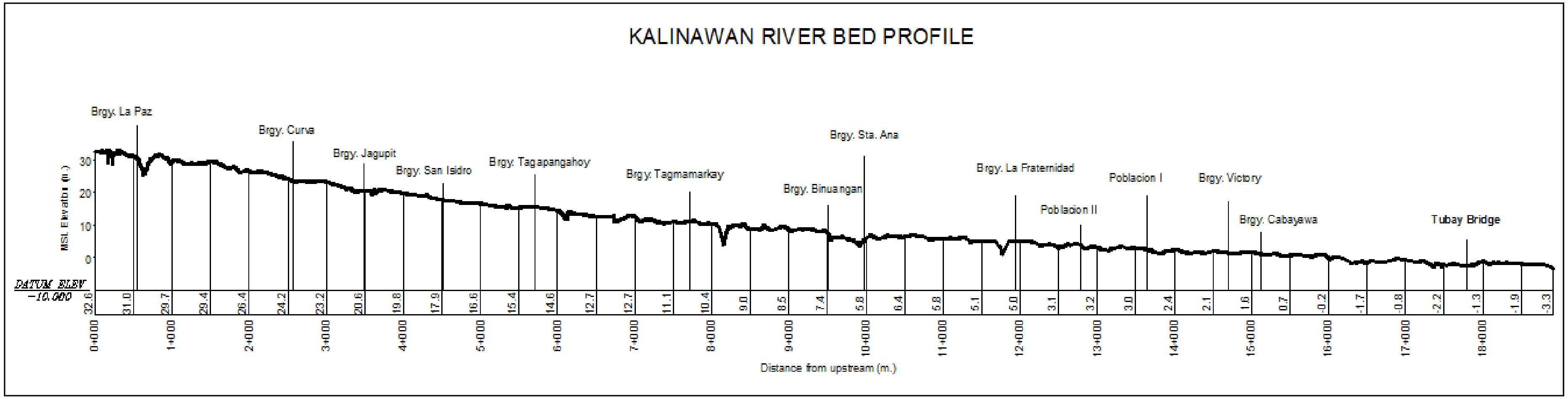


Figure 45. Riverbed profile of Kalinawan River

CHAPTER 5: FLOOD MODELING AND MAPPING

Dr. Alfredo Mahar Lagmay, Christopher Uichanco, Sylvia Sueno, Marc Moises, Hale Ines, Miguel del Rosario, Kenneth Punay, Neil Tingin

The methods applied in this Chapter were based on the DREAM methods manual (Balicanta, et al., 2014) and further enhanced and updated in Paringit, et al. (2017).

5.1 Data Used for Hydrologic Modeling

5.1.1 Hydrometry and Rating Curves

All data that affect the hydrologic cycle of the Mainit-Tubay River Basin were monitored, collected, and analyzed. Rainfall, water level, and flow in a certain amount of time, which may affect the hydrologic cycle of the Mainit-Tubay River Basin were monitored, collected, and analyzed.

5.1.2 Precipitation

Precipitation data was taken from fifteen automatic rain gauges (ARGs) installed by the Department of Science and Technology – Advanced Science and Technology Institute (DOST-ASTI). These were the Cabadbaran, Jagupit, Poblacion, Kitcharao Municipality, Kitcharao, Mainit Municipality, Mainit, Tubod, Malimono, San Francisco Municipality, San Francisco, Sison, Gigaquit, Claver and Cantilan ARGs. The locations of the rain gauges are shown in Figure 46.

Based on the nearest rainfall station to Puyo Bridge, the total rain from Poblacion, Jabonga rain gauge is 78.60 mm. It peaked to 7.40 mm. on 26 November 2014 18:30. The lag time between the peak rainfall and its corresponding peak discharge is 4 hours and 30 minutes, as seen in Figure 48.

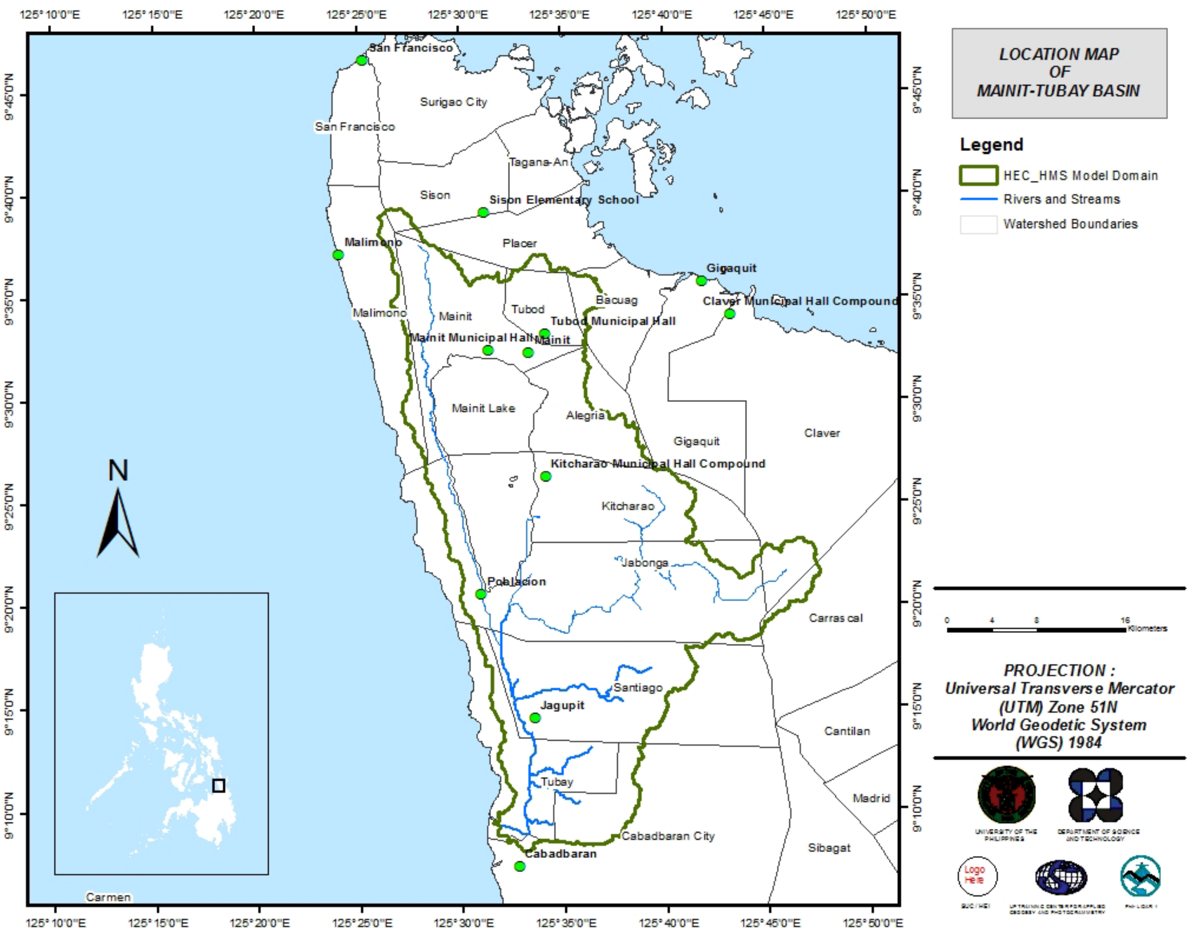


Figure 46. The location map of rain gauge used for the calibration of the Mainit-Tubay HEC- HMS model

5.1.3 Rating Curves and River Outflow

A rating curve was developed at Puyo Bridge, Jabonga, Agusan del Norte (9°19'20.47"N, 125°33'21.30"E). It gives the relationship between the observed water levels from Puyo Bridge and outflow of the watershed at this location.

For Puyo Bridge, the rating curve is expressed as Q = 172.58905376H2 - 13909.87385123H + 280268.41770626 as shown in Figure 47.

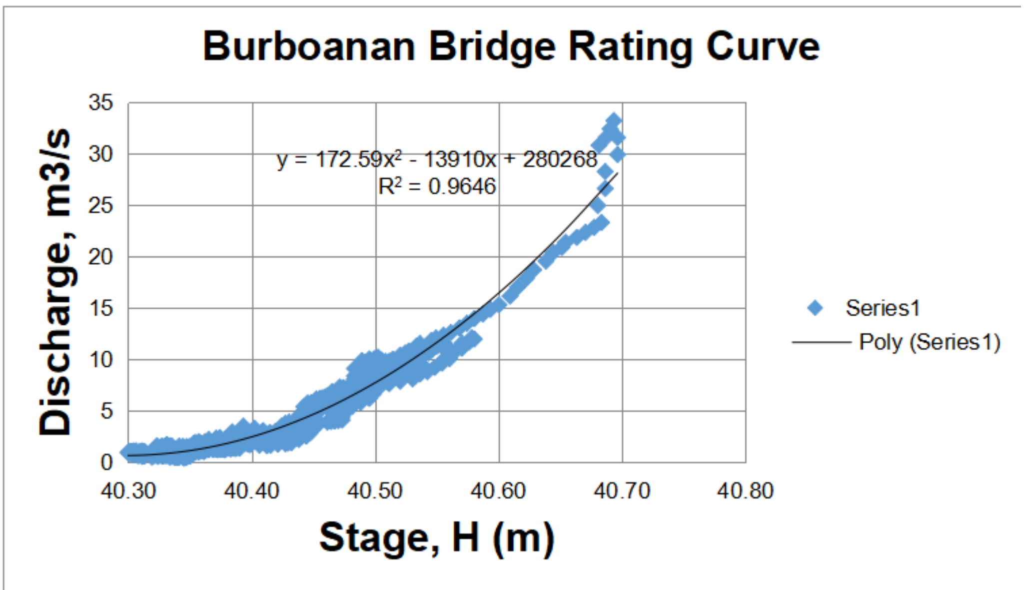


Figure 47. Rating Curve at Puyo Bridge, Jabonga, Agusan del Norte

This rating curve equation was used to compute the river outflow at Puyo Bridge (Figure 48) and was utilized for the calibration of the HEC-HMS model. Peak discharge is 33.2 cubic meter per second (cms) at 11:00 PM, November 26, 2014.

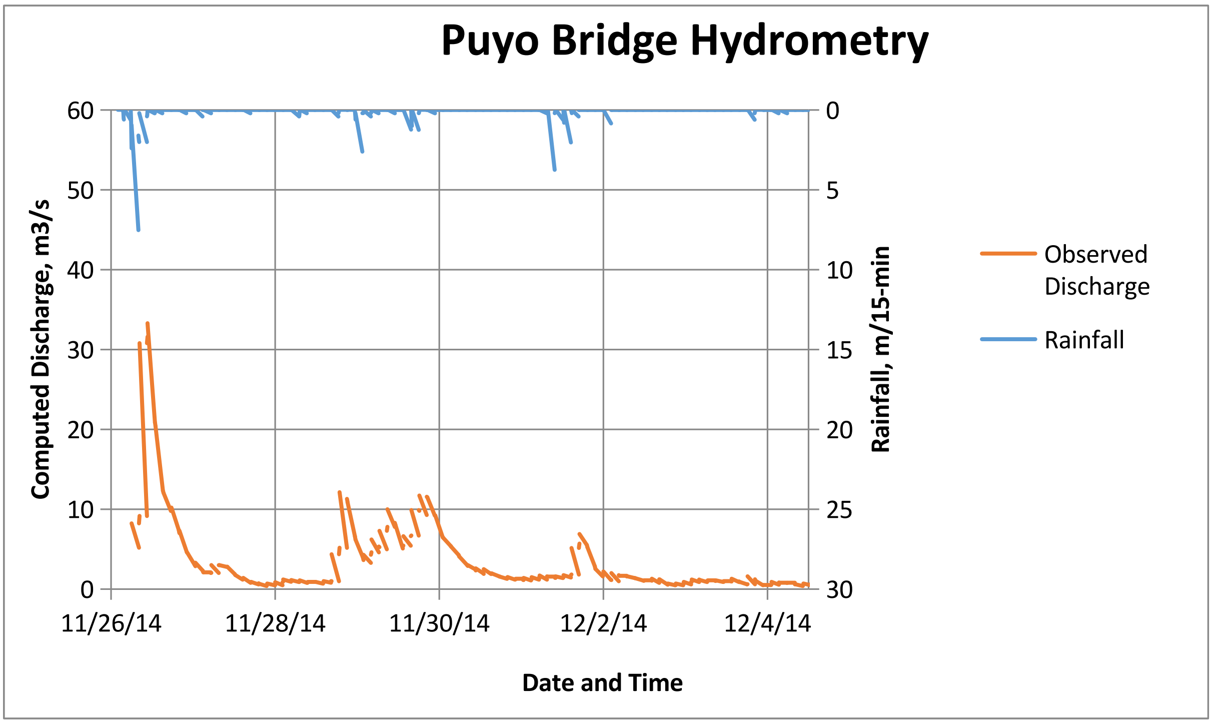


Figure 48. Rainfall and outflow data at Jabonga which was used for modeling

5.2 RIDF Station

The Philippine Atmospheric Geophysical and Astronomical Services Administration (PAGASA) computed for Rainfall Intensity Duration Frequency (RIDF) values for the Baguio Rain Gauge. The RIDF rainfall amount for 24 hours was converted to a synthetic storm by interpolating and the values were re- arranged in such a way a certain peak value will be attained at a certain time. The Butuan and Surigao stations were chosen based on its proximity to the watershed. The extreme values for this watershed were computed based on a 21- and 46-year record, respectively.

Table 32. Computed extreme values (in mm) of precipitation at Mainit-Tubay river basin based on average RIDF data of Butuan and Surigao stations

T (yrs)	5 min	10 min	15 min	20 min	30 min	1 hr	2 hrs	3 hrs	6 hrs	12 hrs	24 hrs
2	10.2	20.35	23.8	31.7	38.25	49.9	68.65	80.4	105.2	128.7	157.55
5	14.55	29.12	33.55	44.8	53.9	70.6	98.5	116.1	151.9	194.45	230.85
10	17.45	34.95	40.1	53.4	64.3	84.25	118.25	139.75	182.75	237.95	279.35
25	21.1	42.25	48.3	64.35	77.4	101.55	143.2	169.55	221.75	293	340.65
50	23.85	47.7	54.4	72.45	87.1	114.35	161.7	191.75	250.7	333.75	386.15
100	26.55	53.05	60.4	80.55	96.8	127.05	180.1	213.7	279.45	374.25	431.25

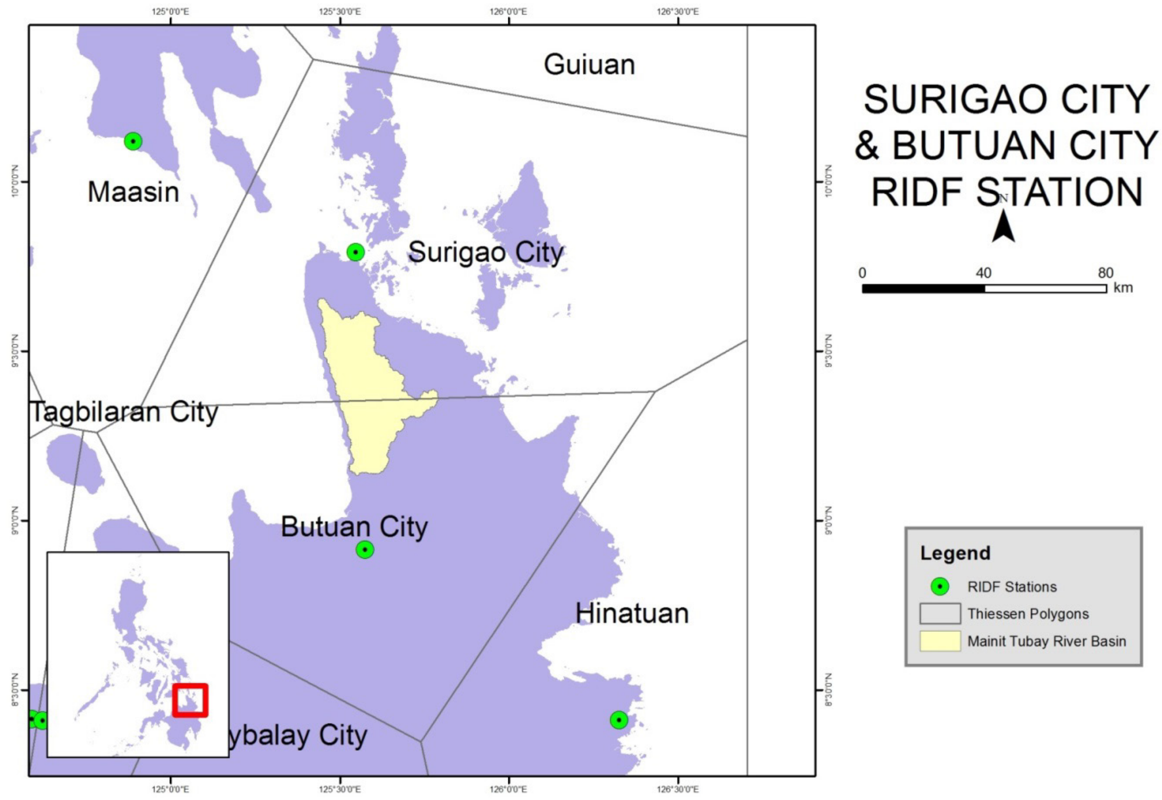


Figure 49. Location of Surigao-Butuan RIDF Station relative to Bislig River Basin

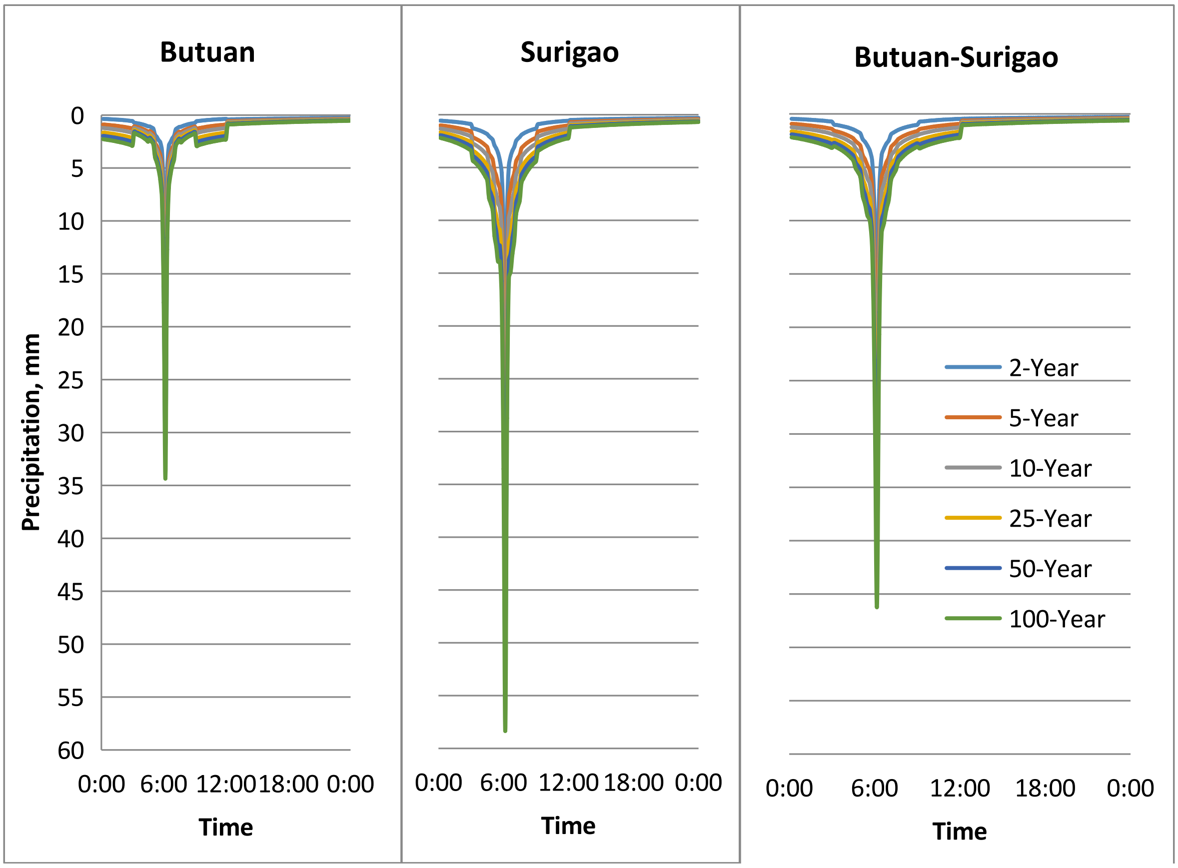


Figure 50. Rainfall-Intensity Frequency Duration (RIDF) curves of Butuan and Surigao stations and their equivalent average

5.3 HMS Model

The soil shape file (dated 2004) was obtained from the Department of Agriculture-Bureau of Soils and Water Management (DA-BSWM). The land cover dataset was from the National Mapping and Resource information Authority (NAMRIA). The soil and land cover of the Mainit-Tubay River Basin are shown in Figures 51 and 52, respectively.

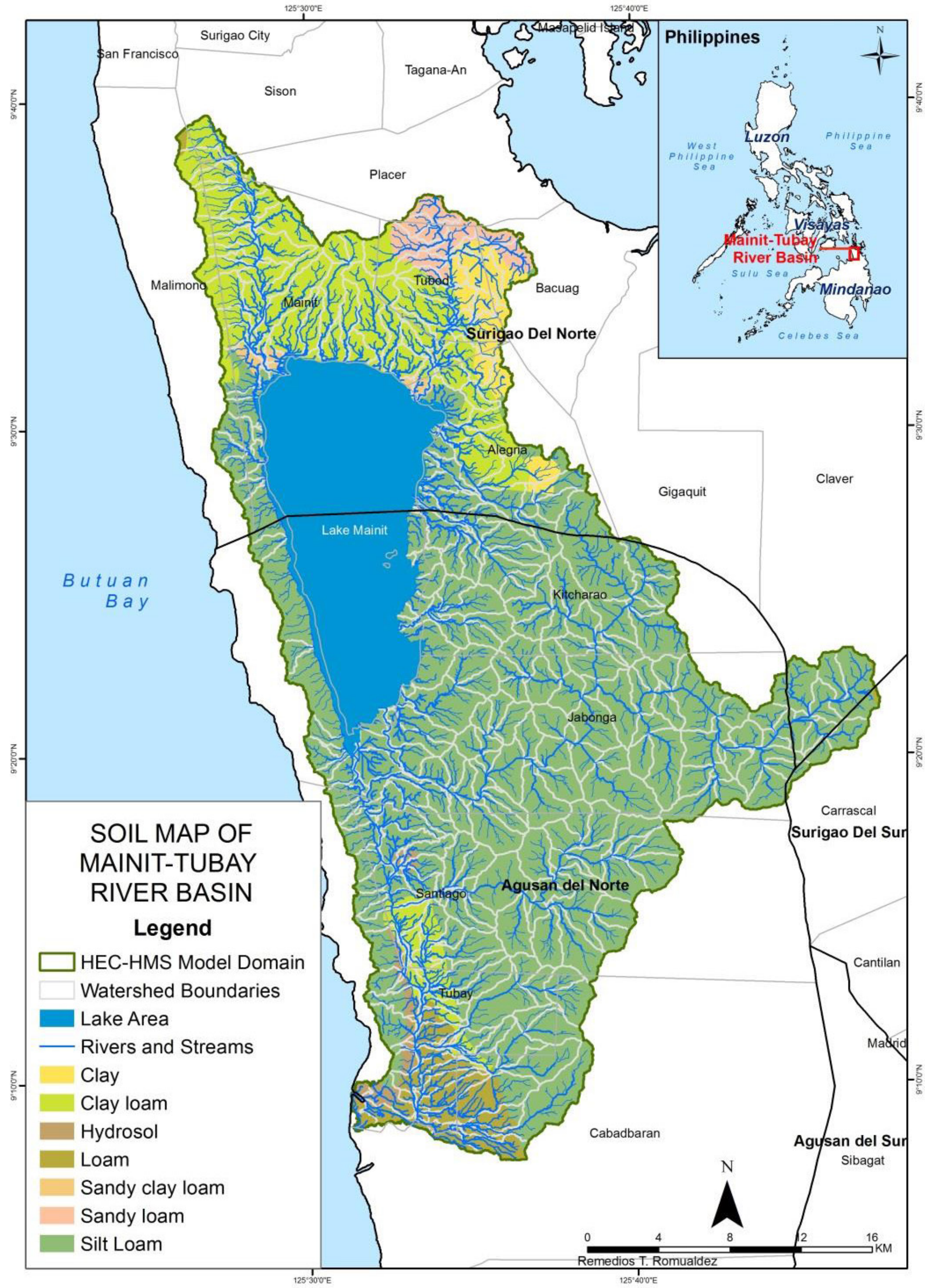


Figure 51. The soil map of the Mainit-Tubay River Basin used for the estimation of the CN parameter. (Source of data: Digital soil map of the Philippines published by the Bureau of Soil and Water Management – Department of Agriculture)

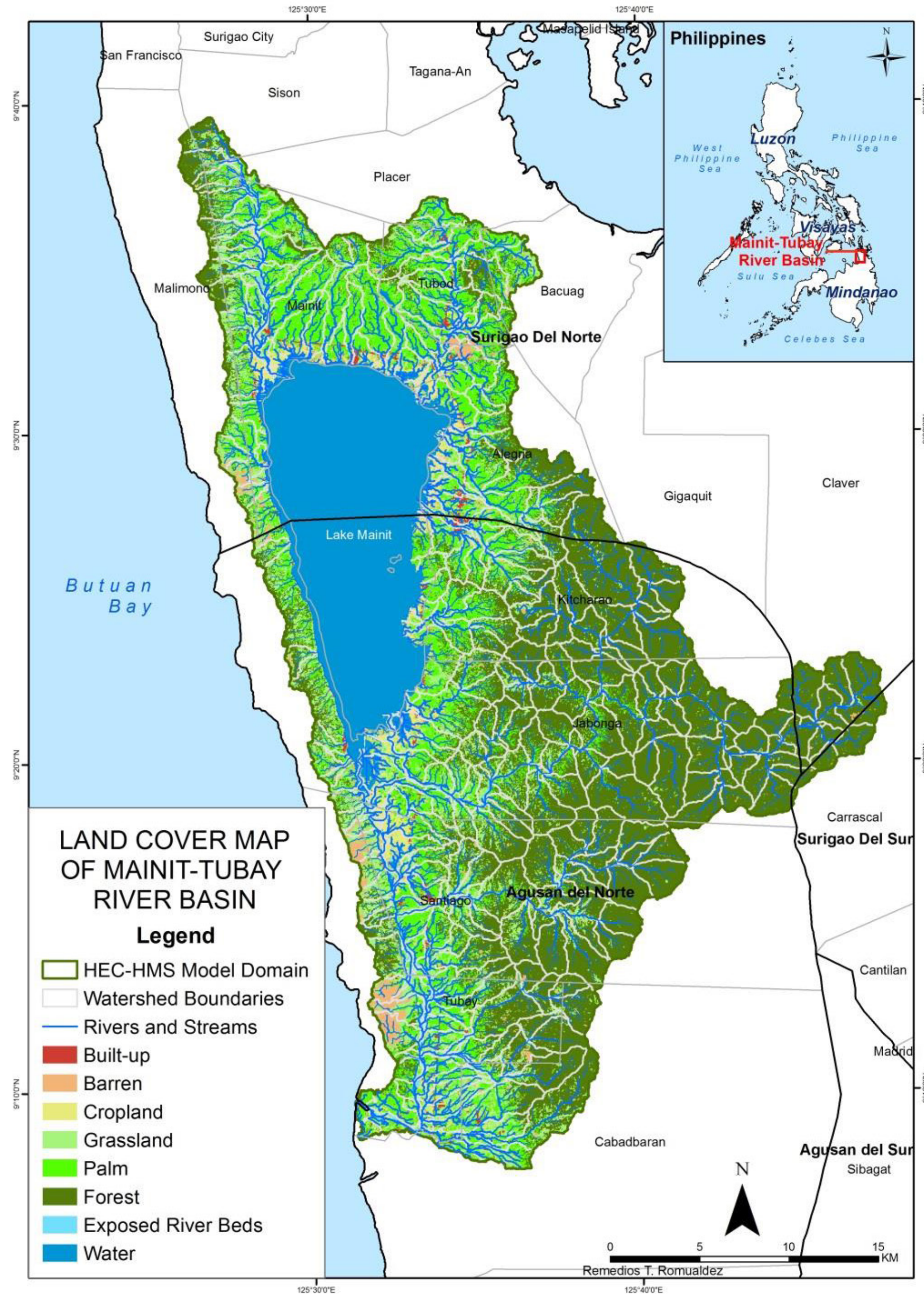


Figure 52. The land cover map of the Mainit-Tubay River Basin used for the estimation of the CN and watershed lag parameters of the rainfall-runoff model (Source: NAMRIA)

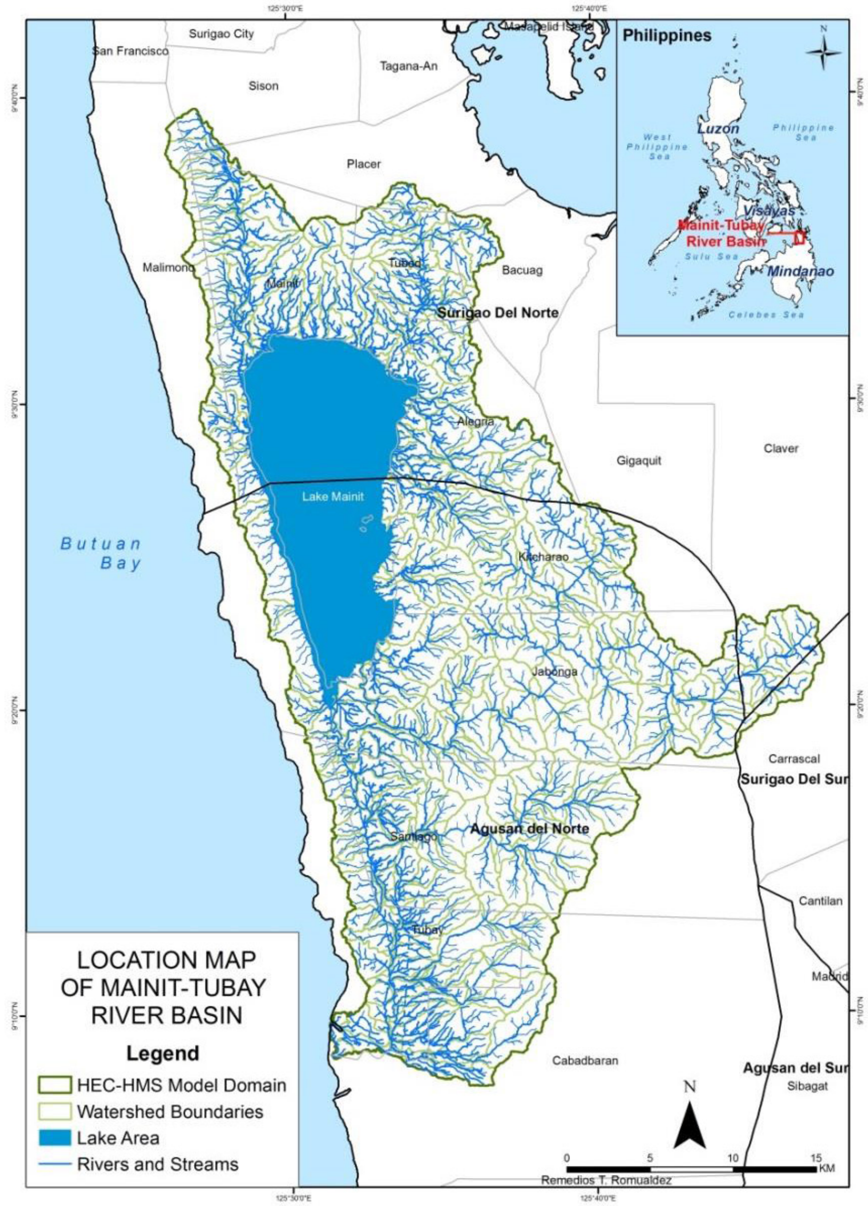


Figure 53. Stream delineation map of Mainit River Basin

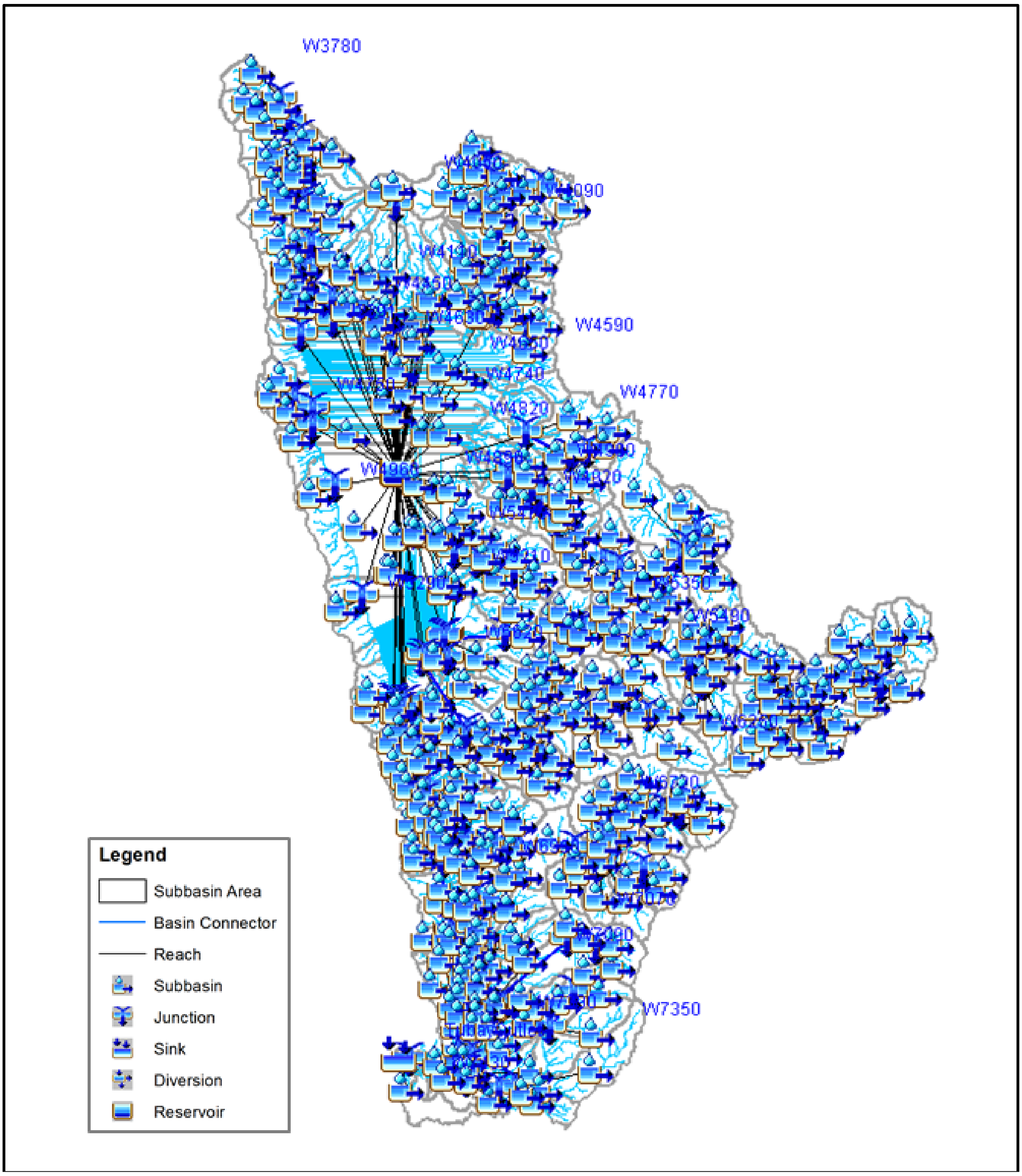


Figure 54. The Mainit-Tubay River Basin model generated using HEC-HMS.

5.4 Cross-section Data

Riverbed cross-sections of the watershed were necessary in the HEC-RAS model setup. The cross-section data for the HEC-RAS model was derived from the LiDAR DEM data. It was defined using the Arc GeoRAS tool and was post-processed in ArcGIS (Figure 55).

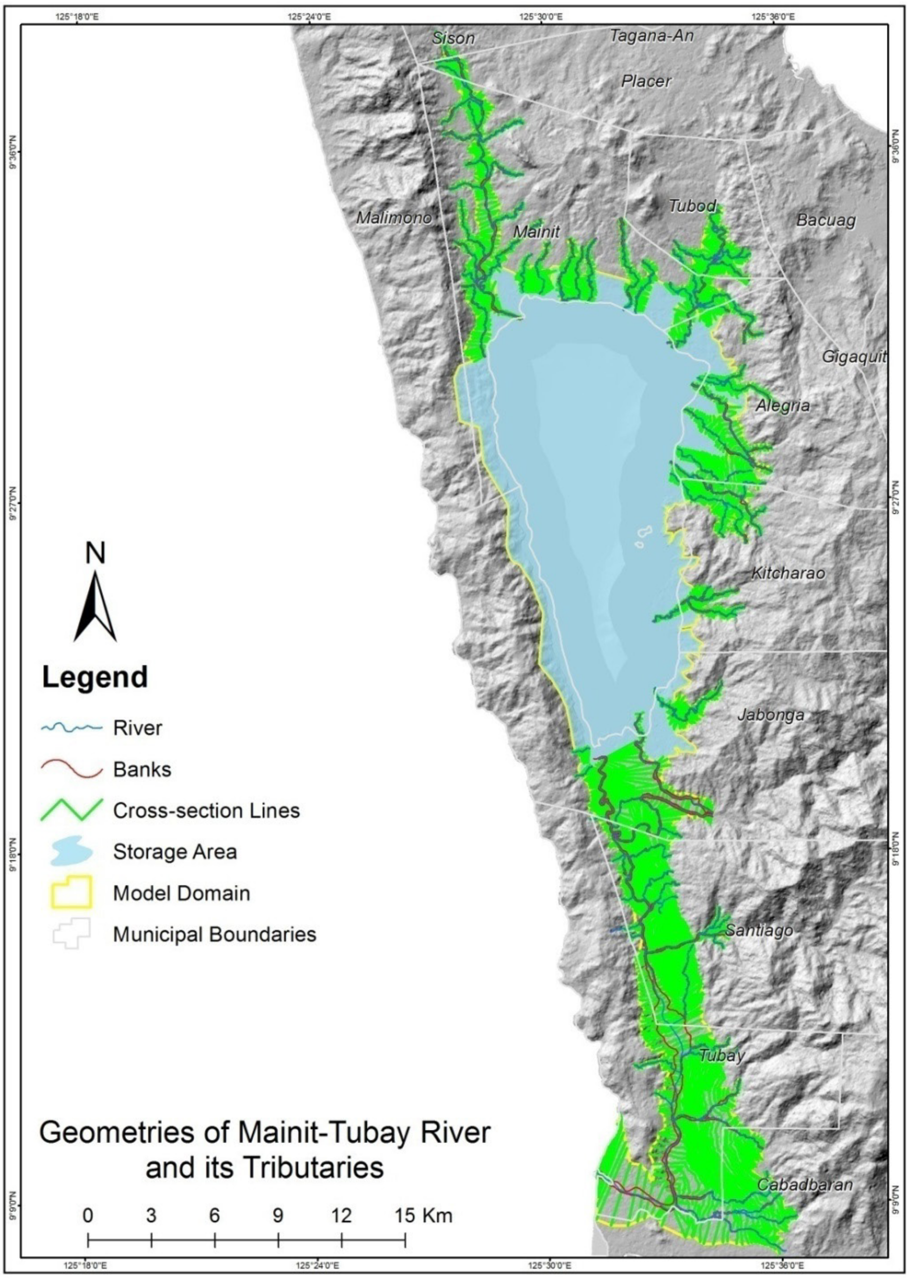


Figure 55. Created geometries of Surigao HEC RAS model

5.5 Flo 2D Model

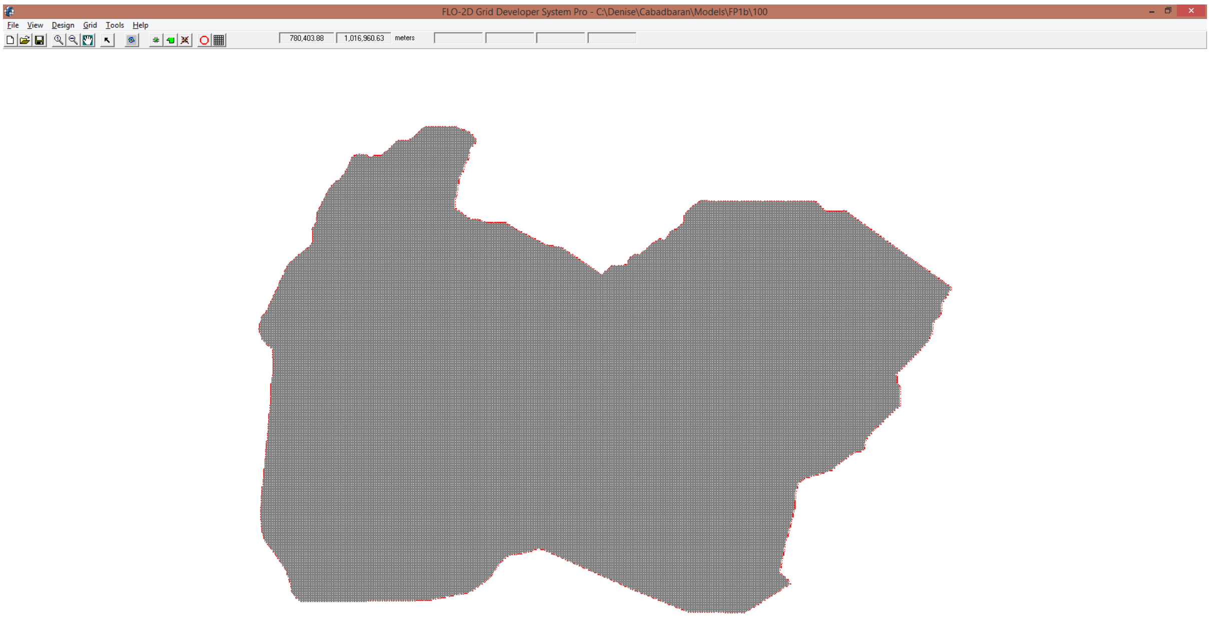


Figure 56. Screenshot of subcatchment with the computational area to be modeled in FLO-2D GDS Pro

5.6 Results of HMS Calibration

After calibrating the Mainit-Tubay HEC-HMS river basin model, its accuracy was measured against the observed values (see Annex 8: Mainit-Tubay Model Basin Parameters). Figure 57 shows the comparison between the two discharge data.

Table 33 shows the adjusted range of values of the parameters used in calibrating the model.

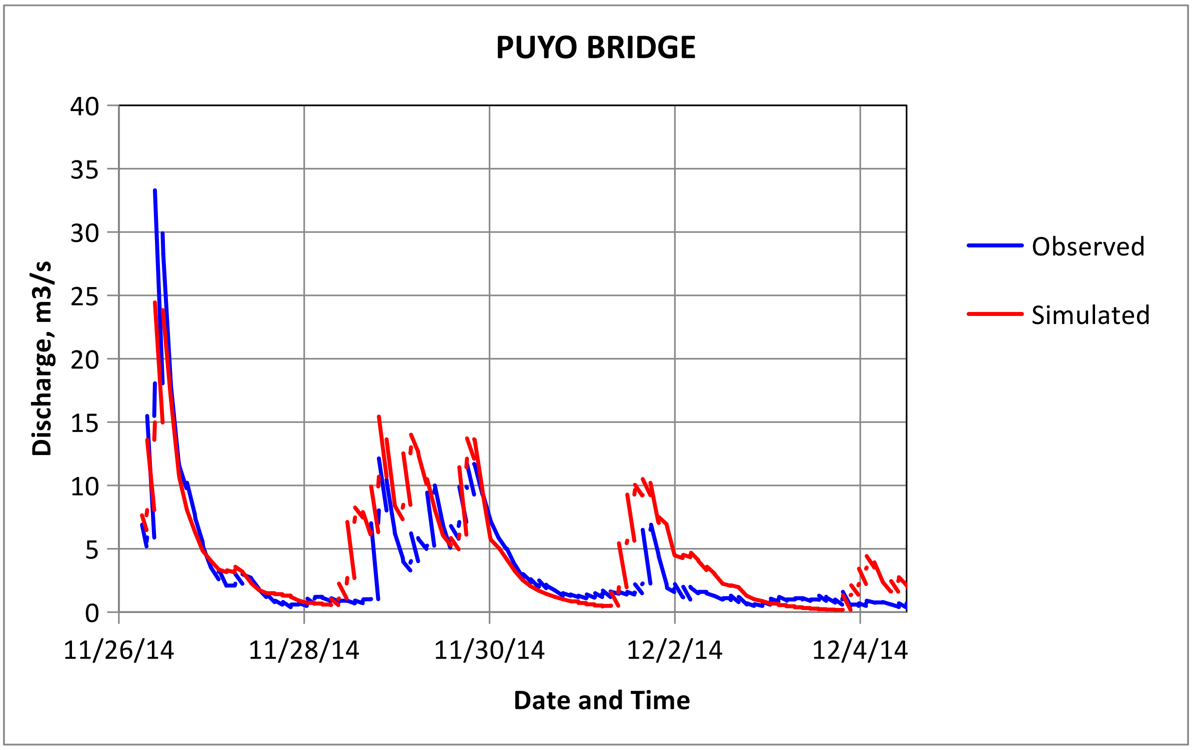


Figure 57. Outflow Hydrograph of Puyo Bridge produced by the HEC-HMS model compared with observed outflow.

Table 33. Range of Calibrated Values for Malinao Inlet

Hydrologic Element	Calculation Type	Method	Parameter	Range of Calibrated Values
Basin	Loss	SCS Curve number	Initial Abstraction (mm)	0-99.98
			Curve Number	35-99
			Impervious (%)	0-32
	Transform	Clark Unit Hydrograph	Time of Concentration (hr)	0.16-13.43
			Storage Coefficient (hr)	0.06-28.57
	Baseflow	Recession	Recession Constant	0.04-0.3
			Ratio to Peak	0.002-0.014
Reach	Routing	Muskingum-Cunge	Manning's Coefficient	0.03-0.067

nitial abstraction defines the amount of precipitation that must fall before surface runoff. The magnitude of the outflow hydrograph increases as initial abstraction decreases. The range of values 0-99.98 mm means that there is an average amount of infiltration or rainfall interception by vegetation.

Curve number is the estimate of the precipitation excess of soil cover, land use, and antecedent moisture. The magnitude of the outflow hydrograph increases as curve number increases. The range of 65 to 90 for curve number is advisable for Philippine watersheds depending on the soil and land cover of the area (M. Horritt, personal communication, 2012).

Time of concentration and storage coefficient are the travel time and index of temporary storage of runoff in a watershed. The range of calibrated values 0.16-13.43 hours determines the reaction time of the model with respect to the rainfall. The peak magnitude of the hydrograph also decreases when these parameters are increased.

Recession constant is the rate at which baseflow recedes between storm events and ratio to peak is the ratio of the baseflow discharge to the peak discharge. Recession constant of 0.04 to 0.3 indicates that the basin will quickly go back to its original discharge. The ratio to peak of 0.002 to 0.014 indicates a steeper receding limb of the outflow hydrograph.

Manning's roughness coefficient of 0.03 to 0.067 corresponds to the common roughness in Malinao Inlet, which is determined to be cultivated with mature field crops (Brunner, 2010).

Table 34. Summary of the Efficiency Test of Mainit HMS Model

r^2	0.7444
NSE	0.677
PBIAS	-22.737
RSR	0.568

The Root Mean Square Error (RMSE) method aggregates the individual differences of these two measurements. It was identified to be 0.043 m3/s.

The Pearson correlation coefficient (r2) assesses the strength of the linear relationship between the observations and the model. This value being close to 1 corresponds to an almost perfect match of the observed discharge and the resulting discharge from the HEC HMS model. Here, it measured 0.7444.

The Nash-Sutcliffe (E) method was also used to assess the predictive power of the model, with E = 1 being the optimal value. The model attained an efficiency coefficient of 0.677.

A positive Percent Bias (PBIAS) indicates a model's propensity towards under-prediction. Negative values indicate bias towards over-prediction. The optimal value is 0. In the model, the PBIAS is -22.737.

The Observation Standard Deviation Ratio, RSR, is an error index. A perfect model attains a value of 0 when the error in the units of the valuable a quantified. The model has an RSR value of 0.568.

5.7 Calculated outflow hydrographs and discharge values for different rainfall return periods

5.7.1 Hydrograph using the Rainfall Runoff Model

The summary graph (Figure 58) shows the Butuan-Surigao RIDF in 5 different return periods (5-year, 10-year, 25-year, 50-year, and 100-year rainfall time series) based on the PAG-ASA data. The simulation results reveal significant increase in outflow magnitude as the rainfall intensity increases for a range of durations and return periods.

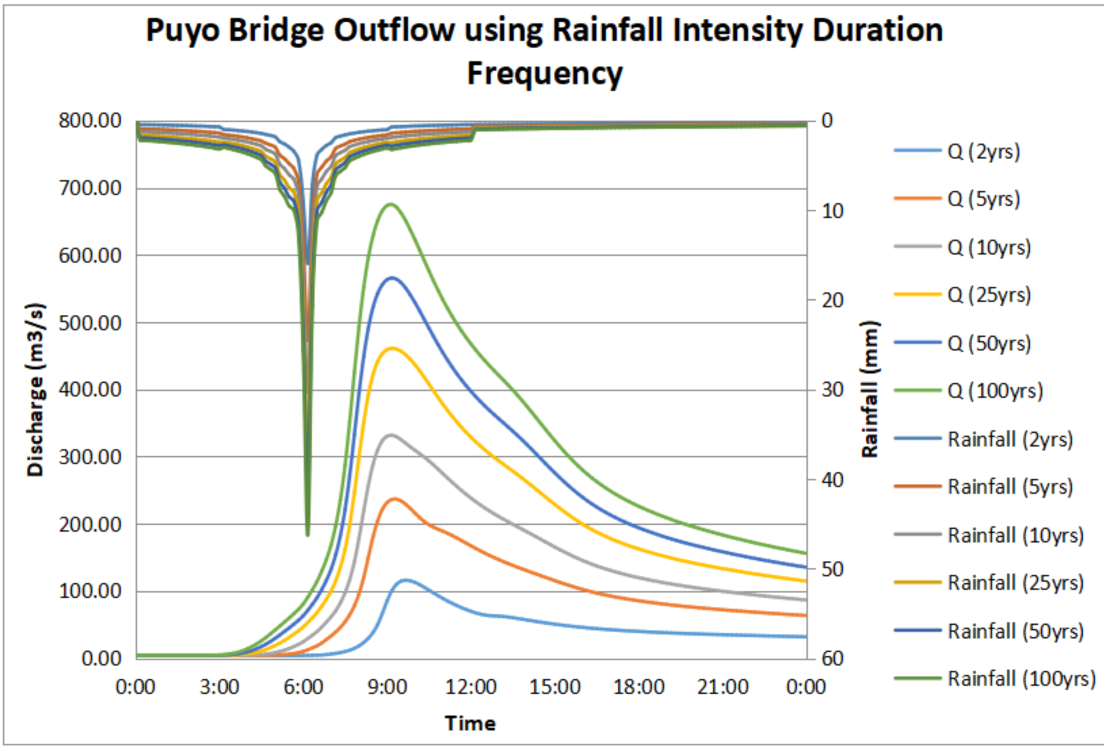


Figure 58. Butuan-Surigao RIDF in 5 different return periods (5-year, 10-year, 25-year, 50-year, and 100-year rainfall time series

A summary of the total precipitation, peak rainfall, peak outflow and time to peak of the Puyo Bridge discharge using the Butuan-Surigao RIDF in five different return periods is shown in Table 35.

Table 35. Peak outflows of the Mainit-Tubay HECHMS Model at Puyo Bridge using the Butuan-Surigao RIDF

RIDF Period	Total Precipitation (mm)	Peak Rainfall (mm)	Peak Outflow (m^3/s)	Time to Peak
5-Year	221.33	24.57	236.9	3 hrs 20 min
10-Year	276.23	30.31	331.9	3 hrs 10 min
25-Year	340.21	36.91	461.0	3 hrs 10 min
50-Year	385.62	41.61	565.8	3 hrs 10 min
100-Year	430.72	46.22	675.0	3 hrs 10 min

5.8 River Analysis (RAS) Model Simulation

The HEC-RAS Flood Model produced a simulated water level at every cross-section for every time step for every flood simulation created. The resulting model will be used in determining the flooded areas within the model. The simulated model will be an integral part in determining real-time flood inundation extent of the river after it has been automated and uploaded on the DREAM website. The Mainit model with was run with the TS Agaton event. The sample generated map of Mainit River using the calibrated HMS base flow is shown in Figure 59.

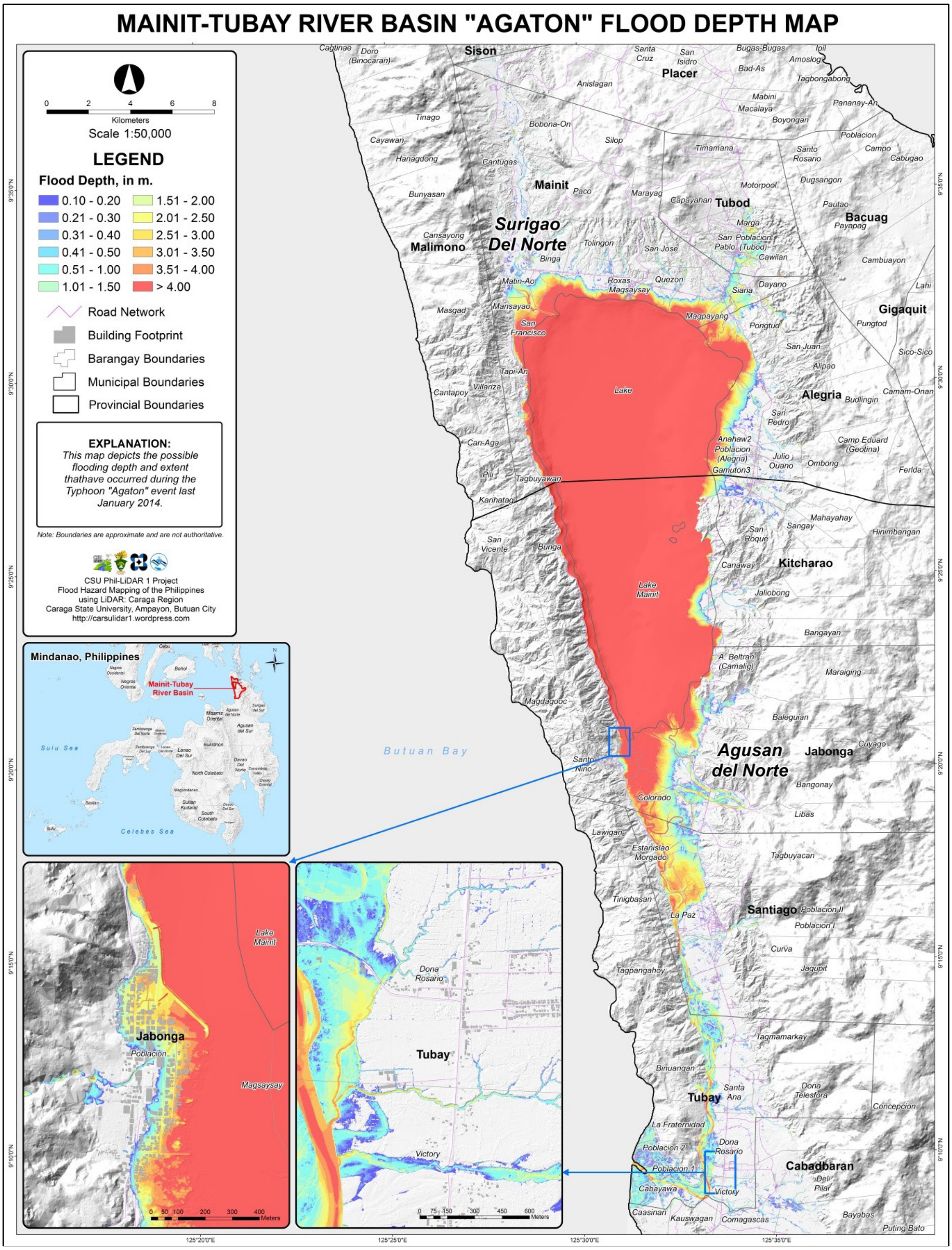


Figure 59. Flood depth and extent at Mainit-Tubay River basin during typhoon “Agaton”

5.9 Flow Depth and Flood Hazard

The resulting hazard and flow depth maps have a 10m resolution. The 5-, 25-, and 100-year rain return scenarios of the Mainit floodplain are shown in Figures 60 to 65. The floodplain, with an area of 116.36 sq. km., covers five municipalities namely Cabadbaran City, Jabonga, Mainit Lake, Santiago and Tubay. Table 36 shows the percentage of area affected by flooding per municipality.

Table 36. Municipalities affected in Mainit floodplain

Municipality	Total Area	Area Flooded	% Flooded
Cabadbaran City	343.9123	2.353306	0.68%
Jabonga	269.8928	31.8482	11.80%
Mainit Lake	69.28169	1.003224	1.45%
Santiago	218.2799	33.96956	15.56%
Tubay	107.138	46.98797	43.86%

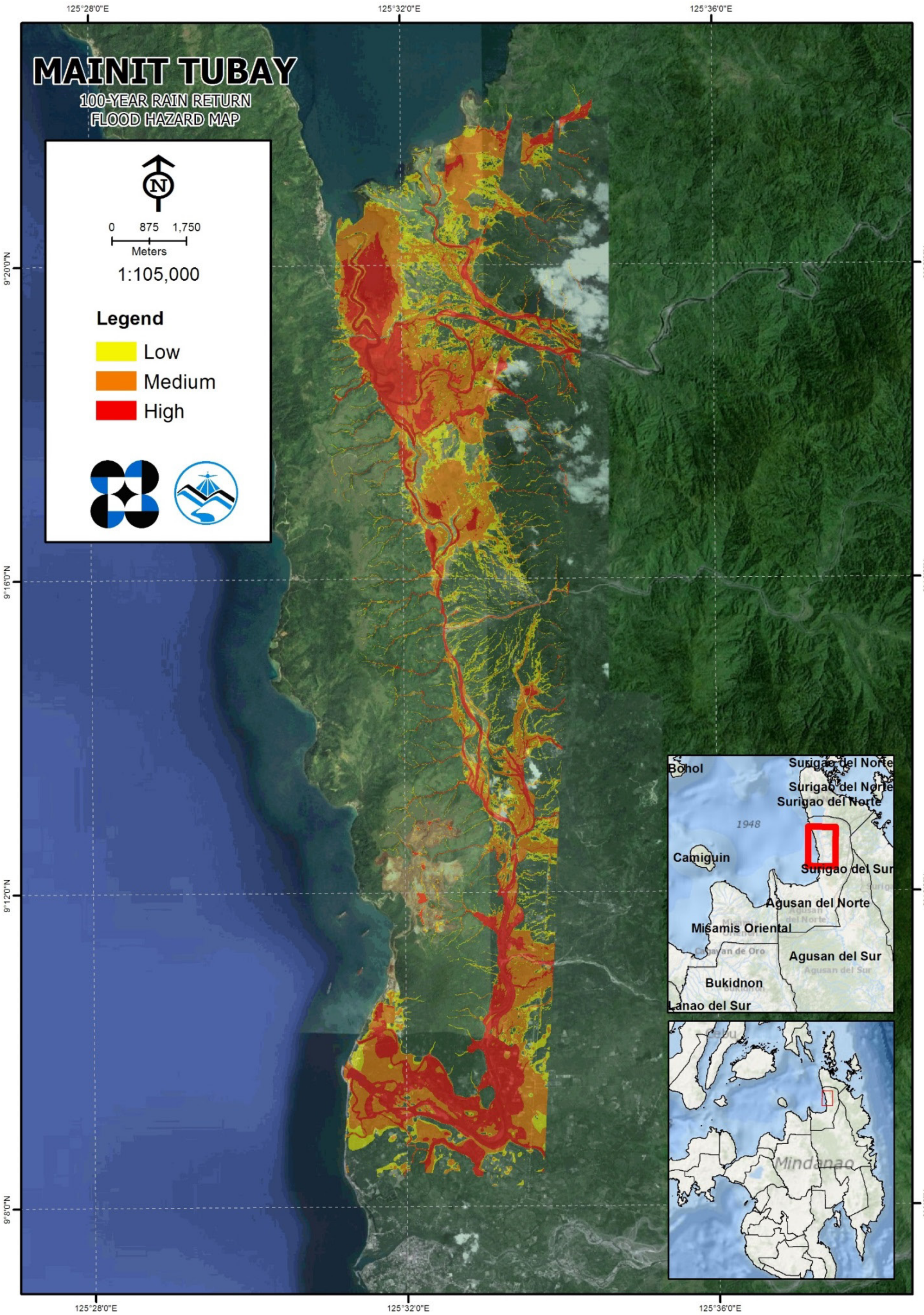


Figure 60. 100-year Flood Hazard Map for Mainit Tubay Floodplain

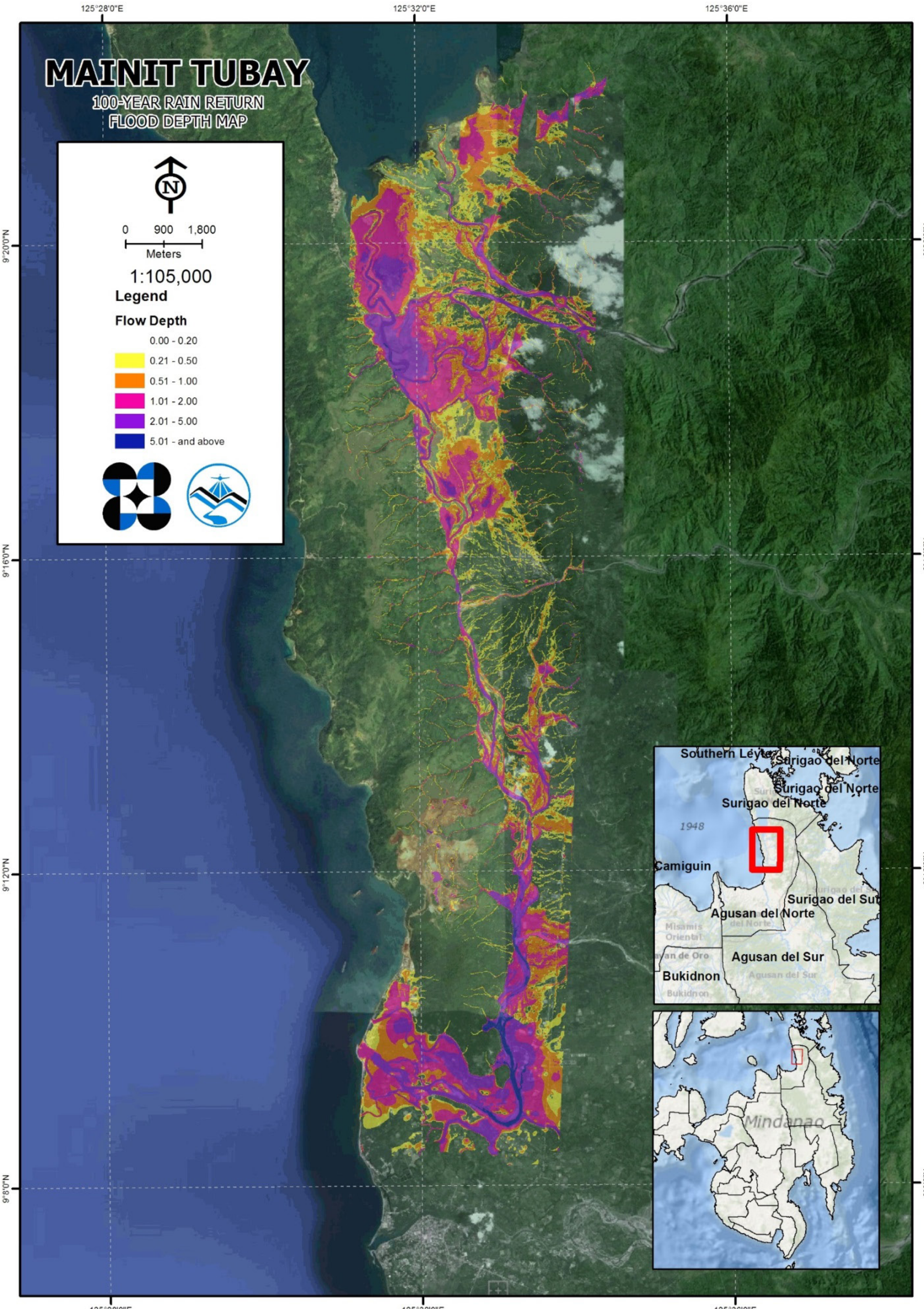


Figure 61. 100-year Flow Depth Map for Mainit Tubay Floodplain

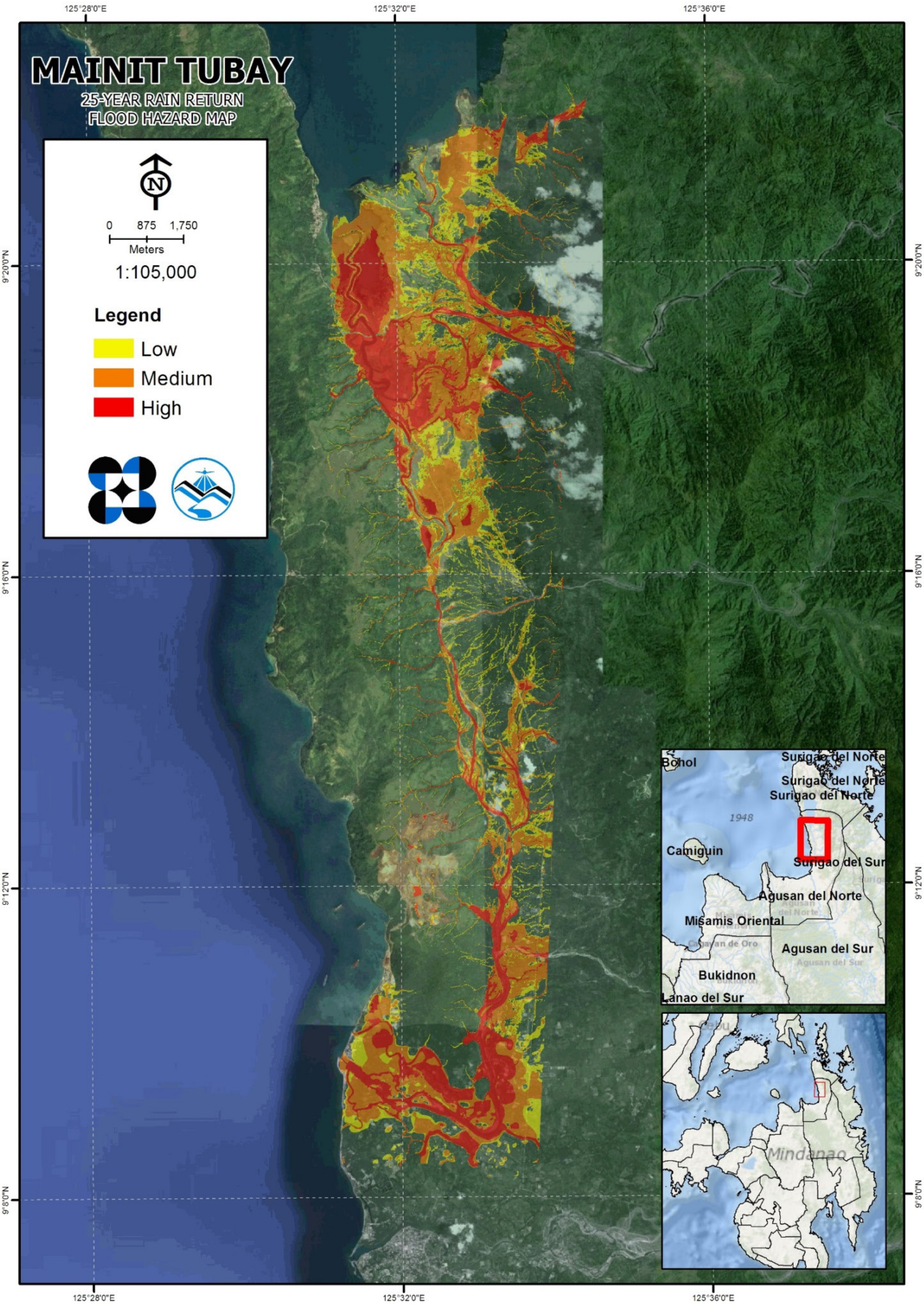


Figure 62. 25-year Flood Hazard Map for Mainit Tubay Floodplain

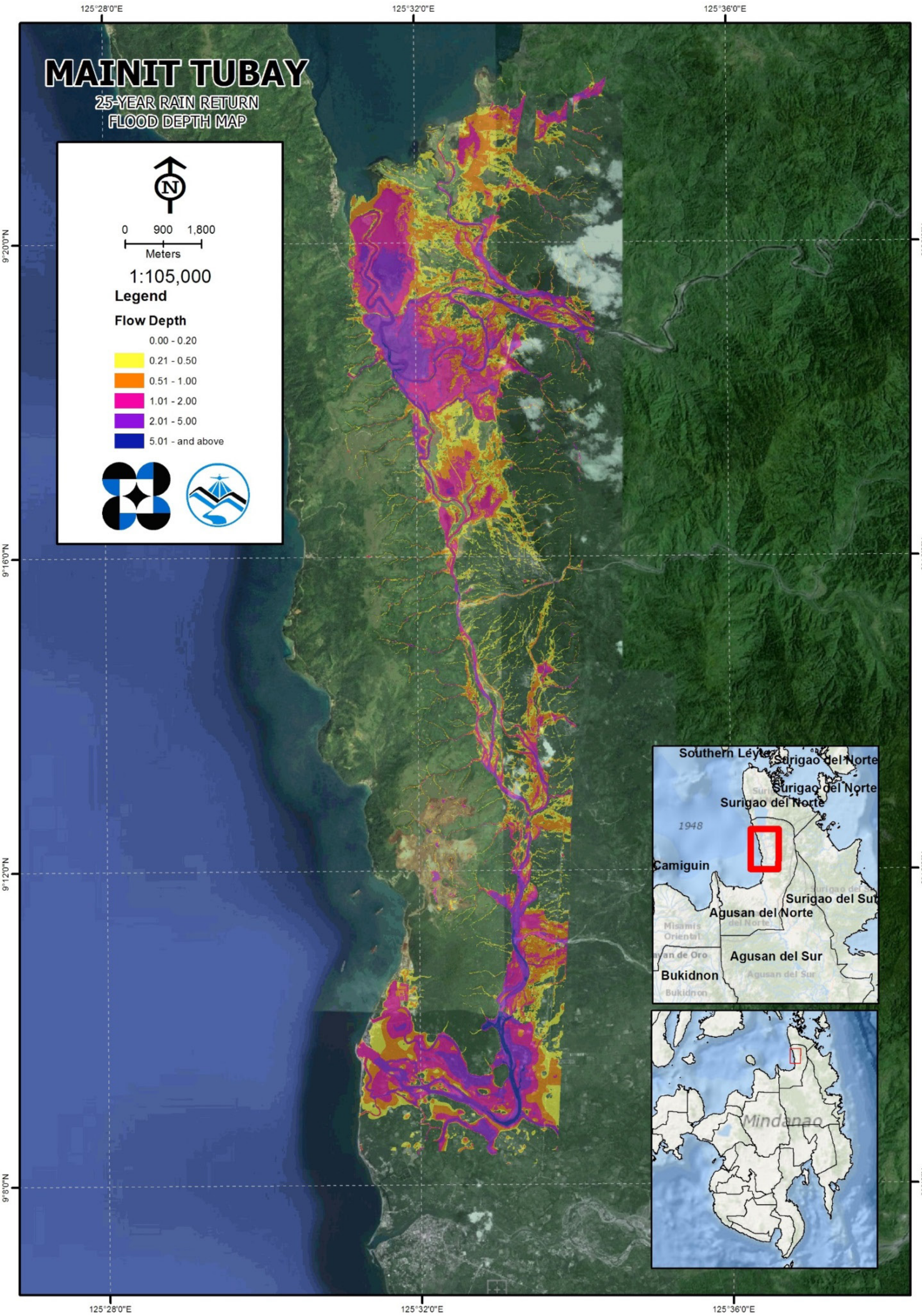


Figure 63. 25-year Flow Depth Map for Mainit Tubay Floodplain

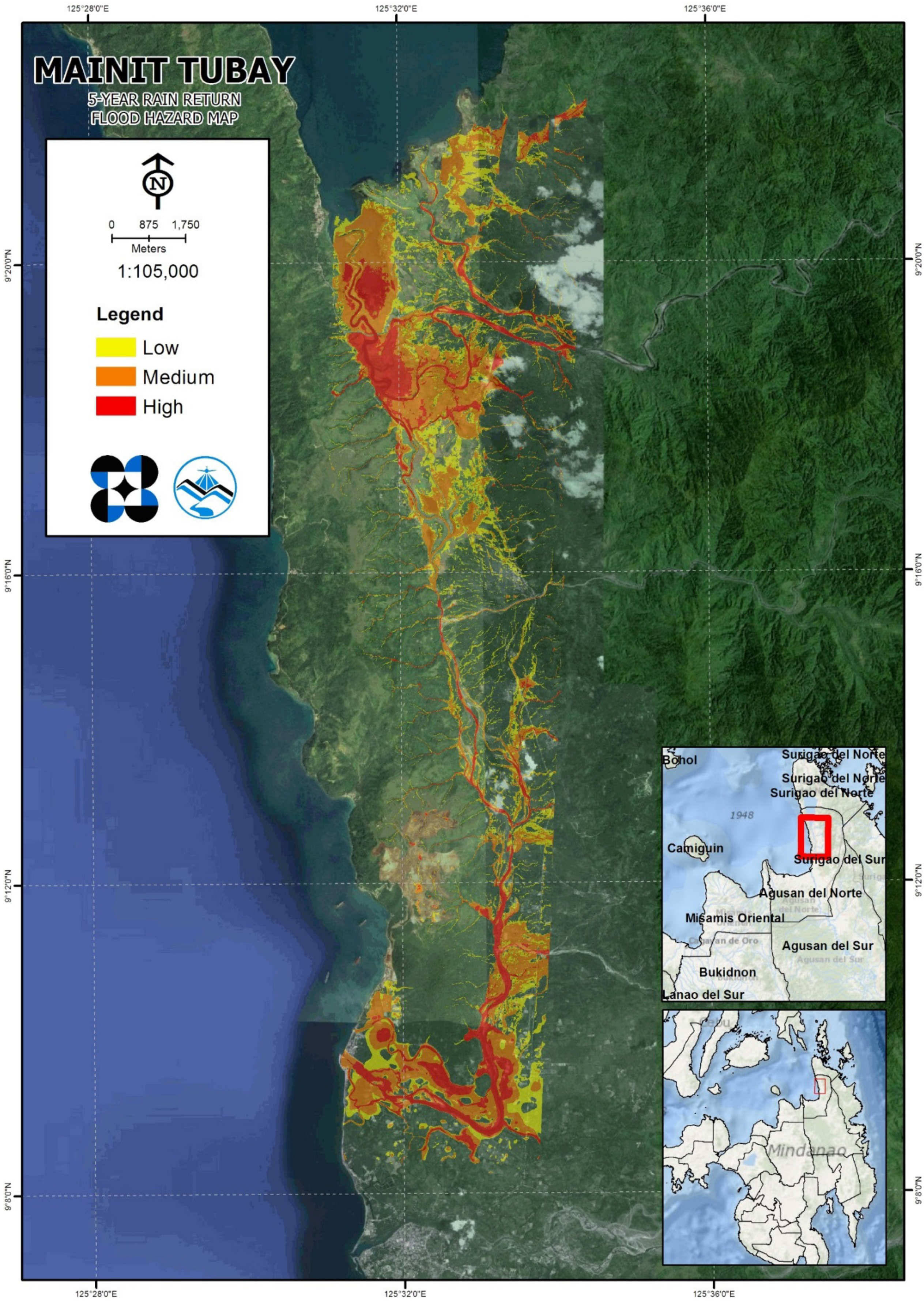


Figure 64. 5-year Flood Hazard Map for Mainit Tubay Floodplain

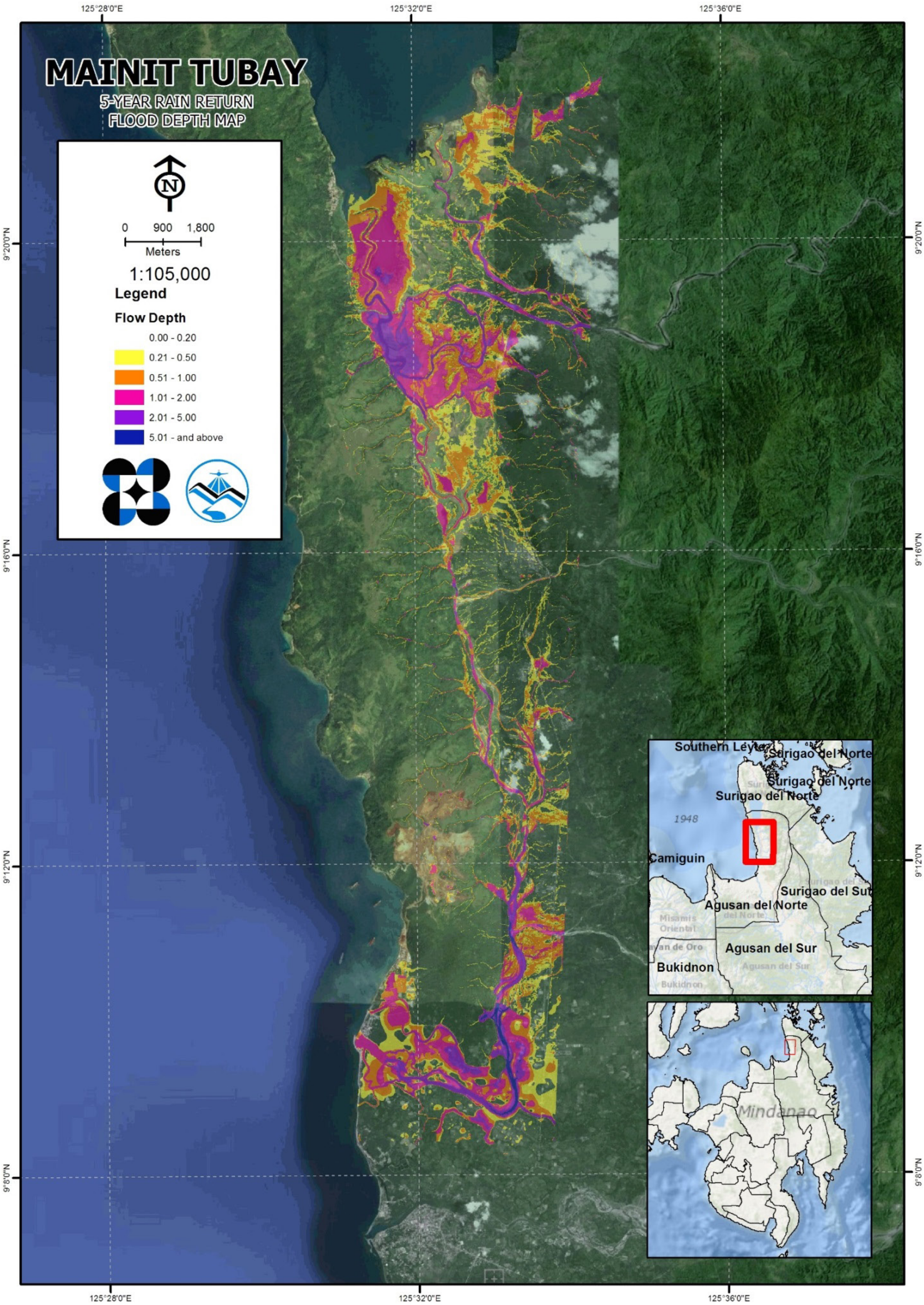


Figure 65. 5-year Flow Depth Map for Mainit Tubay Floodplain

5.10 Inventory of Areas Exposed to Flooding

For the 5-year return period, 0.58% of Cabadbaran City with an area of 343.91 sq. km. will experience flood levels of less than 0.20 meters. 0.04% of the area will experience flood levels of 0.21 to 0.50 meters while 0.02%, 0.02%, 0.01%, and 0.00% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in the table are the affected areas in square kilometers by flood depth per barangay.

Table 37. Affected areas in Cabadbaran City during a 5-Year Rainfall Return Period

Affected areas (in sq. km) by flood depth	Affected Barangays in Cabadbaran City (in sq. km)		
	Caasinan	Comagascas	Kasuwagan
1	0.48	0.24	1.29
2	0.029	0.0018	0.11
3	0.016	0.00066	0.066
4	0.0092	0.00056	0.07
5	0	0.00098	0.032
6	0	0	0.013

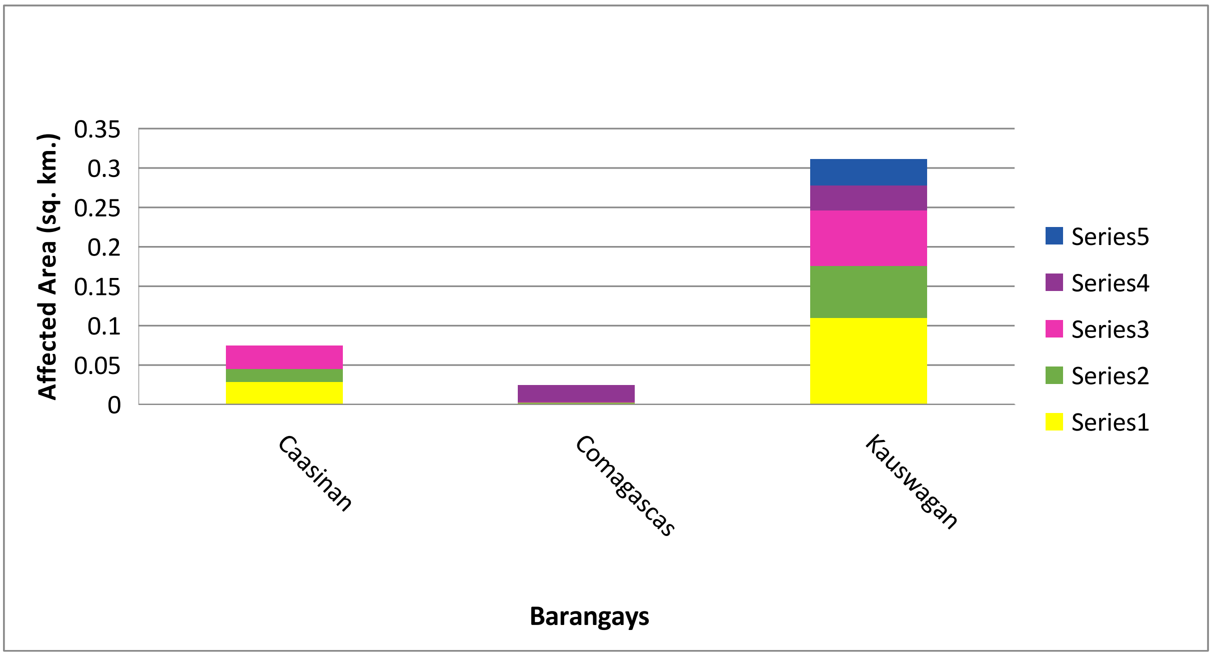


Figure 66. Affected areas in Cabadbaran City during a 5-Year Rainfall Return Period

For the 5-year return period, 6.76% of the municipality of Jabonga with an area of 269.89 sq. km. will experience flood levels of less than 0.20 meters. 1.45% of the area will experience flood levels of 0.21 to 0.50 meters while 1.44%, 1.53%, 0.52%, and 0.00% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in the table are the affected areas in square kilometers by flood depth per barangay.

Table 38. Affected areas in the Municipality of Jabonga during a 5-Year Rainfall Return Period

Affected areas (in sq. km) by flood depth	Affected Barangays in Cabadbaran City (in sq. km)							
	Baleguian	Bangonay	Colorado	Cuyago	Libas	Magsaysay	Maraiging	Poblacion
1	2.98	3.27	1.4	5.26	2.52	2.65	0.066	0.096
2	0.71	0.27	0.72	0.9	0.4	0.79	0.012	0.11
3	0.61	0.19	1.06	0.45	0.53	0.79	0.012	0.25
4	0.34	0.22	2.01	0.1	0.41	0.62	0.041	0.39
5	0.042	0.17	0.83	0.064	0.23	0.061	0.0057	0
6	0	0	0	0	0.0027	0	0	0

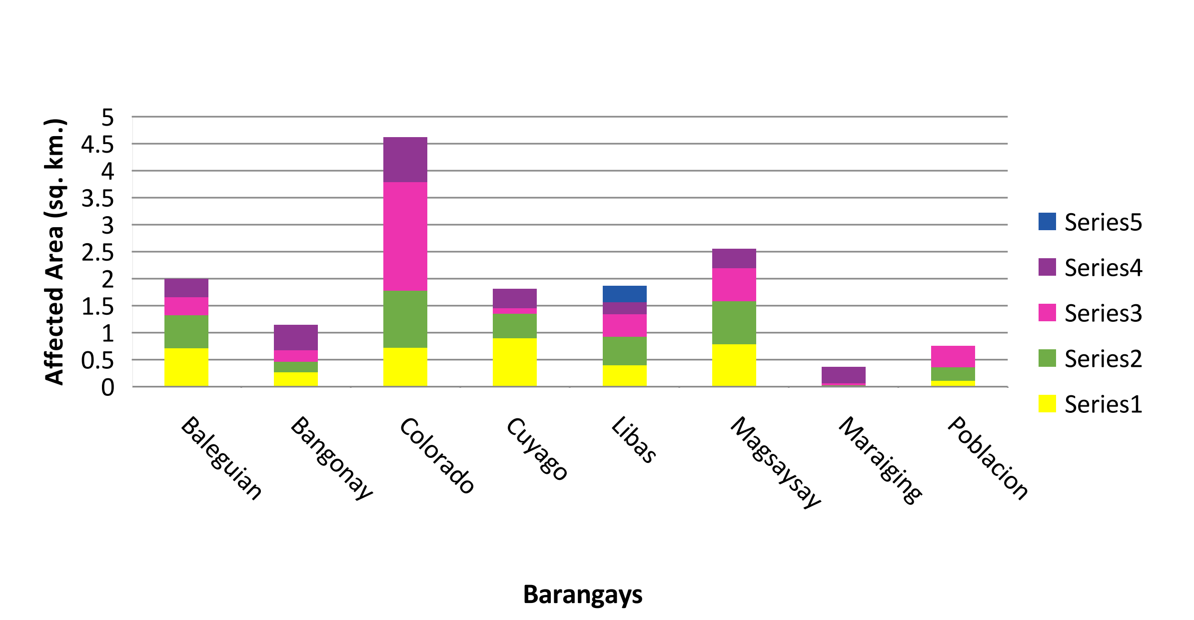


Figure 67. Affected areas in the Municipality of Jabonga during a 5-Year Rainfall Return Period

For the 5-year return period, 1.02% of the municipality of Mainit Lake with an area of 69.28 sq. km. will experience flood levels of less than 0.20 meters. 0.17% of the area will experience flood levels of 0.21 to 0.50 meters while 0.19%, 0.05%, 0.00%, and 0.00% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in the table are the affected areas in square kilometers by flood depth per barangay.

Table 39. Affected areas in Mainit Lake during a 5-Year Rainfall Return Period

Affected areas (in sq. km) by flood depth	Affected Barangays in Cabadbaran City (in sq. km)
	Mainit Lake
1	0.71
2	0.12
3	0.13
4	0.038
5	0.0015
6	0

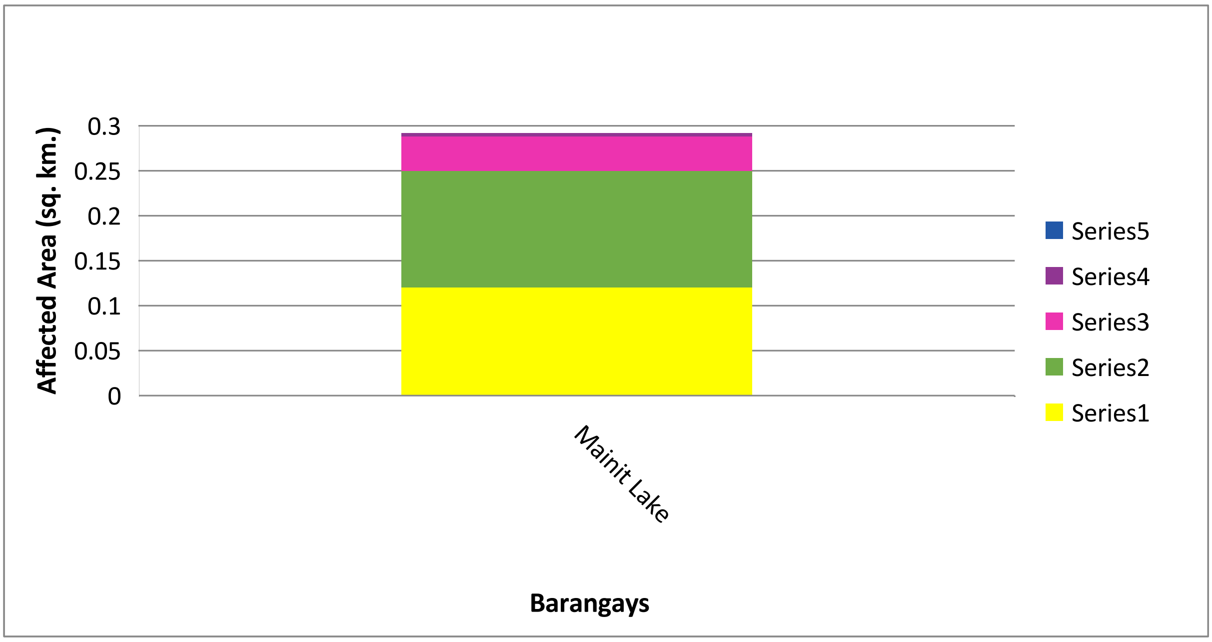


Figure 68. Affected areas in Mainit Lake during a 5-Year Rainfall Return Period

For the 5-year return period, 11.13% of the municipality of Santiago with an area of 218.28 sq. km. will experience flood levels of less than 0.20 meters. 1.70% of the area will experience flood levels of 0.21 to 0.50 meters while 1.23%, 1.08%, 0.42%, and 0.00% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in the table are the affected areas in square kilometers by flood depth per barangay.

Table 40. Affected areas in the Municipality of Santiago during a 5-Year Rainfall Return Period

Affected areas (in sq. km) by flood depth	Affected Barangays in Cabadbaran City (in sq. km)							
	Curva	Estanilao Morgado	Jagupit	La Paz	Poblacion I	Poblacion II	San Isidro	Tagbuyacan
1	3.87	2.64	2.15	3.41	1.92	2.02	2.04	6.25
2	0.38	0.25	0.35	0.5	0.19	0.33	0.33	1.4
3	0.14	0.25	0.17	0.36	0.048	0.085	0.085	1.37
4	0.083	0.3	0.11	0.28	0.012	0.0084	0.0084	1.38
5	0.022	0.35	0.026	0.0062	0.00088	0.0009	0.0009	0.49
6	0.0023	0.0001	0.00021	0	0	0	0	0.0001

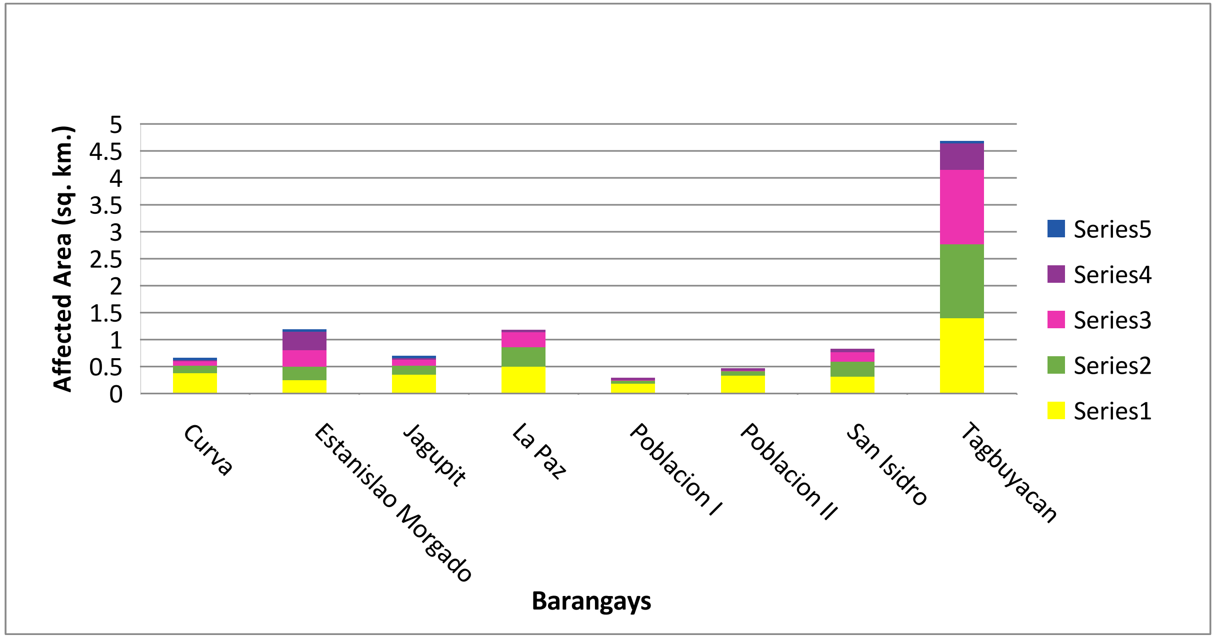


Figure 69. Affected areas in the Municipality of Santiago during a 5-Year Rainfall Return Period

For the 5-year return period, 30.64% of the municipality of Tubay with an area of 107.14 sq. km. will experience flood levels of less than 0.20 meters. 3.50% of the area will experience flood levels of 0.21 to 0.50 meters while 3.35%, 3.04%, 1.59%, and 0.19% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in the table are the affected areas in square kilometers by flood depth per barangay.

Table 41. Affected areas in the municipality of Tubay during a 5–Year Rainfall Return Period

Affected areas (in sq. km) by flood depth	Affected Barangays in Cabadbaran City (in sq. km)										
	Binuangan	Cabayawa	Dona Rosario	La Fraternidad	Lawigan	Poblacion 1	Poblacion 2	Santa Ana	Tagmamarkay	Tagpangahoy	Tinigbasan
1	6.2	2.14	1.4	3.7	1.52	1.1	1.64	1.33	2.26	8.34	3.2
2	0.3	0.38	0.85	0.24	0.057	0.43	0.14	0.34	0.65	0.27	0.096
3	0.24	0.52	0.79	0.27	0.022	0.49	0.19	0.49	0.37	0.17	0.037
4	0.2	0.53	0.57	0.22	0.012	0.71	0.34	0.34	0.21	0.11	0.01
5	0.1	0.39	0.45	0.065	0.0075	0.37	0.055	0.14	0.07	0.059	0.0009
6	0.0035	0.0094	0.16	0.0084	0.0001	0	0.01	0.014	0	0.0012	0

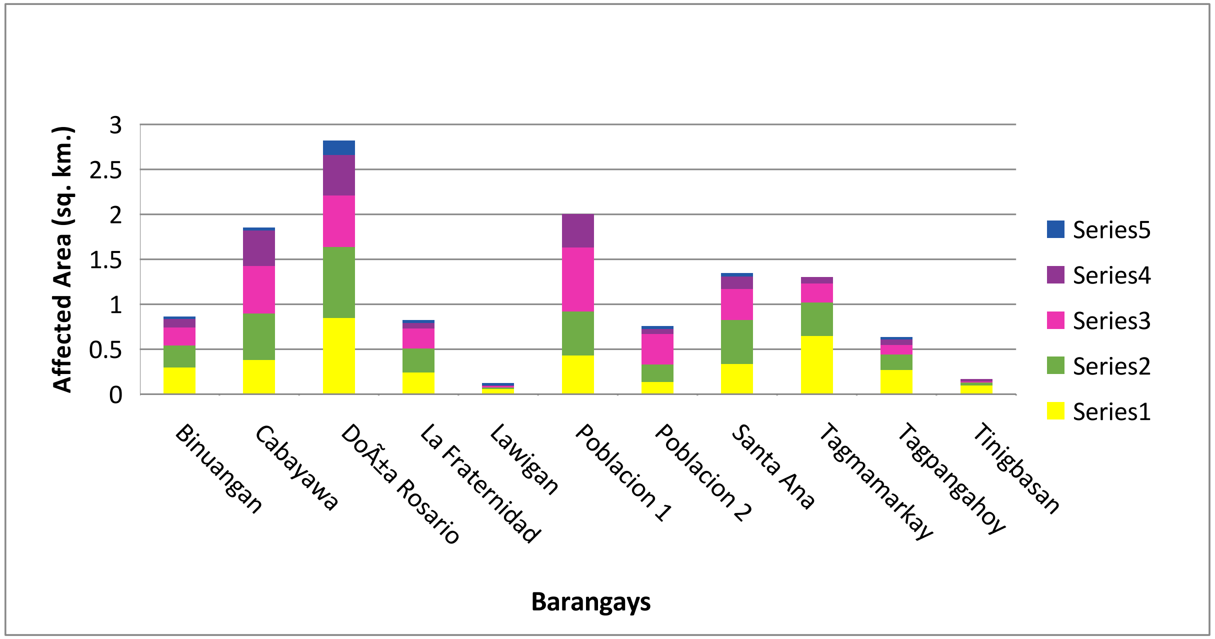


Figure 70. Affected areas in the municipality of Tubay during a 5–Year Rainfall Return Period

For the 25-year return period, 0.54% of Cabadbaran City with an area of 343.9123 sq. km. will experience flood levels of less than 0.20 meters. 0.06% of the area will experience flood levels of 0.21 to 0.50 meters while 0.03%, 0.03%, 0.03%, and 0.01% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in the table are the affected areas in square kilometers by flood depth per barangay.

Table 42. Affected areas in Cabadbaran City during a 25-Year Rainfall Return Period

Affected areas (in sq. km) by flood depth	Affected Barangays in Cabadbaran City (in sq. km)		
	Caasinan	Comagascas	Kasuwagan
1	0.44	0.24	1.16
2	0.058	0.0071	0.14
3	0.015	0.0012	0.095
4	0.015	0.0007	0.08
5	0.0067	0.0012	0.08
6	0	0	0.023

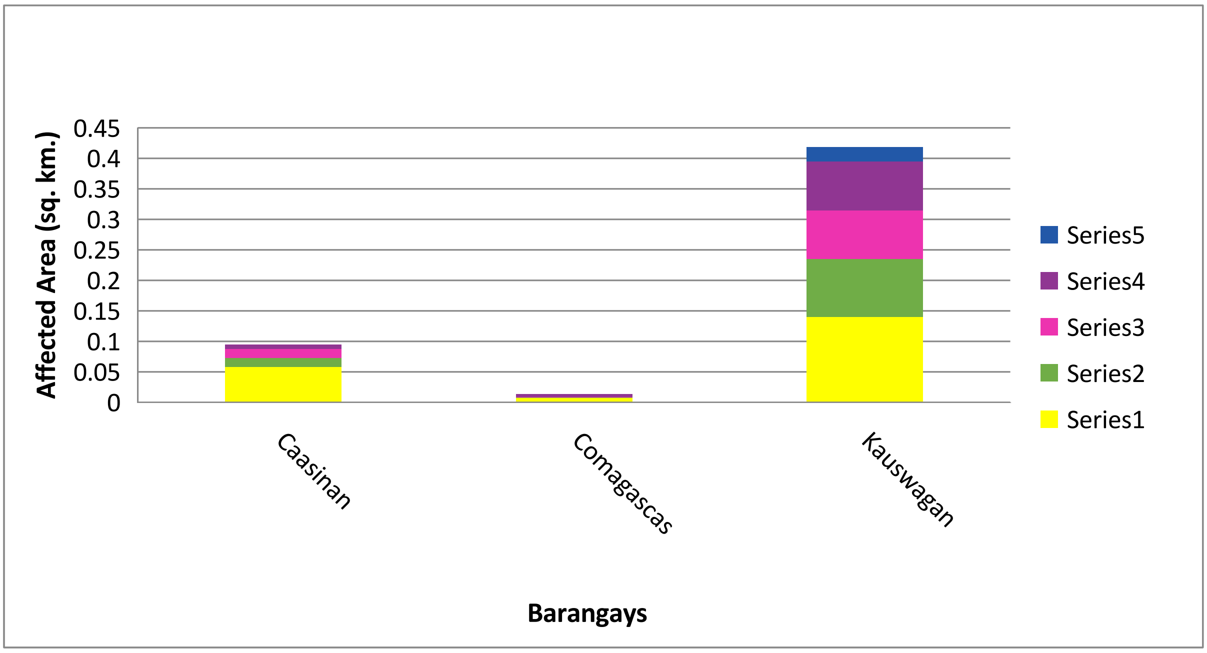


Figure 71. Affected areas in Cabadbaran City during a 25-Year Rainfall Return Period

For the 25-year return period, 5.33% of the municipality of Jabonga with an area of 269.8928 sq. km. will experience flood levels of less than 0.20 meters. 1.47% of the area will experience flood levels of 0.21 to 0.50 meters while 1.83%, 1.96%, 1.11%, and 0.01% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in the table are the affected areas in square kilometers by flood depth per barangay.

Table 43. Affected areas in the Municipality of Jabonga during a 25–Year Rainfall Return Period

Affected areas (in sq. km) by flood depth	Affected Barangays in Cabadbaran City (in sq. km)							
	Baleguian	Bangonay	Colorado	Cuyago	Libas	Magsaysay	Maraiging	Poblacion
1	2.74	2.76	0.73	4.64	2.04	1.36	0.063	0.061
2	0.51	0.27	0.57	1.09	0.4	1.05	0.012	0.057
3	0.81	0.35	0.97	0.77	0.68	1.21	0.0071	0.14
4	0.53	0.37	1.82	0.19	0.65	1.18	0.043	0.5
5	0.093	0.38	1.92	0.083	0.3	0.11	0.011	0.094
6	0.0004	0	0.0033	0	0.015	0	0	0

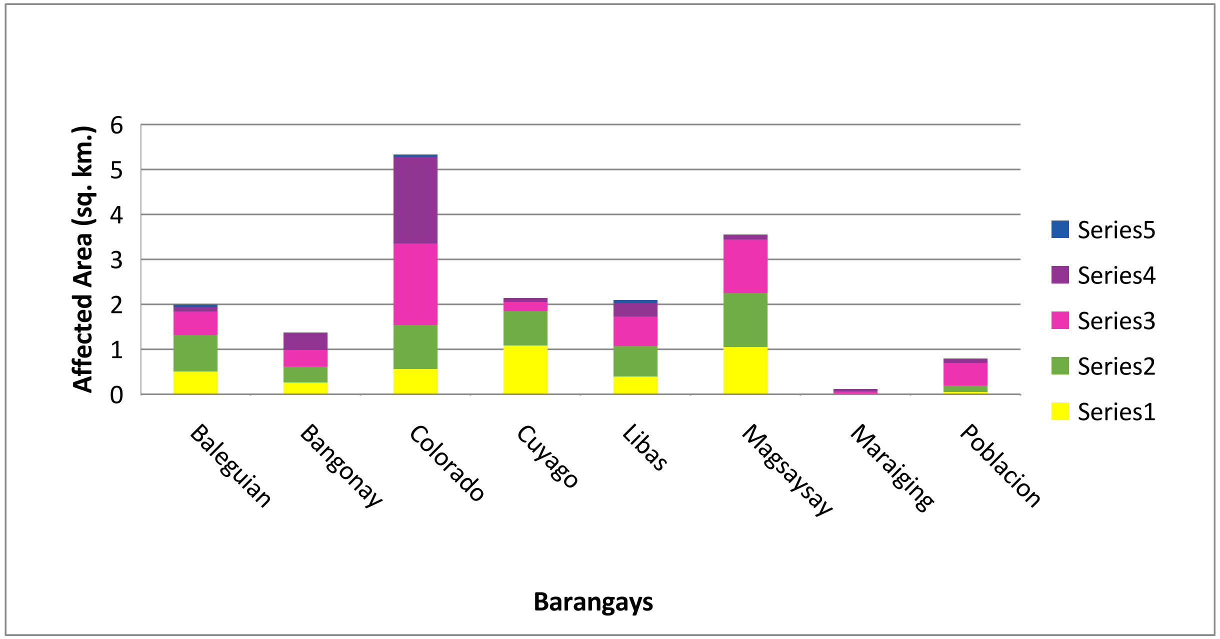


Figure 72. Affected areas in the Municipality of Jabonga during a 25–Year Rainfall Return Period

For the 25-year return period, 0.87% of the municipality of Mainit Lake with an area of 69.28169 sq. km. will experience flood levels of less than 0.20 meters. 0.20% of the area will experience flood levels of 0.21 to 0.50 meters while 0.17%, 0.22%, 0.00%, and 0.00% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in the table are the affected areas in square kilometers by flood depth per barangay.

Table 44. Affected areas in Mainit Lake during a 25–Year Rainfall Return Period

Affected areas (in sq. km) by flood depth	Affected Barangays in Cabadbaran City (in sq. km)
	Mainit Lake
1	0.6
2	0.14
3	0.12
4	0.15
5	0.0021
6	0

Figure 73. Affected areas in Mainit Lake during a 25–Year Rainfall Return Period

For the 25-year return period, 10.09% of the municipality of Santiago with an area of 218.2799 sq. km. will experience flood levels of less than 0.20 meters. 1.81% of the area will experience flood levels of 0.21 to 0.50 meters while 1.43%, 1.57%, 0.68%, and 0.02% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in the table are the affected areas in square kilometers by flood depth per barangay.

Table 45. Affected areas in the Municipality of Santiago during a 25–Year Rainfall Return Period

Affected areas (in sq. km) by flood depth	Affected Barangays in Cabadbaran City (in sq. km)							
	Curva	Estanilao Morgado	Jagupit	La Paz	Poblacion I	Poblacion II	San Isidro	Tagbuyacan
1	3.67	2.44	1.94	3.08	1.83	1.91	1.75	5.41
2	0.5	0.23	0.39	0.55	0.25	0.37	0.39	1.26
3	0.18	0.28	0.28	0.36	0.067	0.14	0.35	1.47
4	0.11	0.33	0.13	0.55	0.022	0.025	0.27	1.99
5	0.052	0.49	0.064	0.014	0.0018	0.0013	0.078	0.78
6	0.0026	0.035	0.00027	0	0	0	0	0.0015

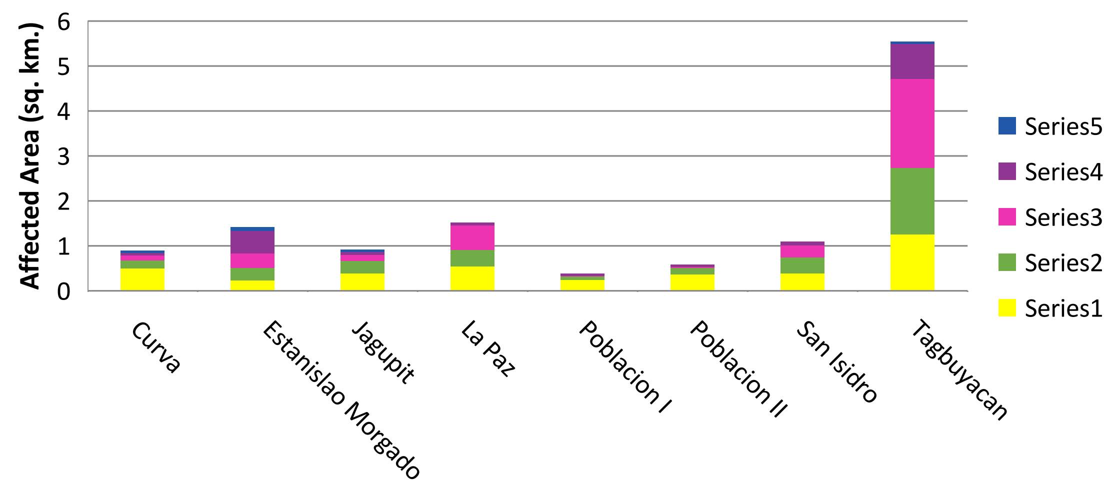


Figure 74. Affected areas in the Municipality of Santiago during a 25–Year Rainfall Return Period

For the 25-year return period, 28.05% of the municipality of Tubay with an area of 107.138 sq. km. will experience flood levels of less than 0.20 meters. 3.36% of the area will experience flood levels of 0.21 to 0.50 meters while 3.76%, 4.16%, 2.71%, and 0.29% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in the table are the affected areas in square kilometers by flood depth per barangay.

Table 46. Affected areas in the Municipality of Tubay during a 25–Year Rainfall Return Period

Affected areas (in sq. km) by flood depth	Affected Barangays in Cabadbaran City (in sq. km)										
	Binuangan	Cabayawa	Dona Rosario	La Fraternidad	Lawigan	Poblacion 1	Poblacion 2	Santa Ana	Tagmamarkay	Tagpangahoy	Tinigbasan
1	6	1.57	0.95	3.6	1.5	0.74	1.45	1.13	1.75	8.19	3.17
2	0.34	0.42	0.71	0.24	0.065	0.26	0.18	0.27	0.71	0.29	0.11
3	0.25	0.59	0.89	0.16	0.028	0.55	0.19	0.48	0.65	0.19	0.047
4	0.24	0.75	0.78	0.38	0.015	0.88	0.43	0.5	0.29	0.17	0.017
5	0.21	0.62	0.66	0.13	0.0099	0.66	0.099	0.24	0.17	0.1	0.0017
6	0.0044	0.022	0.23	0.0097	0.0004	0	0.026	0.02	0	0.0014	0

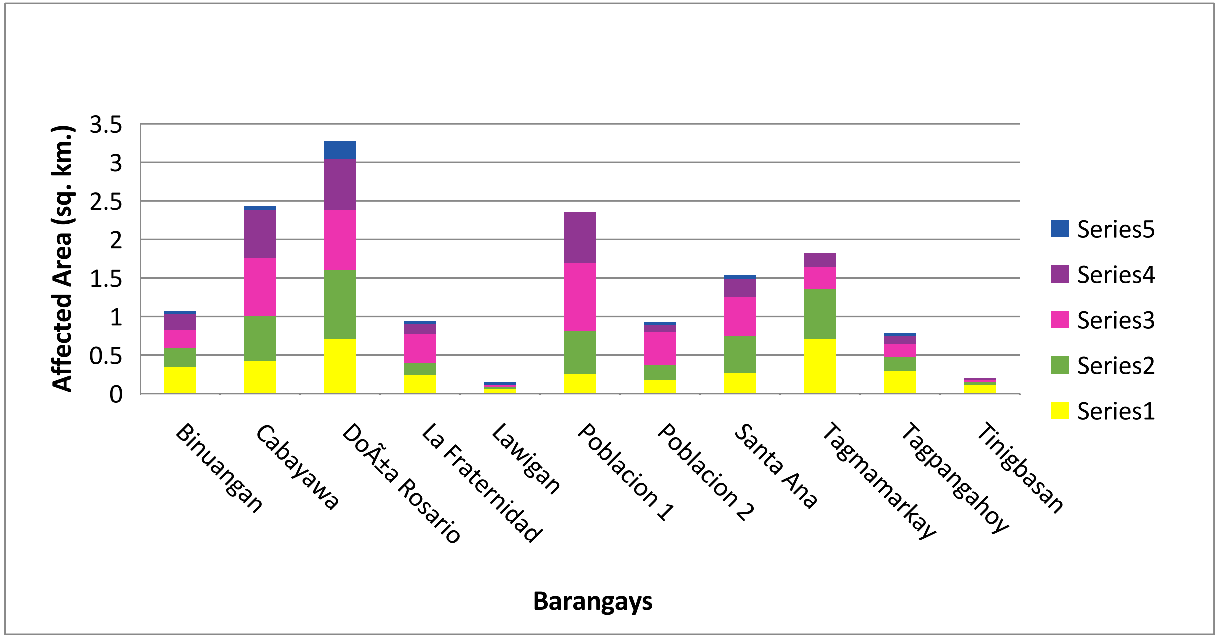


Figure 75. Affected areas in the Municipality of Tubay during a 25–Year Rainfall Return Period

For the 100-year return period, 0.50% of the municipality of Cabadbaran City with an area of 343.9123 sq. km. will experience flood levels of less than 0.20 meters. 0.07% of the area will experience flood levels of 0.21 to 0.50 meters while 0.04%, 0.03%, 0.03%, and 0.01% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in the table are the affected areas in square kilometers by flood depth per barangay.

Table 47. Affected areas in Cabadbaran City during a 100-Year Rainfall Return Period

Affected areas (in sq. km) by flood depth	Affected Barangays in Cabadbaran City (in sq. km)		
	Caasinan	Comagascas	Kasuwagan
1	0.4	0.23	1.09
2	0.077	0.015	0.15
3	0.03	0.0018	0.11
4	0.016	0.00088	0.095
5	0.0088	0.0013	0.1
6	0	0	0.024

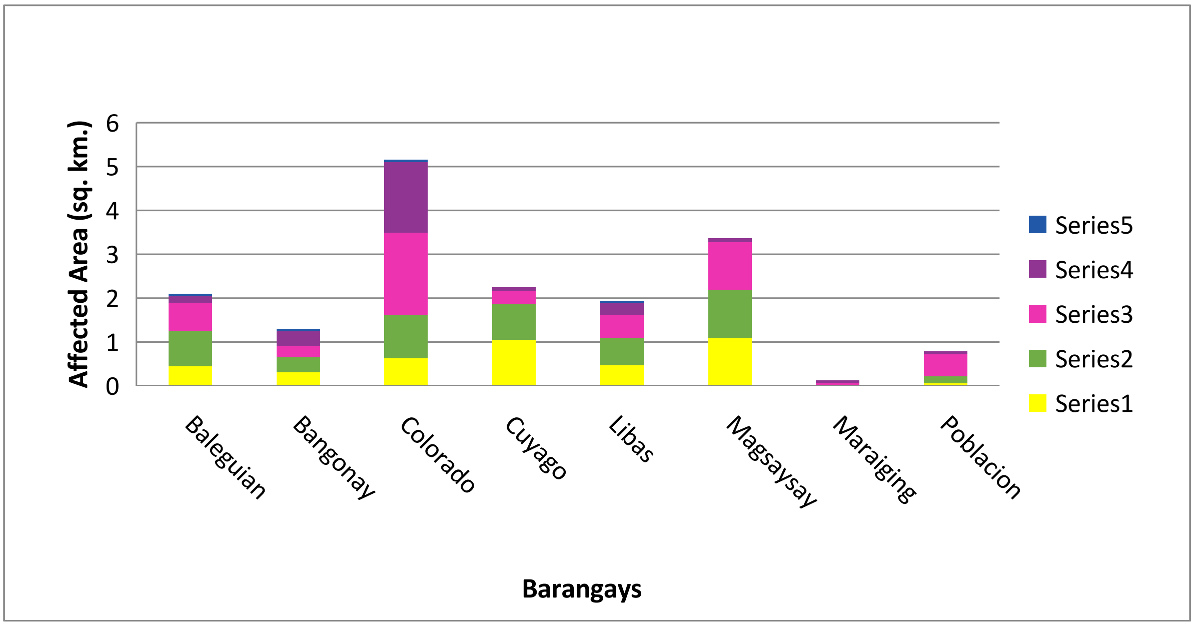


Figure 76. Affected areas in Cabadbaran City during a 100-Year Rainfall Return Period

For the 100-year return period, 5.48% of the municipality of Jabonga with an area of 269.8928 sq. km. will experience flood levels of less than 0.20 meters. 1.51% of the area will experience flood levels of 0.21 to 0.50 meters while 1.80%, 1.94%, 0.97%, and 0.00% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in the table are the affected areas in square kilometers by flood depth per barangay.

Table 48. Affected areas in the Municipality of Jabonga during a 100–Year Rainfall Return Period

Affected areas (in sq. km) by flood depth	Affected Barangays in Cabadbaran City (in sq. km)							
	Baleguian	Bangonay	Colorado	Cuyago	Libas	Magsaysay	Maraiging	Poblacion
1	2.63	2.87	0.91	4.54	2.18	1.55	0.06	0.06
2	0.45	0.31	0.63	1.05	0.47	1.09	0.012	0.064
3	0.79	0.34	0.99	0.83	0.63	1.1	0.0063	0.16
4	0.66	0.27	1.88	0.28	0.52	1.09	0.038	0.5
5	0.15	0.33	1.61	0.083	0.27	0.082	0.02	0.06
6	0.00043	0.0001	0.001	0	0.0082	0	0	0

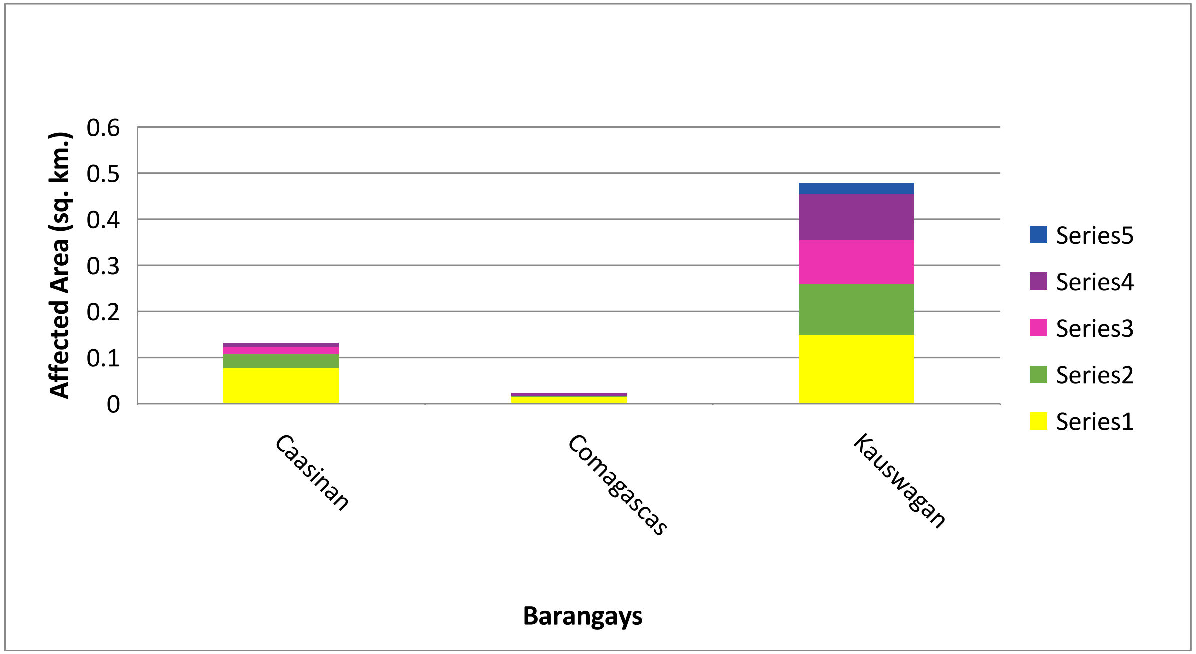


Figure 77. Affected areas in the Municipality of Jabonga during a 100–Year Rainfall Return Period

For the 100-year return period, 0.85% of the municipality of Mainit Lake with an area of 69.28169 sq. km. will experience flood levels of less than 0.20 meters. 0.20% of the area will experience flood levels of 0.21 to 0.50 meters while 0.17%, 0.22%, 0.00%, and 0.00% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in the table are the affected areas in square kilometers by flood depth per barangay.

Table 49. Affected areas in Mainit Lake during a 100–Year Rainfall Return Period

Affected areas (in sq. km) by flood depth	Affected Barangays in Cabadbaran City (in sq. km)
	Mainit Lake
1	0.59
2	0.14
3	0.12
4	0.15
5	0.0021
6	0

Figure 78. Affected areas in Mainit Lake during a 100–Year Rainfall Return Period

For the 100-year return period, 9.67% of the municipality of Santiago with an area of 218.2799 sq. km. will experience flood levels of less than 0.20 meters. 1.83% of the area will experience flood levels of 0.21 to 0.50 meters while 1.58%, 1.75%, 0.72%, and 0.01% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in the table are the affected areas in square kilometers by flood depth per barangay.

Table 50. Affected areas in the Municipality of Santiago during a 100-Year Rainfall Return Period

Affected areas (in sq. km) by flood depth	Affected Barangays in Cabadbaran City (in sq. km)							
	Curva	Estanilao Morgado	Jagupit	La Paz	Poblacion I	Poblacion II	San Isidro	Tagbuyacan
1	3.53	2.42	1.8	2.89	1.76	1.84	1.57	5.3
2	0.58	0.23	0.42	0.58	0.29	0.39	0.4	1.11
3	0.19	0.3	0.33	0.37	0.075	0.17	0.39	1.62
4	0.12	0.35	0.16	0.62	0.037	0.039	0.35	2.14
5	0.077	0.49	0.081	0.079	0.0033	0.0013	0.11	0.72
6	0.0031	0.016	0.00033	0	0.0001	0	0	0.0008

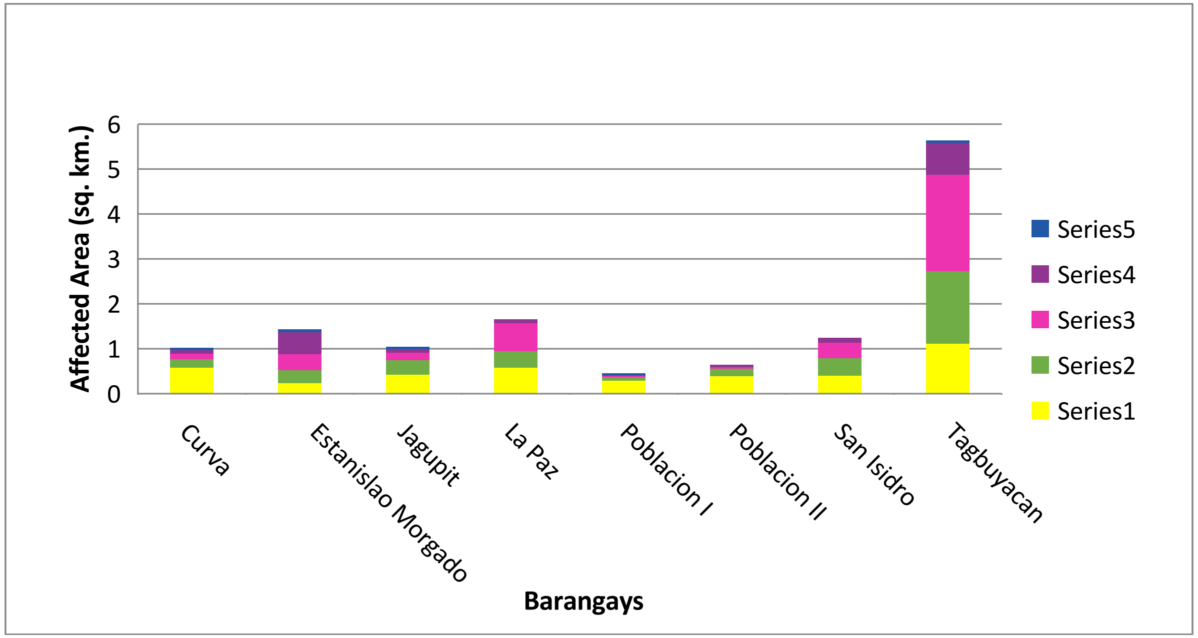


Figure 79. Affected areas in the Municipality of Santiago during a 100-Year Rainfall Return Period

For the 100-year return period, 26.83% of the municipality of Tubay with an area of 107.138 sq. km. will experience flood levels of less than 0.20 meters. 3.14% of the area will experience flood levels of 0.21 to 0.50 meters while 3.80%, 4.66%, 3.53%, and 0.37% of the area will experience flood depths of 0.51 to 1 meter, 1.01 to 2 meters, 2.01 to 5 meters, and more than 5 meters, respectively. Listed in the table are the affected areas in square kilometers by flood depth per barangay.

Table 51. Affected areas in the Municipality of Tubay during a 100-Year Rainfall Return Period

Affected areas (in sq. km) by flood depth	Affected Barangays in Cabadbaran City (in sq. km)										
	Binuangan	Cabayawa	Dona Rosario	La Fraternidad	Lawigan	Poblacion 1	Poblacion 2	Santa Ana	Tagmamarkay	Tagpangahoy	Tinigbasan
1	5.89	1.24	0.76	3.53	1.49	0.68	1.38	1.05	1.47	8.12	3.14
2	0.35	0.46	0.54	0.27	0.068	0.11	0.17	0.26	0.72	0.3	0.12
3	0.26	0.57	0.9	0.14	0.031	0.54	0.18	0.4	0.77	0.22	0.055
4	0.27	0.92	0.9	0.39	0.017	0.89	0.38	0.62	0.4	0.18	0.023
5	0.27	0.76	0.84	0.18	0.0092	0.88	0.22	0.29	0.21	0.12	0.0025
6	0.008	0.026	0.28	0.012	0.0002	0.0027	0.035	0.032	0	0.0016	0

Moreover, the generated flood hazard maps for the Mainit Floodplain were used to assess the vulnerability of the educational and medical institutions in the floodplain. Using the flood depth units of PAGASA for hazard maps - "Low", "Medium", and "High" - the affected institutions were given their individual assessment for each Flood Hazard Scenario (5 yr, 25 yr, and 100 yr).

Table 52. Affected areas in Cabadbaran City during a 100–Year Rainfall Return Period

Warning Level	Area Covered in sq. km		
	5 year	25 year	100 year
Low	12.29	12.09	11.97
Medium	17.43	21.05	21.79
High	8.70	14.50	15.83

Of the 26 identified education institutions in Mainit flood plain, the number of schools were assessed to be exposed to the low- and medium-level flooding during a 5-year scenario were 3 and 7, respectively.

In the 25-year scenario, the number of schools were assessed to be exposed to the low-, medium-, and high-level flooding were 5, 7 and 1, respectively.

For the 100-year scenario, the number of schools were assessed to be exposed to the low-, medium-, and high-level flooding were 3, 10, and 1, respectively.

Of the 4 identified medical institutions, 2 health centers were assessed to be exposed to the low-level flooding during a 5-year scenario.

In the 25-year scenario, 2 health centers were assessed to be exposed to the medium-level flooding.

For the 100-year scenario, 2 health centers were assessed to be exposed to the medium-level flooding.

5.11 Flood Validation

In order to check and validate the extent of flooding in different river systems, a validation survey work was performed. Field personnel gathered secondary data regarding flood occurrence in the area within the major river system in the Philippines.

From the Flood Depth Maps produced by Phil-LiDAR 1 Program, multiple points representing the different flood depths for different scenarios were identified for validation. The validation points are founf in Annex 10.

The validation personnel went to the specified points identified in a river basin and gathered data regarding the actual flood level in each location. Data gathering was done through a local DRRM office in obtaining maps or situation reports about the past flooding events and through interviews of some residents with knowledge of or have had experienced flooding in a particular area.

After which, the actual data from the field was compared to the simulated data to assess the accuracy of the Flood Depth Maps produced and to improve on what is needed.
The flood validation consisted of 396 points randomly selected all over the Mainit-Tubay flood plain. It has an RMSE value of 0.67.

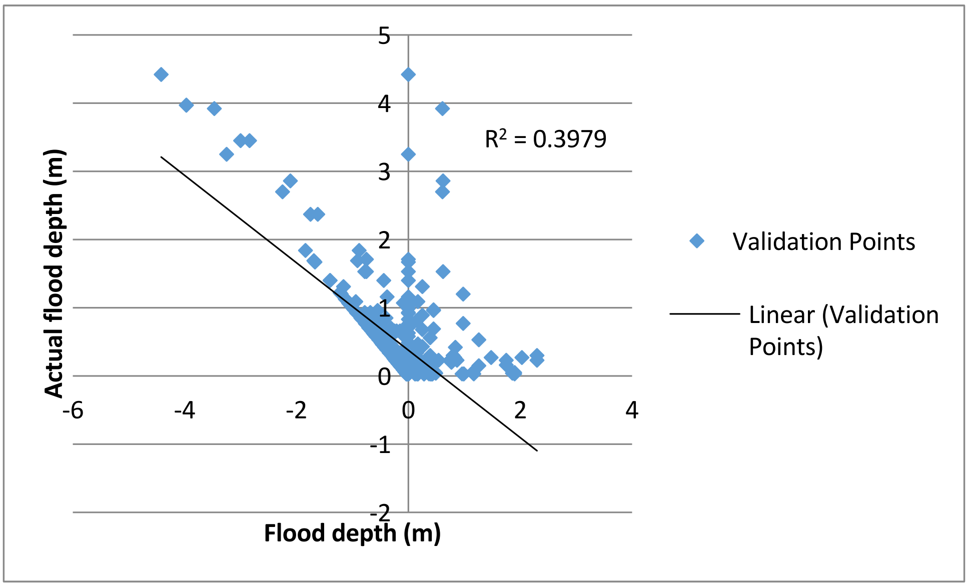


Figure 80. Flood map depth vs actual flood depth

Table 53. Actual Flood Depth vs Simulated Flood Depth in Mainit-Tubay

MAINIT-TUBAY BASIN		Modeled Flood Depth (m)						
		0-0.20	0.21-0.50	0.51-1.00	1.01-2.00	2.01-5.00	>5.00	Total
Actual Flood Depth (m)	0-0.20	72	24	4	8	0	0	108
	0.21-0.50	18	2	6	2	3	0	31
	0.51-1.00	9	6	1	1	0	0	17
	1.01-2.00	9	1	2	0	0	0	12
	2.01-5.00	2	0	3	0	0	0	5
	>5.00	0	0	0	0	0	0	0
	Total	110	33	16	11	3	0	173

The overall accuracy generated by the flood model is estimated at 43.35%, with 75 points correctly matching the actual flood depths. In addition, there were 57 points estimated one level above and below the correct flood depths while there were 19 points and 22 points estimated two levels above and below, and three or more levels above and below the correct flood. A total of 48 points were overestimated while a total of 50 points were underestimated in the modelled flood depths of Mainit-Tubay.

Table 54. Summary of Accuracy Assessment in Mainit-Tubay

	No. of Points	%
Correct	75	**43.35**
Overestimated	48	**27.75**
Underestimated	50	**28.90**
Total	173	**100.00**

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ANNEXES

Annex 1. Technical Specifications of the LiDAR Sensors used in the Mainit-Tubay Floodplain Survey

1. Technical Specifications of the Aquarius sensor used in the Mainit-Tubay Floodplain Survey

Table A-1.1. Technical Specifications of the Aquarius sensor used in the Mainit-tubay Floodplain Survey

Parameter	Specification
Operational altitude	300-600 m AGL
Laser pulse repetition rate	33, 50, 70 kHz
Scan rate	0-70 Hz
Scan half-angle	0 to ± 25
Laser footprint on water surface	30-60 cm
Depth range	0 to > 10 m (for k < 0.1/m)
Topographic mode	
Operational altitiude	300-2500
Range Capture	Up to 4 range measurements, including 1st, 2nd, 3rd, and last returns
Intensity capture	12-bit dynamic measurement range
Position and orientation system	POS AVTM 510 (OEM) includes embedded 72-channel GNSS receiver (GPS and GLONASS)
Data Storage	Ruggedized removable SSD hard disk (SATA III)
Power	28 V, 900 W, 35 A
Image capture	5 MP interline camera (standard); 60 MP full frame (optional)
Full waveform capture	12-bit Optech IWD-2 Intelligent Waveform Digitizer (optional)
Dimensions and weight	Sensor:250 x 430 x 320 mm; 30 kg; Control rack: 591 x 485 x 578 mm; 53 kg
Operating temperature	0-35˚C
Relative humidity	0-95% no-condensing

2. Technical Specifications of the Gemini sensor used in the Mainit-Tubay Floodplain Survey

Table A-1.2. Technical Specifications of the Gemini sensor used in the Mainit-tubay Floodplain Survey

Parameter	Specification
Operational envelope (1,2,3,4)	150-4000 m AGL, nominal
Laser wavelength	1064 nm
Horizontal accuracy (2)	1/5,500 x altitude, (m AGL)
Elevation accuracy (2)	<5-35 cm, 1 σ
Effective laser repetition rate	Programmable, 33-167 kHz
Position and orientation system	POS AV™ AP50 (OEM); 220-channel dual frequency GPS/GNSS/Galileo/L-Band receiver
Scan width (WOV)	Programmable, 0-50˚
Scan frequency (5)	Programmable, 0-70 Hz (effective)
Sensor scan product	1000 maximum
Beam divergence	Dual divergence: 0.25 mrad (1/e) and 0.8 mrad (1/e), nominal
Roll compensation	Programmable, ±5˚ (FOV dependent)
Range capture	Up to 4 range measurements, including 1st, 2nd, 3rd, and last returns
Intensity capture	Up to 4 intensity returns for each pulse, including last (12 bit)
Video Camera	Internal video camera (NTSC or PAL)
Image capture	Compatible with full Optech camera line (optional)
Full waveform capture	12-bit Optech IWD-2 Intelligent Waveform Digitizer (optional)
Data storage	Removable solid state disk SSD (SATA II)
Power requirements	28 V; 900 W;35 A(peak)
Dimensions and weight	Sensor: 260 mm (w) x 190 mm (l) x 570 mm (h); 23 kg Control rack: 650 mm (w) x 590 mm (l) x 530 mm (h); 53 kg
Operating temperature	-10˚C to +35˚C (with insulating jacket)
Relative humidity	0-95% no-condensing

Annex 2. NAMRIA Certification of Reference Points Used in the LiDAR Survey

1. SRN-119

Republic of the Philippines
Department of Environment and Natural Resources
NATIONAL MAPPING AND RESOURCE INFORMATION AUTHORITY

June 06, 2014

CERTIFICATION

To whom it may concern:

This is to certify that according to the records on file in this office, the requested survey information is as follows -

Province: **SURIGAO DEL NORTE**
Station Name: **SRN-119**
Order: **2nd**

Island: **MINDANAO**
Municipality: **SURIGAO CITY (CAPITAL)**
Barangay: **LIPATA**

	PRS92 Coordinates	
Latitude: **9° 48' 39.52825"**	Longitude: **125° 27' 19.47825"**	Ellipsoidal Hgt: **26.17900 m.**
	WGS84 Coordinates	
Latitude: **9° 48' 35.66803"**	Longitude: **125° 27' 24.75607"**	Ellipsoidal Hgt: **92.90500 m.**
	PTM Coordinates	
Northing: **1084859.315 m.**	Easting: **549958.116 m.**	Zone: **5**
	UTM Coordinates	
Northing:	Easting:	Zone:

Location Description

SRN-119
From Surigao City plaza travel NW distance of 10 km passing Surigao/ Butuan/ Lipata junction road. Upon reaching km post 114, SRN-119 is located beside km post 1114 along the national highway. Mark is the head of a 3" copper nail set at the center of cement block embedded on the ground inscribe with SRN-119 2007 NAMRIA.

Requesting Party: **UP-TCAGP**
Pupose: **Reference**
OR Number: **8796290 A**
T.N.: **2014-1297**

for **RUEL DM. BELEN, MNSA**
Director, Mapping And Geodesy Branch

9 9 0 6 0 6 2 0 1 4 1 6 4 3 2 1

CIP/4701/12/09/814

NAMRIA OFFICES:
Main : Lawton Avenue, Fort Bonifacio, 1634 Taguig City, Philippines Tel. No.: (632) 810-4831 to 41
Branch : 421 Barraca St. San Nicolas, 1010 Manila, Philippines, Tel. No. (632) 241-3494 to 98
www.namria.gov.ph

ISO 9001: 2008 CERTIFIED FOR MAPPING AND GEOSPATIAL INFORMATION MANAGEMENT

Figure A-2.1. SRN-119

2. AGN-3074

Republic of the Philippines
Department of Environment and Natural Resources
NATIONAL MAPPING AND RESOURCE INFORMATION AUTHORITY

June 06, 2014

CERTIFICATION

To whom it may concern:

This is to certify that according to the records on file in this office, the requested survey information is as follows -

Province: **AGUSAN DEL NORTE**
Station Name: **AGN-3074**
Order: **4th**

Island: **MINDANAO**
Municipality: **KITCHARAO**
Barangay: **JALIOBONG**

PRS92 Coordinates

Latitude: **9° 24' 4.13108"**	Longitude: **125° 33' 31.76634"**	Ellipsoidal Hgt: **39.75900 m.**

WGS84 Coordinates

Latitude: **9° 24' 0.38679"**	Longitude: **125° 33' 37.07966"**	Ellipsoidal Hgt: **107.65200 m.**

PTM Coordinates

Northing: **1039549.784 m.**	Easting: **561376.548 m.**	Zone: **5**

UTM Coordinates

Northing:	Easting:	Zone:

Location Description

AGN-3074

The station is located at the entrance gate of Jaliobong National High School.

30 x 30 x 100cm. concrete block with 80cm. set forth below the ground and 20cm. above the ground, marked with a 2" concrete nail in the center, embedded in the ground with inscriptions "AGN-3074; 2007; DENR/LMS XIII."

Requesting Party: **UP-TCAGP**
Pupose: **Reference**
OR Number: **8796290 A**
T.N.: **2014-1302**

For **RUEL DM. BELEN, MNSA**
Director, Mapping And Geodesy Branch

NAMRIA OFFICES:
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Figure A-2.2. AGN-3074

3. AGN-3075

Republic of the Philippines
Department of Environment and Natural Resources
NATIONAL MAPPING AND RESOURCE INFORMATION AUTHORITY

June 06, 2014

CERTIFICATION

To whom it may concern:

This is to certify that according to the records on file in this office, the requested survey information is as follows -

Province: **AGUSAN DEL NORTE**
Station Name: **AGN-3075**
Order: **4th**

Island: **MINDANAO**
Municipality: **KITCHARAO**
Barangay: **JALIOBONG**

PRS92 Coordinates

Latitude: **9° 24' 7.19957"**	Longitude: **125° 33' 29.91739"**	Ellipsoidal Hgt: **38.99400 m.**

WGS84 Coordinates

Latitude: **9° 24' 3.45501"**	Longitude: **125° 33' 35.23064"**	Ellipsoidal Hgt: **106.88400 m.**

PTM Coordinates

Northing: **1039643.962 m.**	Easting: **561319.987 m.**	Zone: **5**

UTM Coordinates

Northing:	Easting:	Zone:

Location Description

AGN-3075

The station is located beside Jaliobong Elementary School near the flagpole.

30 x 30 x 100cm. concrete block with 80cm. set forth below the ground and 20cm. above the ground, marked with a 2" concrete nail in the center, embedded in the ground with inscriptions "AGN-3075; 2007; DENR/LMS XIII."

Requesting Party: **UP-TCAGP**
Pupose: **Reference**
OR Number: **8796290 A**
T.N.: **2014-1303**

For RUEL DM. BELEN, MNSA
Director, Mapping And Geodesy Branch

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NAMRIA OFFICES:
Main : Lawton Avenue, Fort Bonifacio, 1634 Taguig City, Philippines Tel. No.: (632) 810-4831 to 41
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ISO 9001: 2008 CERTIFIED FOR MAPPING AND GEOSPATIAL INFORMATION MANAGEMENT

CIP/4701/12/09/814

Figure A-2.3. AGN-3075

4. AGN-3026

Republic of the Philippines
Department of Environment and Natural Resources
NATIONAL MAPPING AND RESOURCE INFORMATION AUTHORITY

June 26, 2014

CERTIFICATION

To whom it may concern:

This is to certify that according to the records on file in this office, the requested survey information is as follows -

Province: **AGUSAN DEL NORTE**
Station Name: **AGN-3026**
Order: **4th**

Island: **MINDANAO**
Municipality: **MAGALLANES**
Barangay: **BUHANG**

	PRS92 Coordinates	
Latitude: **9° 2' 2.08829"**	Longitude: **125° 31' 15.56287"**	Ellipsoidal Hgt: **3.24800 m.**
	WGS84 Coordinates	
Latitude: **9° 1' 58.43690"**	Longitude: **125° 31' 20.90948"**	Ellipsoidal Hgt: **71.84600 m.**
	PTM Coordinates	
Northing: **998929.182 m.**	Easting: **557280.19 m.**	Zone: **5**
	UTM Coordinates	
Northing: **999,496.52**	Easting: **777,155.05**	Zone: **51**

Location Description

30 x 30 x 100 cm. concrete block with 80 cm. set forth below the ground and 20 cm. above the ground, marked with a 2" concrete nail in the center, embedded in the ground with inscriptions "AGN-3026; 2007; DENR/LMS." The station is located at the right side of the main gate or entrance of Buhang National Highway School in front of guard house.

23.5 km. north from Butuan City through national highway going to Surigao, passing Magallanes proper.

Requesting Party: **UP-TCAGP**
Pupose: **Reference**
OR Number: **8796391 A**
T.N.: **2014-1474**

RUEL DM. BELEN, MNSA
Director, Mapping And Geodesy Branch

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CIP/4701/12/09/814

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Branch : 421 Barraca St. San Nicolas, 1010 Manila, Philippines, Tel. No. (632) 241-3494 to 98
www.namria.gov.ph

ISO 9001: 2008 CERTIFIED FOR MAPPING AND GEOSPATIAL INFORMATION MANAGEMENT

Figure A-2.4. AGN-3026

5. AGN-3740

Republic of the Philippines
Department of Environment and Natural Resources
NATIONAL MAPPING AND RESOURCE INFORMATION AUTHORITY

June 26, 2014

CERTIFICATION

To whom it may concern:

This is to certify that according to the records on file in this office, the requested survey information is as follows -

Province: **AGUSAN DEL NORTE**
Station Name: **AGN-3740**
Order: **4th**

Island: **Mindanao**
Municipality: **CABADBARAN**
Barangay: **SANGHAN**

	PRS92 Coordinates	
Latitude: **9° 5' 7.75859"**	Longitude: **125° 34' 15.24993"**	Ellipsoidal Hgt: **9.80800 m.**
	WGS84 Coordinates	
Latitude: **9° 5' 4.09807"**	Longitude: **125° 34' 20.59141"**	Ellipsoidal Hgt: **78.41800 m.**
	PTM Coordinates	
Northing: **1004641.328 m.**	Easting: **562759.097 m.**	Zone: **5**
	UTM Coordinates	
Northing: **1,005,242.03**	Easting: **782,605.58**	Zone: **51**

Location Description

AGN-3740

STA. MARK: AGN 3740 is a quadrilateral concrete monument 20cm x 20 cm x 100 cm with variable depth set on the ground (60 cm-100 cm) inscribed name "AGN 3740, 2012, 4th order, DENR and Copper nail embedded at the center.

ACCESS: AGN 3740 is located at Barangay Sanghan, from Butuan City, this monument is on the right side of the road and near at the bridge with an approximate distance of 5 m.

Requesting Party: **UP-TCAGP**
Pupose: **Reference**
OR Number: **8796391 A**
T.N.: **2014-1472**

RUEL DM. BELEN, MNSA
Director, Mapping And Geodesy Branch

9 9 0 6 2 6 2 0 1 4 1 1 1 3 8 4 3

NAMRIA OFFICES:
Main : Lawton Avenue, Fort Bonifacio, 1634 Taguig City, Philippines Tel. No.: (632) 810-4831 to 41
Branch : 421 Barraca St. San Nicolas, 1010 Manila, Philippines, Tel. No. (632) 241-3494 to 98
www.namria.gov.ph

ISO 9001: 2008 CERTIFIED FOR MAPPING AND GEOSPATIAL INFORMATION MANAGEMENT

CIP/4701/12/09/814

Figure A-2.5. AGN-3740

6. SRN-102

Republic of the Philippines
Department of Environment and Natural Resources
NATIONAL MAPPING AND RESOURCE INFORMATION AUTHORITY

June 06, 2014

CERTIFICATION

To whom it may concern:

This is to certify that according to the records on file in this office, the requested survey information is as follows -

Province: **SURIGAO DEL NORTE**
Station Name: **SRN-102**
Order: **2nd**

Island: **MINDANAO**
Municipality: **SISON**
Barangay: **POBLACION (SAN PEDRO)**

PRS92 Coordinates

Latitude: **9° 39' 24.81730"** Longitude: **125° 31' 35.42419"** Ellipsoidal Hgt: **35.04700 m.**

WGS84 Coordinates

Latitude: **9° 39' 21.00341"** Longitude: **125° 31' 40.71501"** Ellipsoidal Hgt: **102.29400 m.**

PTM Coordinates

Northing: **1067829.026 m.** Easting: **557783.962 m.** Zone: **5**

UTM Coordinates

Northing: Easting: Zone:

Location Description

SRN-102
From Brgy. Bad-as junction landmark travel towards municipality of Sison for 7.1 km NE, turn left in the first municipality of Sison for 50 m to the barangay hall landmark then turn left by 300 m up to Patag bridge where SRN-102 monument is located. Mark is the head of a 3" copper nail set at the center of cement block embedded on the ground inscribe with SRN-102 2007 NAMRIA.

Requesting Party: **UP-TCAGP**
Pupose: **Reference**
OR Number: **8796290 A**
T.N.: **2014-1299**

for **RUEL DM. BELEN, MNSA**
Director, Mapping And Geodesy Branch

9906062014164418

NAMRIA OFFICES:
Main : Lawton Avenue, Fort Bonifacio, 1634 Taguig City, Philippines Tel. No.: (632) 810-4831 to 41
Branch : 421 Barraca St. San Nicolas, 1010 Manila, Philippines, Tel. No. (632) 241-3494 to 98
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Figure A-2.6. SRN-102

Annex 3. Baseline Processing Reports of Control Points used in the LiDAR Survey

1. AGN-3740

Table A-3.1. AGN-3740 (a)

Project information		Coordinate System	
Name:		Name:	UTM
Size:		Datum:	PRS 92
Modified:	8/7/2014 11:04:26 AM (UTC:8)	Zone:	51 North (123E)
Time zone:	Malay Peninsula Standard Time	Geoid:	EGMPH
Reference number:		Vertical datum:	
Description:			

Baseline Processing Report

Processing Summary

Observation	From	To	Solution Type	H. Prec. (Meter)	V. Prec. (Meter)	Geodetic Az.	Ellipsoid Dist. (Meter)	ΔHeight (Meter)
AGN-3740 --- LAN-2 (B2)	LAN-2	AGN-3740	Fixed	0.029	0.041	56°43'42"	237218.713	-6.859
AGN-3740 --- AGN-3026 (B3)	AGN-3740	AGN-3026	Fixed	0.036	0.043	223°53'24"	7915.563	-9.579
LAN-2 --- AGN-3026 (B1)	LAN-2	AGN-3026	Fixed	0.047	0.066	57°10'36"	229616.191	-16.407

Acceptance Summary

Processed	Passed	Flag	Fail
3	3	0	0

AGN-3740 - LAN-2 (10:05:34 AM-2:59:59 PM) (S2)

Baseline observation:	AGN-3740 --- LAN-2 (B2)
Processed:	8/7/2014 6:14:30 PM
Solution type:	Fixed
Frequency used:	Dual Frequency (L1, L2)
Horizontal precision:	0.029 m
Vertical precision:	0.041 m
RMS:	0.009 m
Maximum PDOP:	2.421
Ephemeris used:	Broadcast
Antenna model:	NGS Absolute
Processing start time:	6/20/2014 10:09:19 AM (Local: UTC+8hr)
Processing stop time:	6/20/2014 2:59:59 PM (Local: UTC+8hr)
Processing duration:	04:50:40
Processing interval:	5 seconds

1

Table A-3.1. AGN-3740 (b)

Vector Components (Mark to Mark)

From:	LAN-2				
Grid		Local		Global	
Easting	584533.450 m	Latitude	N7°54'46.07860"	Latitude	N7°54'42.56546"
Northing	874680.348 m	Longitude	E123°46'00.86333"	Longitude	E123°46'06.31720"
Elevation	15.242 m	Height	17.364 m	Height	83.921 m

To:	AGN-3740				
Grid		Local		Global	
Easting	782606.301 m	Latitude	N9°05'07.75605"	Latitude	N9°05'04.09554"
Northing	1005241.953 m	Longitude	E125°34'15.27340"	Longitude	E125°34'20.61487"
Elevation	10.642 m	Height	10.495 m	Height	79.105 m

Vector					
ΔEasting	198072.851 m	NS Fwd Azimuth	56°43'42"	ΔX	-152441.295 m
ΔNorthing	130561.605 m	Ellipsoid Dist.	237218.713 m	ΔY	-128745.263 m
ΔElevation	-4.600 m	ΔHeight	-6.869 m	ΔZ	128267.863 m

Standard Errors

Vector errors:					
σ ΔEasting	0.011 m	σ NS fwd Azimuth	0°00'00"	σ ΔX	0.015 m
σ ΔNorthing	0.006 m	σ Ellipsoid Dist.	0.011 m	σ ΔY	0.019 m
σ ΔElevation	0.021 m	σ ΔHeight	0.021 m	σ ΔZ	0.006 m

Aposteriori Covariance Matrix (Meter²)

	X	Y	Z
X	0.0002108411		
Y	-0.0001358583	0.0003598604	
Z	-0.0000465901	0.0000232793	0.0000358429

2. AGN-3026

Table A-3.2. AGN-3026 (a)

Processing style

Elevation mask:	10.0 deg
Auto start processing:	Yes
Start automatic ID numbering:	AUTO0001
Continuous vectors:	No
Generate residuals:	Yes
Antenna model:	Automatic
Ephemeris type:	Automatic
Frequency:	Multiple Frequencies
Processing Interval:	Use all data
Force float:	No

Acceptance Criteria

Vector Component	Flag	Fail
Horizontal Precision >	0.050 m + 1.000 ppm	0.100 m + 1.000 ppm
Vertical Precision >	0.100 m + 1.000 ppm	0.150 m + 1.000 ppm

AGN-3740 - AGN-3026 (10:04:11 AM-2:49:00 PM) (S3)

Baseline observation:	AGN-3740 --- AGN-3026 (B3)
Processed:	8/7/2014 5:16:57 PM
Solution type:	Fixed
Frequency used:	Dual Frequency (L1, L2)
Horizontal precision:	0.036 m
Vertical precision:	0.043 m
RMS:	0.009 m
Maximum PDOP:	5.117
Ephemeris used:	Broadcast
Antenna model:	Trimble Relative
Processing start time:	6/20/2014 10:06:53 AM (Local: UTC+8hr)
Processing stop time:	6/20/2014 2:49:00 PM (Local: UTC+8hr)
Processing duration:	04:42:07
Processing interval:	1 second

Table A-3.2. AGN-3026 (b)

Vector Components (Mark to Mark)

From:	AGN-3740				
Grid		Local		Global	
Easting	782606.301 m	Latitude	N9°06'07.75606"	Latitude	N9°06'04.09654"
Northing	1006241.963 m	Longitude	E125°34'15.27340"	Longitude	E125°34'20.61487"
Elevation	10.642 m	Height	10.495 m	Height	79.105 m

To:	AGN-3026				
Grid		Local		Global	
Easting	777155.999 m	Latitude	N9°02'02.05467"	Latitude	N9°01'58.40327"
Northing	999495.498 m	Longitude	E125°31'15.59370"	Longitude	E125°31'20.94031"
Elevation	1.396 m	Height	0.915 m	Height	69.513 m

Vector					
ΔEasting	-5450.302 m	NS Fwd Azimuth	223°53'24"	ΔX	3947.815 m
ΔNorthing	-5746.455 m	Ellipsoid Dist.	7915.563 m	ΔY	3913.221 m
ΔElevation	-9.246 m	ΔHeight	-9.579 m	ΔZ	-5635.394 m

Standard Errors

Vector errors:					
σ ΔEasting	0.015 m	σ NS fwd Azimuth	0°00'00"	σ ΔX	0.019 m
σ ΔNorthing	0.003 m	σ Ellipsoid Dist.	0.010 m	σ ΔY	0.018 m
σ ΔElevation	0.022 m	σ ΔHeight	0.022 m	σ ΔZ	0.005 m

Aposteriori Covariance Matrix (Meter²)

	X	Y	Z
X	0.0003561480		
Y	-0.0001409460	0.0003199126	
Z	-0.0000339474	0.0000552150	0.0000212682

Annex 4. The LiDAR Survey Team Composition

Table A-4.1. The LiDAR Survey Team Composition

<table>
<tr><th>Date Acquisition Component Sub-team</th><th>Designation</th><th>Name</th><th>Agency/Affiliation</th></tr>
<tr><td>PHIL-LiDAR 1</td><td>Program Leader</td><td>ENRICO C. PARINGIT D. ENG</td><td>UP-TCAGP</td></tr>
<tr><td>Data Acquisition Component Leader</td><td>Data Component Project Leader –I</td><td>ENGR. CZAR JAKIRI S. SARMIENTO</td><td>UP TCAGP</td></tr>
<tr><td rowspan="3">Survey Supervisor</td><td>Chief Science Research Specialist (CSRS)</td><td>ENGR. CHRISTOPHER CRUZ</td><td>UP TCAGP</td></tr>
<tr><td rowspan="2">Supervising Science Research Specialist (Supervising SRS)</td><td>LOVELY GRACIA ACUNA</td><td>UP TCAGP</td></tr>
<tr><td>ENGR. LOVELYN ASUNCION</td><td>UP TCAGP</td></tr>
<tr><td colspan="4">FIELD TEAM</td></tr>
<tr><td rowspan="4">LiDAR Operation</td><td>Research Associate (RA)</td><td>MARY CATHERINE ELIZABETH BALIGUAS</td><td>UP TCAGP</td></tr>
<tr><td rowspan="3">RA</td><td>MA VERLINA TONGA</td><td>UP TCAGP</td></tr>
<tr><td>MA. REMEDIOS VILLANUEVA</td><td>UP TCAGP</td></tr>
<tr><td>ENGR. LARAH KRISELLE PARAGAS</td><td>UP TCAGP</td></tr>
<tr><td rowspan="2">Ground Survey, Data download and transfer</td><td rowspan="2">RA</td><td>KRISTINE JOY ANDAYA</td><td>UP TCAGP</td></tr>
<tr><td>KENNETH QUISADO</td><td>UP TCAGP</td></tr>
<tr><td rowspan="6">LiDAR Operation</td><td rowspan="2">Airborne Security</td><td>SSG. MICHAEL BERONILLA</td><td>PHILIPPINE AIR FORCE (PAF)</td></tr>
<tr><td>SSG. MIKE DIAPANA</td><td>PAF</td></tr>
<tr><td rowspan="4">Pilot</td><td>CAPT. JEFFREY JEREMY ALAJAR</td><td>ASIAN AEROSPACE CORPORATION (AAC)</td></tr>
<tr><td>CAPT. RAUL CZ SAMAR II</td><td>AAC</td></tr>
<tr><td>CAPT. NEIL ACHILLES AGAWIN</td><td>AAC</td></tr>
<tr><td>CAPT. JOHN BRYAN DONGUINES</td><td>AAC</td></tr>
</table>

Annex 5. Data Transfer Sheet for Mainit-Tubay Floodplain

DATA TRANSFER SHEET
06/16/2014(Surigao)

DATE	FLIGHT NO.	MISSION NAME	SENSOR	RAW LAS		LOGS(MB)	POS	RAW IMAGES/CASI	MISSION LOG FILE/CASI LOGS	RANGE	DIGITIZER	BASE STATION(S)		OPERATOR LOGS (OPLOG)	FLIGHT PLAN		SERVER LOCATION
				Output LAS	KML (swath)							BASE STATION(S)	Base Info (.txt)		Actual	KML	
5/30/2014	7280GC	2BLK59FG150A	Gemini	na	82.6	236	100	na	na	8.34	NA	3.96	1KB	1KB	8	9.91	Z:\Airborne_Raw\7280GC
5/30/2014	7281GC	2BLK59F150B	Gemini	na	143	259	139	na	na	10.4	NA	4.42	1KB	1KB	9.16	NA	Z:\Airborne_Raw\7281GC
5/31/2014	7282GC	2BLK59EFS151A	Gemini	na	557	560	245	na	na	20.3	NA	2.86	1KB	1KB	7.14	NA	Z:\Airborne_Raw\7282GC
5/31/2014	7283GC	2BLK59GS151B	Gemini	na	150	334	133	na	na	12.3	NA	4.36	1KB	1KB	9.54	25.9	Z:\Airborne_Raw\7283GC
6/1/2014	7284GC	2BLK59GS152A	Gemini	na	23.3	188	117	na	na	6.03	NA	4.98	1KB	1KB	3.99	NA	Z:\Airborne_Raw\7284GC
6/2/2014	7286GC	2BLK59CD153A	Gemini	na	235	375	214	na	na	13.8	NA	4.32	1KB	1KB	10	NA	Z:\Airborne_Raw\7286GC
6/3/2014	7288GC	2BLK59C+BLK60D154A	Gemini	na	417	540	261	na	na	22.2	NA	4.6	1KB	1KB	7.4	9.44	Z:\Airborne_Raw\7288GC

Received from

Name [illegible]
Position [illegible]
Signature

Received by

Name JOIDA F. PRIETO
Position SSRS
Signature 6/16/14

Figure A-5.1. Data Transfer Sheet for Mainit-Tubay Floodplain - A

DATA TRANSFER SHEET
06/20/2014(Surigao)

DATE	FLIGHT NO.	MISSION NAME	SENSOR	RAW LAS		LOGS(MB)	POS	RAW IMAGES/CASI	MISSION LOG FILE/CASI LOGS	RANGE	DIGITIZER	BASE STATION(S)		OPERATOR LOGS (OPLOG)	FLIGHT PLAN		SERVER LOCATION
				Output LAS	KML (swath)							BASE STATION(S)	Base Info (.txt)		Actual	KML	
5-Jun-14	7292GC	2BLK60DS156A	Gemini	na	352	483	230	na	na	19.1	NA	1.09	1KB	1KB	16	29	Z:\Airborne_Raw\7292GC
5-Jun-14	7293GC	2BLK59GS156B	Gemini	na	312	291	122	na	na	12.4	NA	4.07	1KB	1KB	4	NA	Z:\Airborne_Raw\7293GC
6-Jun-14	7294GC	2BLK59AB157A	Gemini	na	345	595	260	na	na	6.18	NA	8.24	1KB	1KB	6	15	Z:\Airborne_Raw\7294GC
6-Jun-14	7295GC	2BLK59GS+FV157B	Gemini	na	32.7	275	123	na	na	9.98	NA	8.24	1KB	1KB	13	na	Z:\Airborne_Raw\7295GC
7-Jun-14	7296GC	2BLK60CDS158A	Gemini	na	95.8	557	257	na	na	20.9	NA	8.45	1KB	1KB	10	NA	Z:\Airborne_Raw\7296GC
7-Jun-14	7297GC	2BLK59ES158B	Gemini	na	61.2	149	99.9	na	na	5.1	NA	8.45	1KB	1KB	22	14	Z:\Airborne_Raw\7297GC
8-Jun-14	7298GC	2BLK59ASDS159A	Gemini	na	73.6	463	204	na	na	17.9	NA	8.52	1KB	1KB	10	17	Z:\Airborne_Raw\7298GC
9-Jun-14	7300GC	2BLK59FG+BLK60DCV160A	Gemini	na	258	468	216	na	na	15.4	NA	4.78	1KB	1KB	18	na	Z:\Airborne_Raw\7300GC

Received from

Name C. Joaquin
Position RA
Signature [signature]

Received by

Name JOIDA F. PRIETO 6/20/2014
Position SSRS
Signature [signature]

14-45

Figure A-5.2. Data Transfer Sheet for Mainit-Tubay Floodplain - B

DATA TRANSFER SHEET
07/03/2014(BUTUAN - ready)

DATE	FLIGHT NO.	MISSION NAME	SENSOR	RAW LAS		LOGS(MB)	POS	RAW IMAGES/CASI	MISSION LOG FILE/CASI LOGS	RANGE	DIGITIZER	BASE STATION(S)		OPERATOR LOGS (OPLOG)	FLIGHT PLAN		SERVER LOCATION
				Output LAS	KML (swath)							BASE STATION(S)	Base Info (.txt)		Actual	KML	
20-Jun-14	1604A	3AGUS171A	AQUARIUS	NA	564	978	245	67.9	457	10.8	149	61.4	2KB	1KB	8	16	Z:\Airborne_Raw\1604A
22-Jun-14	1612A	3AGU1AB173A	AQUARIUS	NA	232/215	807	262	43.4	322	10	67.7	59.7	1KB	1KB	4	6	Z:\Airborne_Raw\1612A
23-Jun-14	1614A	3BLK63A174A	AQUARIUS	NA	637	1.04MB	196	86.4	551	10.3	48.8	63.2	1KB	1KB	6	14	Z:\Airborne_Raw\1614A
28-Jun-14	1634A	3BLK63BC179A	AQUARIUS	NA	661	1.07MB	244	77.7	313	12.6	NA	13.1	1KB	1KB	9	NA	Z:\Airborne_Raw\1634A
28-Jun-14	1636A	3BLK63CSD179B	AQUARIUS	NA	982	1.05MB	164	30.2	259	6.48	NA	91.6	1KB	1KB	12	NA	Z:\Airborne_Raw\1636A

Received from

Name C.JOAQUIN
Position RA
Signature [signature]

Received by

Name JOIDA F. PRIETO
Position SSRS
Signature [signature] 7/3/2014

14-47

Figure A-5.3. Data Transfer Sheet for Mainit-Tubay Floodplain - C

Annex 6. Flight logs for the flight missions

1. Flight Log for Mission 3AGUS171A

DREAM Data Acquisition Flight Log — Flight Log No.: 1604

1 LiDAR Operator: MCE Balicanta	2 ALTM Model: Aquarius	3 Mission Name: 3AGUS171A	4 Type: VFR	5 Aircraft Type: Cessna T206H	6 Aircraft Identification: 9122
7 Pilot: JJ Alagar	8 Co-Pilot: NA Aquino	9 Route:			
10 Date: 06-20-2014	12 Airport of Departure (Airport, City/Province): Butuan		12 Airport of Arrival (Airport, City/Province):		
13 Engine On: 10:34	14 Engine Off: 14:51	15 Total Engine Time: 4:17	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather: fair					

20 Remarks: Completed LiDAR Acquisition over Agusan Floodplain voids

21 Problems and Solutions:

Acquisition Flight Approved by: Lovely Acuna — Signature over Printed Name (End User Representative)

Acquisition Flight Certified by: Signature over Printed Name (PAF Representative)

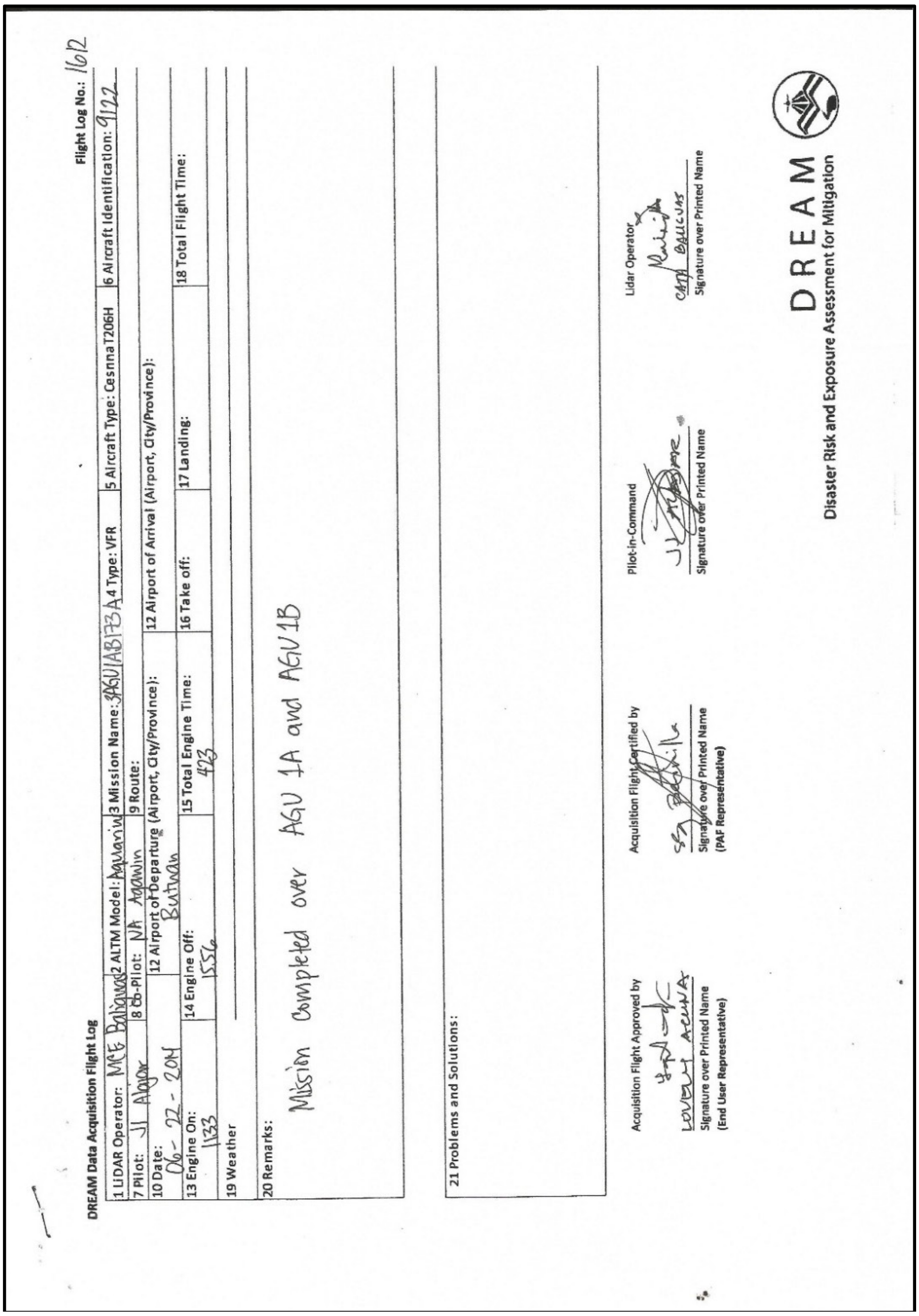
Pilot-in-Command: Signature over Printed Name

Lidar Operator: Signature over Printed Name

DREAM — Disaster Risk and Exposure Assessment for Mitigation

Figure A-6.1. Flight Log for Mission 3AGUS171A

2. Flight Log for Mission 3AGU1AB173A



Flight Log No.: 1612

DREAM Data Acquisition Flight Log

1 LIDAR Operator: MCE Baliguas	2 ALTM Model: Aquarius	3 Mission Name: 3AGU1AB173A	4 Type: VFR	5 Aircraft Type: Cesnna T206H	6 Aircraft Identification: 9122
7 Pilot: JJ Alajar	8 Co-Pilot: NA Agawin	9 Route:			
10 Date: 06-22-2014	12 Airport of Departure (Airport, City/Province): Butuan		12 Airport of Arrival (Airport, City/Province):		
13 Engine On: 1133	14 Engine Off: 1556	15 Total Engine Time: 423	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather					

20 Remarks:

Mission Completed over AGU 1A and AGU 1B

21 Problems and Solutions:

Acquisition Flight Approved by
LOVELY ACUNA
Signature over Printed Name
(End User Representative)

Acquisition Flight Certified by
Signature over Printed Name
(PAF Representative)

Pilot-in-Command
JJ Alajar
Signature over Printed Name

Lidar Operator
Signature over Printed Name

DREAM
Disaster Risk and Exposure Assessment for Mitigation

Figure A-6.2. Flight Log for Mission 3AGU1AB173A

3. Flight Log for Mission 2BLK59CD153A

DREAM Data Acquisition Flight Log

Flight Log No.: 7286

1 LIDAR Operator: LK Paragas	2 ALTM Model: Com/CAS	3 Mission Name: 2BLK59CD153A	4 Type: VFR	5 Aircraft Type: Cesnna T206H	6 Aircraft Identification: RP-C9322
7 Pilot: R. Samaril	8 Co-Pilot: B. Domingines	9 Route:			
10 Date: 6-2-14	12 Airport of Departure (Airport, City/Province): RPMS		12 Airport of Arrival (Airport, City/Province): RPMS		
13 Engine On: 6+16	14 Engine Off: 10+3	15 Total Engine Time: 3+47	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather					

20 Remarks:

Mission 59D completed and surveyed 5 lines in 59C (without CASI)

21 Problems and Solutions:

Acquisition Flight Approved by: R. Hernandez — Signature over Printed Name (End User Representative)

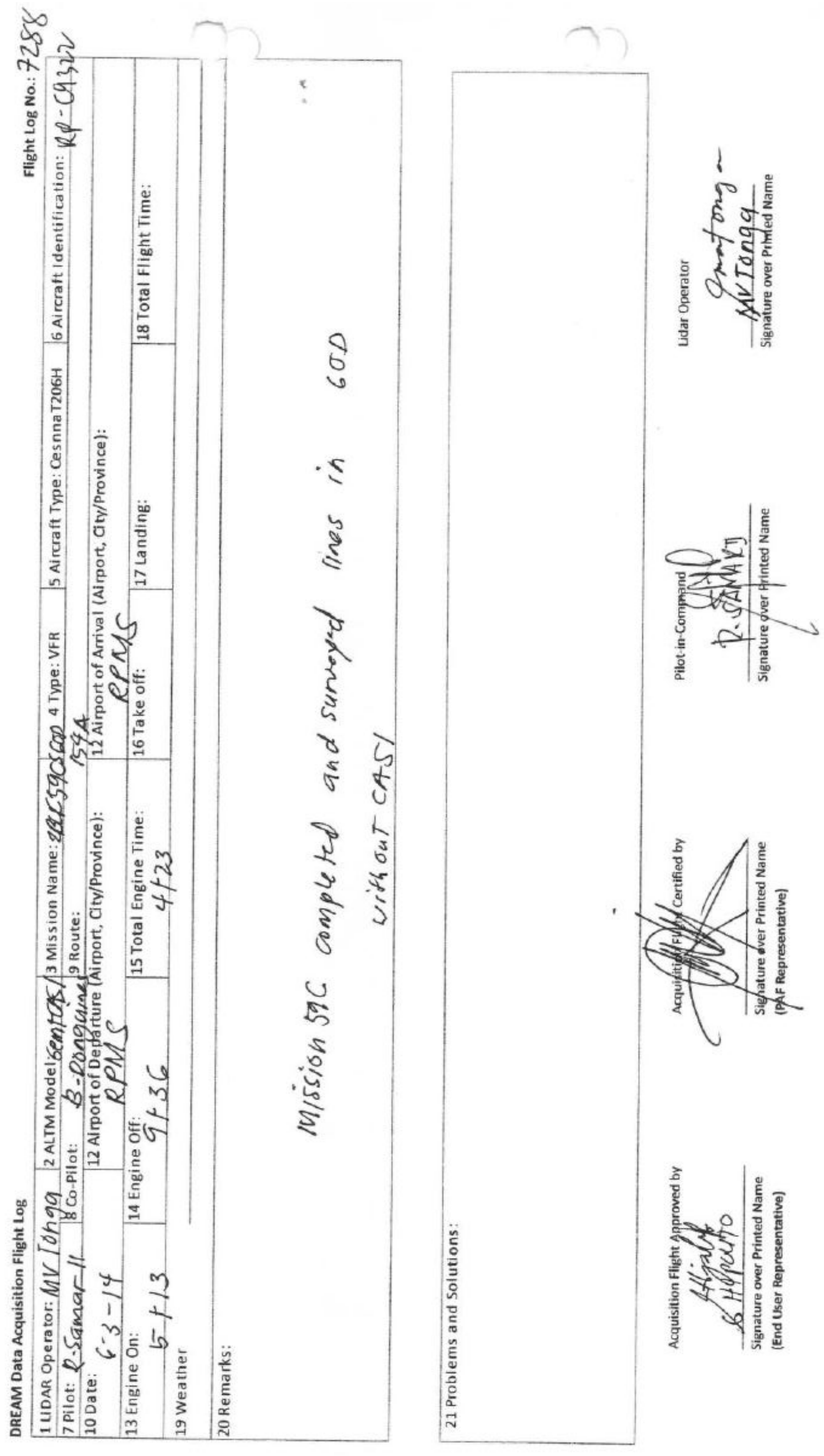
Acquisition Flight Certified by — Signature over Printed Name (PAF Representative)

Pilot-in-Command: R. Samaril — Signature over Printed Name

Lidar Operator: LK Paragas — Signature over Printed Name

Figure A-6.3. Flight Log for Mission 2BLK59CD153A

4. Flight Log for Mission 2BLK59C + BLK60D154A



DREAM Data Acquisition Flight Log

Flight Log No.: 7258

1 LIDAR Operator: MV Tongga	2 ALTM Model: Gemini	3 Mission Name: 2BLK59CS60D154A	4 Type: VFR	5 Aircraft Type: Cesnna T206H	6 Aircraft Identification: RP-C9322
7 Pilot: R. Samar II	8 Co-Pilot: B. Dongiuinas	9 Route:			
10 Date: 6-3-14	12 Airport of Departure (Airport, City/Province): RPMS		12 Airport of Arrival (Airport, City/Province): RPMS		
13 Engine On: 5+13	14 Engine Off: 9+36	15 Total Engine Time: 4+23	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather					

20 Remarks:

Mission 59C completed and surveyed lines in 60D without CASI

21 Problems and Solutions:

Acquisition Flight Approved by — Signature over Printed Name (End User Representative)

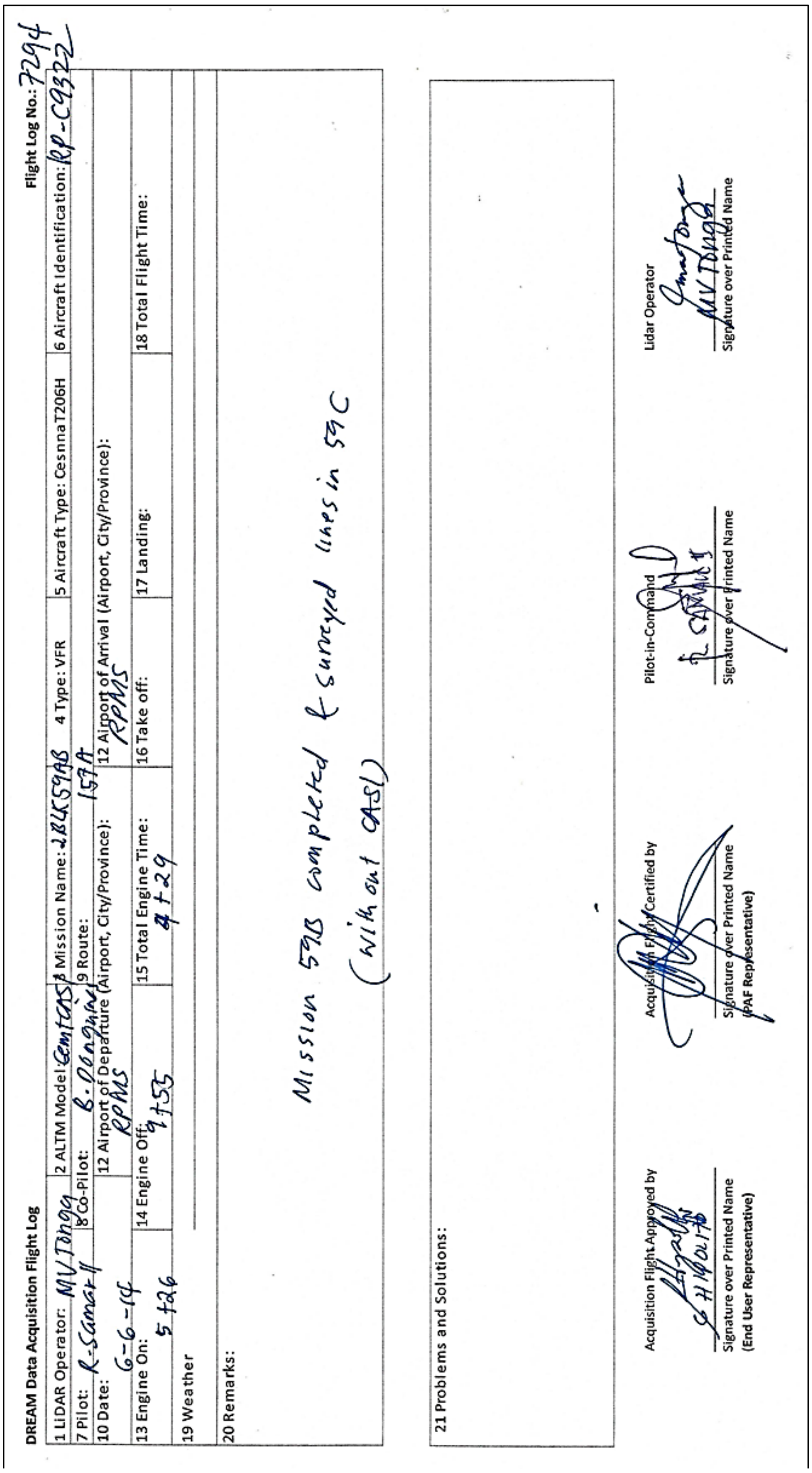
Acquisition Flight Certified by — Signature over Printed Name (PAF Representative)

Pilot-in-Command — R. Samar II — Signature over Printed Name

Lidar Operator — MV Tongga — Signature over Printed Name

Figure A-6.4. Flight Log for Mission 2BLK59C + BLK60D154A

5. Flight Log for Mission 2BLK59AB157A


DREAM Data Acquisition Flight Log

Flight Log No.: 7294

1 LiDAR Operator: MV Tongo	2 ALTM Model: Gemini/CASI	3 Mission Name: 2BLK59AB157A	4 Type: VFR	5 Aircraft Type: CesnnaT206H	6 Aircraft Identification: RP-C9322
7 Pilot: R. Samar II	8 Co-Pilot: B. Dongui	9 Route:			
10 Date: 6-6-14	12 Airport of Departure (Airport, City/Province): RPMS		12 Airport of Arrival (Airport, City/Province): RPMS		
13 Engine On: 5+26	14 Engine Off: 9+55	15 Total Engine Time: 4+29	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather					

20 Remarks:

Mission 59B completed & surveyed lines in 59C (without CASI)

21 Problems and Solutions:

Acquisition Flight Approved by — Signature over Printed Name (End User Representative)

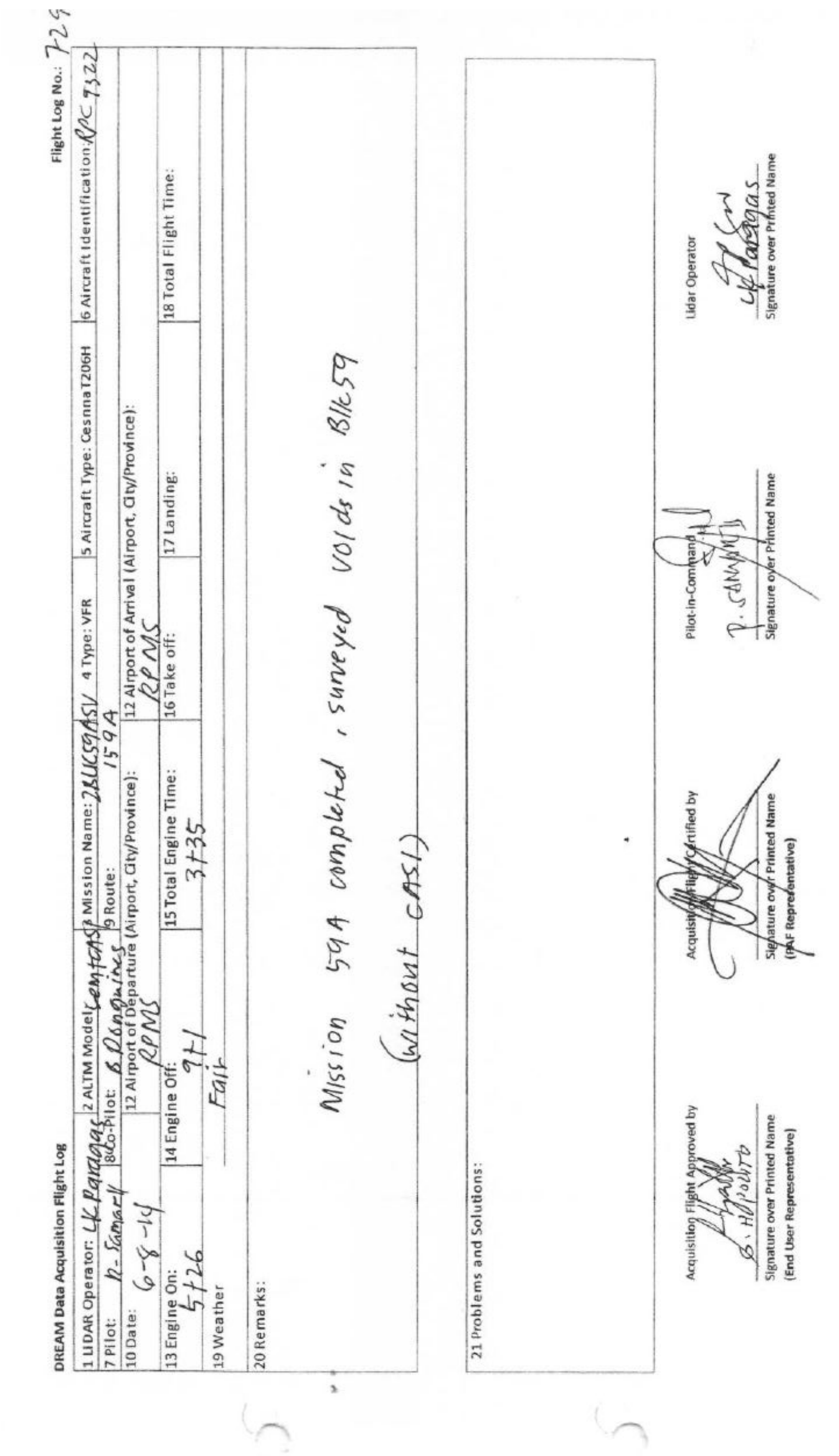
Acquisition Flight Certified by — Signature over Printed Name (PAF Representative)

Pilot-in-Command — Signature over Printed Name

Lidar Operator — MV Tongo — Signature over Printed Name

Figure A-6.5. Flight Log for Mission 2BLK59AB157A

6. Flight Log for Mission 2BLK59AB157A



DREAM Data Acquisition Flight Log

Flight Log No.: 729

1 LIDAR Operator: LK Paragas	2 ALTM Model: Gemini/CASI	3 Mission Name: 2BLK59ASV	4 Type: VFR	5 Aircraft Type: Cesnna T206H	6 Aircraft Identification: RPC 9322
7 Pilot: R. Samaria	8 Co-Pilot: B. Dongumes	9 Route: 159A			
10 Date: 6-8-14	12 Airport of Departure (Airport, City/Province): RPMS		12 Airport of Arrival (Airport, City/Province): RPMS		
13 Engine On: 5+26	14 Engine Off: 9+1	15 Total Engine Time: 3+35	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather: Fair					

20 Remarks:

Mission 59A completed, surveyed voids in Blk59 (without CASI)

21 Problems and Solutions:

Acquisition Flight Approved by — Signature over Printed Name (End User Representative)

Acquisition Flight Certified by — Signature over Printed Name (PAF Representative)

Pilot-in-Command — Signature over Printed Name

Lidar Operator — Signature over Printed Name

Figure A-6.6. Flight Log for Mission 2BLK59AB157A

Annex 7. Flight Status Reports

Table A-7.1. Flight Status Report

FLIGHT NO	AREA	MISSION	OPERATOR	DATE FLOWN	REMARKS
1604	AGU	3AGUS171A	MCE BALIGUAS	20 JUNE 14	Completed LiDAR Acquisition over Agusan Floodplain voids
1612	AGU1A & AGU1B	3AGU1AB173A	MCE BALIGUAS	22 JUNE 14	Mission completed over AGU 1A and AGU 1B
7286GC	BLK59C & BLK59D	2BLK59CD153A	L. PARAGAS	02-Jun-14	Completed area D however there are voids due to clouds. Also surveyed 5 lines of area C.
7288GC	BLK59C & BLK60D	2BLK59C + BLK60D154A	MV. TONGA	03-Jun-14	Completed area C, but there are gaps due to high terrain, also covered 7 strips of area BLK60D.
7294GC	BLK59A & BLK59B	2BLK59ASDS159A	L. PARAGAS	08-Jun-14	Completed area A and covered the gaps in area DS.

SWATH PER FLIGHT MISSION

Flight No:	1604		
Area:	AGU		
Mission Name:	3AGUS171A		
Altitude:	600m		
PRF:	50 kHz	SCF:	45Hz
LiDAR FOV:	18 deg	Sidelap:	30%

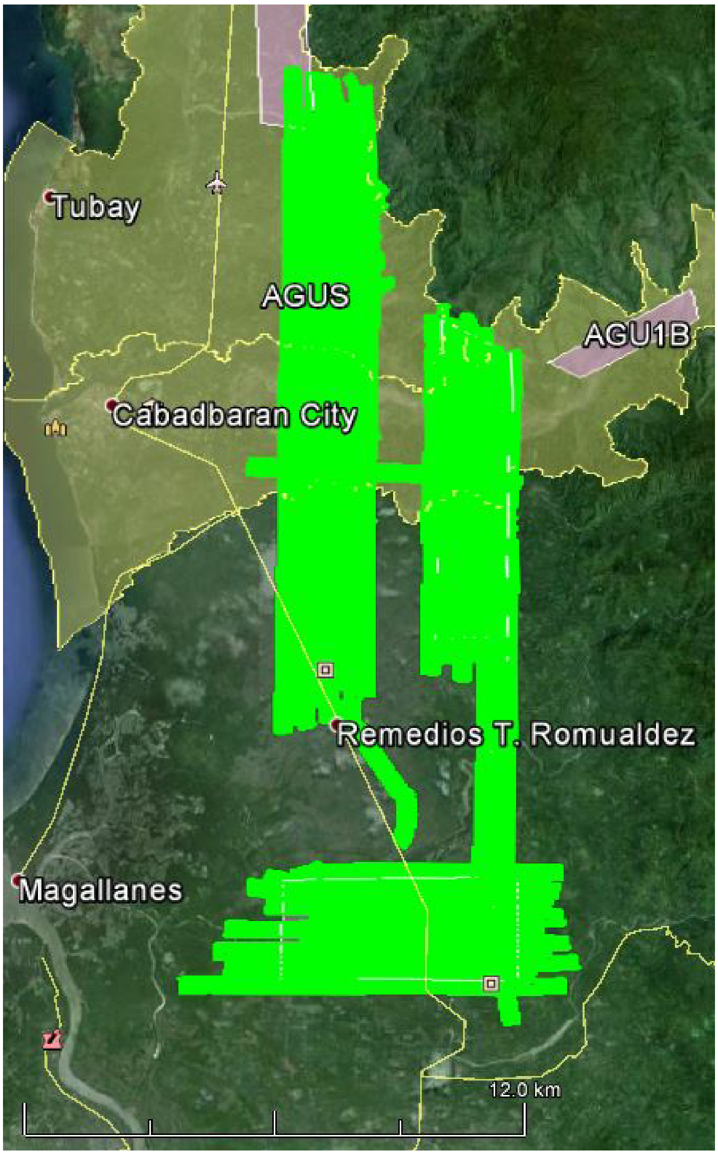


Figure A-7.1. Swath for Flight No. 1604

Flight No: 1612
Area: AGU1A & AGU1B
Mission Name: 3AGU1AB173A

Altitude: 600m
PRF: 50 kHz SCF: 45Hz
LiDAR FOV: 18 deg Sidelap: 40-50%

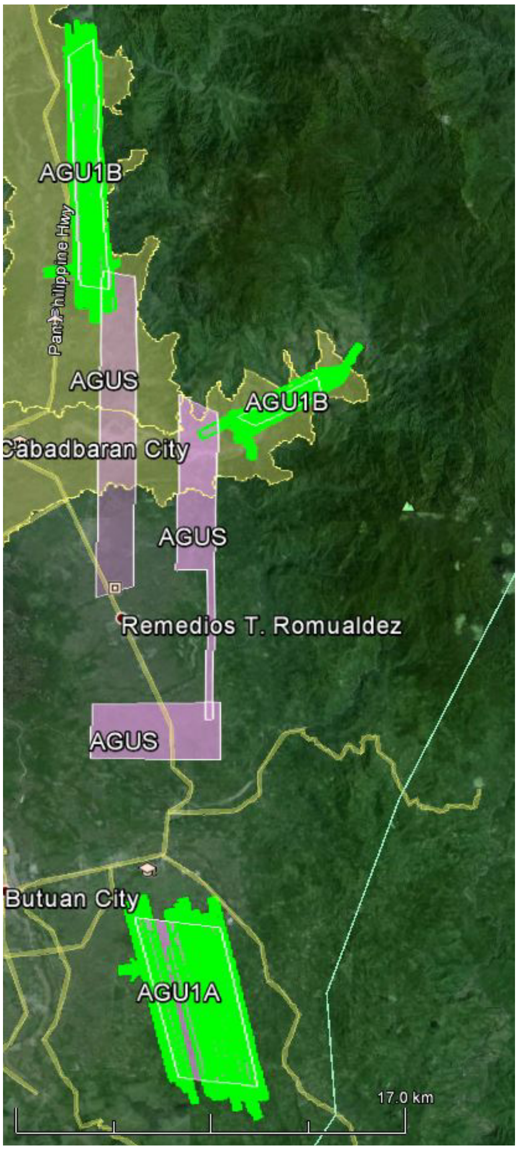


Figure A-7.2. Swath for Flight No. 1612

FLIGHT LOG NO. 7286GC
AREA: BLK59C & BLK59D
MISSION NAME: 2BLK59CD153A
SURVEY COVERAGE:

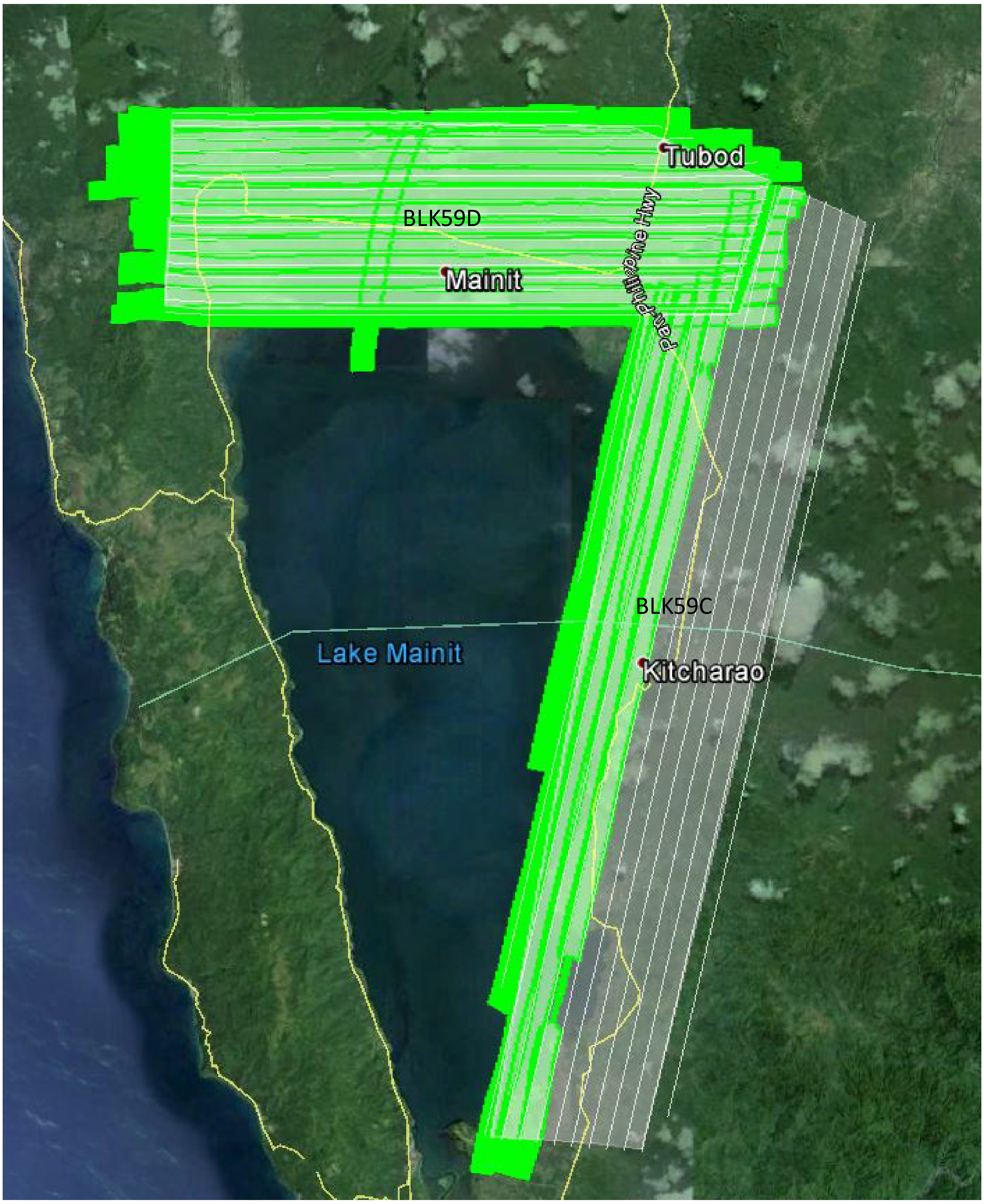


Figure A-7.3. Swath for Flight No. 7286GC

FLIGHT LOG NO. 7288GC
AREA: BLK59C & BLK60D
MISSION NAME: 2BLK59C+BLK60D154A
SURVEY COVERAGE:

Figure A-7.4. Swath for Flight No. 7288GC

FLIGHT LOG NO. 7294GC
AREA: BLK59A & BLK59B
MISSION NAME: 2BLK59AB157A
SURVEY COVERAGE:

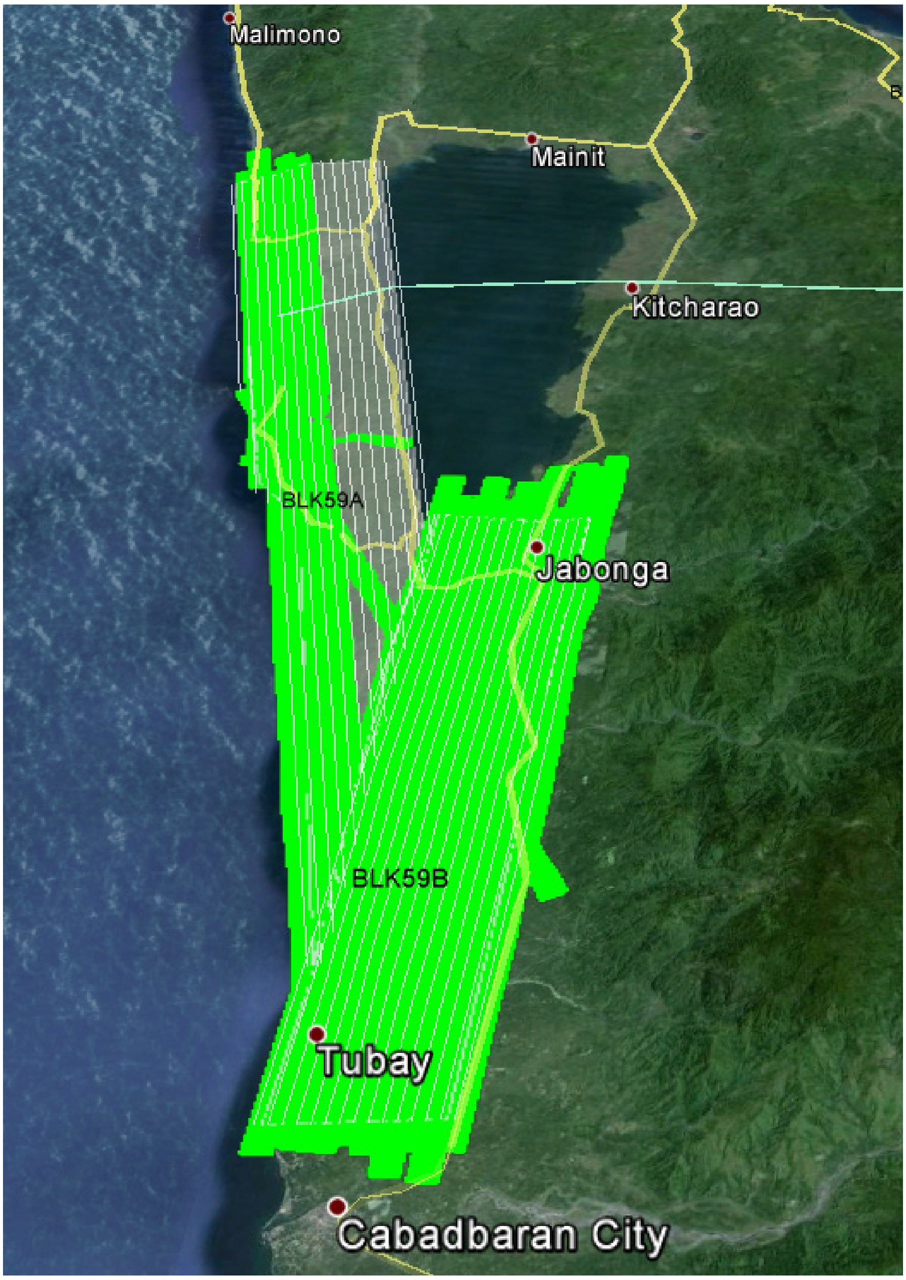


Figure A-7.5. Swath for Flight No. 7294GC

FLIGHT LOG NO. 7298GC
AREA: BLK59A & BLK59DS
MISSION NAME: 2BLK59ASDS159A
SWATH AREA: 132.67 sq.km
SURVEY COVERAGE:

Figure A-7.6. Swath for Flight No. 7298GC

Annex 8. Mainit-Tubay Model Basin Parameters

Table A-8.1. Mainit-Tubay Model Basin Parameters

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Baseflow				
	Initial Abstraction	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (m3/s)	Recession Constant	Threshold Type	Ratio to Peak
W2600	9.46	61.39	0.0000	1.4881	3.1793	Discharge	0.1552	0.1493	Ratio to Peak	0.0052
W2610	8.11	63.01	0.0000	0.9741	2.0811	Discharge	0.1232	0.1493	Ratio to Peak	0.0052
W2620	5.41	67.86	0.1425	0.7788	1.6639	Discharge	0.0245	0.1493	Ratio to Peak	0.0052
W2630	6.67	65.43	0.9854	0.9122	1.9489	Discharge	0.1173	0.1493	Ratio to Peak	0.0052
W2640	5.80	67.05	0.1505	0.8150	1.7412	Discharge	0.0466	0.1493	Ratio to Peak	0.0052
W2650	7.00	64.63	0.0000	1.0286	2.1977	Discharge	0.1384	0.1493	Ratio to Peak	0.0052
W2660	6.02	67.05	0.0259	1.1539	2.4654	Discharge	0.1348	0.1493	Ratio to Peak	0.0052
W2670	6.40	66.24	0.0000	1.5484	3.3082	Discharge	0.1885	0.1493	Ratio to Peak	0.0052
W2680	37.87	36.35	2.2373	3.0822	6.5852	Discharge	0.1031	0.1493	Ratio to Peak	0.0052
W2690	6.88	65.43	0.0000	0.8088	1.7281	Discharge	0.0859	0.1493	Ratio to Peak	0.0052
W2700	4.85	69.47	0.0000	0.1862	0.3977	Discharge	0.0018	0.1493	Ratio to Peak	0.0052
W2710	37.75	36.35	2.2589	2.6600	5.6831	Discharge	0.0805	0.1493	Ratio to Peak	0.0052
W2720	36.78	37.16	7.1338	2.3185	4.9534	Discharge	0.1093	0.1493	Ratio to Peak	0.0052
W2730	6.16	66.24	0.0000	1.0676	2.2809	Discharge	0.1874	0.1493	Ratio to Peak	0.0052
W2740	20.36	52.51	0.4449	2.3006	4.9152	Discharge	0.2595	0.1493	Ratio to Peak	0.0052
W2750	24.68	48.47	0.0236	3.3286	7.1116	Discharge	0.2962	0.1493	Ratio to Peak	0.0052
W2760	6.74	65.43	0.0822	1.0883	2.3251	Discharge	0.1274	0.1493	Ratio to Peak	0.0052
W2770	8.10	64.63	0.0000	0.2883	0.6160	Discharge	0.0067	0.1493	Ratio to Peak	0.0052
W2780	31.03	41.20	6.6950	2.0045	4.2827	Discharge	0.0331	0.1493	Ratio to Peak	0.0052
W2790	6.85	65.43	0.0000	0.2549	0.5446	Discharge	0.0048	0.1493	Ratio to Peak	0.0052
W2800	5.47	67.86	2.8333	0.4260	0.9102	Discharge	0.0210	0.1493	Ratio to Peak	0.0052
W2810	7.27	64.63	0.0000	1.2391	2.6473	Discharge	0.1709	0.1493	Ratio to Peak	0.0052
W2820	28.53	44.43	1.4106	2.3697	5.0629	Discharge	0.0919	0.1493	Ratio to Peak	0.0052

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Baseflow				
	Initial Abstraction	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (m3/s)	Recession Constant	Threshold Type	Ratio to Peak
W2830	5.93	67.05	1.3320	2.6798	5.7255	Discharge	0.3933	0.1493	Ratio to Peak	0.0052
W2840	12.74	59.78	3.9275	0.8440	1.8031	Discharge	0.0693	0.1493	Ratio to Peak	0.0052
W2850	7.20	64.63	0.2424	0.8172	1.7460	Discharge	0.1014	0.1493	Ratio to Peak	0.0052
W2860	14.95	58.16	0.7127	1.4798	3.1616	Discharge	0.0782	0.1493	Ratio to Peak	0.0052
W2870	6.22	66.24	2.7989	1.6442	3.5128	Discharge	0.1748	0.1493	Ratio to Peak	0.0052
W2880	5.99	67.05	2.9281	2.4781	5.2945	Discharge	0.2429	0.1493	Ratio to Peak	0.0052
W2890	6.60	65.43	0.4855	1.0970	2.3438	Discharge	0.2084	0.1493	Ratio to Peak	0.0052
W2900	6.27	66.24	0.0000	1.4934	3.1906	Discharge	0.1106	0.1493	Ratio to Peak	0.0052
W2910	6.11	66.24	1.2214	3.3036	7.0582	Discharge	0.2339	0.1493	Ratio to Peak	0.0052
W2920	5.52	67.86	0.0000	1.3762	2.9402	Discharge	0.1279	0.1493	Ratio to Peak	0.0052
W2930	5.40	67.86	4.5643	0.7746	1.6549	Discharge	0.0167	0.1493	Ratio to Peak	0.0052
W2940	6.77	65.43	0.1934	1.0546	2.2532	Discharge	0.0904	0.1493	Ratio to Peak	0.0052
W2950	5.19	68.67	1.8575	2.6036	5.5625	Discharge	0.1801	0.1493	Ratio to Peak	0.0052
W2970	5.49	67.86	5.2869	1.6108	3.4414	Discharge	0.0772	0.1493	Ratio to Peak	0.0052
W2980	6.04	67.05	5.1556	1.6865	3.6033	Discharge	0.1831	0.1493	Ratio to Peak	0.0052
W2990	6.29	66.24	0.0000	0.7679	1.6407	Discharge	0.0822	0.1493	Ratio to Peak	0.0052
W3000	3.75	71.90	2.6415	1.0323	2.2056	Discharge	0.0369	0.1493	Ratio to Peak	0.0052
W3010	4.09	71.09	21.1180	0.6232	1.3314	Discharge	0.0113	0.1493	Ratio to Peak	0.0052
W3020	5.87	67.05	0.2249	0.9679	2.0679	Discharge	0.0938	0.1493	Ratio to Peak	0.0052
W3030	5.44	67.86	1.8016	2.1439	4.5804	Discharge	0.1885	0.1493	Ratio to Peak	0.0052
W3040	5.91	67.05	3.3894	2.4227	5.1761	Discharge	0.1365	0.1493	Ratio to Peak	0.0052
W3050	6.80	65.43	2.2727	0.8382	1.7907	Discharge	0.1611	0.1493	Ratio to Peak	0.0052
W3060	8.57	63.01	1.8707	0.6203	1.3253	Discharge	0.0206	0.1493	Ratio to Peak	0.0052
W3070	4.95	68.67	13.5760	1.0917	2.3325	Discharge	0.0605	0.1493	Ratio to Peak	0.0052
W3080	4.71	69.47	3.5240	1.2085	2.5820	Discharge	0.1205	0.1493	Ratio to Peak	0.0052
W3090	5.13	68.67	2.4515	1.0168	2.1724	Discharge	0.1569	0.1493	Ratio to Peak	0.0052

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Baseflow				
	Initial Abstraction	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (m3/s)	Recession Constant	Threshold Type	Ratio to Peak
W3100	3.37	72.70	1.5276	0.8853	1.8915	Discharge	0.0587	0.1493	Ratio to Peak	0.0052
W3110	4.06	71.09	15.6240	2.0305	4.3382	Discharge	0.0955	0.1493	Ratio to Peak	0.0052
W3120	0.00	79.97	0.0000	1.2572	2.6860	Discharge	0.0027	0.1493	Ratio to Peak	0.0052
W3130	0.00	79.97	0.0000	1.8542	3.9616	Discharge	0.0038	0.1493	Ratio to Peak	0.0052
W3140	5.21	68.67	0.0000	0.3407	0.7278	Discharge	0.0027	0.1493	Ratio to Peak	0.0052
W3150	0.45	79.97	0.7506	2.0642	4.4101	Discharge	0.0566	0.1493	Ratio to Peak	0.0052
W3170	6.71	65.43	0.8964	1.4278	3.0505	Discharge	0.2534	0.1493	Ratio to Peak	0.0052
W3180	0.36	79.97	0.0821	1.5817	3.3793	Discharge	0.0426	0.1493	Ratio to Peak	0.0052
W3190	8.16	63.82	1.1494	1.3479	2.8797	Discharge	0.0970	0.1493	Ratio to Peak	0.0052
W3200	4.64	69.47	3.4281	3.1868	6.8086	Discharge	0.1702	0.1493	Ratio to Peak	0.0052
W3210	0.17	79.97	0.0000	2.1652	4.6260	Discharge	0.0419	0.1493	Ratio to Peak	0.0052
W3220	1.75	77.55	0.9590	1.8040	3.8542	Discharge	0.2099	0.1493	Ratio to Peak	0.0052
W3230	3.44	74.32	0.9612	2.1951	4.6899	Discharge	0.2618	0.1493	Ratio to Peak	0.0052
W3240	2.87	75.13	0.7338	3.4455	7.3614	Discharge	0.8233	0.1493	Ratio to Peak	0.0052
W3250	7.03	65.43	4.1984	3.3091	7.0700	Discharge	0.1463	0.1493	Ratio to Peak	0.0052
W3260	1.08	79.17	0.0264	3.2766	7.0005	Discharge	0.2608	0.1493	Ratio to Peak	0.0052
W3270	7.53	64.63	2.4166	1.1526	2.4625	Discharge	0.1214	0.1493	Ratio to Peak	0.0052
W3280	5.57	69.47	0.4505	5.7790	12.3469	Discharge	0.0545	0.1493	Ratio to Peak	0.0052
W3290	1.86	76.74	0.5175	5.1570	11.0179	Discharge	0.6317	0.1493	Ratio to Peak	0.0052
W3300	15.72	52.51	0.0672	1.3800	2.9484	Discharge	0.1040	0.1493	Ratio to Peak	0.0052
W3310	7.27	64.63	1.7915	1.4108	3.0142	Discharge	0.1839	0.1493	Ratio to Peak	0.0052
W3320	13.91	54.93	0.0000	1.1999	2.5636	Discharge	0.0842	0.1493	Ratio to Peak	0.0052
W3330	11.37	58.97	0.9909	1.3343	2.8507	Discharge	0.0878	0.1493	Ratio to Peak	0.0052
W3340	1.10	78.36	0.2628	3.7444	8.0000	Discharge	0.3624	0.1493	Ratio to Peak	0.0052
W3350	11.26	58.97	0.0000	1.8467	3.9455	Discharge	0.2726	0.1493	Ratio to Peak	0.0052
W3360	12.49	57.36	7.8897	6.8475	14.6296	Discharge	0.1682	0.1493	Ratio to Peak	0.0052

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Baseflow				
	Initial Abstraction	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (m3/s)	Recession Constant	Threshold Type	Ratio to Peak
W3370	5.72	70.28	0.3051	2.0862	4.4572	Discharge	0.1310	0.1493	Ratio to Peak	0.0052
W3380	1.51	77.55	0.0483	2.8465	6.0816	Discharge	0.2888	0.1493	Ratio to Peak	0.0052
W3390	10.20	60.59	12.2200	5.8056	12.4038	Discharge	0.0879	0.1493	Ratio to Peak	0.0052
W3400	18.02	50.89	0.0000	1.8173	3.8826	Discharge	0.1214	0.1493	Ratio to Peak	0.0052
W3410	5.07	71.90	0.0809	2.3178	4.9521	Discharge	0.2529	0.1493	Ratio to Peak	0.0052
W3420	20.67	47.66	0.0000	1.1895	2.5415	Discharge	0.0901	0.1493	Ratio to Peak	0.0052
W3430	14.78	54.12	0.0000	0.8271	1.7670	Discharge	0.0490	0.1493	Ratio to Peak	0.0052
W3440	9.55	63.01	0.3009	4.1946	8.9618	Discharge	0.0930	0.1493	Ratio to Peak	0.0052
W3450	4.46	72.70	0.3910	3.7860	8.0887	Discharge	2.4290	0.1493	Ratio to Peak	0.0052
W3460	14.16	54.93	0.1988	1.9519	4.1703	Discharge	0.1579	0.1493	Ratio to Peak	0.0052
W3470	12.46	57.36	16.0010	5.4980	11.7465	Discharge	0.1641	0.1493	Ratio to Peak	0.0052
W3480	19.72	48.47	0.0000	1.8827	4.0224	Discharge	0.1172	0.1493	Ratio to Peak	0.0052
W3490	12.67	56.55	9.7328	1.3534	2.8915	Discharge	0.0184	0.1493	Ratio to Peak	0.0052
W3500	13.86	54.93	5.6513	1.2685	2.7102	Discharge	0.0507	0.1493	Ratio to Peak	0.0052
W3510	15.68	35.54	0.0000	13.4300	13.9740	Discharge	0.0412	0.1960	Ratio to Peak	0.0044
W3520	16.85	51.70	1.1412	1.2487	2.6678	Discharge	0.0825	0.1493	Ratio to Peak	0.0052
W3530	16.23	51.70	1.1769	1.6302	3.4830	Discharge	0.0919	0.1493	Ratio to Peak	0.0052
W3540	16.35	51.70	0.1506	1.8842	4.0255	Discharge	0.1164	0.1493	Ratio to Peak	0.0052
W3550	14.55	54.12	6.5051	0.8443	1.8039	Discharge	0.0273	0.1493	Ratio to Peak	0.0052
W3560	18.99	49.28	0.0000	1.7340	3.7047	Discharge	0.0963	0.1493	Ratio to Peak	0.0052
W3570	18.99	49.28	0.0939	2.0320	4.3414	Discharge	0.2602	0.1493	Ratio to Peak	0.0052
W3580	26.15	62.03	0.0000	2.1289	6.8506	Discharge	0.1113	0.1845	Ratio to Peak	0.0029
W3590	26.15	99.00	0.0000	1.9519	0.4961	Discharge	0.0412	0.1845	Ratio to Peak	0.0020
W3600	15.74	98.08	0.0000	1.9053	1.1453	Discharge	0.0735	0.1845	Ratio to Peak	0.0030
W3610	15.60	99.00	0.0000	2.1846	0.9137	Discharge	0.1113	0.0854	Ratio to Peak	0.0098
W3620	10.83	40.42	0.0000	2.1930	0.2686	Discharge	0.0412	0.1255	Ratio to Peak	0.0029

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Baseflow				
	Initial Abstraction	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (m3/s)	Recession Constant	Threshold Type	Ratio to Peak
W3630	15.39	99.00	0.0000	2.2329	0.3630	Discharge	0.7162	0.1845	Ratio to Peak	0.0044
W3640	18.07	50.09	0.0850	1.6837	3.5973	Discharge	0.1643	0.1493	Ratio to Peak	0.0052
W3650	17.20	43.16	0.0000	2.0673	0.8682	Discharge	0.0412	0.1845	Ratio to Peak	0.0044
W3660	17.27	50.89	0.6022	1.3209	2.8221	Discharge	0.0929	0.1493	Ratio to Peak	0.0052
W3670	17.08	35.23	0.0000	2.0181	6.0067	Discharge	0.0412	0.1845	Ratio to Peak	0.0020
W3680	14.98	99.00	0.0000	2.2911	0.5932	Discharge	0.1113	0.1255	Ratio to Peak	0.0043
W3690	13.94	54.93	1.5267	1.0155	2.1695	Discharge	0.0138	0.1493	Ratio to Peak	0.0052
W3700	11.19	58.97	10.2160	4.6481	9.9308	Discharge	0.0411	0.1493	Ratio to Peak	0.0052
W3710	18.88	49.28	0.0000	2.3642	5.0511	Discharge	0.2889	0.1493	Ratio to Peak	0.0052
W3720	12.44	37.52	0.0000	1.9709	1.2251	Discharge	0.0728	0.1845	Ratio to Peak	0.0100
W3730	12.38	41.71	0.0000	2.2068	15.6820	Discharge	0.1774	0.1921	Ratio to Peak	0.0044
W3740	7.41	67.86	0.6754	2.1817	4.6612	Discharge	0.4093	0.1493	Ratio to Peak	0.0052
W3750	11.31	35.23	0.0000	3.1010	2.0055	Discharge	0.0728	0.1845	Ratio to Peak	0.0020
W3760	14.87	54.93	0.6751	2.6151	5.5873	Discharge	0.0856	0.1493	Ratio to Peak	0.0052
W3770	5.19	71.90	0.6298	2.1165	4.5220	Discharge	0.7326	0.1493	Ratio to Peak	0.0052
W3780	16.25	44.81	0.0000	2.5274	2.4196	Discharge	0.2314	0.1255	Ratio to Peak	0.0074
W3790	18.39	50.09	0.0000	1.5945	3.4067	Discharge	0.1554	0.1493	Ratio to Peak	0.0052
W3800	15.31	35.72	0.0000	1.1779	0.7274	Discharge	0.0412	0.1845	Ratio to Peak	0.0044
W3810	13.32	99.00	0.0000	2.3438	0.5878	Discharge	0.0412	0.1255	Ratio to Peak	0.0067
W3820	16.37	39.64	0.0000	3.6282	10.5340	Discharge	0.1094	0.1255	Ratio to Peak	0.0043
W3830	14.51	43.26	0.0000	3.2635	0.4719	Discharge	0.1094	0.1255	Ratio to Peak	0.0074
W3840	20.32	47.66	0.0000	1.3476	2.8792	Discharge	0.0931	0.1493	Ratio to Peak	0.0052
W3850	17.69	41.03	0.0000	1.5531	0.8492	Discharge	0.1222	0.0581	Ratio to Peak	0.0148
W3860	16.58	51.70	1.3207	1.7679	3.7770	Discharge	0.1327	0.1493	Ratio to Peak	0.0052
W3870	4.61	72.70	0.4084	1.2887	2.7534	Discharge	0.2125	0.1493	Ratio to Peak	0.0052
W3880	15.76	43.15	0.0000	2.2327	8.5034	Discharge	0.5585	0.0854	Ratio to Peak	0.0029

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Baseflow				
	Initial Abstraction	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (m3/s)	Recession Constant	Threshold Type	Ratio to Peak
W3890	11.54	42.64	0.0000	1.2066	0.3009	Discharge	0.1103	0.1845	Ratio to Peak	0.0020
W3900	25.62	38.75	0.0000	2.2612	2.3959	Discharge	0.1103	0.1845	Ratio to Peak	0.0020
W3910	8.25	42.64	0.0000	0.6325	0.5999	Discharge	0.0728	0.0854	Ratio to Peak	0.0029
W3920	17.98	39.84	0.0000	1.8752	1.2757	Discharge	0.2206	0.1845	Ratio to Peak	0.0141
W3930	16.89	39.14	0.0000	1.2563	2.8638	Discharge	0.0565	0.1845	Ratio to Peak	0.0029
W3940	16.55	45.42	0.0000	1.1369	0.7460	Discharge	0.5585	0.1255	Ratio to Peak	0.0020
W3950	12.21	57.36	4.9572	3.0117	6.4346	Discharge	0.0795	0.1493	Ratio to Peak	0.0052
W3960	1.37	77.55	0.0000	0.8850	1.8908	Discharge	0.0256	0.1493	Ratio to Peak	0.0052
W3970	7.20	67.86	2.0373	1.3277	2.8365	Discharge	0.3047	0.1493	Ratio to Peak	0.0052
W3980	16.85	51.70	0.1563	1.2351	2.6389	Discharge	0.1115	0.1493	Ratio to Peak	0.0052
W3990	12.09	58.97	2.6764	2.1956	4.6910	Discharge	0.2183	0.1493	Ratio to Peak	0.0052
W4000	10.03	52.30	1.0475	1.8896	1.8896	Discharge	0.0000	0.3000	Ratio to Peak	0.0100
W4010	15.52	43.09	0.0000	2.0271	2.9371	Discharge	0.1435	0.1845	Ratio to Peak	0.0043
W4020	17.15	41.77	0.0000	1.1919	1.0252	Discharge	0.0565	0.1845	Ratio to Peak	0.0030
W4030	5.82	43.84	0.0000	0.4629	0.7810	Discharge	0.0421	0.0854	Ratio to Peak	0.0043
W4040	18.13	38.70	0.0000	1.0447	1.9832	Discharge	0.0565	0.1845	Ratio to Peak	0.0043
W4050	16.43	47.38	0.0000	1.0636	1.1604	Discharge	0.0565	0.1845	Ratio to Peak	0.0063
W4060	17.17	44.49	0.0000	1.4197	1.5913	Discharge	0.0565	0.0581	Ratio to Peak	0.0029
W4070	17.26	43.31	0.0000	2.1118	7.6819	Discharge	0.2440	0.1255	Ratio to Peak	0.0029
W4080	14.76	40.56	0.0000	3.8535	1.0142	Discharge	0.2460	0.1845	Ratio to Peak	0.0067
W4090	17.90	38.59	0.0000	1.4663	1.1932	Discharge	0.0565	0.1845	Ratio to Peak	0.0029
W4100	24.87	35.14	0.0000	1.7658	1.0549	Discharge	0.1349	0.1845	Ratio to Peak	0.0145
W4110	5.87	35.47	0.0000	4.2833	1.9301	Discharge	0.1349	0.1845	Ratio to Peak	0.0034
W4120	18.13	44.38	0.0000	1.1803	0.4732	Discharge	0.1349	0.0581	Ratio to Peak	0.0085
W4130	99.98	40.41	0.0000	1.1251	10.7920	Discharge	0.3894	0.0854	Ratio to Peak	0.0063
W4140	7.95	46.44	0.0000	2.7829	2.4213	Discharge	0.1386	0.1845	Ratio to Peak	0.0029

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Baseflow				
	Initial Abstraction	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (m3/s)	Recession Constant	Threshold Type	Ratio to Peak
W4150	16.95	39.72	0.0000	6.0121	3.2167	Discharge	0.0565	0.1845	Ratio to Peak	0.0063
W4160	18.13	38.22	0.0000	2.0230	10.5480	Discharge	0.1386	0.1845	Ratio to Peak	0.0094
W4170	58.25	37.59	0.0000	2.7978	13.8370	Discharge	0.1349	0.1845	Ratio to Peak	0.0043
W4180	6.87	67.05	0.7071	2.0225	4.3211	Discharge	0.1473	0.1493	Ratio to Peak	0.0052
W4190	12.88	57.36	11.0710	0.5467	1.1679	Discharge	0.0102	0.1493	Ratio to Peak	0.0052
W4200	13.72	45.97	0.0000	1.8396	0.9207	Discharge	0.0769	0.1845	Ratio to Peak	0.0029
W4210	16.92	36.51	0.0000	3.6362	8.0951	Discharge	0.4394	0.1845	Ratio to Peak	0.0063
W4220	13.50	56.55	0.9644	1.8348	3.9200	Discharge	0.1667	0.1493	Ratio to Peak	0.0052
W4230	83.49	37.79	0.0000	2.8255	3.2016	Discharge	0.0769	0.1845	Ratio to Peak	0.0029
W4240	13.00	40.82	0.0000	1.5363	1.5126	Discharge	0.0769	0.1255	Ratio to Peak	0.0043
W4250	34.52	44.30	0.0000	0.2435	0.0685	Discharge	0.0519	0.0581	Ratio to Peak	0.0029
W4260	12.04	35.10	0.0000	3.5260	3.5007	Discharge	0.0769	0.1845	Ratio to Peak	0.0044
W4270	18.05	41.86	0.0000	1.8036	1.2112	Discharge	0.2070	0.0854	Ratio to Peak	0.0141
W4280	40.98	38.06	0.0000	2.7326	9.3890	Discharge	0.2070	0.1845	Ratio to Peak	0.0063
W4290	34.69	48.24	0.0000	0.1716	0.0981	Discharge	0.0412	0.1255	Ratio to Peak	0.0092
W4300	10.10	35.14	0.0000	1.6257	2.7075	Discharge	0.2070	0.1845	Ratio to Peak	0.0030
W4310	31.56	41.03	0.0000	2.2195	28.5730	Discharge	0.2070	0.0854	Ratio to Peak	0.0044
W4320	91.89	35.31	0.0000	0.7635	5.4523	Discharge	0.2070	0.0854	Ratio to Peak	0.0029
W4330	14.94	38.76	0.0000	1.1137	2.7971	Discharge	0.2070	0.1845	Ratio to Peak	0.0063
W4350	16.89	37.68	0.0000	1.7735	12.5970	Discharge	0.2070	0.1255	Ratio to Peak	0.0063
W4360	11.15	35.23	0.0000	1.0866	8.8249	Discharge	0.2070	0.0395	Ratio to Peak	0.0063
W4380	66.47	37.61	0.0000	7.4895	11.3030	Discharge	0.1073	0.1845	Ratio to Peak	0.0063
W4390	81.85	35.75	0.0000	3.2672	10.9890	Discharge	0.1066	0.1845	Ratio to Peak	0.0043
W4410	13.25	35.12	0.0000	3.4269	5.1291	Discharge	0.2068	0.1845	Ratio to Peak	0.0029
W4420	10.63	59.78	0.0400	1.1771	2.5149	Discharge	0.0876	0.1493	Ratio to Peak	0.0052
W4430	12.89	56.55	3.4513	2.4520	5.2387	Discharge	0.0808	0.1493	Ratio to Peak	0.0052

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Baseflow				
	Initial Abstraction	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (m3/s)	Recession Constant	Threshold Type	Ratio to Peak
W4440	8.46	63.01	0.0000	0.7256	1.5501	Discharge	0.0105	0.1493	Ratio to Peak	0.0052
W4450	14.17	54.93	2.1096	2.4234	5.1777	Discharge	0.2109	0.1493	Ratio to Peak	0.0052
W4460	22.90	45.24	0.0000	1.4278	3.0505	Discharge	0.1140	0.1493	Ratio to Peak	0.0052
W4470	22.64	45.24	0.0000	1.9189	4.0998	Discharge	0.3264	0.1493	Ratio to Peak	0.0052
W4480	23.18	44.43	0.0000	1.3975	2.9858	Discharge	0.1494	0.1493	Ratio to Peak	0.0052
W4490	23.11	44.43	0.0000	1.3678	2.9223	Discharge	0.0469	0.1493	Ratio to Peak	0.0052
W4500	21.96	46.05	0.0000	1.6317	3.4862	Discharge	0.0995	0.1493	Ratio to Peak	0.0052
W4510	21.17	46.85	0.0000	1.7932	3.8313	Discharge	0.1955	0.1493	Ratio to Peak	0.0052
W4520	22.83	45.24	0.0000	0.6302	1.3464	Discharge	0.0119	0.1493	Ratio to Peak	0.0052
W4530	22.29	46.05	0.0000	1.6459	3.5165	Discharge	0.1822	0.1493	Ratio to Peak	0.0052
W4540	23.30	44.43	0.0000	1.4220	3.0382	Discharge	0.1282	0.1493	Ratio to Peak	0.0052
W4550	23.33	44.43	0.0000	1.3824	2.9534	Discharge	0.1712	0.1493	Ratio to Peak	0.0052
W4560	11.50	58.97	7.6579	1.6549	3.5357	Discharge	0.1878	0.1493	Ratio to Peak	0.0052
W4570	9.62	61.39	1.7574	1.6147	3.4499	Discharge	0.1805	0.1493	Ratio to Peak	0.0052
W4580	18.27	50.09	0.0000	1.4766	3.1548	Discharge	0.1169	0.1493	Ratio to Peak	0.0052
W4590	13.22	56.55	3.0712	1.4515	3.1011	Discharge	0.2619	0.1493	Ratio to Peak	0.0052
W4600	19.39	48.47	0.0000	1.4775	3.1566	Discharge	0.1038	0.1493	Ratio to Peak	0.0052
W4610	19.13	49.28	0.3127	2.0059	4.2856	Discharge	0.3909	0.1493	Ratio to Peak	0.0052
W4620	15.70	52.51	0.0000	0.5125	1.0950	Discharge	0.0081	0.1493	Ratio to Peak	0.0052
W4630	18.03	50.09	0.0000	0.7220	1.5425	Discharge	0.0340	0.1493	Ratio to Peak	0.0052
W4650	15.29	53.32	0.0000	0.5934	1.2677	Discharge	0.0125	0.1493	Ratio to Peak	0.0052
W4660	18.48	50.09	0.0000	1.6602	3.5470	Discharge	0.0880	0.1493	Ratio to Peak	0.0052
W4670	20.83	46.85	0.0000	1.6233	3.4683	Discharge	0.1940	0.1493	Ratio to Peak	0.0052
W4680	15.89	52.51	0.0000	0.4621	0.9874	Discharge	0.0066	0.1493	Ratio to Peak	0.0052
W4690	21.93	46.05	0.0000	1.9650	4.1982	Discharge	0.2103	0.1493	Ratio to Peak	0.0052
W4700	19.62	48.47	0.0000	1.0927	2.3346	Discharge	0.0536	0.1493	Ratio to Peak	0.0052

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Baseflow				
	Initial Abstraction	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (m3/s)	Recession Constant	Threshold Type	Ratio to Peak
W4710	20.09	48.47	0.0000	1.6535	3.5328	Discharge	0.1833	0.1493	Ratio to Peak	0.0052
W4720	22.92	45.24	0.0000	1.5632	3.3398	Discharge	0.1697	0.1493	Ratio to Peak	0.0052
W4730	20.21	47.66	0.0000	0.4858	1.0379	Discharge	0.0177	0.1493	Ratio to Peak	0.0052
W4750	23.25	44.43	0.0000	1.0700	2.2861	Discharge	0.1231	0.1493	Ratio to Peak	0.0052
W4760	23.11	44.43	0.0000	1.0773	2.3017	Discharge	0.1007	0.1493	Ratio to Peak	0.0052
W4770	8.64	63.01	8.7591	1.4247	3.0440	Discharge	0.1391	0.1493	Ratio to Peak	0.0052
W4780	15.86	53.32	0.0897	1.1655	2.4901	Discharge	0.0777	0.1493	Ratio to Peak	0.0052
W4790	5.84	67.05	4.1797	0.7942	1.6968	Discharge	0.0335	0.1493	Ratio to Peak	0.0052
W4800	18.83	50.09	1.0911	1.8483	3.9489	Discharge	0.1667	0.1493	Ratio to Peak	0.0052
W4810	5.71	67.86	2.6805	1.8037	3.8536	Discharge	0.1445	0.1493	Ratio to Peak	0.0052
W4820	7.57	64.63	0.0000	0.8665	1.8513	Discharge	0.0788	0.1493	Ratio to Peak	0.0052
W4830	5.24	68.67	0.0000	0.8978	1.9181	Discharge	0.0759	0.1493	Ratio to Peak	0.0052
W4840	17.06	51.70	1.0586	2.1308	4.5525	Discharge	0.1649	0.1493	Ratio to Peak	0.0052
W4850	20.78	47.66	0.0247	3.6334	7.7628	Discharge	0.7062	0.1493	Ratio to Peak	0.0052
W4860	16.11	53.32	1.9000	2.0401	4.3588	Discharge	0.1600	0.1493	Ratio to Peak	0.0052
W4870	4.09	71.09	0.0000	0.1929	0.4122	Discharge	0.0017	0.1493	Ratio to Peak	0.0052
W4880	5.36	68.67	0.0000	0.4088	0.8734	Discharge	0.0080	0.1493	Ratio to Peak	0.0052
W4890	4.13	71.09	0.5465	0.3789	0.8094	Discharge	0.0064	0.1493	Ratio to Peak	0.0052
W4900	7.66	64.63	0.0916	1.2234	2.6138	Discharge	0.1143	0.1493	Ratio to Peak	0.0052
W4910	10.30	60.59	3.8740	1.5274	3.2632	Discharge	0.0821	0.1493	Ratio to Peak	0.0052
W4920	3.68	72.70	0.0000	0.4620	0.9871	Discharge	0.0057	0.1493	Ratio to Peak	0.0052
W4930	10.25	62.20	0.0000	0.3324	0.7102	Discharge	0.0035	0.1493	Ratio to Peak	0.0052
W4940	10.87	58.97	8.6957	2.2734	4.8571	Discharge	0.0907	0.1493	Ratio to Peak	0.0052
W4950	10.80	59.78	5.8236	1.2057	2.5759	Discharge	0.0420	0.1493	Ratio to Peak	0.0052
W4960	9.07	62.20	0.6378	1.3195	2.8192	Discharge	0.1535	0.1493	Ratio to Peak	0.0052
W4970	20.85	47.66	0.1360	2.1616	4.6183	Discharge	0.3596	0.1493	Ratio to Peak	0.0052

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Baseflow				
	Initial Abstraction	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (m3/s)	Recession Constant	Threshold Type	Ratio to Peak
W4980	9.57	62.20	0.0000	0.5064	1.0819	Discharge	0.0043	0.1493	Ratio to Peak	0.0052
W4990	9.81	61.39	6.1069	1.0706	2.2874	Discharge	0.0182	0.1493	Ratio to Peak	0.0052
W5010	13.91	55.74	0.7979	2.0766	4.4367	Discharge	0.2278	0.1493	Ratio to Peak	0.0052
W5020	21.85	46.05	0.2951	2.0493	4.3783	Discharge	0.2250	0.1493	Ratio to Peak	0.0052
W5030	19.21	49.28	0.3636	3.3640	7.1872	Discharge	0.4802	0.1493	Ratio to Peak	0.0052
W5040	13.18	55.74	5.1004	3.0380	6.4907	Discharge	0.1479	0.1493	Ratio to Peak	0.0052
W5050	7.01	66.24	6.9650	1.5381	3.2861	Discharge	0.0897	0.1493	Ratio to Peak	0.0052
W5060	11.97	57.36	7.3709	3.2060	6.8497	Discharge	0.0885	0.1493	Ratio to Peak	0.0052
W5070	11.71	58.16	10.9020	2.1568	4.6081	Discharge	0.0373	0.1493	Ratio to Peak	0.0052
W5080	17.57	50.89	0.2825	2.3516	5.0242	Discharge	0.2228	0.1493	Ratio to Peak	0.0052
W5090	12.53	56.55	3.8494	2.0740	4.4312	Discharge	0.0417	0.1493	Ratio to Peak	0.0052
W5100	10.28	60.59	5.2632	0.3776	0.8068	Discharge	0.0033	0.1493	Ratio to Peak	0.0052
W5110	12.81	56.55	5.4926	3.8819	8.2938	Discharge	0.1572	0.1493	Ratio to Peak	0.0052
W5120	9.47	62.20	1.8987	0.4649	0.9932	Discharge	0.0055	0.1493	Ratio to Peak	0.0052
W5130	9.60	62.20	3.2939	1.7300	3.6962	Discharge	0.0826	0.1493	Ratio to Peak	0.0052
W5140	12.99	55.74	5.8579	3.8770	8.2832	Discharge	0.1430	0.1493	Ratio to Peak	0.0052
W5150	14.06	54.12	3.8862	2.0335	4.3446	Discharge	0.0504	0.1493	Ratio to Peak	0.0052
W5160	12.82	56.55	13.1100	2.1240	4.5380	Discharge	0.0573	0.1493	Ratio to Peak	0.0052
W5170	14.15	54.12	2.9300	3.2645	6.9747	Discharge	0.1756	0.1493	Ratio to Peak	0.0052
W5180	11.84	58.16	19.4060	3.1993	6.8352	Discharge	0.1951	0.1493	Ratio to Peak	0.0052
W5200	12.27	57.36	1.3947	1.6099	3.4396	Discharge	0.2004	0.1493	Ratio to Peak	0.0052
W5210	8.24	65.43	1.5354	1.5171	3.2414	Discharge	0.0704	0.1493	Ratio to Peak	0.0052
W5250	13.74	55.74	2.5358	3.6025	7.6968	Discharge	0.2629	0.1493	Ratio to Peak	0.0052
W5260	2.30	46.33	0.3731	4.0500	1.9217	Discharge	0.3926	0.1255	Ratio to Peak	0.0044
W5300	11.57	58.97	2.5109	0.8878	1.8968	Discharge	0.0323	0.1493	Ratio to Peak	0.0052
W5310	11.80	58.16	1.4365	1.8967	4.0524	Discharge	0.2020	0.1493	Ratio to Peak	0.0052

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Baseflow				
	Initial Abstraction	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (m3/s)	Recession Constant	Threshold Type	Ratio to Peak
W5350	13.29	57.36	0.0000	1.8707	3.9968	Discharge	0.2594	0.1493	Ratio to Peak	0.0052
W5360	11.52	59.78	0.0000	0.5046	1.0782	Discharge	0.0138	0.1493	Ratio to Peak	0.0052
W5400	5.41	67.86	4.1026	1.2222	2.6112	Discharge	0.0408	0.1493	Ratio to Peak	0.0052
W5410	15.54	53.32	1.2638	0.7837	1.6744	Discharge	0.0219	0.1493	Ratio to Peak	0.0052
W5450	80.70	55.55	0.0000	0.2050	0.0766	Discharge	0.1128	0.0395	Ratio to Peak	0.0029
W5460	51.22	52.63	0.0000	0.1607	0.0587	Discharge	0.1128	0.0596	Ratio to Peak	0.0020
W5500	4.34	71.09	0.9420	4.7514	10.1514	Discharge	0.0705	0.1493	Ratio to Peak	0.0052
W5510	3.80	71.09	31.9530	0.3784	0.8084	Discharge	0.0058	0.1493	Ratio to Peak	0.0052
W5550	4.72	69.47	2.8681	1.2885	2.7528	Discharge	0.0368	0.1493	Ratio to Peak	0.0052
W5560	5.13	68.67	9.9010	0.3611	0.7715	Discharge	0.0036	0.1493	Ratio to Peak	0.0052

Annex 9. Mainit-Tubay Model Reach Parameters

Table A-9.1. Mainit-Tubay Model Reach Parameters

Reach Number	Muskingum Cunge Channel Routing					
	Time Step Method	Length (m)	Slope	Manning's n	Shape	Width
R1000	Automatic Fixed Interval	1260.50	0.0296	0.050	Rectangle	12.89
R1010	Automatic Fixed Interval	987.11	0.0156	0.050	Rectangle	58.16
R1050	Automatic Fixed Interval	1028.40	0.0084	0.030	Rectangle	27.78
R1070	Automatic Fixed Interval	1569.10	0.0266	0.050	Rectangle	25.98
R110	Automatic Fixed Interval	305.56	0.0009	0.040	Rectangle	43.54
R1130	Automatic Fixed Interval	2823.10	0.0244	0.050	Rectangle	37.05
R1140	Automatic Fixed Interval	2926.60	0.0333	0.050	Rectangle	57.91
R1210	Automatic Fixed Interval	2637.10	0.0314	0.050	Rectangle	26.46
R1240	Automatic Fixed Interval	3442.80	0.0150	0.050	Rectangle	58.36
R1260	Automatic Fixed Interval	2624.10	0.0366	0.050	Rectangle	26.75
R1270	Automatic Fixed Interval	1041.80	0.0341	0.050	Rectangle	90.99
R130	Automatic Fixed Interval	2335.20	0.0015	0.045	Rectangle	13.00
R1310	Automatic Fixed Interval	2820.50	0.0084	0.040	Rectangle	28.55
R1340	Automatic Fixed Interval	3285.80	0.0277	0.050	Rectangle	50.63
R1360	Automatic Fixed Interval	4661.10	0.0239	0.050	Rectangle	89.95
R1380	Automatic Fixed Interval	3123.40	0.0099	0.050	Rectangle	19.06
R1390	Automatic Fixed Interval	4338.70	0.0216	0.050	Rectangle	51.46
R140	Automatic Fixed Interval	419.71	0.0166	0.040	Rectangle	12.89
R1410	Automatic Fixed Interval	448.70	0.0260	0.050	Rectangle	12.89
R1420	Automatic Fixed Interval	1614.10	0.0747	0.050	Rectangle	26.45
R1440	Automatic Fixed Interval	3265.50	0.0087	0.050	Rectangle	22.84
R1480	Automatic Fixed Interval	2264.90	0.0376	0.050	Rectangle	40.60
R150	Automatic Fixed Interval	1746.50	0.0009	0.040	Rectangle	86.22
R1500	Automatic Fixed Interval	4216.20	0.0139	0.050	Rectangle	78.50

Reach Number	Muskingum Cunge Channel Routing					
	Time Step Method	Length (m)	Slope	Manning's n	Shape	Width
R1520	Automatic Fixed Interval	1342.10	0.0196	0.050	Rectangle	105.98
R1540	Automatic Fixed Interval	5004.40	0.0009	0.050	Rectangle	29.15
R1550	Automatic Fixed Interval	1892.70	0.0009	0.050	Rectangle	12.89
R1580	Automatic Fixed Interval	914.14	0.0009	0.050	Rectangle	12.89
R1610	Automatic Fixed Interval	1234.90	0.0121	0.050	Rectangle	88.78
R1620	Automatic Fixed Interval	2660.40	0.0216	0.050	Rectangle	21.93
R1650	Automatic Fixed Interval	850.00	0.0133	0.050	Rectangle	79.92
R1660	Automatic Fixed Interval	3275.60	0.0168	0.050	Rectangle	105.55
R1670	Automatic Fixed Interval	699.41	0.1119	0.050	Rectangle	12.89
R1710	Automatic Fixed Interval	3766.30	0.0084	0.040	Rectangle	118.75
R1750	Automatic Fixed Interval	718.41	0.0009	0.040	Rectangle	141.17
R1780	Automatic Fixed Interval	460.00	0.0383	0.040	Rectangle	164.88
R180	Automatic Fixed Interval	792.55	0.0019	0.030	Rectangle	18.58
R1800	Automatic Fixed Interval	2317.80	0.0032	0.031	Rectangle	94.60
R1810	Automatic Fixed Interval	8183.30	0.0012	0.040	Rectangle	51.45
R1830	Automatic Fixed Interval	1584.10	0.0009	0.037	Rectangle	77.27
R1850	Automatic Fixed Interval	502.84	0.0009	0.030	Rectangle	118.56
R1900	Automatic Fixed Interval	720.71	0.1126	0.050	Rectangle	21.72
R1910	Automatic Fixed Interval	791.13	0.0923	0.050	Rectangle	20.33
R1930	Automatic Fixed Interval	3082.50	0.0568	0.050	Rectangle	32.86
R1950	Automatic Fixed Interval	3226.60	0.0009	0.030	Rectangle	105.57
R2000	Automatic Fixed Interval	2461.70	0.0230	0.050	Rectangle	42.73
R2010	Automatic Fixed Interval	751.13	0.0132	0.050	Rectangle	25.67
R2020	Automatic Fixed Interval	484.14	0.0124	0.040	Rectangle	47.44
R2030	Automatic Fixed Interval	6117.50	0.0229	0.045	Rectangle	53.80
R2050	Automatic Fixed Interval	1268.80	0.0366	0.050	Rectangle	37.50

Reach Number	Muskingum Cunge Channel Routing					
	Time Step Method	Length (m)	Slope	Manning's n	Shape	Width
R2060	Automatic Fixed Interval	1488.30	0.0048	0.050	Rectangle	58.42
R2070	Automatic Fixed Interval	585.27	0.0416	0.050	Rectangle	26.92
R2080	Automatic Fixed Interval	666.57	0.0575	0.050	Rectangle	23.66
R2090	Automatic Fixed Interval	2455.50	0.0009	0.033	Rectangle	140.47
R210	Automatic Fixed Interval	693.55	0.0082	0.030	Rectangle	23.09
R2100	Automatic Fixed Interval	2619.20	0.0083	0.040	Rectangle	67.14
R2110	Automatic Fixed Interval	3237.00	0.0705	0.050	Rectangle	20.02
R2190	Automatic Fixed Interval	1077.40	0.0170	0.030	Rectangle	20.93
R220	Automatic Fixed Interval	715.69	0.0406	0.040	Rectangle	58.07
R2220	Automatic Fixed Interval	3864.30	0.0060	0.040	Rectangle	99.11
R2230	Automatic Fixed Interval	2194.10	0.0052	0.030	Rectangle	145.19
R2250	Automatic Fixed Interval	218.99	0.0009	0.030	Rectangle	60.34
R2260	Automatic Fixed Interval	1916.90	0.0009	0.040	Rectangle	198.61
R2270	Automatic Fixed Interval	485.27	0.0009	0.033	Rectangle	124.71
R2290	Automatic Fixed Interval	543.14	0.0181	0.040	Rectangle	247.66
R2320	Automatic Fixed Interval	984.26	0.0009	0.040	Rectangle	448.95
R2330	Automatic Fixed Interval	305.56	0.0257	0.040	Rectangle	277.46
R2360	Automatic Fixed Interval	1133.60	0.0009	0.040	Rectangle	171.75
R2370	Automatic Fixed Interval	142.43	0.0033	0.040	Rectangle	121.73
R2390	Automatic Fixed Interval	1492.00	0.0086	0.035	Rectangle	140.62
R2410	Automatic Fixed Interval	4552.40	0.0314	0.038	Rectangle	89.21
R2450	Automatic Fixed Interval	1736.40	0.0009	0.037	Rectangle	207.83
R2460	Automatic Fixed Interval	1156.00	0.0023	0.040	Rectangle	149.49
R2470	Automatic Fixed Interval	1192.30	0.0132	0.030	Rectangle	32.11
R2480	Automatic Fixed Interval	200.71	0.0009	0.040	Rectangle	90.99
R2500	Automatic Fixed Interval	342.43	0.0009	0.040	Rectangle	74.76

Reach Number	Muskingum Cunge Channel Routing					
	Time Step Method	Length (m)	Slope	Manning's n	Shape	Width
R2520	Automatic Fixed Interval	3134.90	0.0017	0.040	Rectangle	164.87
R2530	Automatic Fixed Interval	1976.50	0.0020	0.040	Rectangle	10.66
R2540	Automatic Fixed Interval	2514.20	0.0081	0.038	Rectangle	18.61
R2560	Automatic Fixed Interval	2455.60	0.0076	0.067	Rectangle	12.89
R260	Automatic Fixed Interval	2084.80	0.0069	0.042	Rectangle	17.43
R270	Automatic Fixed Interval	2680.40	0.0009	0.038	Rectangle	178.64
R290	Automatic Fixed Interval	3665.50	0.0019	0.037	Rectangle	23.95
R310	Automatic Fixed Interval	895.27	0.0170	0.040	Rectangle	54.45
R330	Automatic Fixed Interval	884.26	0.0050	0.030	Rectangle	22.84
R350	Automatic Fixed Interval	739.71	0.0170	0.040	Rectangle	12.89
R380	Automatic Fixed Interval	1887.90	0.0009	0.030	Rectangle	21.39
R40	Automatic Fixed Interval	1523.00	0.0140	0.039	Rectangle	41.74
R400	Automatic Fixed Interval	2136.60	0.0074	0.030	Rectangle	20.00
R410	Automatic Fixed Interval	550.12	0.0009	0.040	Rectangle	74.22
R520	Automatic Fixed Interval	1927.90	0.0010	0.030	Rectangle	23.68
R5230	Automatic Fixed Interval	4851.70	0.0009	0.031	Rectangle	94.60
R530	Automatic Fixed Interval	413.85	0.0096	0.030	Rectangle	15.91
R5330	Automatic Fixed Interval	3189.80	0.0039	0.040	Rectangle	149.49
R5370	Automatic Fixed Interval	380.71	0.0206	0.040	Rectangle	99.11
R5420	Automatic Fixed Interval	836.98	0.0146	0.040	Rectangle	67.14
R5470	Automatic Fixed Interval	337.28	0.0041	0.040	Rectangle	164.88
R5520	Automatic Fixed Interval	364.56	0.0009	0.040	Rectangle	129.75
R5570	Automatic Fixed Interval	154.85	0.0263	0.030	Rectangle	20.00
R580	Automatic Fixed Interval	2890.80	0.0170	0.039	Rectangle	48.49
R60	Automatic Fixed Interval	1827.50	0.0163	0.041	Rectangle	53.29
R70	Automatic Fixed Interval	1532.00	0.0067	0.040	Rectangle	103.14

Reach Number	Muskingum Cunge Channel Routing					
	Time Step Method	Length (m)	Slope	Manning's n	Shape	Width
R730	Automatic Fixed Interval	1928.20	0.0275	0.030	Rectangle	23.97
R760	Automatic Fixed Interval	3480.50	0.0076	0.035	Rectangle	53.84
R850	Automatic Fixed Interval	3373.60	0.0301	0.035	Rectangle	27.37
R860	Automatic Fixed Interval	1294.00	0.0732	0.050	Rectangle	12.89
R890	Automatic Fixed Interval	993.55	0.0015	0.040	Rectangle	12.89
R920	Automatic Fixed Interval	1656.80	0.0063	0.035	Rectangle	33.02
R940	Automatic Fixed Interval	944.26	0.0125	0.035	Rectangle	19.63

Annex 10. Mainit-Tubay Field Validation Points

Table A-10.1. Mainit-Tubay Field Validation Points

Point Number	Validation Coordinates		Validation Points (m)	Model Var (m)	Error	Event/Date	Rain Return / Scenario
	Lat	Long					
1	9.295288	125.5223	0.06	0.15	0.09	Agaton/January 2014	5-year
2	9.161834	125.5236	0.63	0	-0.63	Agaton/January 2014	5-year
3	9.161629	125.5299	0.26	0.15	-0.11	Agaton/January 2014	5-year
4	9.163031	125.5379	0.93	0	-0.93	Agaton/January 2014	5-year
5	9.156377	125.544	2.7	0.61	-2.09	Agaton/January 2014	5-year
6	9.162364	125.5504	0.03	0	-0.03	Agaton/January 2014	5-year
7	9.16252	125.5543	1.53	0.62	-0.91	Agaton/January 2014	5-year
8	9.159665	125.5563	3.25	0	-3.25	Agaton/January 2014	5-year
9	9.15391	125.5603	0.23	0	-0.23	Agaton/January 2014	5-year
10	9.149136	125.5589	0.43	0.25	-0.18	Agaton/January 2014	5-year
11	9.145112	125.5522	0.2	0.45	0.25	Agaton/January 2014	5-year
12	9.147361	125.5435	0.03	0	-0.03	Agaton/January 2014	5-year
13	9.148895	125.535	0.03	0	-0.03	Agaton/January 2014	5-year
14	9.151787	125.5276	0.47	0.17	-0.3	Agaton/January 2014	5-year
15	9.176494	125.5607	0.03	0	-0.03	Agaton/January 2014	5-year
16	9.180718	125.5623	0.68	0.25	-0.43	Agaton/January 2014	5-year
17	9.183404	125.5625	0.39	0	-0.39	Agaton/January 2014	5-year
18	9.188105	125.5626	0.69	0.45	-0.24	Agaton/January 2014	5-year
19	9.194339	125.5627	0.03	0	-0.03	Agaton/January 2014	5-year
20	9.202379	125.5636	0.03	0	-0.03	Agaton/January 2014	5-year
21	9.21569	125.5646	0.25	0	-0.25	Agaton/January 2014	5-year
22	9.230095	125.5651	0.03	0	-0.03	Agaton/January 2014	5-year
23	9.238852	125.56	0.03	0.42	0.39	Agaton/January 2014	5-year
24	9.24147	125.5585	0.49	0	-0.49	Agaton/January 2014	5-year
25	9.248603	125.5568	0.03	0	-0.03	Agaton/January 2014	5-year
26	9.25712	125.5605	0.05	0	-0.05	Agaton/January 2014	5-year
27	9.261752	125.5599	0.2	0	-0.2	Agaton/January 2014	5-year
28	9.261653	125.5623	0.03	0.43	0.4	Agaton/January 2014	5-year
29	9.2641	125.5598	0.12	0	-0.12	Agaton/January 2014	5-year
30	9.262961	125.5544	0.05	0	-0.05	Agaton/January 2014	5-year
31	9.264777	125.5543	0.03	0	-0.03	Agaton/January 2014	5-year
32	9.264658	125.5528	0.03	0.15	0.12	Agaton/January 2014	5-year
33	9.262307	125.5447	0.12	0.3	0.18	Agaton/January 2014	5-year
34	9.26072	125.5429	0.15	0	-0.15	Agaton/January 2014	5-year
35	9.260374	125.5424	0.03	1.9	1.87	Agaton/January 2014	5-year
36	9.267154	125.5445	0.2	0.77	0.57	Agaton/January 2014	5-year
37	9.271815	125.5449	0.23	2.3	2.07	Agaton/January 2014	5-year
38	9.294567	125.5491	0.03	0.99	0.96	Agaton/January 2014	5-year
39	9.295288	125.5492	0.13	0	-0.13	Agaton/January 2014	5-year
40	9.296329	125.5412	0.16	1.75	1.59	Agaton/January 2014	5-year
41	9.299612	125.5501	1.03	0	-1.03	Agaton/January 2014	5-year

Point Number	Validation Coordinates		Validation Points (m)	Model Var (m)	Error	Event/Date	Rain Return / Scenario
	Lat	Long					
42	9.299922	125.5491	0.24	0	-0.24	Agaton/January 2014	5-year
43	9.322167	125.5198	0.04	0	-0.04	Agaton/January 2014	5-year
44	9.318167	125.5218	0.16	0	-0.16	Agaton/January 2014	5-year
45	9.314639	125.5233	0.27	0	-0.27	Agaton/January 2014	5-year
46	9.309472	125.525	0.92	0	-0.92	Agaton/January 2014	5-year
47	9.317722	125.5275	0.03	0	-0.03	Agaton/January 2014	5-year
48	9.362306	125.5521	0.03	0	-0.03	Agaton/January 2014	5-year
49	9.361139	125.5537	0.15	1.26	1.11	Agaton/January 2014	5-year
50	9.359417	125.5531	0.77	0.98	0.21	Agaton/January 2014	5-year
51	9.341139	125.5485	0.03	0	-0.03	Agaton/January 2014	5-year
52	9.332917	125.548	0.1	0	-0.1	Agaton/January 2014	5-year
53	9.326917	125.5516	0.03	0	-0.03	Agaton/January 2014	5-year
54	9.325528	125.554	0.03	0	-0.03	Agaton/January 2014	5-year
55	9.323528	125.5561	0.07	0	-0.07	Agaton/January 2014	5-year
56	9.32325	125.5574	0.03	0	-0.03	Agaton/January 2014	5-year
57	9.321667	125.5561	0.09	0	-0.09	Agaton/January 2014	5-year
58	9.321111	125.5551	0.03	0	-0.03	Agaton/January 2014	5-year
59	9.324972	125.5481	0.03	0	-0.03	Agaton/January 2014	5-year
60	9.325944	125.5408	0.3	0.39	0.09	Agaton/January 2014	5-year
61	9.317722	125.5299	1.16	0	-1.16	Agaton/January 2014	5-year
62	9.318472	125.5311	1.4	0	-1.4	Agaton/January 2014	5-year
63	9.319667	125.5556	0.03	0	-0.03	Agaton/January 2014	5-year
64	9.318111	125.5551	0.03	0	-0.03	Agaton/January 2014	5-year
65	9.317111	125.5528	0.03	0	-0.03	Agaton/January 2014	5-year
66	9.314722	125.5626	0.04	0	-0.04	Agaton/January 2014	5-year
67	9.164119	125.5223	0.06	0.14	0.2	Seniang/December 2014	5-year
68	9.161834	125.5236	0.63	-0.63	0	Seniang/December 2014	5-year
69	9.161629	125.5299	0.26	-0.21	0.05	Seniang/December 2014	5-year
70	9.163031	125.5379	0.93	-0.93	0	Seniang/December 2014	5-year
71	9.156377	125.544	2.7	-2.25	0.45	Seniang/December 2014	5-year
72	9.162364	125.5504	0.03	-0.03	0	Seniang/December 2014	5-year
73	9.16252	125.5543	1.53	-0.78	0.75	Seniang/December 2014	5-year
74	9.159665	125.5563	3.25	-3.25	0	Seniang/December 2014	5-year
75	9.15391	125.5603	0.23	-0.23	0	Seniang/December 2014	5-year
76	9.149136	125.5589	0.43	-0.28	0.15	Seniang/December 2014	5-year
77	9.145112	125.5522	0.2	0.21	0.41	Seniang/December 2014	5-year
78	9.147361	125.5435	0.03	-0.03	0	Seniang/December 2014	5-year
79	9.148895	125.535	0.03	-0.03	0	Seniang/December 2014	5-year
80	9.151787	125.5276	0.47	-0.32	0.15	Seniang/December 2014	5-year
81	9.176494	125.5607	0.03	-0.03	0	Seniang/December 2014	5-year
82	9.180718	125.5623	0.68	-0.44	0.24	Seniang/December 2014	5-year
83	9.183404	125.5625	0.39	-0.39	0	Seniang/December 2014	5-year
84	9.188105	125.5626	0.69	-0.69	0	Seniang/December 2014	5-year
85	9.194339	125.5627	0.03	-0.03	0	Seniang/December 2014	5-year

Point Number	Validation Coordinates		Validation Points (m)	Model Var (m)	Error	Event/Date	Rain Return / Scenario
	Lat	Long					
86	9.202379	125.5636	0.03	-0.03	0	Seniang/December 2014	5-year
87	9.21569	125.5646	0.25	-0.25	0	Seniang/December 2014	5-year
88	9.230095	125.5651	0.03	0.28	0.31	Seniang/December 2014	5-year
89	9.238852	125.56	0.03	0.37	0.4	Seniang/December 2014	5-year
90	9.24147	125.5585	0.49	-0.49	0	Seniang/December 2014	5-year
91	9.248603	125.5568	0.03	-0.03	0	Seniang/December 2014	5-year
92	9.25712	125.5605	0.05	-0.05	0	Seniang/December 2014	5-year
93	9.261752	125.5599	0.2	-0.2	0	Seniang/December 2014	5-year
94	9.261653	125.5623	0.03	0.4	0.43	Seniang/December 2014	5-year
95	9.2641	125.5598	0.12	-0.12	0	Seniang/December 2014	5-year
96	9.262961	125.5544	0.05	-0.05	0	Seniang/December 2014	5-year
97	9.264777	125.5543	0.03	-0.03	0	Seniang/December 2014	5-year
98	9.264658	125.5528	0.03	0.12	0.15	Seniang/December 2014	5-year
99	9.262307	125.5447	0.12	-0.12	0	Seniang/December 2014	5-year
100	9.26072	125.5429	0.15	-0.15	0	Seniang/December 2014	5-year
101	9.260374	125.5424	0.03	1.17	1.2	Seniang/December 2014	5-year
102	9.267154	125.5445	0.2	-0.2	0	Seniang/December 2014	5-year
103	9.271815	125.5449	0.23	0.87	1.1	Seniang/December 2014	5-year
104	9.294567	125.5491	0.03	-0.03	0	Seniang/December 2014	5-year
105	9.295288	125.5492	0.13	-0.13	0	Seniang/December 2014	5-year
106	9.296329	125.5412	0.16	0.27	0.43	Seniang/December 2014	5-year
107	9.299612	125.5501	1.03	-1.03	0	Seniang/December 2014	5-year
108	9.299922	125.5491	0.24	-0.24	0	Seniang/December 2014	5-year
109	9.322167	125.5198	0.04	0.49	0.53	Seniang/December 2014	5-year
110	9.318167	125.5218	0.16	-0.16	0	Seniang/December 2014	5-year
111	9.314639	125.5233	0.27	-0.27	0	Seniang/December 2014	5-year
112	9.309472	125.525	0.92	-0.92	0	Seniang/December 2014	5-year
113	9.317722	125.5275	0.03	-0.03	0	Seniang/December 2014	5-year
114	9.362306	125.5521	0.03	0.17	0.2	Seniang/December 2014	5-year
115	9.361139	125.5537	0.15	-0.15	0	Seniang/December 2014	5-year
116	9.359417	125.5531	0.77	-0.77	0	Seniang/December 2014	5-year
117	9.341139	125.5485	0.03	-0.03	0	Seniang/December 2014	5-year
118	9.332917	125.548	0.1	0.41	0.51	Seniang/December 2014	5-year
119	9.326917	125.5516	0.03	-0.03	0	Seniang/December 2014	5-year
120	9.325528	125.554	0.03	-0.03	0	Seniang/December 2014	5-year
121	9.323528	125.5561	0.07	-0.07	0	Seniang/December 2014	5-year
122	9.32325	125.5574	0.03	-0.03	0	Seniang/December 2014	5-year
123	9.321667	125.5561	0.09	-0.09	0	Seniang/December 2014	5-year
124	9.321111	125.5551	0.03	-0.03	0	Seniang/December 2014	5-year
125	9.324972	125.5481	0.03	-0.03	0	Seniang/December 2014	5-year
126	9.325944	125.5408	0.3	-0.08	0.22	Seniang/December 2014	5-year
127	9.317722	125.5299	1.16	-0.38	0.78	Seniang/December 2014	5-year
128	9.318472	125.5311	1.4	-0.44	0.96	Seniang/December 2014	5-year
129	9.319667	125.5556	0.03	-0.03	0	Seniang/December 2014	5-year

Point Number	Validation Coordinates		Validation Points (m)	Model Var (m)	Error	Event/Date	Rain Return / Scenario
	Lat	Long					
130	9.318111	125.5551	0.03	-0.03	0	Seniang/December 2014	5-year
131	9.317111	125.5528	0.03	-0.03	0	Seniang/December 2014	5-year
132	9.314722	125.5626	0.04	-0.04	0	Seniang/December 2014	5-year
133	9.295288	125.5223	0.19	-0.04	-0.04	Agaton/January 2014	25-year
134	9.161834	125.5236	0.92	-0.92	-0.92	Agaton/January 2014	25-year
135	9.161629	125.5299	0.59	-0.44	-0.44	Agaton/January 2014	25-year
136	9.163031	125.5379	1.4	-1.4	-1.4	Agaton/January 2014	25-year
137	9.156377	125.544	3.45	-2.84	-2.84	Agaton/January 2014	25-year
138	9.162364	125.5504	0.03	-0.03	-0.03	Agaton/January 2014	25-year
139	9.16252	125.5543	2.37	-1.75	-1.75	Agaton/January 2014	25-year
140	9.159665	125.5563	3.97	-3.97	-3.97	Agaton/January 2014	25-year
141	9.15391	125.5603	0.46	-0.46	-0.46	Agaton/January 2014	25-year
142	9.149136	125.5589	0.93	-0.68	-0.68	Agaton/January 2014	25-year
143	9.145112	125.5522	0.66	-0.21	-0.21	Agaton/January 2014	25-year
144	9.147361	125.5435	0.03	-0.03	-0.03	Agaton/January 2014	25-year
145	9.148895	125.535	0.09	-0.09	-0.09	Agaton/January 2014	25-year
146	9.151787	125.5276	0.83	-0.66	-0.66	Agaton/January 2014	25-year
147	9.176494	125.5607	0.03	-0.03	-0.03	Agaton/January 2014	25-year
148	9.180718	125.5623	0.81	-0.56	-0.56	Agaton/January 2014	25-year
149	9.183404	125.5625	0.58	-0.58	-0.58	Agaton/January 2014	25-year
150	9.188105	125.5626	0.85	-0.4	-0.4	Agaton/January 2014	25-year
151	9.194339	125.5627	0.03	-0.03	-0.03	Agaton/January 2014	25-year
152	9.202379	125.5636	0.03	-0.03	-0.03	Agaton/January 2014	25-year
153	9.21569	125.5646	0.34	-0.34	-0.34	Agaton/January 2014	25-year
154	9.230095	125.5651	0.03	-0.03	-0.03	Agaton/January 2014	25-year
155	9.238852	125.56	0.04	0.38	0.38	Agaton/January 2014	25-year
156	9.24147	125.5585	0.71	-0.71	-0.71	Agaton/January 2014	25-year
157	9.248603	125.5568	0.03	-0.03	-0.03	Agaton/January 2014	25-year
158	9.25712	125.5605	0.06	-0.06	-0.06	Agaton/January 2014	25-year
159	9.261752	125.5599	0.23	-0.23	-0.23	Agaton/January 2014	25-year
160	9.261653	125.5623	0.03	0.4	0.4	Agaton/January 2014	25-year
161	9.2641	125.5598	0.15	-0.15	-0.15	Agaton/January 2014	25-year
162	9.262961	125.5544	0.06	-0.06	-0.06	Agaton/January 2014	25-year
163	9.264777	125.5543	0.03	-0.03	-0.03	Agaton/January 2014	25-year
164	9.264658	125.5528	0.03	0.12	0.12	Agaton/January 2014	25-year
165	9.262307	125.5447	0.16	0.14	0.14	Agaton/January 2014	25-year
166	9.26072	125.5429	0.18	-0.18	-0.18	Agaton/January 2014	25-year
167	9.260374	125.5424	0.04	1.86	1.86	Agaton/January 2014	25-year
168	9.267154	125.5445	0.23	0.54	0.54	Agaton/January 2014	25-year
169	9.271815	125.5449	0.27	2.03	2.03	Agaton/January 2014	25-year
170	9.294567	125.5491	0.03	0.96	0.96	Agaton/January 2014	25-year
171	9.295288	125.5492	0.14	-0.14	-0.14	Agaton/January 2014	25-year
172	9.296329	125.5412	0.27	1.48	1.48	Agaton/January 2014	25-year
173	9.299612	125.5501	1.22	-1.22	-1.22	Agaton/January 2014	25-year

Point Number	Validation Coordinates		Validation Points (m)	Model Var (m)	Error	Event/Date	Rain Return / Scenario
	Lat	Long					
174	9.299922	125.5491	0.42	-0.42	-0.42	Agaton/January 2014	25-year
175	9.322167	125.5198	0.05	-0.05	-0.05	Agaton/January 2014	25-year
176	9.318167	125.5218	0.22	-0.22	-0.22	Agaton/January 2014	25-year
177	9.314639	125.5233	0.34	-0.34	-0.34	Agaton/January 2014	25-year
178	9.309472	125.525	1.06	-1.06	-1.06	Agaton/January 2014	25-year
179	9.317722	125.5275	0.03	-0.03	-0.03	Agaton/January 2014	25-year
180	9.362306	125.5521	0.03	-0.03	-0.03	Agaton/January 2014	25-year
181	9.361139	125.5537	0.42	0.84	0.84	Agaton/January 2014	25-year
182	9.359417	125.5531	1.07	-0.09	-0.09	Agaton/January 2014	25-year
183	9.341139	125.5485	0.03	-0.03	-0.03	Agaton/January 2014	25-year
184	9.332917	125.548	0.66	-0.66	-0.66	Agaton/January 2014	25-year
185	9.326917	125.5516	0.03	-0.03	-0.03	Agaton/January 2014	25-year
186	9.325528	125.554	0.04	-0.04	-0.04	Agaton/January 2014	25-year
187	9.323528	125.5561	0.09	-0.09	-0.09	Agaton/January 2014	25-year
188	9.32325	125.5574	0.03	-0.03	-0.03	Agaton/January 2014	25-year
189	9.321667	125.5561	0.61	-0.61	-0.61	Agaton/January 2014	25-year
190	9.321111	125.5551	0.47	-0.47	-0.47	Agaton/January 2014	25-year
191	9.324972	125.5481	0.19	-0.19	-0.19	Agaton/January 2014	25-year
192	9.325944	125.5408	0.7	-0.31	-0.31	Agaton/January 2014	25-year
193	9.317722	125.5299	1.69	-1.69	-1.69	Agaton/January 2014	25-year
194	9.318472	125.5311	1.84	-1.84	-1.84	Agaton/January 2014	25-year
195	9.319667	125.5556	0.39	-0.39	-0.39	Agaton/January 2014	25-year
196	9.318111	125.5551	0.03	-0.03	-0.03	Agaton/January 2014	25-year
197	9.317111	125.5528	0.03	-0.03	-0.03	Agaton/January 2014	25-year
198	9.314722	125.5626	0.18	-0.18	-0.18	Agaton/January 2014	25-year
199	9.164119	125.5223	0.19	0.01	0.2	Seniang/December 2014	25-year
200	9.161834	125.5236	0.92	-0.92	0	Seniang/December 2014	25-year
201	9.161629	125.5299	0.59	-0.54	0.05	Seniang/December 2014	25-year
202	9.163031	125.5379	1.4	-1.4	0	Seniang/December 2014	25-year
203	9.156377	125.544	3.45	-3	0.45	Seniang/December 2014	25-year
204	9.162364	125.5504	0.03	-0.03	0	Seniang/December 2014	25-year
205	9.16252	125.5543	2.37	-1.62	0.75	Seniang/December 2014	25-year
206	9.159665	125.5563	3.97	-3.97	0	Seniang/December 2014	25-year
207	9.15391	125.5603	0.46	-0.46	0	Seniang/December 2014	25-year
208	9.149136	125.5589	0.93	-0.78	0.15	Seniang/December 2014	25-year
209	9.145112	125.5522	0.66	-0.25	0.41	Seniang/December 2014	25-year
210	9.147361	125.5435	0.03	-0.03	0	Seniang/December 2014	25-year
211	9.148895	125.535	0.09	-0.09	0	Seniang/December 2014	25-year
212	9.151787	125.5276	0.83	-0.68	0.15	Seniang/December 2014	25-year
213	9.176494	125.5607	0.03	-0.03	0	Seniang/December 2014	25-year
214	9.180718	125.5623	0.81	-0.57	0.24	Seniang/December 2014	25-year
215	9.183404	125.5625	0.58	-0.58	0	Seniang/December 2014	25-year
216	9.188105	125.5626	0.85	-0.85	0	Seniang/December 2014	25-year
217	9.194339	125.5627	0.03	-0.03	0	Seniang/December 2014	25-year

Point Number	Validation Coordinates		Validation Points (m)	Model Var (m)	Error	Event/Date	Rain Return / Scenario
	Lat	Long					
218	9.202379	125.5636	0.03	-0.03	0	Seniang/December 2014	25-year
219	9.21569	125.5646	0.34	-0.34	0	Seniang/December 2014	25-year
220	9.230095	125.5651	0.03	0.28	0.31	Seniang/December 2014	25-year
221	9.238852	125.56	0.04	0.36	0.4	Seniang/December 2014	25-year
222	9.24147	125.5585	0.71	-0.71	0	Seniang/December 2014	25-year
223	9.248603	125.5568	0.03	-0.03	0	Seniang/December 2014	25-year
224	9.25712	125.5605	0.06	-0.06	0	Seniang/December 2014	25-year
225	9.261752	125.5599	0.23	-0.23	0	Seniang/December 2014	25-year
226	9.261653	125.5623	0.03	0.4	0.43	Seniang/December 2014	25-year
227	9.2641	125.5598	0.15	-0.15	0	Seniang/December 2014	25-year
228	9.262961	125.5544	0.06	-0.06	0	Seniang/December 2014	25-year
229	9.264777	125.5543	0.03	-0.03	0	Seniang/December 2014	25-year
230	9.264658	125.5528	0.03	0.12	0.15	Seniang/December 2014	25-year
231	9.262307	125.5447	0.16	-0.16	0	Seniang/December 2014	25-year
232	9.26072	125.5429	0.18	-0.18	0	Seniang/December 2014	25-year
233	9.260374	125.5424	0.04	1.16	1.2	Seniang/December 2014	25-year
234	9.267154	125.5445	0.23	-0.23	0	Seniang/December 2014	25-year
235	9.271815	125.5449	0.27	0.83	1.1	Seniang/December 2014	25-year
236	9.294567	125.5491	0.03	-0.03	0	Seniang/December 2014	25-year
237	9.295288	125.5492	0.14	-0.14	0	Seniang/December 2014	25-year
238	9.296329	125.5412	0.27	0.16	0.43	Seniang/December 2014	25-year
239	9.299612	125.5501	1.22	-1.22	0	Seniang/December 2014	25-year
240	9.299922	125.5491	0.42	-0.42	0	Seniang/December 2014	25-year
241	9.322167	125.5198	0.05	0.48	0.53	Seniang/December 2014	25-year
242	9.318167	125.5218	0.22	-0.22	0	Seniang/December 2014	25-year
243	9.314639	125.5233	0.34	-0.34	0	Seniang/December 2014	25-year
244	9.309472	125.525	1.06	-1.06	0	Seniang/December 2014	25-year
245	9.317722	125.5275	0.03	-0.03	0	Seniang/December 2014	25-year
246	9.362306	125.5521	0.03	0.17	0.2	Seniang/December 2014	25-year
247	9.361139	125.5537	0.42	-0.42	0	Seniang/December 2014	25-year
248	9.359417	125.5531	1.07	-1.07	0	Seniang/December 2014	25-year
249	9.341139	125.5485	0.03	-0.03	0	Seniang/December 2014	25-year
250	9.332917	125.548	0.66	-0.15	0.51	Seniang/December 2014	25-year
251	9.326917	125.5516	0.03	-0.03	0	Seniang/December 2014	25-year
252	9.325528	125.554	0.04	-0.04	0	Seniang/December 2014	25-year
253	9.323528	125.5561	0.09	-0.09	0	Seniang/December 2014	25-year
254	9.32325	125.5574	0.03	-0.03	0	Seniang/December 2014	25-year
255	9.321667	125.5561	0.61	-0.61	0	Seniang/December 2014	25-year
256	9.321111	125.5551	0.47	-0.47	0	Seniang/December 2014	25-year
257	9.324972	125.5481	0.19	-0.19	0	Seniang/December 2014	25-year
258	9.325944	125.5408	0.7	-0.48	0.22	Seniang/December 2014	25-year
259	9.317722	125.5299	1.69	-0.91	0.78	Seniang/December 2014	25-year
260	9.318472	125.5311	1.84	-0.88	0.96	Seniang/December 2014	25-year
261	9.319667	125.5556	0.39	-0.39	0	Seniang/December 2014	25-year

Point Number	Validation Coordinates		Validation Points (m)	Model Var (m)	Error	Event/Date	Rain Return / Scenario
	Lat	Long					
262	9.318111	125.5551	0.03	-0.03	0	Seniang/December 2014	25-year
263	9.317111	125.5528	0.03	-0.03	0	Seniang/December 2014	25-year
264	9.314722	125.5626	0.18	-0.18	0	Seniang/December 2014	25-year
265	9.295288	125.5223	0.34	0.15	-0.19	Agaton/January 2014	100-year
266	9.161834	125.5236	1.13	0	-1.13	Agaton/January 2014	100-year
267	9.161629	125.5299	0.81	0.15	-0.66	Agaton/January 2014	100-year
268	9.163031	125.5379	1.67	0	-1.67	Agaton/January 2014	100-year
269	9.156377	125.544	3.92	0.61	-3.31	Agaton/January 2014	100-year
270	9.162364	125.5504	0.03	0	-0.03	Agaton/January 2014	100-year
271	9.16252	125.5543	2.86	0.62	-2.24	Agaton/January 2014	100-year
272	9.159665	125.5563	4.42	0	-4.42	Agaton/January 2014	100-year
273	9.15391	125.5603	0.76	0	-0.76	Agaton/January 2014	100-year
274	9.149136	125.5589	1.31	0.25	-1.06	Agaton/January 2014	100-year
275	9.145112	125.5522	0.96	0.45	-0.51	Agaton/January 2014	100-year
276	9.147361	125.5435	0.04	0	-0.04	Agaton/January 2014	100-year
277	9.148895	125.535	0.3	0	-0.3	Agaton/January 2014	100-year
278	9.151787	125.5276	1.09	0.17	-0.92	Agaton/January 2014	100-year
279	9.176494	125.5607	0.03	0	-0.03	Agaton/January 2014	100-year
280	9.180718	125.5623	0.89	0.25	-0.64	Agaton/January 2014	100-year
281	9.183404	125.5625	0.71	0	-0.71	Agaton/January 2014	100-year
282	9.188105	125.5626	0.97	0.45	-0.52	Agaton/January 2014	100-year
283	9.194339	125.5627	0.04	0	-0.04	Agaton/January 2014	100-year
284	9.202379	125.5636	0.03	0	-0.03	Agaton/January 2014	100-year
285	9.21569	125.5646	0.43	0	-0.43	Agaton/January 2014	100-year
286	9.230095	125.5651	0.03	0	-0.03	Agaton/January 2014	100-year
287	9.238852	125.56	0.06	0.42	0.36	Agaton/January 2014	100-year
288	9.24147	125.5585	0.83	0	-0.83	Agaton/January 2014	100-year
289	9.248603	125.5568	0.03	0	-0.03	Agaton/January 2014	100-year
290	9.25712	125.5605	0.07	0	-0.07	Agaton/January 2014	100-year
291	9.261752	125.5599	0.25	0	-0.25	Agaton/January 2014	100-year
292	9.261653	125.5623	0.03	0.43	0.4	Agaton/January 2014	100-year
293	9.2641	125.5598	0.19	0	-0.19	Agaton/January 2014	100-year
294	9.262961	125.5544	0.07	0	-0.07	Agaton/January 2014	100-year
295	9.264777	125.5543	0.06	0	-0.06	Agaton/January 2014	100-year
296	9.264658	125.5528	0.04	0.15	0.11	Agaton/January 2014	100-year
297	9.262307	125.5447	0.19	0.3	0.11	Agaton/January 2014	100-year
298	9.26072	125.5429	0.19	0	-0.19	Agaton/January 2014	100-year
299	9.260374	125.5424	0.05	1.9	1.85	Agaton/January 2014	100-year
300	9.267154	125.5445	0.25	0.77	0.52	Agaton/January 2014	100-year
301	9.271815	125.5449	0.3	2.3	2	Agaton/January 2014	100-year
302	9.294567	125.5491	0.03	0.99	0.96	Agaton/January 2014	100-year
303	9.295288	125.5492	0.13	0	-0.13	Agaton/January 2014	100-year
304	9.296329	125.5412	0.23	1.75	1.52	Agaton/January 2014	100-year
305	9.299612	125.5501	1.12	0	-1.12	Agaton/January 2014	100-year

Point Number	Validation Coordinates		Validation Points (m)	Model Var (m)	Error	Event/Date	Rain Return / Scenario
	Lat	Long					
306	9.299922	125.5491	0.33	0	-0.33	Agaton/January 2014	100-year
307	9.322167	125.5198	0.06	0	-0.06	Agaton/January 2014	100-year
308	9.318167	125.5218	0.23	0	-0.23	Agaton/January 2014	100-year
309	9.314639	125.5233	0.39	0	-0.39	Agaton/January 2014	100-year
310	9.309472	125.525	0.99	0	-0.99	Agaton/January 2014	100-year
311	9.317722	125.5275	0.03	0	-0.03	Agaton/January 2014	100-year
312	9.362306	125.5521	0.03	0	-0.03	Agaton/January 2014	100-year
313	9.361139	125.5537	0.53	1.26	0.73	Agaton/January 2014	100-year
314	9.359417	125.5531	1.2	0.98	-0.22	Agaton/January 2014	100-year
315	9.341139	125.5485	0.03	0	-0.03	Agaton/January 2014	100-year
316	9.332917	125.548	0.58	0	-0.58	Agaton/January 2014	100-year
317	9.326917	125.5516	0.04	0	-0.04	Agaton/January 2014	100-year
318	9.325528	125.554	0.05	0	-0.05	Agaton/January 2014	100-year
319	9.323528	125.5561	0.1	0	-0.1	Agaton/January 2014	100-year
320	9.32325	125.5574	0.03	0	-0.03	Agaton/January 2014	100-year
321	9.321667	125.5561	0.12	0	-0.12	Agaton/January 2014	100-year
322	9.321111	125.5551	0.22	0	-0.22	Agaton/January 2014	100-year
323	9.324972	125.5481	0.04	0	-0.04	Agaton/January 2014	100-year
324	9.325944	125.5408	0.56	0.39	-0.17	Agaton/January 2014	100-year
325	9.317722	125.5299	1.53	0	-1.53	Agaton/January 2014	100-year
326	9.318472	125.5311	1.71	0	-1.71	Agaton/January 2014	100-year
327	9.319667	125.5556	0.03	0	-0.03	Agaton/January 2014	100-year
328	9.318111	125.5551	0.03	0	-0.03	Agaton/January 2014	100-year
329	9.317111	125.5528	0.03	0	-0.03	Agaton/January 2014	100-year
330	9.314722	125.5626	0.09	0	-0.09	Agaton/January 2014	100-year
331	9.164119	125.5223	0.34	-0.14	0.2	Seniang/December 2014	100-year
332	9.161834	125.5236	1.13	-1.13	0	Seniang/December 2014	100-year
333	9.161629	125.5299	0.81	-0.76	0.05	Seniang/December 2014	100-year
334	9.163031	125.5379	1.67	-1.67	0	Seniang/December 2014	100-year
335	9.156377	125.544	3.92	-3.47	0.45	Seniang/December 2014	100-year
336	9.162364	125.5504	0.03	-0.03	0	Seniang/December 2014	100-year
337	9.16252	125.5543	2.86	-2.11	0.75	Seniang/December 2014	100-year
338	9.159665	125.5563	4.42	-4.42	0	Seniang/December 2014	100-year
339	9.15391	125.5603	0.76	-0.76	0	Seniang/December 2014	100-year
340	9.149136	125.5589	1.31	-1.16	0.15	Seniang/December 2014	100-year
341	9.145112	125.5522	0.96	-0.55	0.41	Seniang/December 2014	100-year
342	9.147361	125.5435	0.04	-0.04	0	Seniang/December 2014	100-year
343	9.148895	125.535	0.3	-0.3	0	Seniang/December 2014	100-year
344	9.151787	125.5276	1.09	-0.94	0.15	Seniang/December 2014	100-year
345	9.176494	125.5607	0.03	-0.03	0	Seniang/December 2014	100-year
346	9.180718	125.5623	0.89	-0.65	0.24	Seniang/December 2014	100-year
347	9.183404	125.5625	0.71	-0.71	0	Seniang/December 2014	100-year
348	9.188105	125.5626	0.97	-0.97	0	Seniang/December 2014	100-year
349	9.194339	125.5627	0.04	-0.04	0	Seniang/December 2014	100-year

Point Number	Validation Coordinates		Validation Points (m)	Model Var (m)	Error	Event/Date	Rain Return / Scenario
	Lat	Long					
350	9.202379	125.5636	0.03	-0.03	0	Seniang/December 2014	100-year
351	9.21569	125.5646	0.43	-0.43	0	Seniang/December 2014	100-year
352	9.230095	125.5651	0.03	0.28	0.31	Seniang/December 2014	100-year
353	9.238852	125.56	0.06	0.34	0.4	Seniang/December 2014	100-year
354	9.24147	125.5585	0.83	-0.83	0	Seniang/December 2014	100-year
355	9.248603	125.5568	0.03	-0.03	0	Seniang/December 2014	100-year
356	9.25712	125.5605	0.07	-0.07	0	Seniang/December 2014	100-year
357	9.261752	125.5599	0.25	-0.25	0	Seniang/December 2014	100-year
358	9.261653	125.5623	0.03	0.4	0.43	Seniang/December 2014	100-year
359	9.2641	125.5598	0.19	-0.19	0	Seniang/December 2014	100-year
360	9.262961	125.5544	0.07	-0.07	0	Seniang/December 2014	100-year
361	9.264777	125.5543	0.06	-0.06	0	Seniang/December 2014	100-year
362	9.264658	125.5528	0.04	0.11	0.15	Seniang/December 2014	100-year
363	9.262307	125.5447	0.19	-0.19	0	Seniang/December 2014	100-year
364	9.26072	125.5429	0.19	-0.19	0	Seniang/December 2014	100-year
365	9.260374	125.5424	0.05	1.15	1.2	Seniang/December 2014	100-year
366	9.267154	125.5445	0.25	-0.25	0	Seniang/December 2014	100-year
367	9.271815	125.5449	0.3	0.8	1.1	Seniang/December 2014	100-year
368	9.294567	125.5491	0.03	-0.03	0	Seniang/December 2014	100-year
369	9.295288	125.5492	0.13	-0.13	0	Seniang/December 2014	100-year
370	9.296329	125.5412	0.23	0.2	0.43	Seniang/December 2014	100-year
371	9.299612	125.5501	1.12	-1.12	0	Seniang/December 2014	100-year
372	9.299922	125.5491	0.33	-0.33	0	Seniang/December 2014	100-year
373	9.322167	125.5198	0.06	0.47	0.53	Seniang/December 2014	100-year
374	9.318167	125.5218	0.23	-0.23	0	Seniang/December 2014	100-year
375	9.314639	125.5233	0.39	-0.39	0	Seniang/December 2014	100-year
376	9.309472	125.525	0.99	-0.99	0	Seniang/December 2014	100-year
377	9.317722	125.5275	0.03	-0.03	0	Seniang/December 2014	100-year
378	9.362306	125.5521	0.03	0.17	0.2	Seniang/December 2014	100-year
379	9.361139	125.5537	0.53	-0.53	0	Seniang/December 2014	100-year
380	9.359417	125.5531	1.2	-1.2	0	Seniang/December 2014	100-year
381	9.341139	125.5485	0.03	-0.03	0	Seniang/December 2014	100-year
382	9.332917	125.548	0.58	-0.07	0.51	Seniang/December 2014	100-year
383	9.326917	125.5516	0.04	-0.04	0	Seniang/December 2014	100-year
384	9.325528	125.554	0.05	-0.05	0	Seniang/December 2014	100-year
385	9.323528	125.5561	0.1	-0.1	0	Seniang/December 2014	100-year
386	9.32325	125.5574	0.03	-0.03	0	Seniang/December 2014	100-year
387	9.321667	125.5561	0.12	-0.12	0	Seniang/December 2014	100-year
388	9.321111	125.5551	0.22	-0.22	0	Seniang/December 2014	100-year
389	9.324972	125.5481	0.04	-0.04	0	Seniang/December 2014	100-year
390	9.325944	125.5408	0.56	-0.34	0.22	Seniang/December 2014	100-year
391	9.317722	125.5299	1.53	-0.75	0.78	Seniang/December 2014	100-year
392	9.318472	125.5311	1.71	-0.75	0.96	Seniang/December 2014	100-year
393	9.319667	125.5556	0.03	-0.03	0	Seniang/December 2014	100-year

Point Number	Validation Coordinates		Validation Points (m)	Model Var (m)	Error	Event/Date	Rain Return / Scenario
	Lat	Long					
394	9.318111	125.5551	0.03	-0.03	0	Seniang/December 2014	100-year
395	9.317111	125.5528	0.03	-0.03	0	Seniang/December 2014	100-year
396	9.314722	125.5626	0.09	-0.09	0	Seniang/December 2014	100-year

Annex 11. Educational Institutions affected by flooding in Mainit-Tubay Flood Plain

Table A-11.1. Educational Institutions in Cabadbaran City, Agusan del Norte affected by flooding in Mainit-Tubay Floodplain

Agusan del Norte				
Cabadbaran City				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
Cabayawa Elementary School	Caasinan	0	0	0

Table A-11.2. Educational Institutions in Jabonga, Agusan del Norte affected by flooding in Mainit-Tubay Floodplain

Agusan del Norte				
Jabonga				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
Baleguian Day Care Center	Baleguian	2	2	2
Baleguian Elementary School	Baleguian	2	2	2
Colorado Elementary School	Colorado	2	2	2
Cuyago Day Care Center	Cuyago	0	0	0
Cuyago Elementary School	Cuyago	2	2	2
Cuyago National High School	Cuyago	1	1	1
Bangonay Central Elementary School	Libas	0	0	0
Libas Elementary School	Libas	2	2	2
Magsaysay Elementary School	Magsaysay	0	0	0
Maraiging Elementary School	Maraiging	2	3	3

Table A-11.3. Educational Institutions in Santiago, Agusan del Norte affected by flooding in Mainit-Tubay Floodplain

Agusan del Norte				
Santiago				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
Jose L. Ong Oh Elementary School	Curva	0	1	1
Narcisa M. Bermuadez Elementary School	Estanislao Morgado	1	1	1
Jagupit Elementary School	Jagupit	0	0	0
Jagupit National High School	Jagupit	0	0	0
La Paz Elementary School	La Paz	0	0	0
Santiago National High School	La Paz	0	0	1
Santiago Central Elementary School	Poblacion I	0	0	0
San Isidro Elementary School	San Isidro	0	0	0
Prospero D. Salas Elementary School	Tagbuyacan	0	0	0

Table A-11.4. Educational Institutions in Tubay, Agusan del Norte affected by flooding in Mainit-Tubay Floodplain

Agusan del Norte				
Tubay				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
Dona	Doña Rosario	0	1	2
Tubay Central Elementary School	Poblacion 2	0	1	2
Tubay National High School	Poblacion 2	0	0	0
Sta. Ana Elementary School	Santa Ana	0	0	0
Tagmamarkay Elementary School	Tagmamarkay	1	2	2
Victory Elementary School	Victory	2	2	2

Annex 12. Health Institutions Affected in Mainit-Tubay Flood Plain

Table A-12.1. Health Institutions in Jabonga, Agusan del Norte affected by flooding in Mainit-Tubay Floodplain

Agusan del Norte				
Jabonga				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
Magsaysay Health Center	Magsaysay	0	0	0