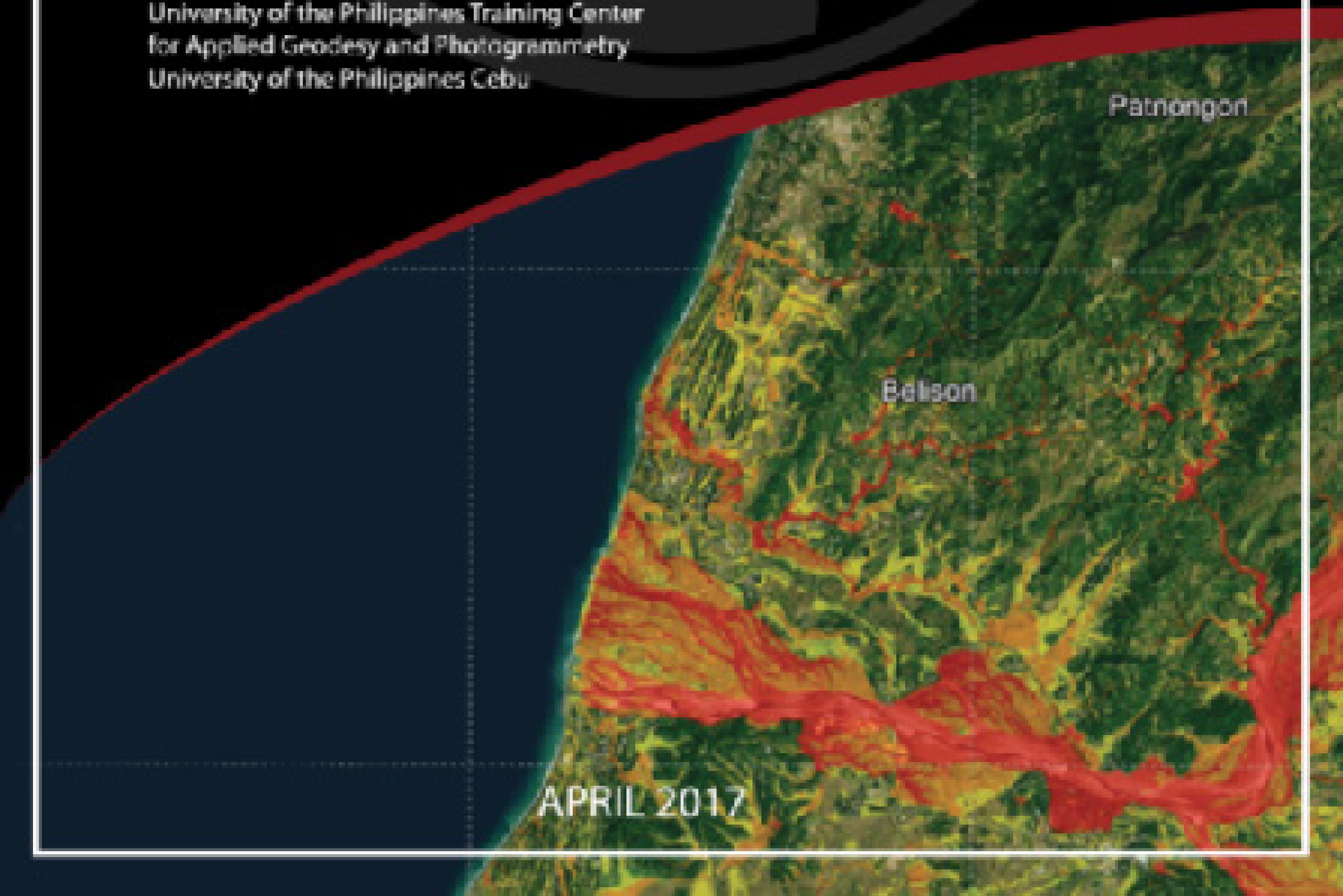
Hazard Mapping of the Philippines Using LIDAR (Phil-LIDAR 1)

LiDAR Surveys and Flood Mapping of Sibalom 2 River

University of the Philippines Training Center
for Applied Geodesy and Photogrammetry
University of the Philippines Cebu



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

CHAPTER 1: OVERVIEW OF THE PROGRAM AND SIBALOM 2RIVER

Dr. Jonnifer R. Sinogaya and Enrico C. Paringit, Dr. Eng.

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) Grant-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) available separately.

The implementing partner university for the Phil-LiDAR 1 Program is the University of the Philippines Cebu (UPC). UPC 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 22 river basins in the Western Visayas Region. The university is located in Cebu City in the province of Cebu.

1.2 Overview of the Sibalom 2River Basin

The Sibalom 2(Antique) River Basin is located in the province of Antique located at the southwest of Panay Island. The floodplain and drainage area of 153.78 km2 and 130.473 km2 respectively covers the municipalities of San Remigio and Sibalom. The floodplain is 99.83% covered with LiDAR data which compromises 8 blocks. Bathy burning was not conducted since the water was shallow when the LiDAR data was gathered. However, bathy survey was still done, the bathy survey conducted reached a total length of 17.64 km starting from Magdalena San Remigio up to the river mouth with 537 points surveyed. There are 21297 buildings, 166.52 km roads, 17 waterbodies and 7 bridges digitized based from the LiDAR data. Feature Extraction Attribution was conducted and among the building features, 20073 of them are Residential, 456 are schools and 35 are Medical Institutions.

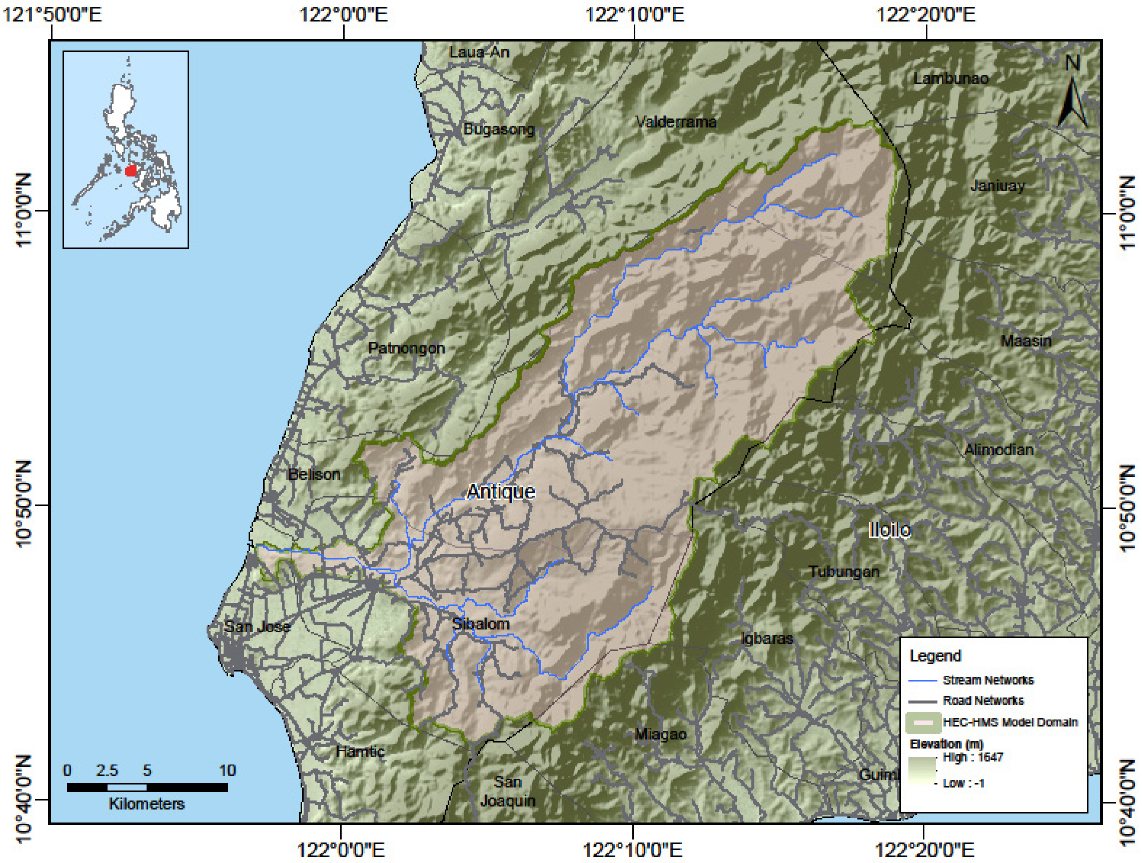


Figure 1. Map of Sibalom 2River Basin.

The flood hazard map produced covers the 61.70 km2, 72.34 km2, 80.17 km2 for the 5-year, 25-year, and 100 year rainfall return period in Patnongon which affects 13 barangays. A flood depth validation was conducted using 180 randomly generated points which is spread throughout the 6 ranges namely 0m-0.2m, 0.21m-0.5m, 0.51m-1m, 1.01m-2m, 2.10m-5m, 5m+ depth using the 25-yr rainfall flood depth map. It yielded a 0.782m RMSE.

A rating curve was developed at Bogo Bridge, San Remegio, Antique, which shows the relationship between the observed water levels at Bogo Bridge and outflow of the watershed at this location. This rating curve equation, expressed as Q = 66.291e0.5476x, was used to compute the river outflow at Bogo Bridge for the calibration of the HEC-HMS model. The resulting outflow was used to simulate the flooded areas using HEC-RAS. The simulated model will be an integral part in determining the real-time flood inundation extent of the river after it has been automated and uploaded on the DREAM website.

CHAPTER 2: LIDAR DATA ACQUISITION OF THE SIBALOM 2FLOODPLAIN

Engr. Louie P. Balicanta, Engr. Christopher Cruz, Lovely Gracia Acuña, Engr. Gerome Hipolito, Ms. Julie Pearl S. Mars, For. Regina Aedrianne C. Felismino

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

To initiate the LiDAR acquisition survey of the Sibalom 2floodplain, the Data Acquisition Component (DAC) created flight plans within the delineated priority area for Sibalom 2Floodplain in Antique, Guimaras and Iloilo. 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 parameters for the LiDAR system are outlined in Table 1 to Table 4. Figure 2 to Figure 4 show the flight plan for Sibalom 2floodplain survey.

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

Block Name	Flying Height (m AGL)	Overlap (%)	Field of View (θ)	Pulse Repetition Frequency (PRF) (kHz)	Scan Frequency (Hz)	Average Speed (kts)	Average Turn Time (Minutes)
BLK43 F	1200	30	50	100	50	120	5
BLK43 G	1200	30	50	100	50	120	5
BLK43 H	1200	30	50	100	50	120	5
BLK43 I	1200	30	50	100	50	120	5

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

Block Name	Flying Height (m AGL)	Overlap (%)	Field of View (θ)	Pulse Repetition Frequency (PRF) (kHz)	Scan Frequency (Hz)	Average Speed (kts)	Average Turn Time (Minutes)
BLK43 D	1000	30	50	200	30	130	5
BLK43 E	1000	30	50	200	30	130	5
BLK43 F	1000	30	50	200	30	130	5
BLK43 G	1000	30	50	200	30	130	5

Table 3. Flight planning parameters for the Aquarius LiDAR system.

Block Name	Flying Height (m AGL)	Overlap (%)	Field of View (θ)	Pulse Repetition Frequency (PRF) (kHz)	Scan Frequency (Hz)	Average Speed (kts)	Average Turn Time (Minutes)
BLK43K	600	30	36	50	45	130	5

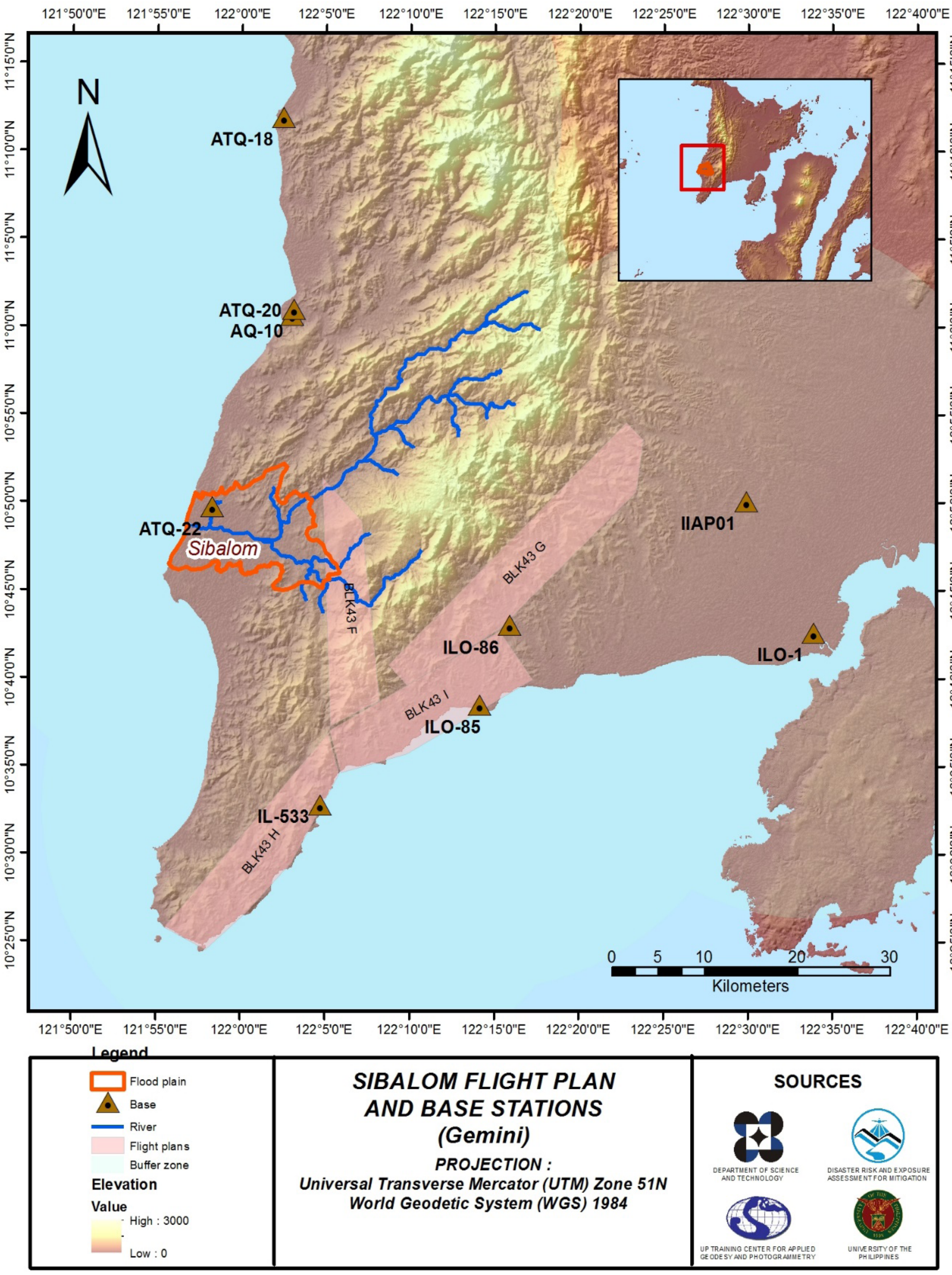


Figure 2. Flight Plan and base stations using Gemini system for the Sibalom 2Floodplain survey.

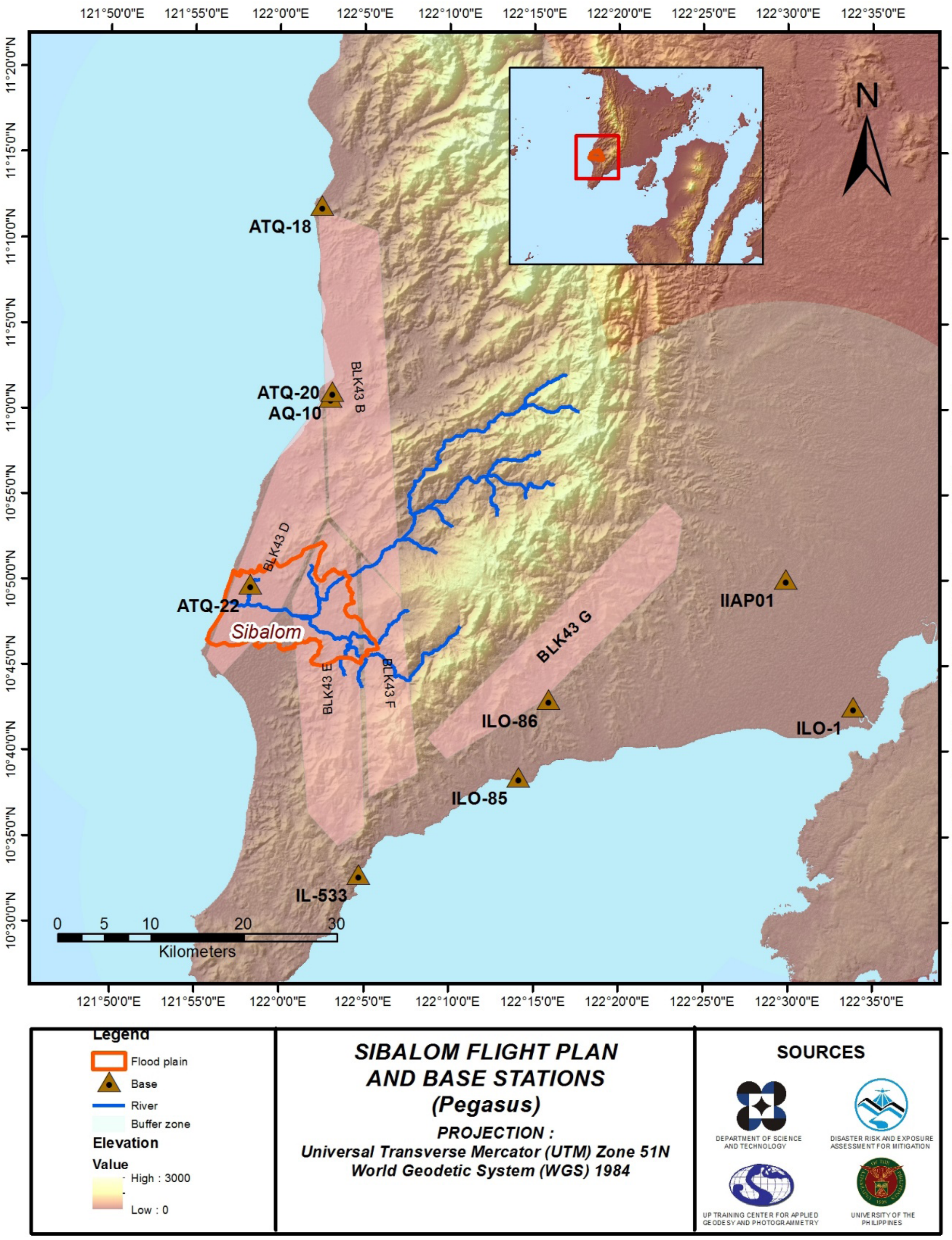


Figure 3. Flight Plan and base stations using Pegasus system for the Sibalom2 Floodplain survey

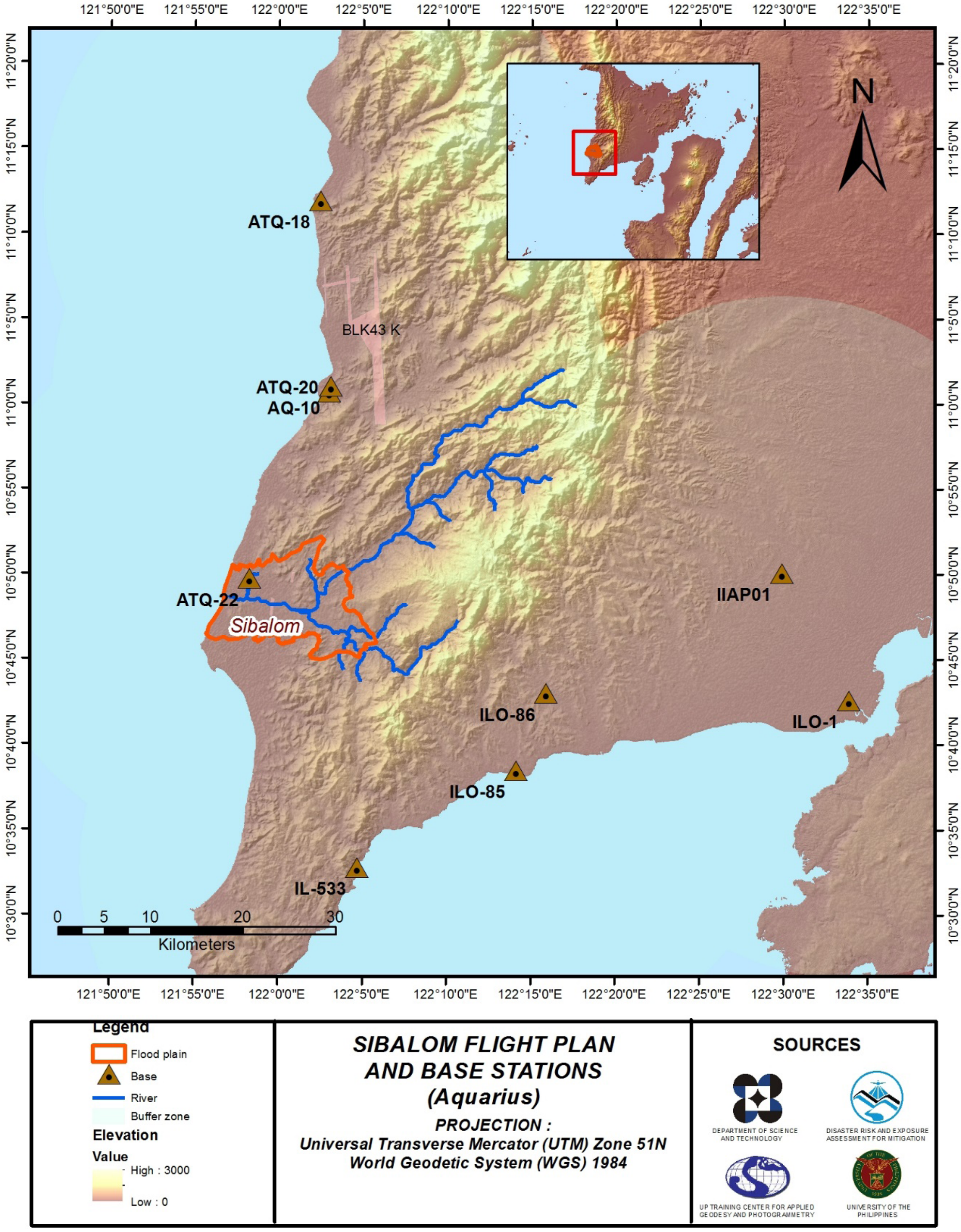


Figure 4. Flight Plan and base stations using Aquiarius system for the Sibalom 2 Floodplain survey

2.2 Ground Base Station

The project team was able to recover six (6) NAMRIA reference points: ILO-01 which is of first (1st) order accuracy; ATQ-18, ATQ-20, ATQ-22, ILO-85, and ILO-86 which are of second (2nd) order accuracy. One (1) established reference point: IIAP-01; two (2) benchmark reference point: IL-533 and AQ-10.

The certification for the base station is found in Annex D. These were used as base stations during flight operations for the entire duration of the survey (February 2015 and October 2016). Base stations were observed using dual frequency GPS receivers, TRIMBLE SPS 852 and TRIMBLE SPS 985. Flight plans and location of base stations used during the aerial LiDAR Acquisition in Sibalom 2floodplain are shown in Figure 2 to Figure 4.

The succeeding sections depict the sets of reference points, control stations and established points, and the ground control points for the entire Sibalom 2Floodplain LiDAR Survey. Figure 5 to Figure 12 shows the recovered NAMRIA control station within the area, in addition Table 4 to Table 12 show the details about the following NAMRIA control stations and established points, Table 13 shows the list of all ground control points occupied during the acquisition together with the dates they are utilized during the survey.

(a) (b)

Figure 5. GPS set-up over ATQ-18 as recovered in Barangay Cubay, Barbaza, Province of Antique (a) NAMRIA reference point ATQ-18 (b) as recovered by the field team.

Table 4. Details of the recovered NAMRIA horizontal control point ATQ-18 used as base station for the LiDAR acquisition.

Station Name	ATQ-18	
Order of Accuracy	2nd	
Relative Error (horizontal positioning)	1 in 50,000	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude	11° 11' 58.67081"
	Longitude	122° 2' 22.83300"
	Ellipsoidal Height	10.902 meters
Grid Coordinates, Philippine Transverse Mercator Zone 5 (PTM Zone 5 PRS 92)	Easting	395155.157 meters
	Northing	1238579.674 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude	11° 11' 54.16068" North
	Longitude	122° 2' 28.01549" East
	Ellipsoidal Height	65.961 meters
Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N PRS 1992)	Easting	395155.87 meters
	Northing	1238146.15 meters

(a) (b)

Figure 6. GPS set-up over ATQ-20 as recovered in Brgy. Zaragoza of Bugasong (a) NAMRIA reference point ATQ-20 (b) as recovered by the field team.

Table 5. Details of the recovered NAMRIA horizontal control point ATQ-20 used as base station for the LiDAR acquisition.

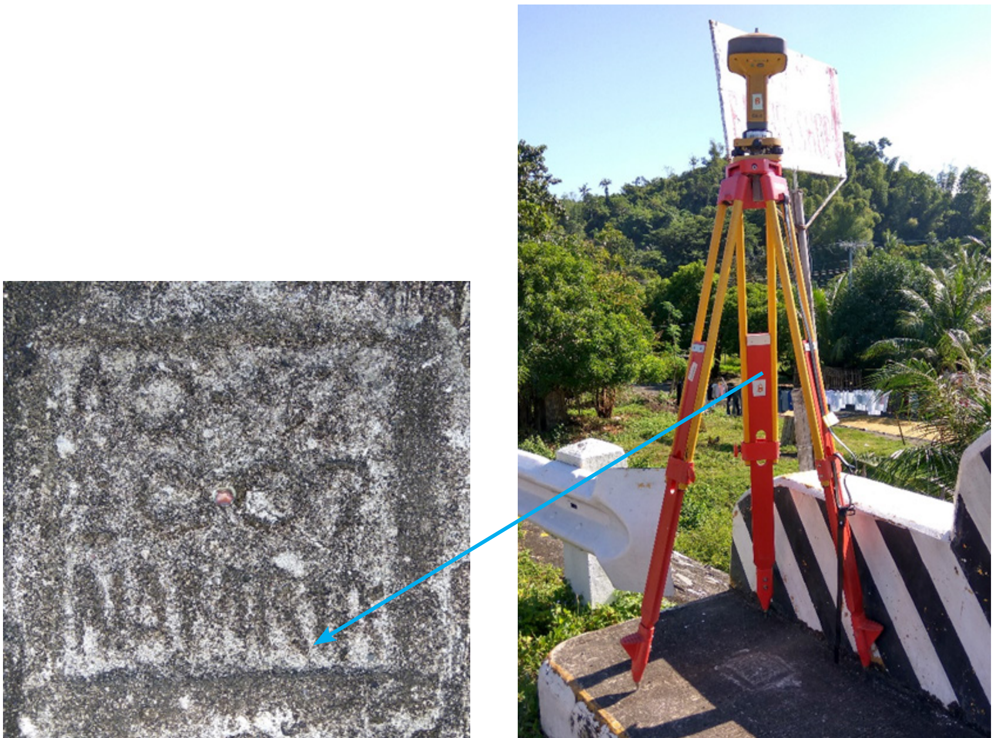
Station Name	ATQ-20	
Order of Accuracy	2nd	
Relative Error (horizontal positioning)	1 in 50,000	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude	11° 0' 42.90484"
	Longitude	122° 2' 54.07144"
	Ellipsoidal Height	10.56200 meters
Grid Coordinates, Philippine Transverse Mercator Zone 5 (PTM Zone 5 PRS 92)	Easting	396000.488 meters
	Northing	1217812.272 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude	11° 0' 38.44240" North
	Longitude	122° 2' 59.27039" East
	Ellipsoidal Height	66.09400 meters
Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N PRS 1992)	Easting	396036.89 meters
	Northing	1217386.02 meters

(a) (b)

Figure 7. (a) ATQ-22 as recovered in Barangay Concepcion, Belison, Province of Antique. (b) NAMRIA reference point ILO-3134 as recovered by the field team.

Table 6. Details of the recovered NAMRIA horizontal control point ATQ-22 used as base station for the LiDAR acquisition.

Station Name	ATQ-22	
Order of Accuracy	2nd	
Relative Error (horizontal positioning)	1 in 50,000	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude	10° 49’ 46.66618”
	Longitude	121° 58’ 11.90221”
	Ellipsoidal Height	12.250 meters
Grid Coordinates, Philippine Transverse Mercator Zone 5 (PTM Zone 5 PRS 92)	Easting	387365.279 meters
	Northing	1197676.056 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude	10° 49’ 42.24271” North
	Longitude	121° 58’ 17.11770” East
	Ellipsoidal Height	68.022 meters
Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N PRS 1992)	Easting	387404.70 meters
	Northing	1197256.85 meters



(a) (b)

Figure 8. GPS set-up over AQ-10 as recoverd in Brgy. Zaragoza (a) NAMRIA benchmark AQ-10 (b) as recovered by the field team.

Table 7. Details of the recovered NAMRIA horizontal control point AQ-10 used as base station for the LiDAR acquisition.

Station Name	AQ-10	
Order of Accuracy	2nd	
Relative Error (horizontal positioning)	1 in 50,000	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude	11° 01' 03.59755"
	Longitude	122° 03' 00.53639"
	Ellipsoidal Height	11.054 meters
Grid Coordinates, Philippine Transverse Mercator Zone 5 (PTM Zone 5 PRS 92)	Easting	396235.105 meters
	Northing	1218020.995 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude	11° 00' 59.12282" North
	Longitude	122° 03' 05.73482" East
	Ellipsoidal Height	66.576 meters

Figure 9. GPS set-up over ILO-1 as recovered on the roof top of St. Clemente Church Bell Tower in La Paz, Iloilo City (a) NAMRIA reference point ILO-1 (b) as recovered by the field team.

Table 8. Details of the recovered NAMRIA vertical control point ILO-1 used as base station for the LiDAR Acquisition.

Station Name	ILO-1	
Order of Accuracy	1st	
Relative Error (horizontal positioning)	1 in 50,000	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude	10°42’40.74251”
	Longitude	122° 33’ 48.38302”
	Ellipsoidal Height	28.93600 meters
Grid Coordinates, Philippine Transverse Mercator Zone 5 (PTM Zone 5 PRS 92)	Easting	452244.945 meters
	Northing	1184434.202 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude	10° 42’ 36.40006”
	Longitude	122° 33’ 53.60515”
	Ellipsoidal Height	86.45300 meters
Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N PRS 1992)	Easting	452261.66 meters
	Northing	1184019.63 meters

Figure 10. GPS set-up over ILO-85 as recovered at the Town Plaza in Miag-ao, Iloilo (a) NAMRIA reference point ILO-85 (b) as recovered by the field team.

Table 9. Details of the recovered NAMRIA vertical control point ILO-85 used as base station for the LiDAR acquisition.

Station Name	ILO-85	
Order of Accuracy	2nd Order	
Relative Error (horizontal positioning)	1:20000	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude	10° 38' 33.11352"
	Longitude	122° 14' 3.70560"
	Ellipsoidal Height	21.96200 m
Grid Coordinates, Philippine Transverse Mercator Zone 5 (PTM Zone 5 PRS 92)	Easting	416226.997m
	Northing	1176896.034m
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude	10 o38' 28.75996"
	Longitude	122 o14' 8.93597"
	Ellipsoidal Height	78.82800 m

(a)

(b)

Table 10. Details of the recovered NAMRIA vertical control point ILO-86 used as base station for the LiDAR acquisition.

Station Name	ILO-86	
Order of Accuracy	2nd	
Relative Error (horizontal positioning)	1 in 50,000	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude	10° 43’ 04.36044”
	Longitude	122° 15’ 48.62123”
	Ellipsoidal Height	47.315 meters
Grid Coordinates, Philippine Transverse Mercator Zone 5 (PTM Zone 5 PRS 92)	Easting	419306.197 meters
	Northing	1185284.087 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude	10° 42’ 59.99043”
	Longitude	122° 15’ 53.84473”
	Ellipsoidal Height	104.076 meters
Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N PRS 1992)	Easting	419463.955 meters
	Northing	1184807.437 meters

(a) (b)

Figure 12. GPS set-up over IL-533 as recovered in Barangay Amboyu-an, San Joaquin, Province of Iloilo (a) NAMRIA reference point IL-533 (b) as recovered by the field team.

Table 11. Details of the recovered NAMRIA vertical control point IL-533 used as base station for the LiDAR acquisition.

Station Name	IL-533	
Order of Accuracy	2nd	
Relative Error (horizontal positioning)	1 in 50,000	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude Longitude Ellipsoidal Height	10° 32' 49.29908" 122° 04' 37.25566" 51.412 meters
Grid Coordinates, Philippine Transverse Mercator Zone 5 (PTM Zone 5 PRS 92)	Easting Northing	398848.891 meters 1166439.919 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude Longitude Ellipsoidal Height	10° 32' 44.95602" 122° 04' 42.49544" 64.135 meters
Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N WGS 1984)	Easting Northing	399013.479 meters 1165970.645 meters

Table 12. Details of IIAP-01 GCP used as base station for the LiDAR acquisition.

Station Name	IIAP-01	
Order of Accuracy	2ND	
Relative Error (horizontal positioning)	1:50,000	
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS92)	Latitude Longitude Ellipsoidal Height	10° 50' 08.21923" 122° 29' 48.82359" 43.390 m
Grid Coordinates, Philippine Transverse Mercator Zone 5 (PTM Zone PRS92)	Easting Northing	445007.365 m 1197773.97 m
Grid Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude Longitude Ellipsoidal Height	10° 50' 03.83971" 122° 29' 54.03518" 100.449 m
Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N PRS 1992)	Easting Northing	445007.365 m 1197773.97 m

Table 13. Ground control points used during LiDAR data acquisition.

Date Surveyed	Flight Number	Mission Name	Ground Control Points
7-Feb-15	2532G	2BLK43IV038B	ILO-1 and ILO-85
14-Feb-15	2558G	2BLK43G045A	IIAP-1 and ILO-85
14-Feb-15	2569P	1BLK43D045A	IIAP-1 and ILO-85
17-Feb-15	2570G	2BLK43H048A	ILO-85 and IL-533
19-Feb-15	2580G	2BLK43F050B	ILO-85 and ILO-86
17-Feb-15	2583P	1BLK43D048B	ILO-85 and IL-533
18-Feb-15	2585P	1BLK43EF049A	ILO-85 and ILO-86
18-Feb-15	2587P	1BLK43ED049B	ILO-85 and ILO-86
19-Feb-15	2589P	1BLK43EFD050A	ILO-85 and ILO-86
20-Feb-15	2593P	1BLK43BDG051A	ATQ-18 and ATQ-22
25-Oct-16	8511AC	3BLK43KJ299A	ATQ-20 and AQ-10

2.3 Flight Missions

A total of Eleven (11) missions were conducted to complete the LiDAR Data Acquisition in Sibalom 2Floodplain, for a total of forty-two hours and twelve minutes (42+12) of flying time for RP-C9122, RP-C9022 and RP-C9322. All missions were acquired using the Gemini, Pegasus and Aquarius LiDAR system. As shown below, the total area of actual coverage per mission and the flying length for each mission are depicted in Table 14, while the actual parameters used during the LiDAR data acquisition are presented in Table 15.

Table 14. Flight missions for the LiDAR data acquisition of the Sibalom 2Floodplain.

Date Surveyed	Flight Number	Flight Plan Area (km²)	Surveyed Area (km²)	Area Surveyed within the Floodplain (km²)	Area Surveyed Outside the Floodplain (km²)	No. of Images (Frames)	Flying Hours	
							Hr	Min
7-Feb-15	2532G	132.16	198.85	0	198.85	603	4	35
14-Feb-15	2558G	188.42	477.14	0	477.14	668	4	11
14-Feb-15	2569P	121.47	78.21	27.04	51.17	163	3	29
17-Feb-15	2570G	129.45	172.98	0	172.98	698	4	35
19-Feb-15	2580G	106.64	131.7	2.4	129.3	414	3	41
17-Feb-15	2583P	150.51	114.05	30.96	83.09	253	2	53
18-Feb-15	2585P	308.66	263.14	66.12	197.02	621	4	11
18-Feb-15	2587P	352.53	153.07	26.8	126.27	332	3	47
19-Feb-15	2589P	497.08	132.26	27.28	104.98	261	3	41
20-Feb-15	2593P	587.2	20.02	0	20.02	427	3	29
25-Oct-16	8511AC	29.89	25.58	0	25.58	0	3	35
	TOTAL	**2604.01**	**1767**	**180.6**	**1586.4**	**4440**	**42**	**12**

Table 15. Actual parameters used during the LiDAR data acquisition of the Sibalom 2Floodplain.

Flight Number	Flying Height (m AGL)	Overlap (%)	FOV (θ)	PRF (khz)	Scan Frequency (Hz)	Average Speed (kts)	Average Turn Time (Minutes)
2532G	1200	30	50	125	40	120	5
2558G	1200	30	40	200	50	120	5
2569P	1800	40	40	100	50	120	5
2570G	1000	40	40	100	50	120	5
2580G	1200	40	40	200	50	120	5
2583P	1800	40	40	200	50	120	5
2585P	1800	40	40	200	50	120	5
2587P	1800	40	40	200	50	120	5
2589P	1800	40	40	200	50	120	5
2593P	1800	40	50	125	40	120	5
8511AC	600	30	36	50	45	130	5

2.4 Survey Coverage

This certain LiDAR acquisition survey covered the Sibalom 2floodplain (See ANNEX 7). It is located in the provinces of Antique, Guimaras and Iloilo with majority of the floodplain situated within the municipality of Sibalom. The list of municipalities and cities surveyed with at least one (1) square kilometer coverage is shown in Figure 16. The actual coverage of the LiDAR acquisition for Sibalom 2floodplain is presented in Figure 13.

Table 16. The list of municipalities and cities surveyed of the Sibalom 2Floodplain LiDAR acquisition.

Province	Municipality/City	Area of Municipality/City	Total Area Surveyed	Percentage of Area Surveyed =(Total Area covered/ Area of Municipality)*100
Antique	Belison	36.80	36.77	100
	San Jose	44.26	39.68	90
	Anini-Y	55.15	44.48	81
	Patnongon	135.69	105.25	78
	Sibalom	240.55	185.10	77
	Hamtic	139.85	65.55	47
	Tobias Fornier	102.18	24.05	24
	San Remigio	370.90	49.32	13
	Laua-An	165.65	13.58	8
	Bugasong	178.80	7.26	4
Guimaras	San Lorenzo	118.69	59.73	50
	Sibunag	152.77	54.64	36
	Buenavista	109.72	14.89	14
	Nueva Valencia	122.76	16.64	14
Iloilo	San Joaquin	200.06	190.50	95
	Miagao	170.53	127.39	75
	Igbaras	132.37	80.74	61
	Tubungan	87.73	52.02	59
	Leon	147.46	67.55	46
	Guimbal	40.69	10.98	27
	Alimodian	118.19	30.00	25
	Oton	85.38	17.36	20
	Iloilo City	70.78	8.48	12
	Maasin	137.81	7.38	5
	Tigbauan	90.20	3.63	4
	Pavia	27.89	1.06	4
Total		**3282.86**	**1314.03**	**40.03%**

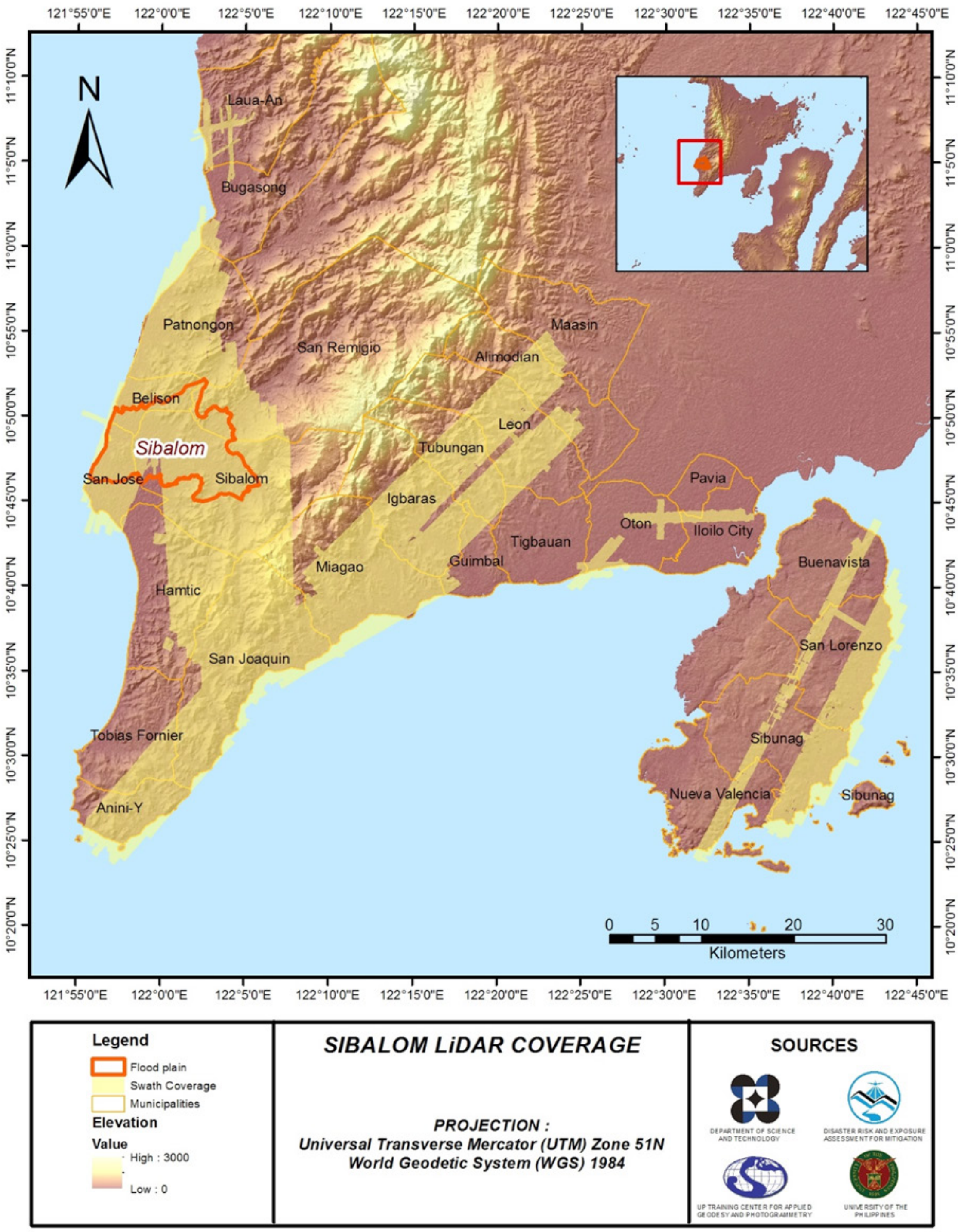


Figure 13. Actual LiDAR survey coverage of the Sibalom 2Floodplain.

CHAPTER 3: LIDAR DATA PROCESSING OF THE SIBALOM 2FLOODPLAIN

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

3.1 Overview of the LIDAR Data 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 14.

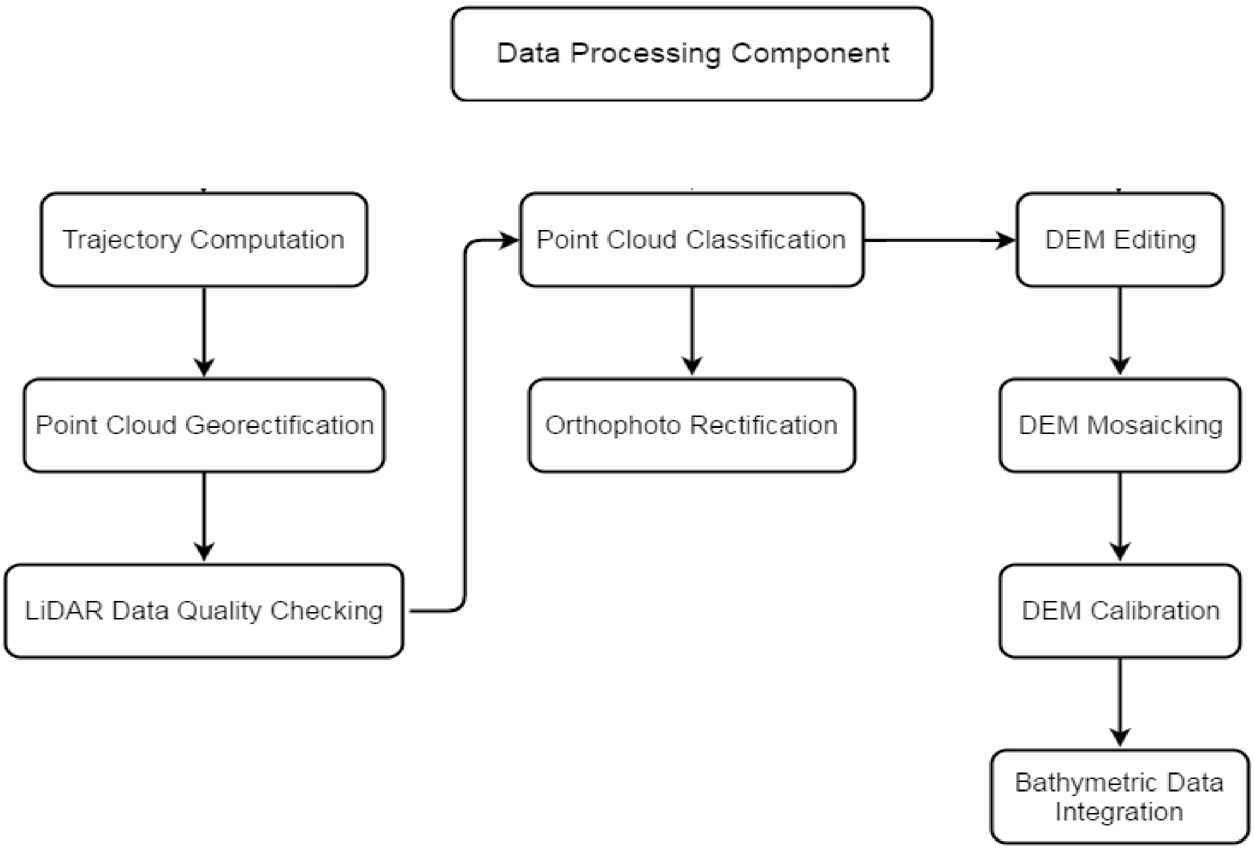


Figure 14. Schematic diagram for the data pre-processing.

3.2 Transmittal of Acquired LiDAR Data

Data transfer sheets for all the LiDAR missions of the Sibalom 2Floodplain can be found in ANNEX 5. The missions flown during the conduct of the first survey in April 2014 utilized the Airborne LiDAR Terrain Mapper (ALTM™ Optech Inc.) Aquarius system. Missions acquired during the second survey on February 2015 were flown using the Gemini and Pegasus system while the third survey on October 2016 were also flown using the Aquarius system over San Remegio, Antique.

The Data Acquisition Component (DAC) transferred a total of 210.41 Gigabytes of Range data, 2.79 Gigabytes of POS data, 212.87 Megabytes of GPS base station data, and 363.3 Gigabytes of raw image data to the data server on April 2, 2015 for the first survey and and October 25, 2016 for the last survey. The Data Pre-processing Component (DPPC) verified the completeness of the transferred data. The whole dataset for Sibalom 2was fully transferred on November 22, 2016, as indicated on the Data Transfer Sheets for the Sibalom 2Floodplain.

3.3 Trajectory Computation

The Smoothed Performance Metrics of the computed trajectory for Flight 2569P, one of the Sibalom 2flights, which is the North, East, and Down position RMSE values are shown in Figure 15. The x-axis corresponds to the time of the flight, which was measured by the number of seconds from the midnight of the start of the GPS week, which fell on the date and time of February 14, 2015 00:00AM. The y-axis, on the other hand, represents the RMSE value for that particular position.

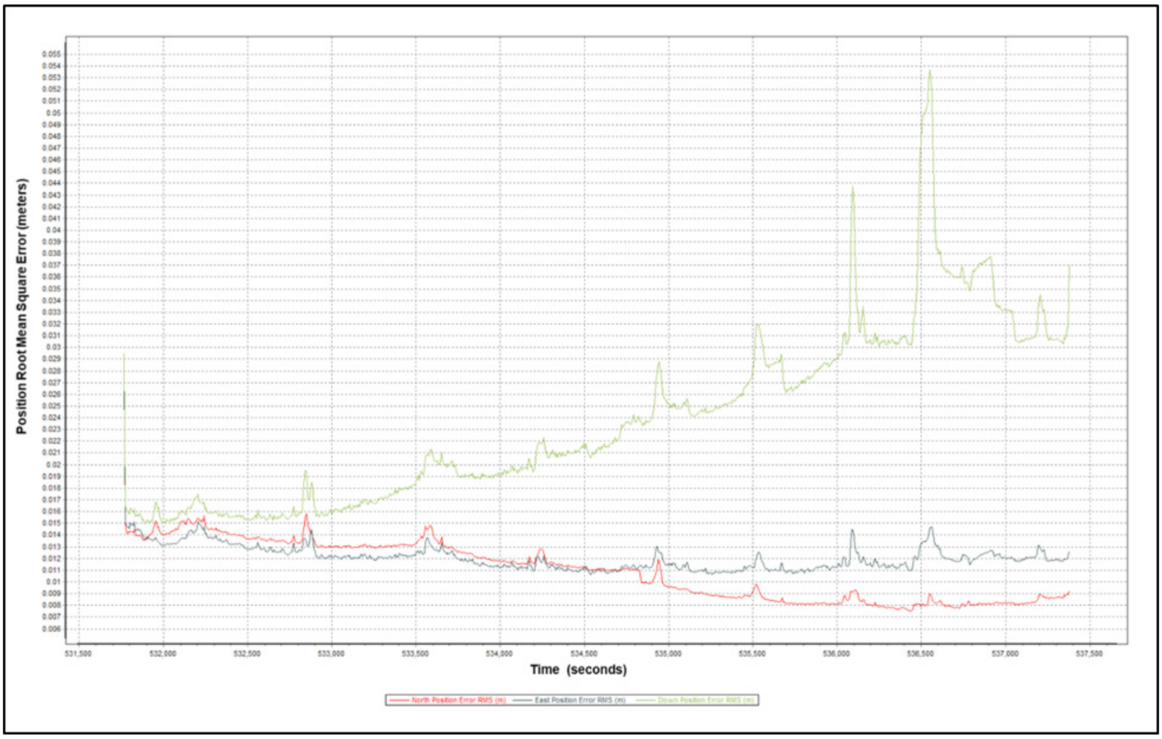


Figure 15. Smoothed Performance Metrics of a Sibalom 2Flight 2569P.

The time of flight was from 531,000 seconds to 537,400 seconds, which corresponds to morning of February 14, 2015. 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 minimize 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 15 shows that the North position RMSE peaks at 1.60 centimeters, the East position RMSE peaks at 1.50 centimeters, and the Down position RMSE peaks at 5.40 centimeters, which are within the prescribed accuracies described in the methodology.

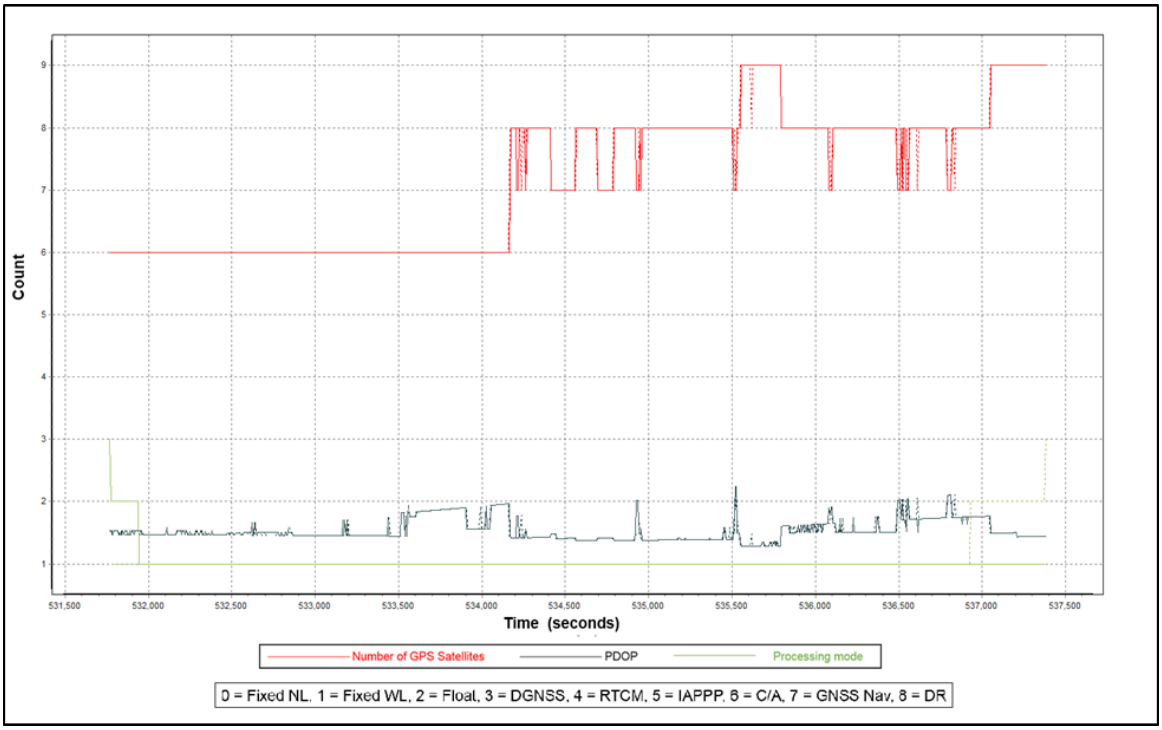


Figure 16. Solution Status Parameters of Sibalom 2Flight 2569P.

The Solution Status parameters, which indicate the number of GPS satellites; Positional Dilution of Precision (PDOP); and the GPS processing mode used for Sibalom 2Flight 2569P are shown in Figure 16. For the Solution Status parameters, the figure above signifies that the number of satellites utilized and tracked during the acquisition were between 6 and 9, not going lower than 6. Similarly, the PDOP value did not go above the value of 3, which indicates optimal GPS geometry. The processing mode also remained at 1 for the majority of the survey, with some observed peaks of up to 2, which were attributed to the turns performed by the aircraft. The value of 1 corresponds to a Fixed, Narrow-Lane Mode, which is the optimum carrier-cycle integer ambiguity resolution technique available for the POSPAC MMS. Fundamentally, 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 Sibalom 2flights is shown in Figure 17.

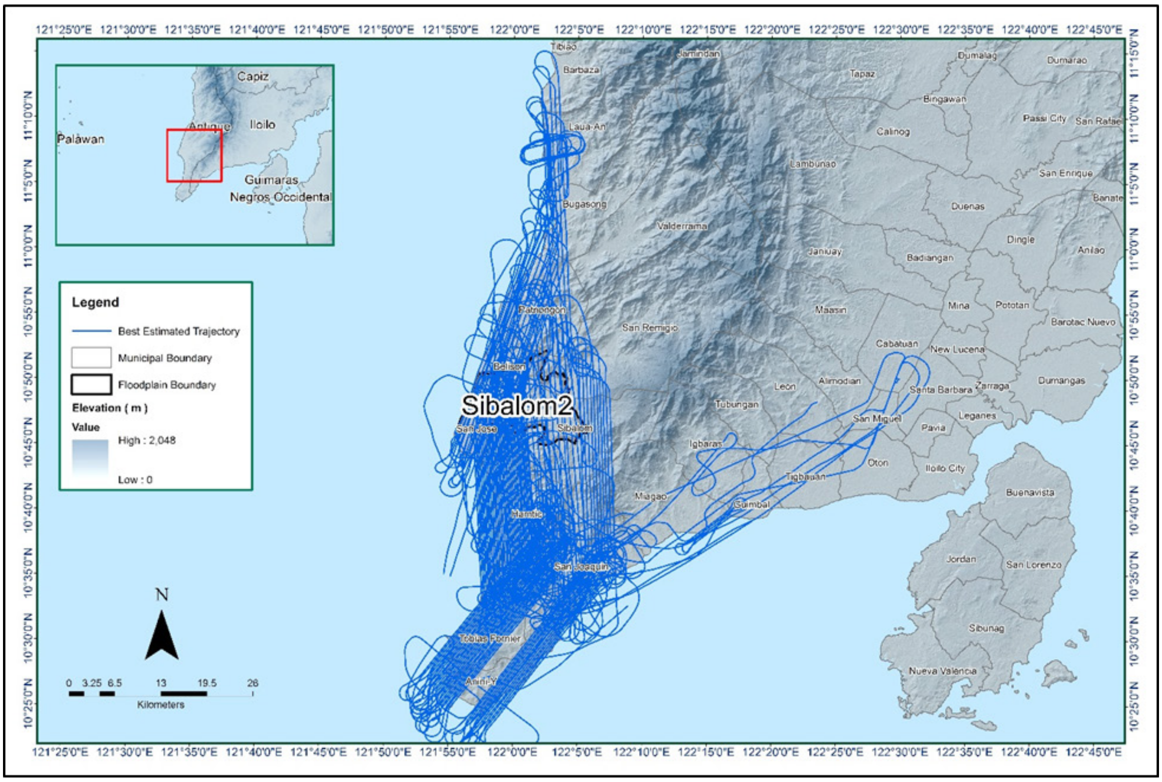


Figure 17. Best estimated trajectory for Sibalom 2Floodplain.

3.4 LiDAR Point Cloud Computation

The produced LAS contains 37 flight lines, with each flight line containing one channel for both the Gemini and Aquarius systems and two channels for the Pegasus system. The summary of the self-calibration results obtained from LiDAR processing in the LiDAR Mapping Suite (LMS) software for all flights over the Sibalom 2floodplain are given in Table 17.

Table 17. Self-calibration values for all Sibalom 2flood plain flights.

Parameter	Acceptable Value	Computed Value
Boresight Correction stdev)	<0.001degrees	0.000286
IMU Attitude Correction Roll and Pitch Corrections stdev)	<0.001degrees	0.000294
GPS Position Z-correction stdev)	<0.01meters	0.0011

The optimum accuracy values were obtained for all Sibalom 2flights based on the computed standard deviations of the corrections of the orientation parameters. The standard deviation values for individual blocks are available in the Mission Summary Reports (ANNEX 8).

3.5 LiDAR Quality Checking

The boundary of the processed LiDAR data is shown in Figure 18. The map shows gaps in the LiDAR coverage that are attributed to cloud coverage.

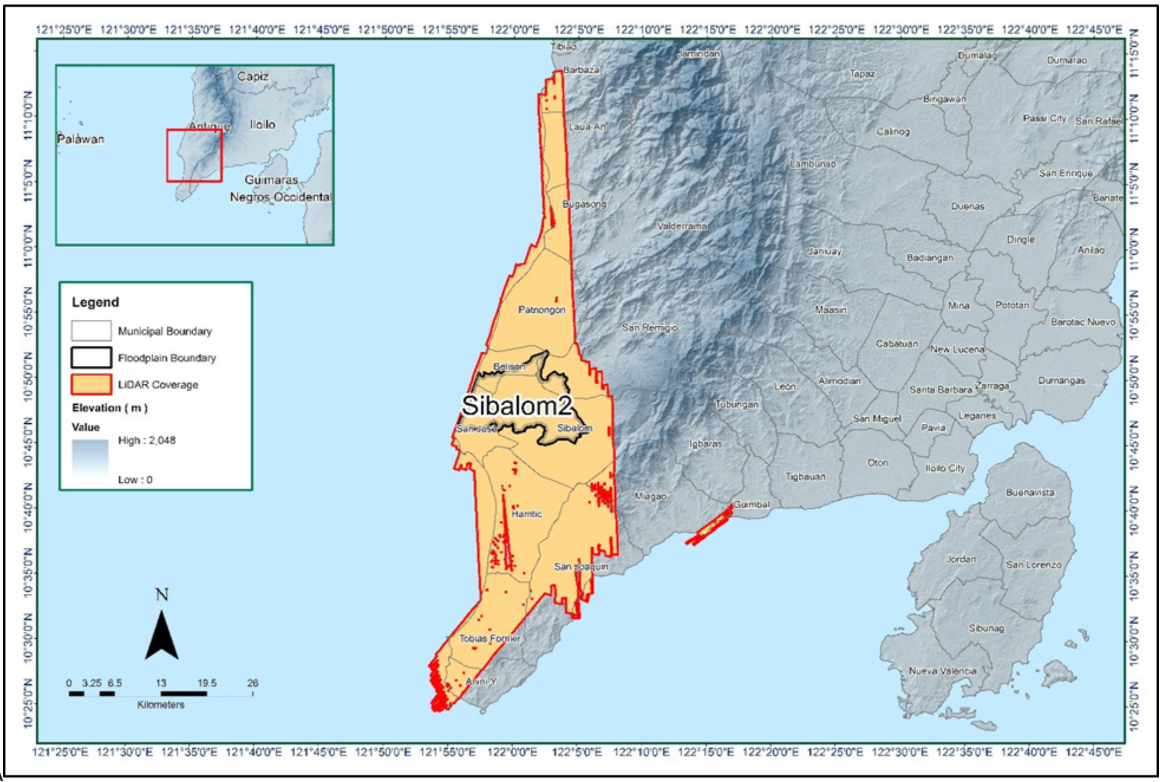


Figure 18. Boundary of the processed LiDAR data on top of SAR Elevation Data over Sibalom 2Floodplain.

The total area covered by the Sibalom 2missions is 1,184.80 sq.km. that is comprised of thirteen (13) flight acquisitions grouped and merged into eight (8) blocks as shown in Table 18.

Table 18. List of LiDAR blocks for the Sibalom 2floodplain.

LiDAR Blocks	Flight Numbers	Area (sq. km)
Iloilo_Blk43B	2593P	136.14
Iloilo_Blk43D	2569P	211.92
	2583P	
	2587P	
	2589P	
	2593P	
Iloilo_Blk43E	2585P	340.92
	2587P	
	2589P	
Iloilo_Blk43F	2580G	125.29
Iloilo_Antique_Blk43H	2570G	98.83
Iloilo_Antique_Blk43I	2532G	89.92
Iloilo_Antique_Blk43G	2558G	167.60
Iloilo_Antique_E_Bathy_Surface	1286A	5.69
Iloilo_reflights_Blk43D	8511AC	8.49
	TOTAL	**1,184.80 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 19. Since the Gemini and Aquarius systems employ 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.

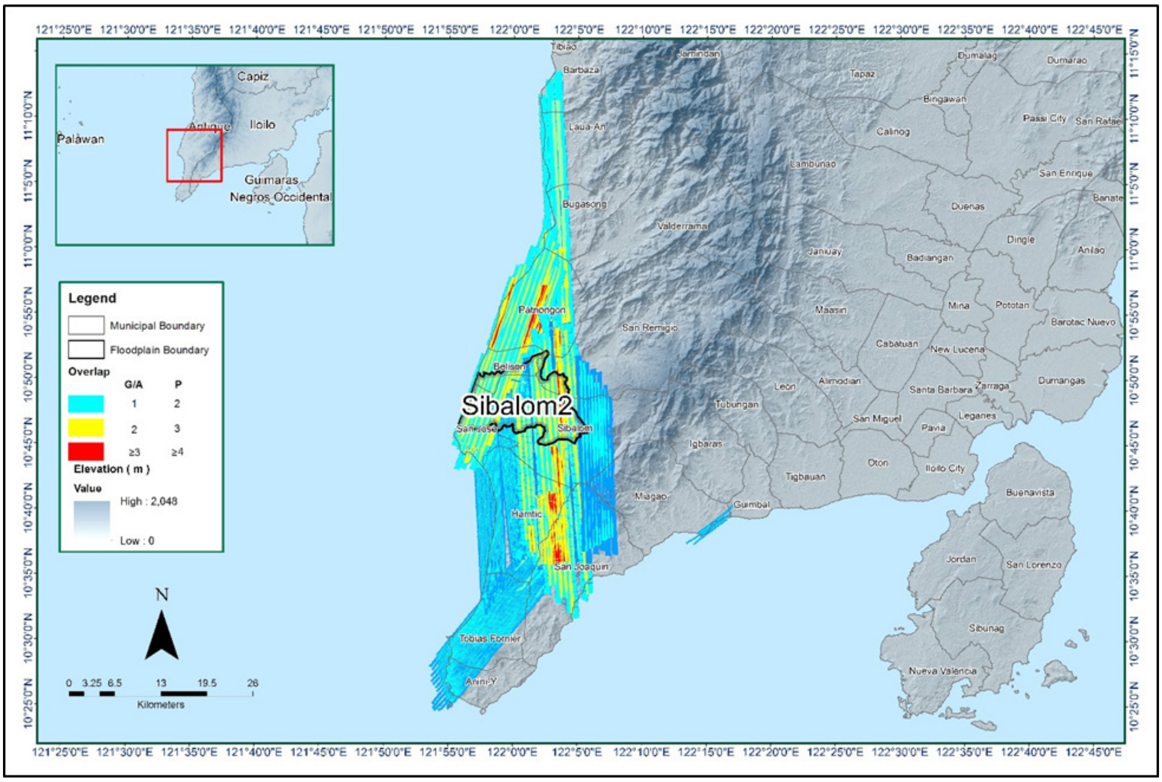


Figure 19. Image of data overlap for the Sibalom 2Floodplain.

The overlap statistics per block for the Sibalom 2Floodplain Survey can be found in the Mission Summary Reports (ANNEX 8). One pixel corresponds to 25.0 square meters on the ground. For this area, the minimum and maximum percent overlaps are 25.93% and 49.01% 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 two (2) points per square meter criterion is shown in Figure 20. As seen in the figure below, it was determined that all LiDAR data for the Sibalom 2Floodplain Survey satisfy the point density requirement, as the average density for the entire survey area is 3.37 points per square meter.

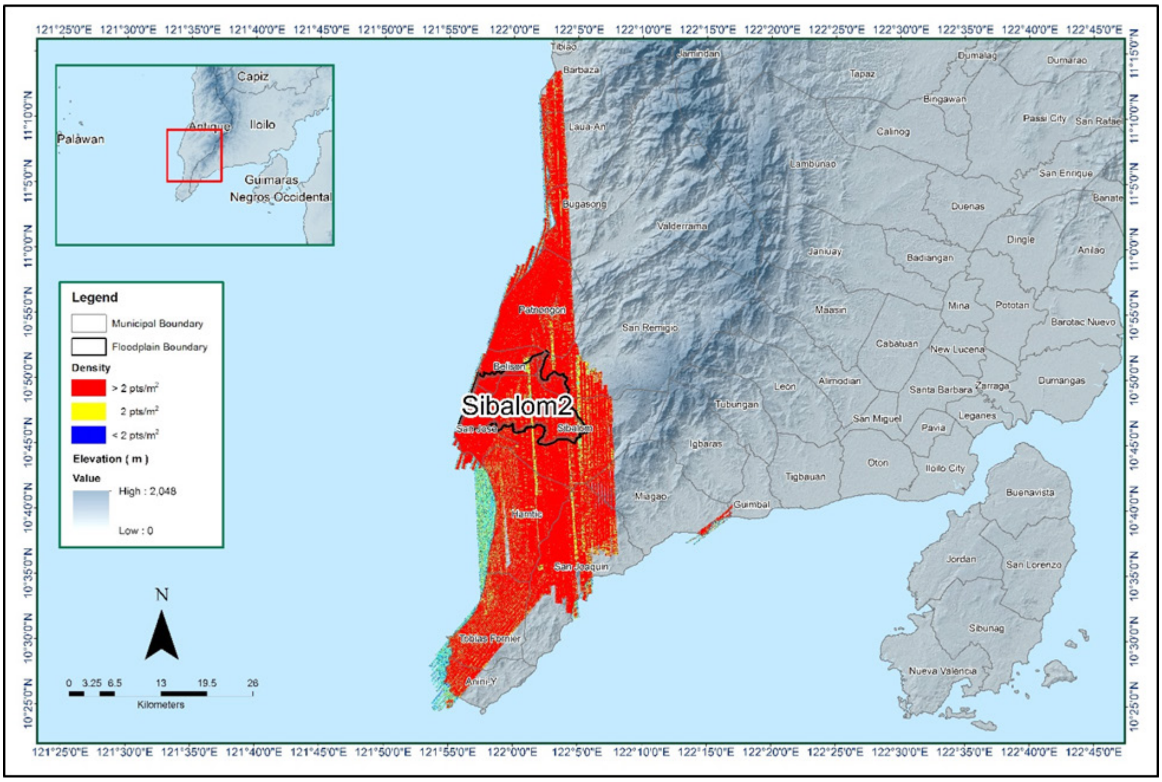


Figure 20. Pulse density map of the merged LiDAR data for the Sibalom 2Floodplain.

The elevation difference between overlaps of adjacent flight lines is shown in Figure 21. The default color range is blue to red, where bright blue areas correspond to portions where elevations of a previous flight line are higher by more than 0.20m, as identified by its acquisition time; which are relative to the elevations of its adjacent flight line. Similarly, bright red areas indicate portions where elevations of a previous flight line are lower by more than 0.20m, relative to the elevations of its adjacent flight line. Areas highlighted in bright red or bright blue necessitate further investigation using the Quick Terrain Modeler software.

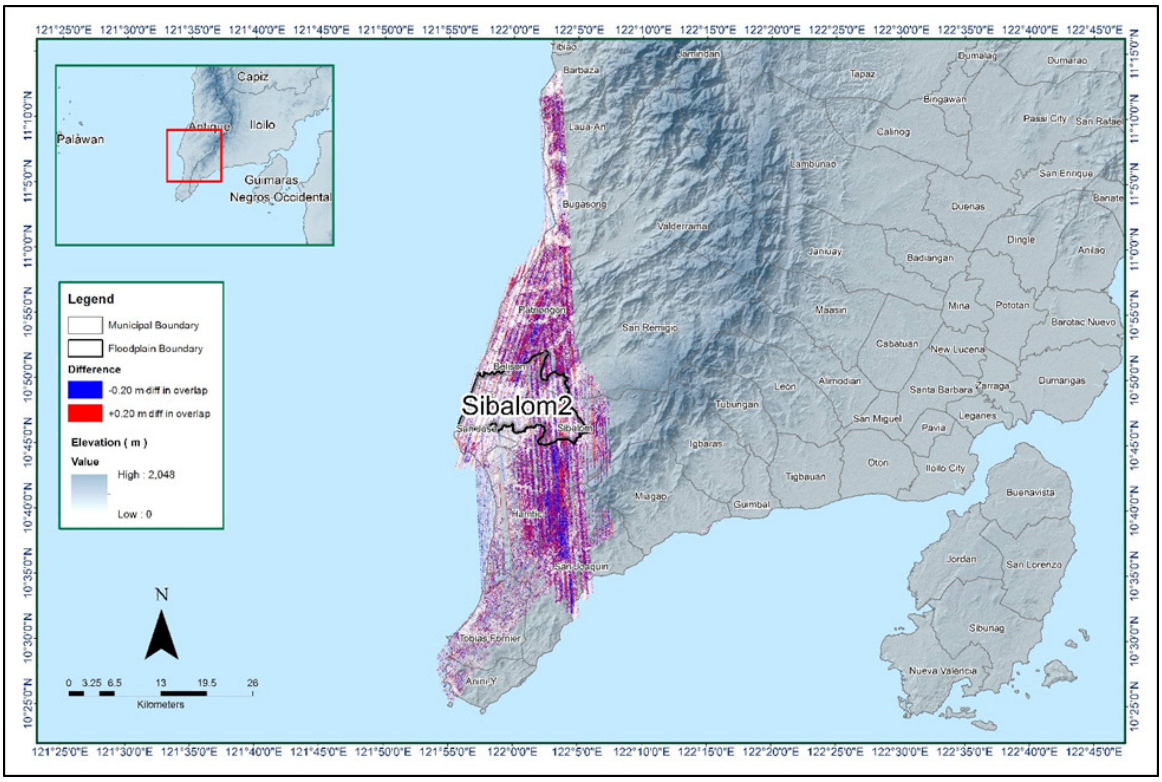


Figure 21. Elevation Difference Map between flight lines for the Sibalom 2Floodplain Survey.

A screen-capture of the processed LAS data from Sibalom 2flight 2569P loaded in QT Modeler is shown in Figure 22. The upper left image shows the elevations of the points from two overlapping flight strips traversed by the profile, illustrated by a dashed yellow 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 generated satisfactory results. No reprocessing was done for this LiDAR dataset.

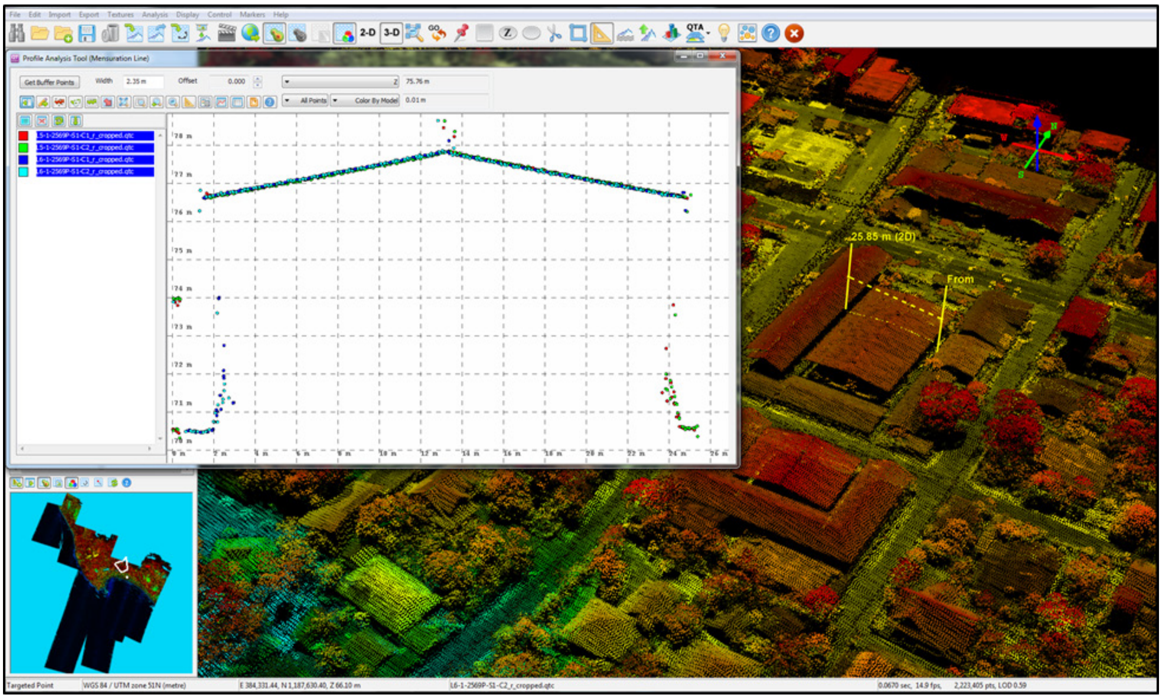


Figure 22. Quality checking for a Sibalom 2flight 2569P using the Profile Tool of QT Modeler.

3.6 LiDAR Point Cloud Classification and Rasterization

Table 19. Sibalom 2classification results in TerraScan.

Pertinent Class	Total Number of Points
Ground	1,143,897,564
Low Vegetation	804,125,329
Medium Vegetation	1,240,912,055
High Vegetation	2,287,446,399
Building	43,868,281

The tile system that TerraScan employed for the LiDAR data as well as the final classification image for a block of the Sibalom 2floodplain is shown in Figure 23. A total of 1,574 tiles with 1 km. X 1 km. (one kilometer by one kilometer) size were produced. The number of points classified to the pertinent categories is illustrated in Table 19. The point cloud has a maximum and minimum height of 1,093.82 meters and 39.01 meters respectively.

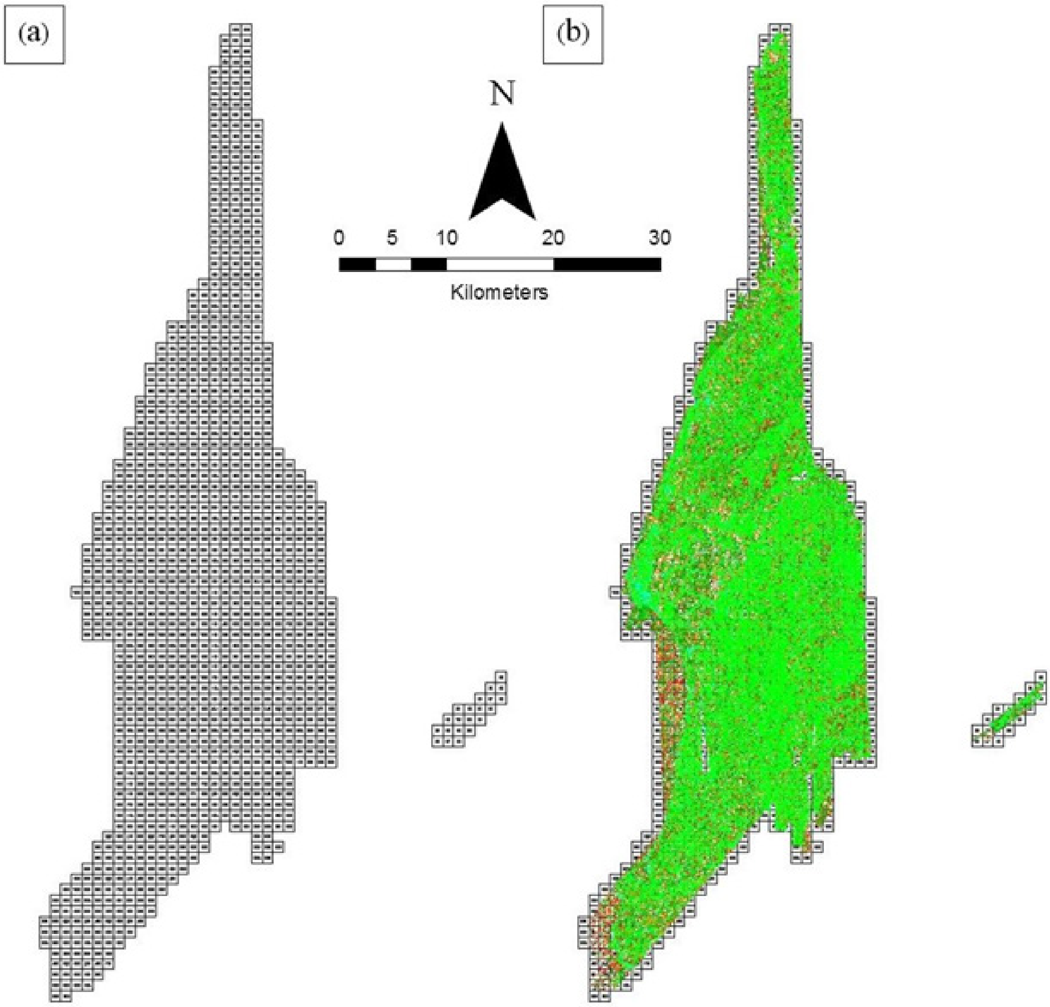


Figure 23Tiles for Sibalom 2floodplain (a) and classification results (b) in TerraScan.

An isometric view of an area before and after running the classification routines is shown in Figure 24. The ground points are highlighted in orange, while 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 the canopy are classified correctly, due to the density of the LiDAR data.

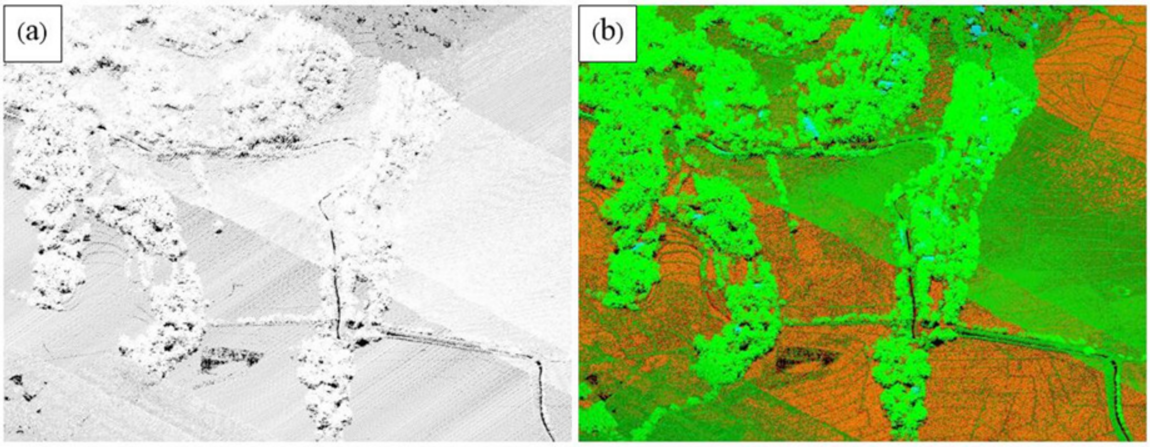


Figure 24. Point cloud before (a) and after (b) classification.

The production of the last return (V_ASCII) and secondary (T_ ASCII) DTM, first (S_ ASCII) and last (D_ ASCII) return DSM of the area in top view display are shown in Figure 25. It shows that DTMs are the representation of the bare earth while on the DSMs all features are present, such as buildings and vegetation.

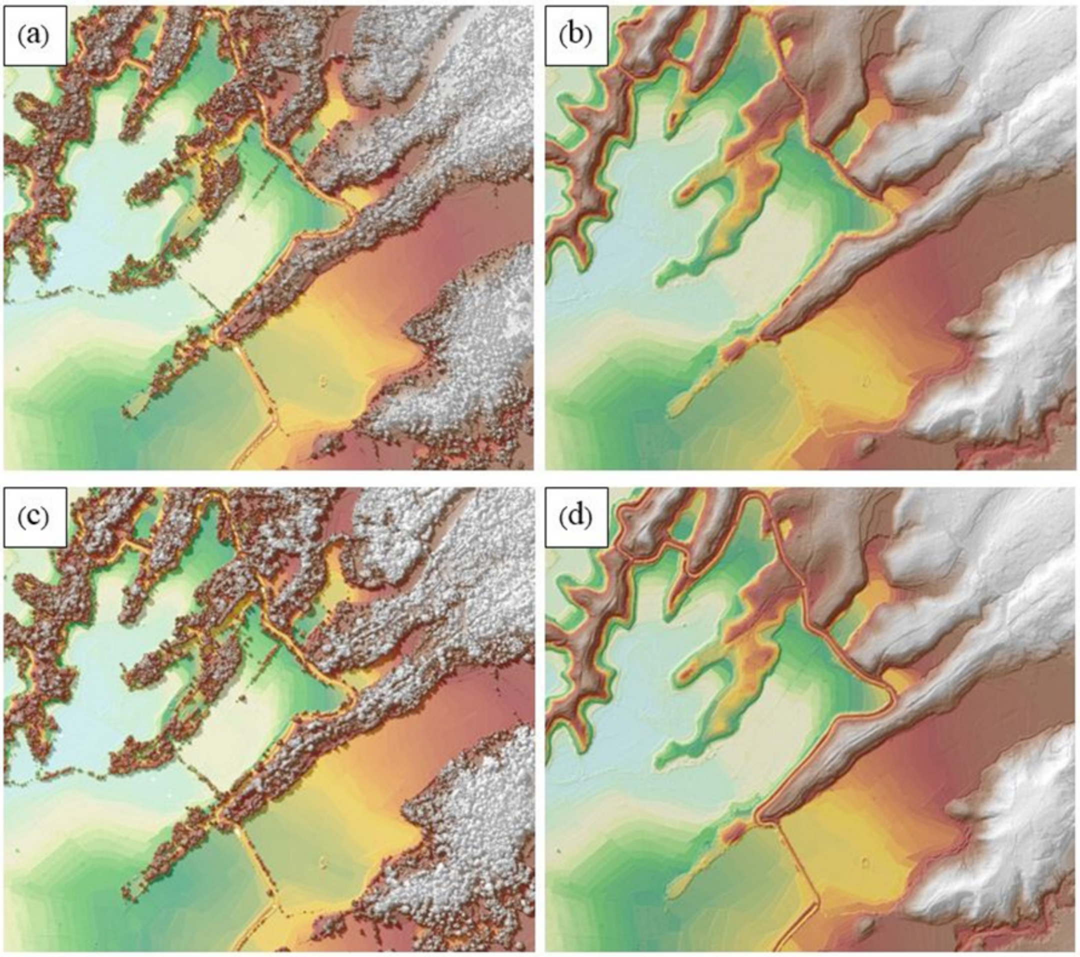


Figure 25. The production of last return DSM (a) and DTM (b) first return DSM (c) and secondary DTM (d) in some portion of Sibalom 2floodplain.

3.7 LiDAR Image Processing and Orthophotograph Rectification

The 1,163 1km by 1km tiles area covered by the Sibalom 2floodplain is shown in Figure 26. After the tie point selection to fix photo misalignments, color points were added to smooth out visual inconsistencies along the seam lines where photos overlap. The Sibalom 2floodplain attained a total of 1,029.47 sq. kms. in orthophotograph coverage comprised of 5,709 images. A zoomed-in version of sample orthophotographs named in reference to its tile number is shown in Figure 27.

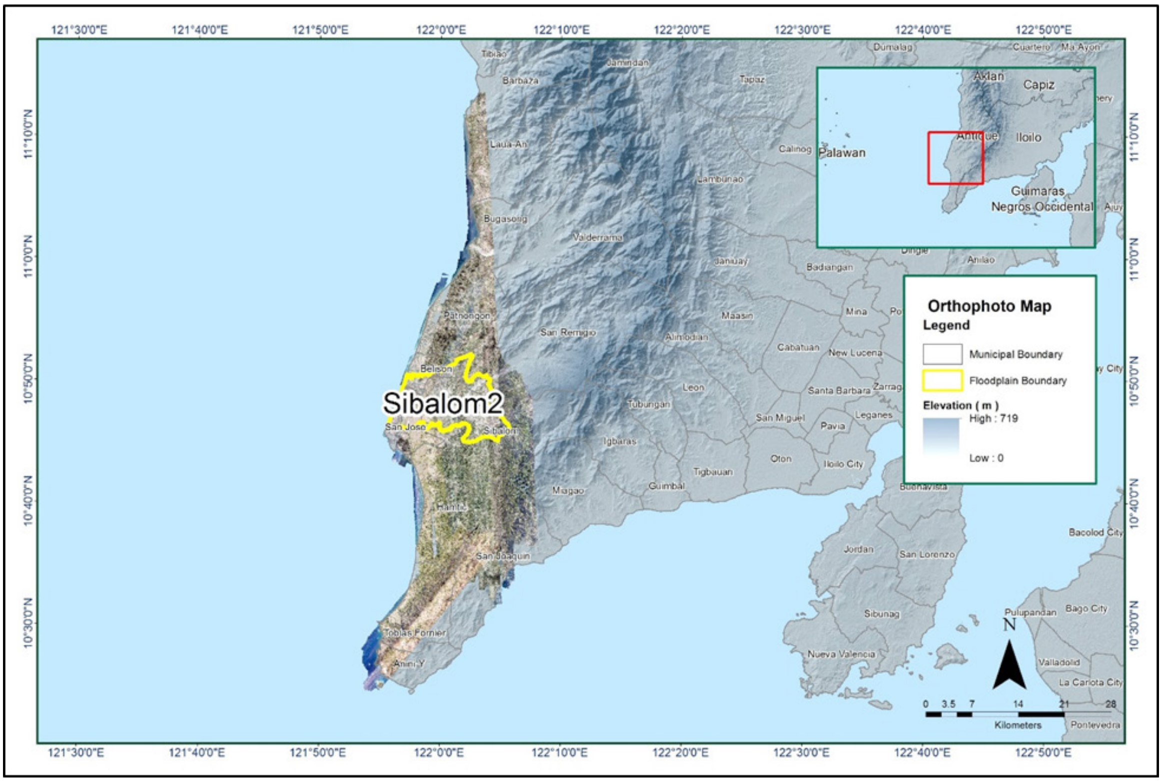


Figure 26. The Sibalom 2Floodplain with the available orthophotographs.

Figure 27. Sample orthophotograph tiles for the Sibalom 2Floodplain

3.8 DEM Editing and Hydro-Correction

Nine (9) mission blocks were processed for the Sibalom 2Floodplain Survey. Essentially, these blocks are composed of 'Iloilo_Antique' blocks, which arrive at a total area of 1,184.80 sq. kms. As listed in Table 20, the name and corresponding area of each block are measured out in square kilometers.

Table 20. LiDAR blocks with its corresponding areas.

LiDAR Blocks	Area (sq. km.)
Iloilo_Blk43B	136.14
Iloilo_Blk43D	211.92
Iloilo_Blk43E	340.92
Iloilo_Blk43F	125.29
Iloilo_Antique_Blk43H	98.83
Iloilo_Antique_Blk43I	89.92
Iloilo_Antique_Blk43G	167.60
Iloilo_Antique_E_Bathy_Surface	5.69
Iloilo_reflights_Blk43D	8.49
TOTAL	**1,184.80 sq.km**

Figure 28 shows portions of a DTM before and after manual editing. As evident in the figure, the bridge (Figure 28a) has obstructed the flow of water along the river. To correct the river hydrologically, the bridge was removed through manual editing (Figure 28b). Likewise, the paddy field (Figure 28c) was misclassified and removed during the classification process. To complete the surface, the paddy field (Figure 28d) was retrieved and reclassified through manual editing to allow the correct water flow. Also, the mountain (Figure 28e) was misclassified and removed during classification process and was retrieved to complete the surface (Figure 28f).

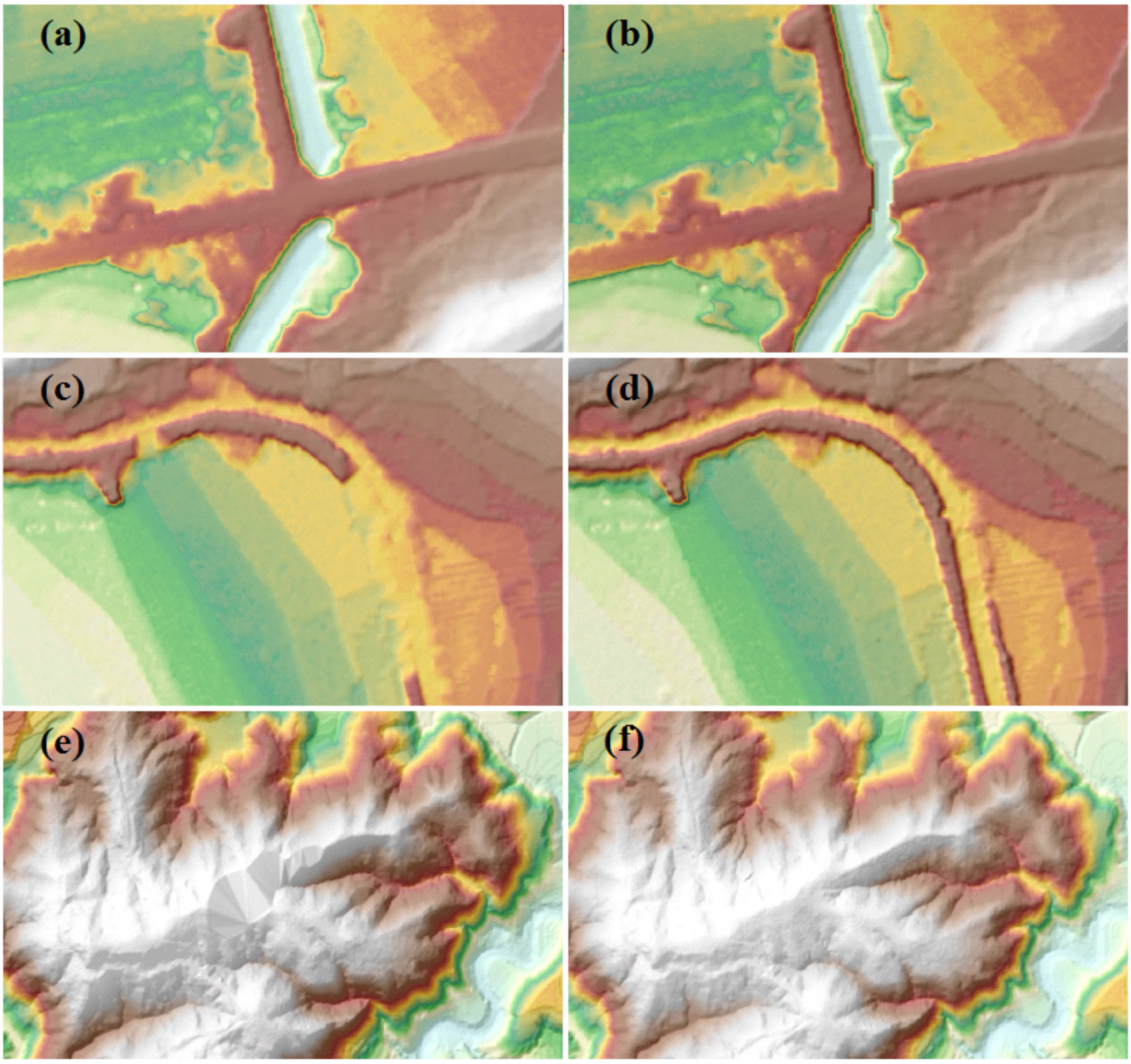


Figure 28. Portions in the DTM of Sibalom 2floodplain – bridge before (a) and after (b) manual editing; road before (c) and after (d) data retrieval; mountain before (e) and after (f) data retrieval.

3.9 Mosaicking of Blocks

Iloilo_Blk43B was used as the reference block at the start of mosaicking because it was referred to a base station with an acceptable order of accuracy. Correspondingly, Table 21 shows the shifts in values applied to each LiDAR block during mosaicking.

Mosaicked LiDAR DTM for Tanao Floodplain is shown in Figure 29. It can be seen that the entire Sibalom 2floodplain is 99.83% covered by LiDAR data.

Table 21. Shift values of each LiDAR block of Sibalom 2Floodplain.

Mission Blocks	Shift Values (meters)		
	x	y	z
Iloilo_Blk43B	0.00	0.00	-1.29
Iloilo_Blk43D	0.00	0.00	-1.23
Iloilo_Blk43E	0.00	0.00	-1.38
Iloilo_Blk43F	1.00	0.00	-1.85
Iloilo_Antique_Blk43H	-1.00	0.00	-0.34
Iloilo_Antique_Blk43I	-0.68	0.22	-0.38
Iloilo_Antique_Blk43G	-1.00	0.00	4.91
Iloilo_Antique_E_Bathy_Surface	0.00	0.00	7.60
Iloilo_reflights_Blk43D	-1.00	0.00	-0.63

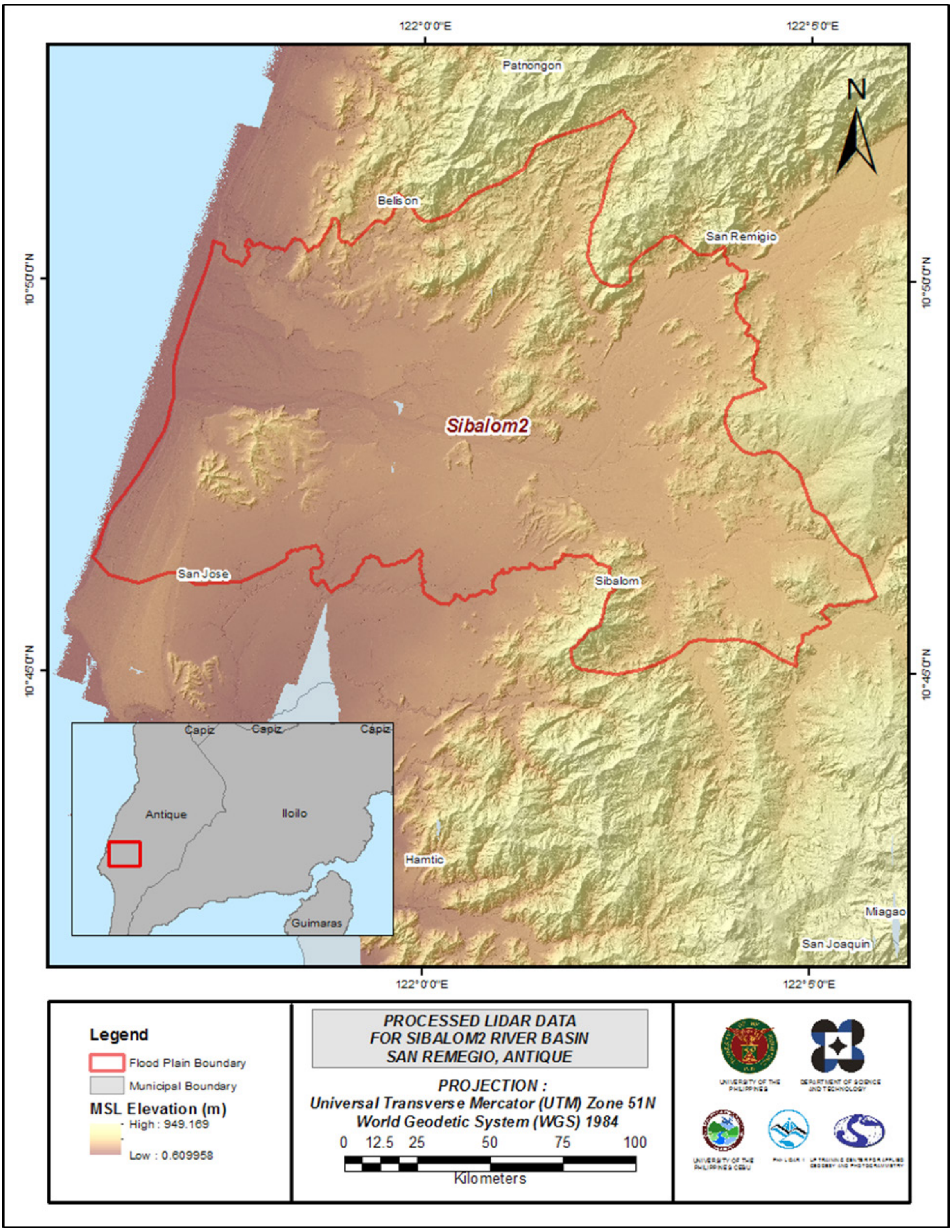


Figure 29. Map of processed LiDAR data for the Sibalom 2Floodplain.

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 Sibalom 2 to collect points with which the LiDAR dataset is validated is shown in Figure 30. A total of 7511 points were gathered for all the floodplains within the Province of Antique wherein the Sibalom 2 is located. However, the point dataset was not used for the calibration of the LiDAR data for Sibalom 2 because during the mosaicking process, each LiDAR block was referred to the calibrated Jalaur DEM. Therefore, the mosaicked DEM of Sibalom 2 can already be considered as a calibrated DEM.

A good correlation between the uncalibrated Jalaur LiDAR DTM and ground survey elevation values is shown in Figure 31. 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 points is 1.71 meters with a standard deviation of 0.17 meters. Calibration of Jalaur LiDAR data was done by subtracting the height difference value, 1.71 meters, to Jalaur mosaicked LiDAR data. Table 22 shows the statistical values of the compared elevation values between Jalaur LiDAR data and calibration data. These values were also applicable to the Sibalom 2 DEM.

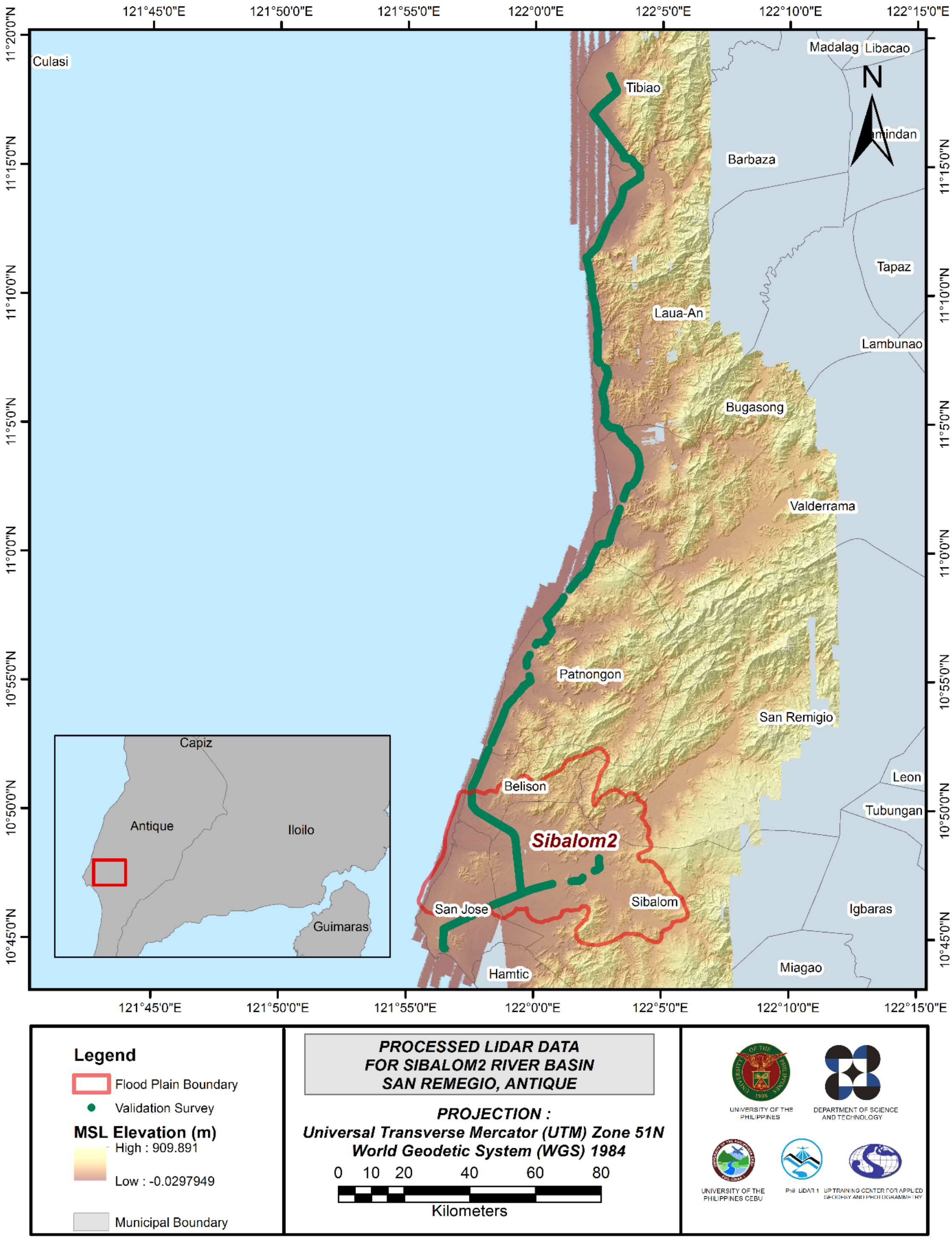


Figure 30. Map of Sibalom 2Flood Plain with validation survey points in green.

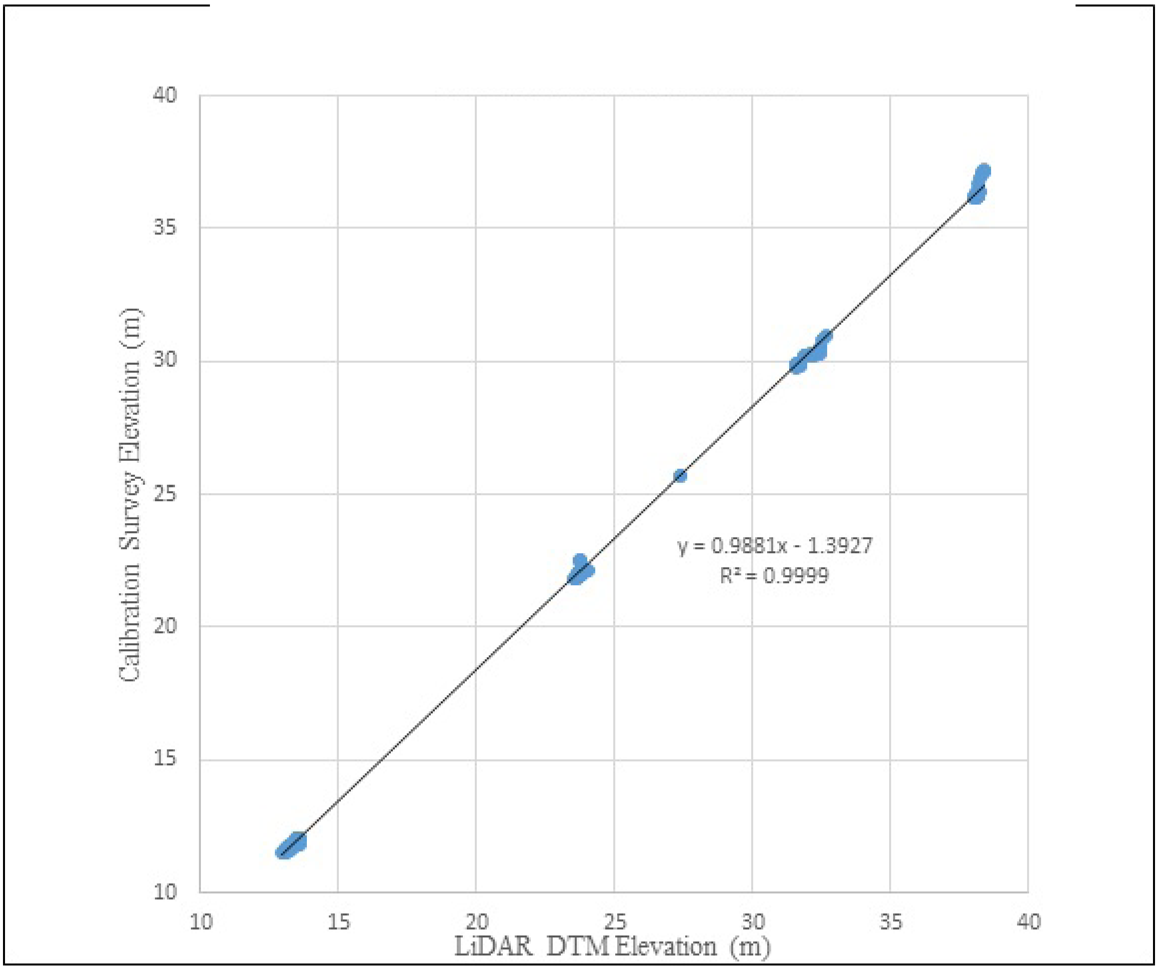


Figure 31. The correlation plot between calibration survey points and LiDAR data

Table 22. Calibration statistical measures

Calibration Statistical Measures	Value (meters)
Height Difference	1.71
Standard Deviation	0.17
Average	-1.70
Minimum	-2.13
Maximum	-1.16

A total of 949 survey points that are within the Sibalom 2flood plain were used for the validation of the calibrated Sibalom 2DTM. 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 32. The computed RMSE between the calibrated LiDAR DTM and validation elevation values is 0.09 meters with a standard deviation of 0.08 meters, as shown in Table 23.

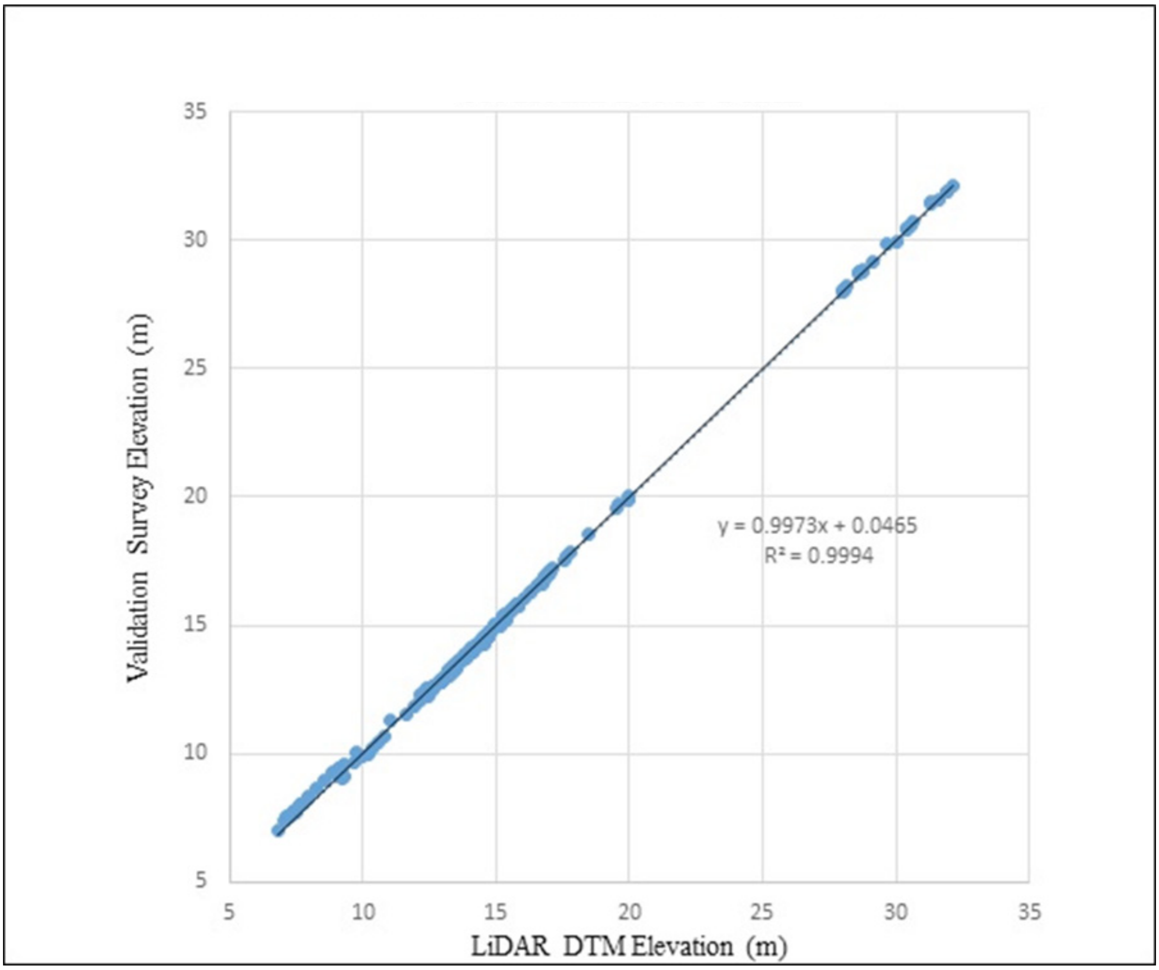


Figure 32. Correlation plot between validation survey points and LiDAR data.

Table 23. Statistical measures for the Sibalom 2River Basin DTM validation.

Validation Statistical Measures	Value (meters)
RMSE	0.09
Standard Deviation	0.08
Average	0.04
Minimum	-0.17
Maximum	0.04

3.11 Integration of Bathymetric Data into the LiDAR Digital Terrain Model

For bathy integration, only centerline data was available for Sibalom 2with 487 bathymetric survey points. However, due to elevation properties of the LiDAR Digital Terrain Model (DTM) of Sibalom 2River which was found to be shallow, bathymetric data burning was not implemented. The LiDAR DTM data served as the source of information for the elevation of Sibalom 2river. The extent of the bathymetric survey done by the Data Validation and Bathymetry Component (DVBC) in Sibalom 2is shown in Figure 33.

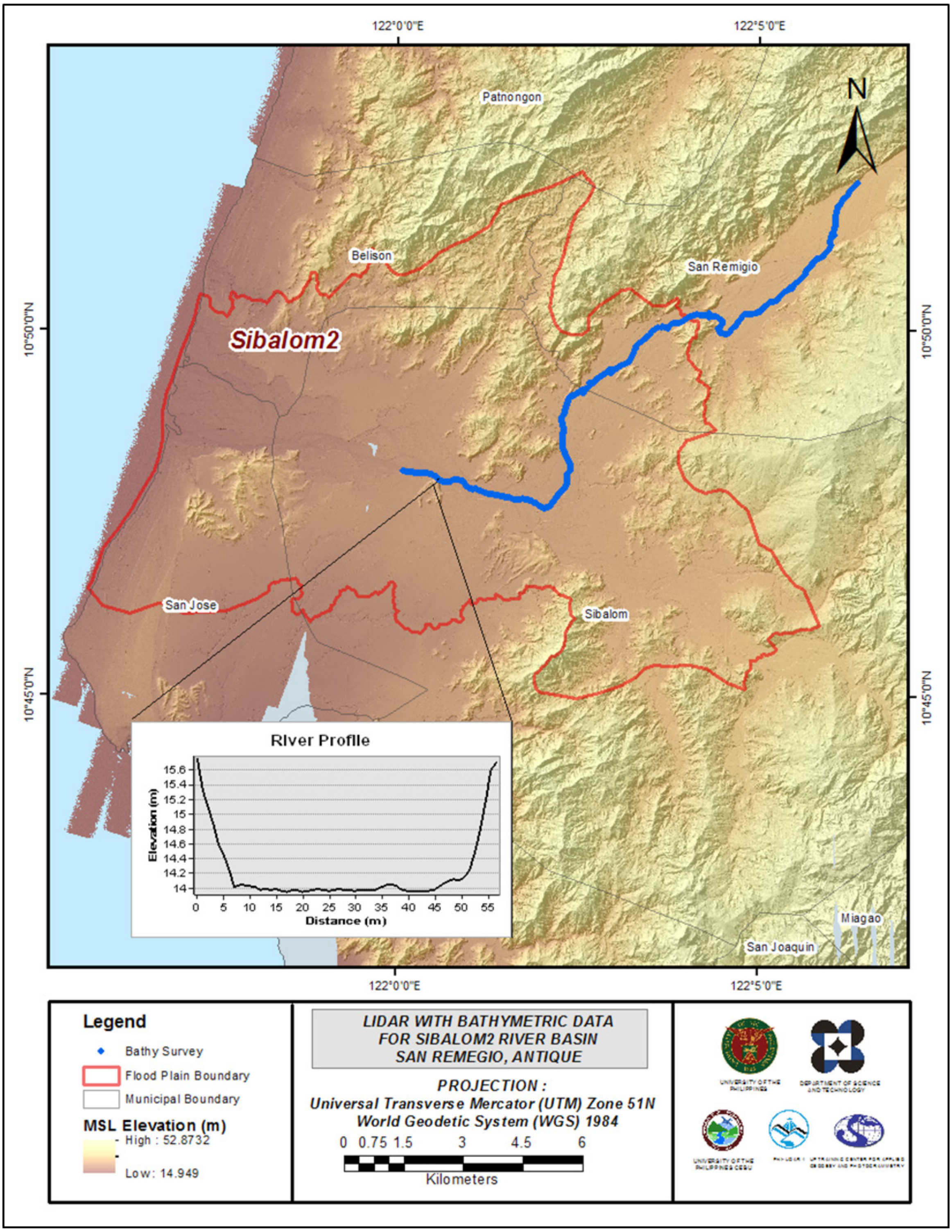


Figure 33. Map of Sibalom 2Flood Plain with bathymetric survey points shown in blue.

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 a 200-meter buffer zone. Mosaicked LiDAR DEMs with a 1-m resolution were used to delineate footprints of building features, which comprised 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 the routing of disaster response efforts. These features are represented by network of road centerlines.

3.12.1 Quality Checking (QC) of Digitized Features' Boundary

Sibalom 2floodplain, including its 200-m buffer, has a total area of 144.55 sq km. For this area, a total of 5.0 sq. km., corresponding to a total of 1,416 building features, were considered for QC. Figure 34 shows the QC blocks for the Sibalom 2floodplain.

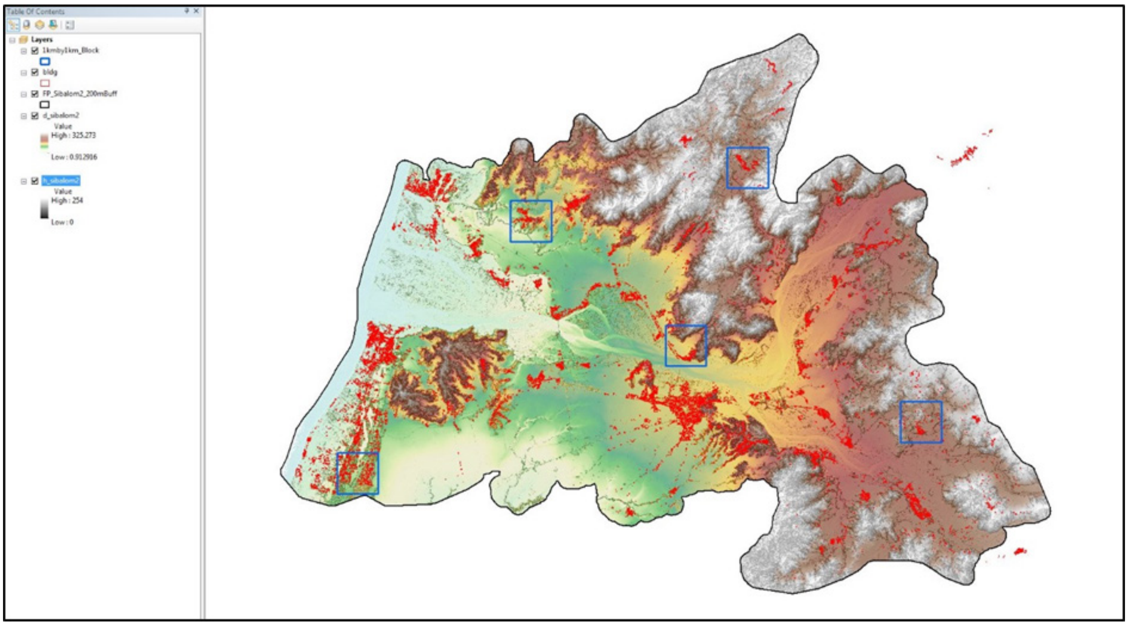


Figure 34. Blocks (in blue) of Sibalom 2building features that were subjected to QC.

Quality checking of Sibalom 2building features resulted in the ratings shown in Table 24.

Table 24. Quality checking ratings for Sibalom 2building features

FLOODPLAIN	COMPLETENESS	CORRECTNESS	QUALITY	REMARKS
Sibalom2	99.65	99.29	95.06	PASSED

3.12.2 Height Extraction

Height extraction was done for 22,670 building features in the Sibalom 2floodplain. Of these building features, 1,373 was filtered out after height extraction, resulting to 21,297 building features with height attributes. The lowest building height is at 2.00 meters, while the highest building is at 13.58 meters.

3.12.3 Feature Attribution

The feature attribution survey was conducted through a participatory community-based mapping in co-ordination with the Local Government Units of the Municipality/City. The research associates of Phil-Li-DAR 1 team visited local barangay units and interviewed local key personnel and officials who possessed expert knowledge of their local environments to identify and map out features.

Maps were displayed on a laptop and were presented to the interviewees for identification. The dis-played map include the orthophotographs, Digital Surface Models, existing landmarks, and extracted feature shapefiles. Physical surveys of the barangay were also done by the Phil-LiDAR 1 team every after interview for validation. The number of days by which the survey was conducted was dependent on the number of features and number of barangays included in the flood plain of the river basin.

Table 25 summarizes the number of building features per type. On the other hand, Table 26 shows the total length of each road type, while Table 27 shows the number of water features extracted per type.

Table 25. Building features extracted for Sibalom 2floodplain.

Facility Type	No. of Features
Residential	20,073
School	456
Market	38
Agricultural/Agro-Industrial Facilities	56
Medical Institutions	35
Barangay Hall	63
Military Institution	0
Sports Center/Gymnasium/Covered Court	41
Telecommunication Facilities	1
Transport Terminal	0
Warehouse	22
Power Plant/Substation	13
NGO/CSO Offices	6
Police Station	5
Water Supply/Sewerage	8
Religious Institutions	181
Bank	2
Factory	0
Gas Station	12
Fire Station	1
Other Government Offices	66
Other Commercial Establishments	179
Others	39
Total	**21, 297**

Table 26. Total length of extracted roads for Sibalom 2floodplain.

Floodplain	Road Network Length (km)					Total
	Barangay Road	City/Municipal Road	Provincial Road	National Road	Others	
Sibalom2	103.85	0.00	5.71	48.15	8.81	**166.52**

Table 27. Number of extracted water bodies for Sibalom 2floodplain.

Floodplain	Water Body Type					Total
	Rivers/ Streams	Lakes/ Ponds	Sea	Dam	Fish Pen	
Sibalom2	17	0	0	0	17	**17**

A total of 5 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 given the complete required attributes. Respectively, all these output features comprise the flood hazard exposure database for the floodplain. The final quality checking completes the feature extraction phase of the project.

Figure 35 shows the completed Digital Surface Model (DSM) of the Sibalom 2Floodplain, with all its ground features.

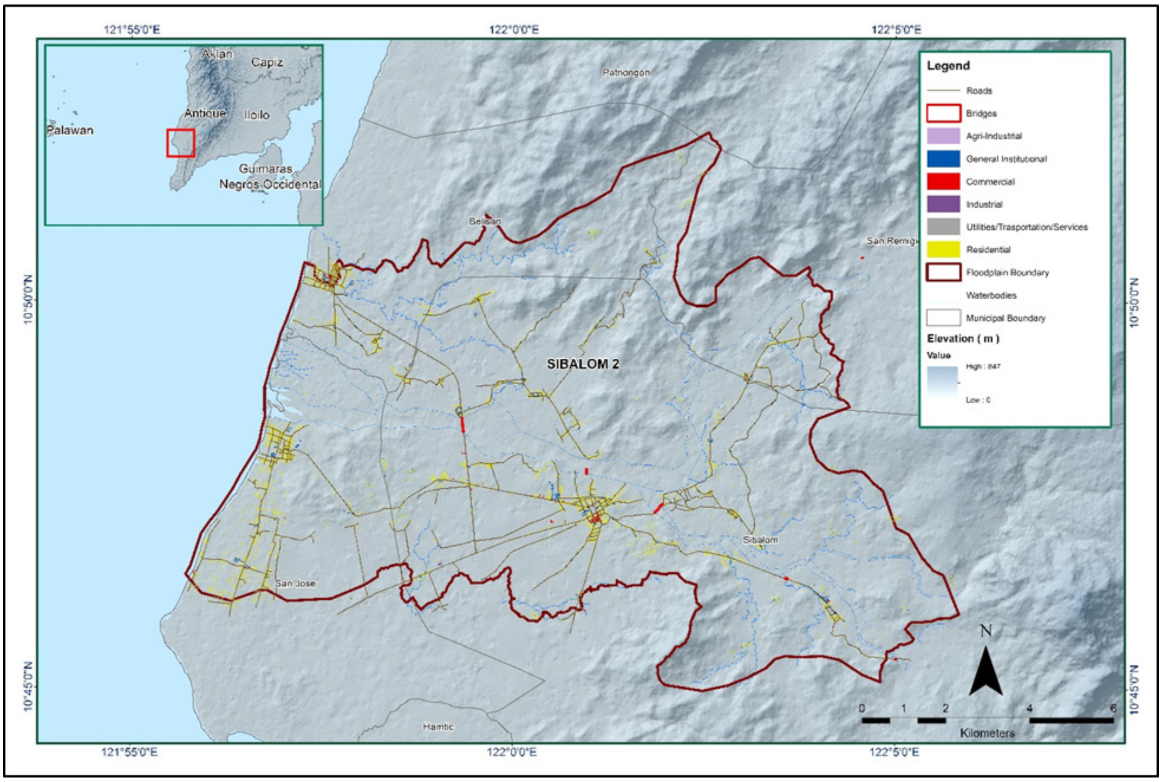


Figure 35. Extracted features of the Sibalom 2Floodplain.

CHAPTER 4: LIDAR VALIDATION SURVEY AND MEASUREMENTS OF THE SIBALOM 2RIVER BASIN

Louie P. Balicanta, Joemarie Caballero, Patrizcia Mae. P. dela Cruz, Dexter T. Lozano, Dona Rina Patricia C. Tajora, Elaine Bennet Salvador, Rodel C. Alberto, Marck Lorenz R. Taguse, and Mary Cibyl J. Atacador

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

DVBC conducted field survey in Sibalom River on September 25 – October 9, 2014 with the following scope of work: reconnaissance; control survey for the establishment of a control point; cross-section, bridge as-built of Bugo Bridge and Tipuluan Bridge piers; ground validation data acquisition of about 82.264 km for the whole province of Antique; and bathymetric survey from Brgy. Magdalena, Municipality of San Remigio, Antique down to Brgy. Bari, Municipality of Sibalom, Antique with an estimated length of 24.48 km using GNSS PPK survey technique.

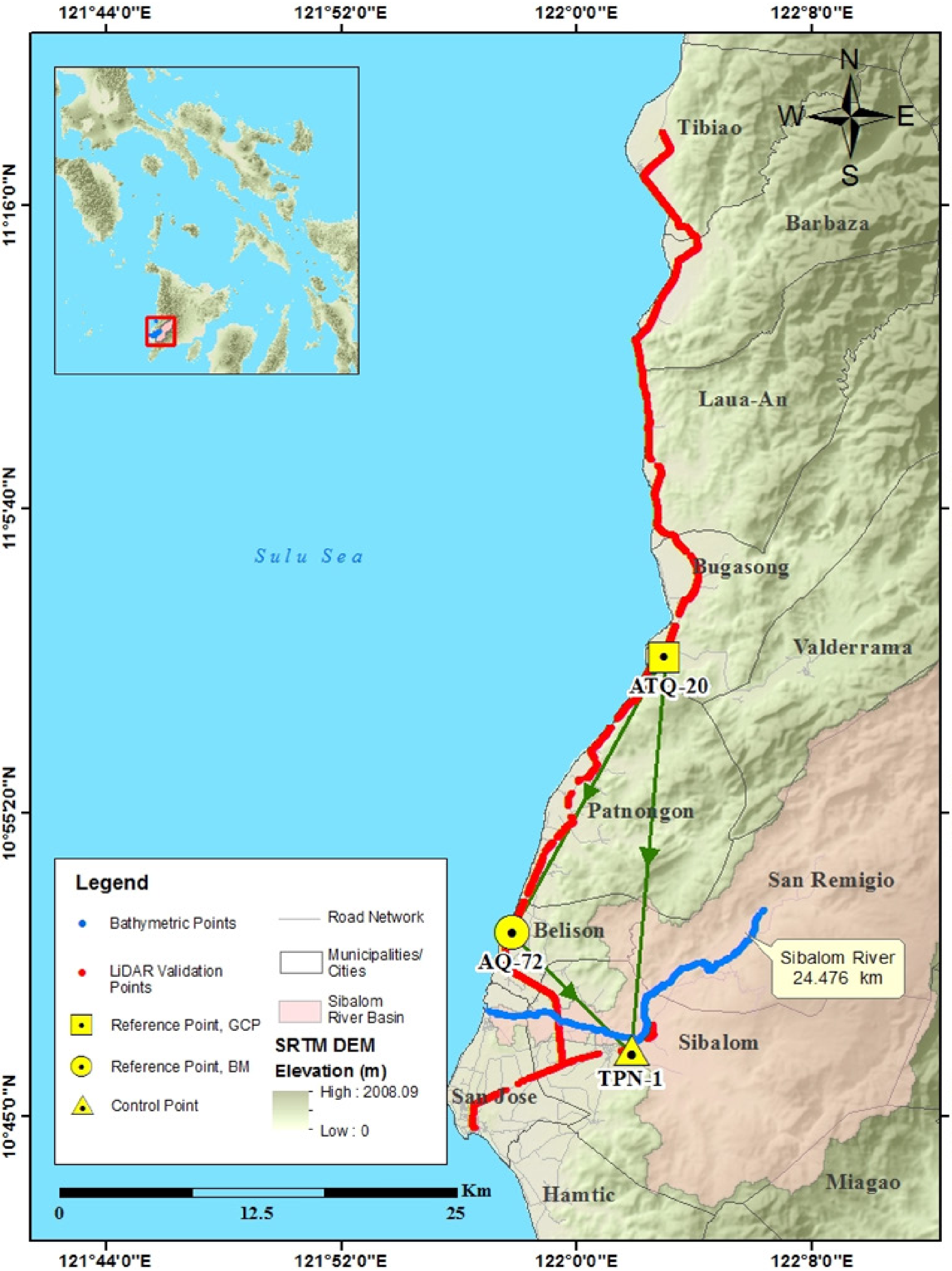


Figure 36. Extent of the bathymetric survey (in blue line) in Sibalom 2River and the LiDAR data validation survey (in red).

4.2 Control Survey

The GNSS network used in Sibalom River Survey is composed of a single loop established on September 26, 2014 occupying the following reference points: ATQ-20, a second-order GCP, located in Brgy. Zaragoza, Municipality of Bugasong, Antique; and AQ-72, a first-order BM, located in Brgy. Delima, Municipality of Belison, Antique.

A control point was established on the approach of Tipuluan Bridge, namely: TPN-1, in Brgy. Pasong, Brgy. Sibalom, Antique, to use as marker during the survey.

Table 28 depicts the summary of reference and control points utilized, with their corresponding locations, while Figure 37 shows the GNSS network established in the Sibalom 2River Survey.

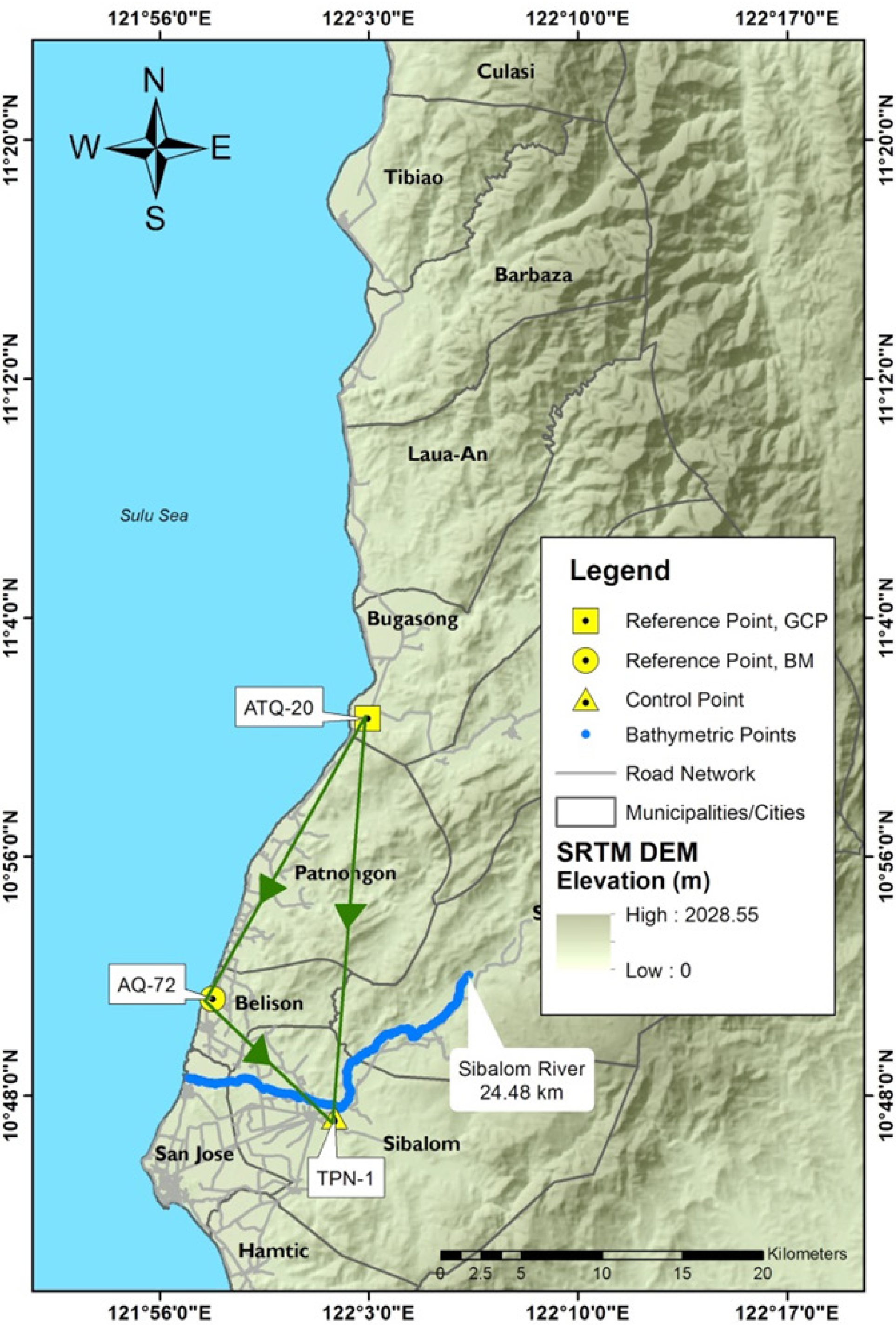


Figure 37. The GNSS Network established in the Sibalom 2River Survey.

Table 28. References used and control points established in the Sibalom 2River Survey (Source: NAMRIA, UP-TCAGP).

Control Point	Order of Accuracy	Geographic Coordinates (WGS 84)				
		Latitude	Longitude	Ellipsoidal Height (Meter)	Elevation in MSL (Meter)	Date Established
ATQ-20	2nd	11°00'38.44240" N	122°02'59.27039" E	66.094	-	2009
AQ-72	1st	-	-	61.541	5.5842	2007
TPN-1	-	-	-	--	-	September 26, 2014

Figure 38 to Figure 40 depict the setup of the GNSS on recovered reference points and established control points in the Sibalom 2River.

Figure 38. GNSS base receiver setup, Trimble® SPS 852 at ATQ-20 in Brgy. Zaragoza, Municipality of Bugasong, Antique.

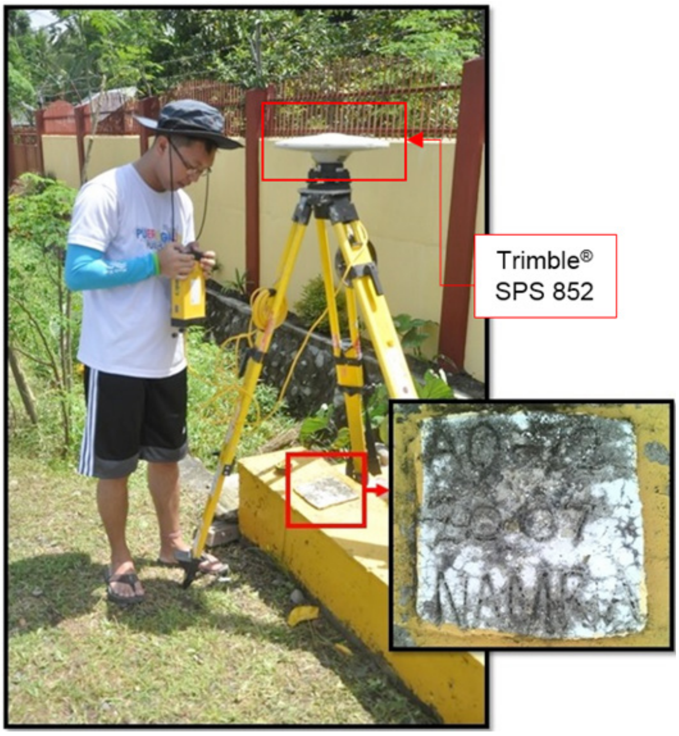


Figure 39. Benchmark, AQ-72, with Trimble® SPS 852 in Brgy. Delima, Municipality of Belison, Antique

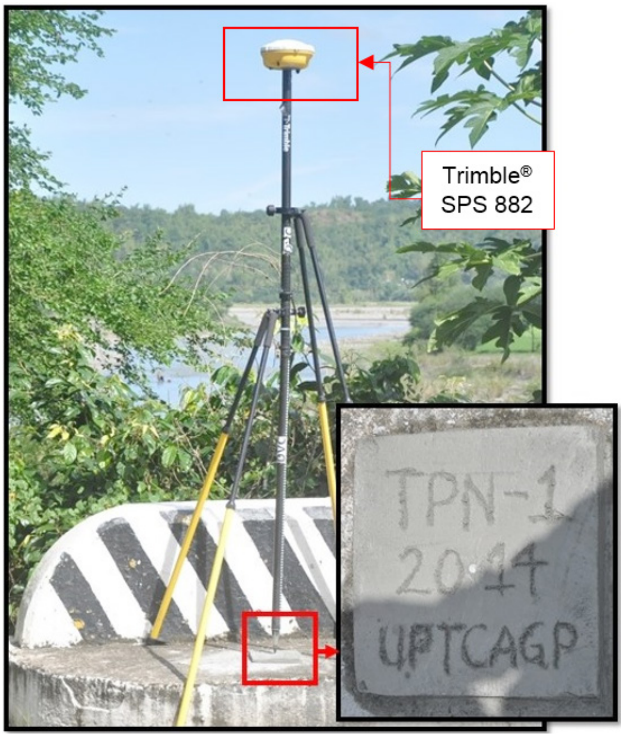


Figure 40. UP-TCAGP established control point, TPN-1, with Trimble® SPS 882 on Tipuluan Bridge in Brgy. Pasong, Municipality of Sibalom, Antique.

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 was performed. Masking is the removal or covering of portions of the baseline data using the same processing software. The data is then repeatedly processed until all baseline requirements are met. If the reiteration yields out of the required accuracy, a resurvey is initiated. Table 29 presents the baseline processing results of control points in the Sibalom 2River Basin, as generated by the TBC software.

Table 29. The Baseline processing report for the Sibalom 2River GNSS static observation survey.

Observation	Date of Observation	Solution Type	H. Prec. (Meter)	V. Prec. (Meter)	Geodetic Az.	Ellipsoid Dist. (Meter)	ΔHeight (Meter)
ATQ-20 --- AQ-72 (B4775)	09-26-2014	Fixed	0.007	0.022	208°43'33"	19743.041	-4.554
ATQ-20 --- TPN-1 (B4775)	09-26-2014	Fixed	0.006	0.021	184°45'37"	24723.786	22.496
AQ-72 --- TPN-1 (B4776)	09-26-2014	Fixed	0.005	0.014	134°32'57"	10438.795	27.074

As shown in Table 29, a total of three (3) baselines were processed with the coordinates of ATQ-20 and AQ-72 held fixed, it is apparent that all baselines passed the required accuracy.

4.4 Network Adjustment

After the baseline processing procedure, the network adjustment is performed using the TBC software. 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 for each control point; or in equation form:

<20cm and where:

x_e is the Easting Error,

y_e is the Northing Error, and

z_e is the Elevation Error

For complete details, see the Network Adjustment Report shown in Table 30 to Table 32.

The control point in which the coordinates were fixed during the network adjustment is shown in Table 30. Through this reference point, the coordinates of the unknown control points were computed. A difference in elevation of 0.9288 m between geoid (EGM2008) and MSL values of the reference point AQ-72 was applied for referring the elevation of the control points to MSL.

Table 30. Constraints applied to the adjustment of the control points.

Point ID	Type	East σ (Meter)	North σ (Meter)	Height σ (Meter)	Elevation σ (Meter)
ATQ-20	Global	Fixed	Fixed	Fixed	
Fixed = 0.000001(Meter)					

Likewise, the list of adjusted grid coordinates (i.e. Northing, Easting, Elevation, and computed standard errors of the control points in the network) is indicated in Table 31. All fixed control points have no values for grid and elevation errors.

Table 31. Adjusted grid coordinates for the control points used in the Sibalom 2River flood plain survey.

Point ID	Easting (Meter)	Easting Error (Meter)	Northing (Meter)	Northing Error (Meter)	Elevation (Meter)	Elevation Error (Meter)	Constraint
AQ-72	386654.679	0.063	1200045.589	0.033	6.513	0.256	
ATQ-20 396195.506 ? 1217324.5 63 ? 10.798						?	LLh
TPN-1	394067.041	0.058	1192699.1 27	0.031	33.065	0.259	

The results of the computation for accuracy are as follows:

a. AQ-72

horizontal accuracy = √((6.3)² + (3.3)²

= √(39.69 + 10.89)

= 7.11 cm < 20 cm

b. TPN-1

horizontal accuracy = √((5.8)² + (3.1)²

= √(33.64 + 9.61)

= 6.58 cm < 20 cm

Following the given formula, the horizontal and vertical accuracy result of the two occupied control points are within the required precision

Table 32. Adjusted geodetic coordinates for control points used in the Sibalom 2River Flood Plain validation.

Point ID	Latitude	Longitude	Ellipsoid Height (Meter)	Height Error (Meter)	Constraint
AQ-72	N10°51’14.92748”	E121°57’46.85471”	61.541	0.256	
ATQ-20	N11°00’38.44240”	E122°02’59.27039”	66.094	?	LLh
TPN-1	N10°47’16.56550”	E122°01’51.73167”	88.644	0.259	

The corresponding geodetic coordinates of the observed points are within the required accuracy as shown in Table 32. Based on the results of the computation, the equation is satisfied; hence, the required accuracy for the program was met. As seen in Table 33, the computed coordinates of the reference and control points utilized in the Sibalom 2River GNSS Static Survey.

Table 33. The reference and control points utilized in the Sibalom 2River Static Survey, with their corresponding locations (Source: NAMRIA, UP-TCAGP)

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)
ATQ-20	2nd Order GCP	11°00’38.44240”	122°02’59.27039”	66.094	1217324.563	396195.506	9.8692
AQ-72	1st Order BM	10°51’14.92748”	121°57’46.85471”	61.541	1200045.589	386654.679	5.5842
TPN-1	UP Established	10°47’16.56550”	122°01’51.73167”	88.644	1192699.127	394067.041	32.1362

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

The cross-section and as-built survey were conducted on September 26, 2016 on the upstream side of Tipuluan Bridge in Brgy. Tipuluan, Municipality of Sibalom2, and downstream side of Bugo Bridge in Municipality of San Remegio; using GNSS receiver, Trimble® SPS 882, in PPK survey technique (Figure 41).

Figure 41. (A)Cross section survey and (B)As-built survey in Tipuluan Bridge, Municipality of Sibalom2.

The cross-sectional line of Tinupulan Bridge is about 240 meters with one hundred sixty-two (162) cross-sectional points; while the Bugo Bridge is about 505 m with one hundred twenty-three (123) cross-sectional points. The cross-section diagrams, the location maps, and the accomplished bridge data forms are shown in Figure 42 to Figure 45.

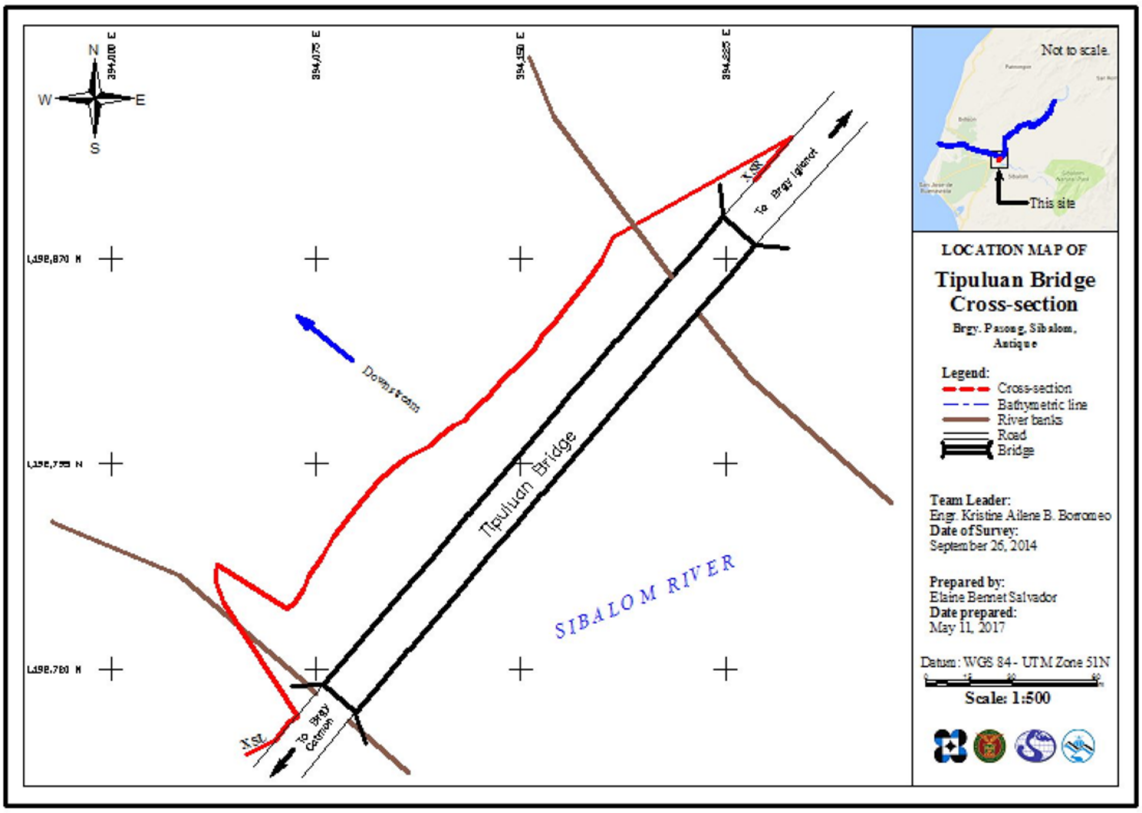


Figure 42. Location map of Tipuluan Bridge cross section

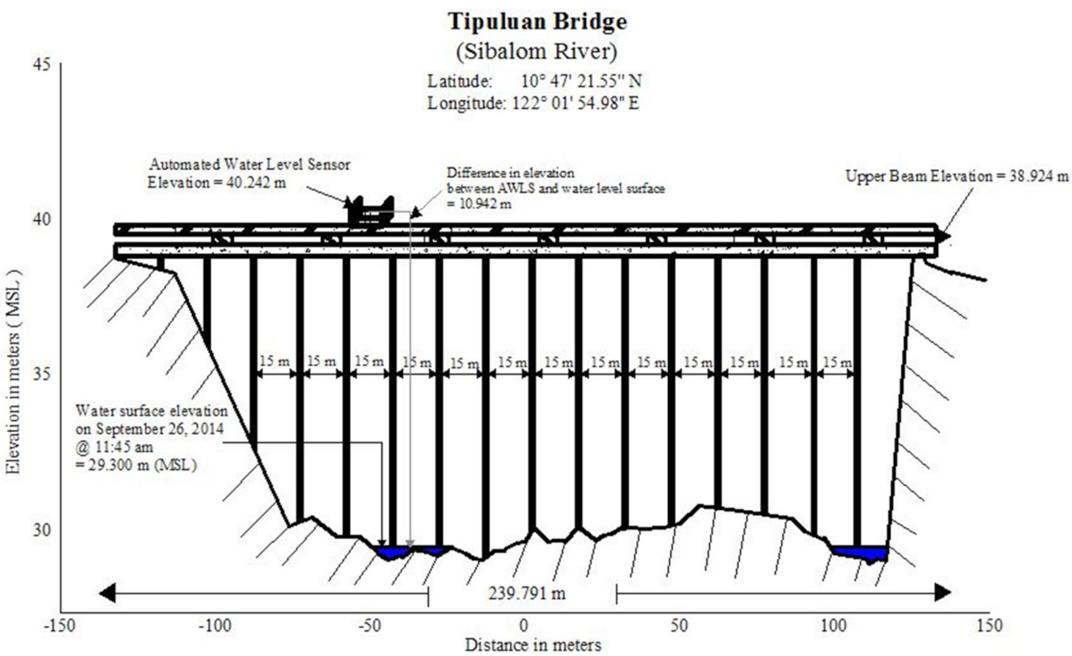


Figure 44. Tipuluan Bridge cross-section diagram.

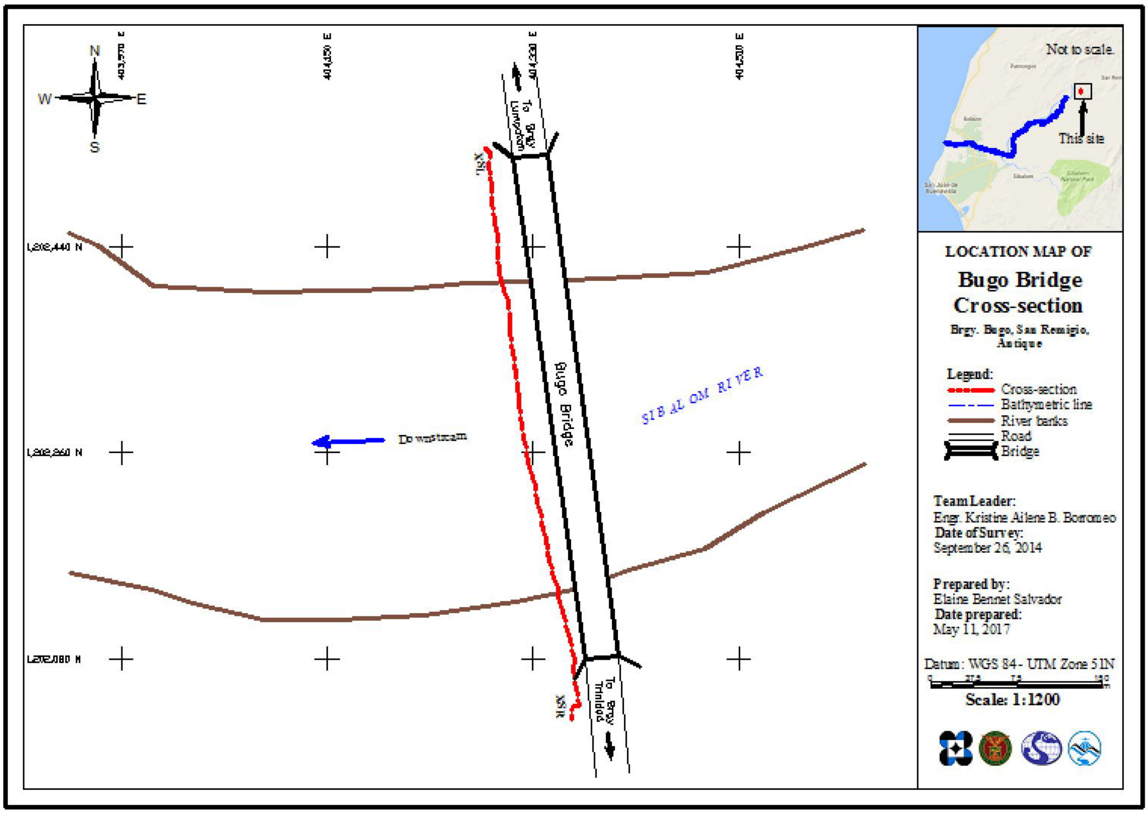


Figure 43. Location map of Bugo bridge cross section

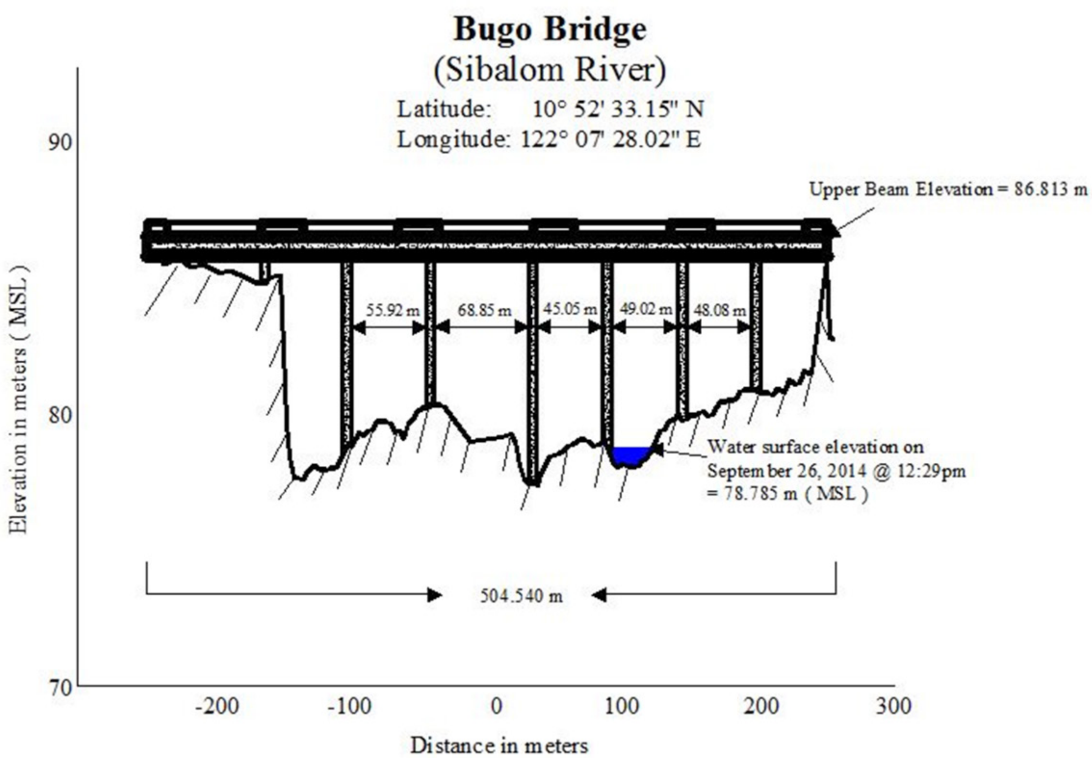


Figure 45. Bugo Bridge cross-section diagram.

Bridge Data Form

Bridge Name: Tipuluan Bridge **Date:** September 26, 2014

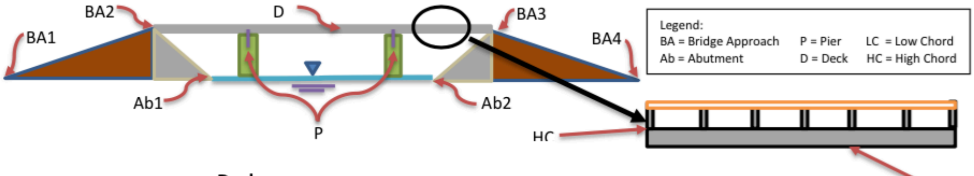
River Name: Sibalom River **Time:** 11:00 AM

Location (Brgy, City,Region): Brgy. Tipuluan, Municipality of Sibalom, Province of Antique

Survey Team: Antique Survey Team

Flow condition: low **normal** high **Weather Condition:** **fair** rainy

Latitude: 10°47'16.24190" **Longitude:** 122°01'51.17001"



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

Elevation: _______________ **Width:** ______________________ **Span (BA3-BA2):** _______________________

	Station	High Chord Elevation	Low Chord Elevation
1			
2			
3			
4			
5			

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	38.0472	BA3	280.8278	38.7412
BA2	23.4425	38.8152	BA4	300.8396	38.2122

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

	Station (Distance from BA1)	Elevation
Ab1	n/a	n/a
Ab2	n/a	n/a

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

Shape: _____________________ Number of Piers: ___________ Height of column footing: _______________

	Station (Distance from BA1)	Elevation	Pier Width
Pier 1	38.2156	38.9252	n/a
Pier 2	53.1053	38.9282	n/a
Pier 3	68.0259	38.8522	n/a
Pier 4	82.9987	38.8622	n/a
Pier 5	97.9220	38.8462	n/a
Pier 6	113.0293	38.8132	n/a
Pier 7	128.0455	38.8002	n/a
Pier 8	142.9736	38.8112	n/a
Pier 9	158.0288	38.7892	n/a
Pier 10	172.9185	38.8442	n/a
Pier 11	187.9039	38.7782	n/a
Pier 12	202.8502	38.8382	n/a
Pier 13	217.7706	38.8262	n/a
Pier 14	232.7856	38.7652	n/a
Pier 15	247.7471	38.8302	n/a
Pier 16	262.8069	38.8182	n/a
Pier 17	277.7965	38.7412	n/a

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

Figure 46. The Tipuluan Bridge as-built survey data.

Bridge Data Form

Culvert Name: Bugo Bridge **Date: September 26, 2014**

River Name: Sibalom River **Time: 10:30AM**

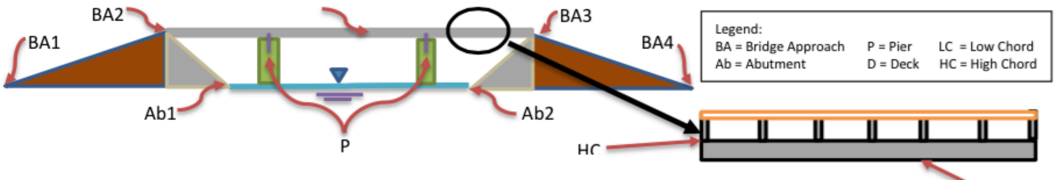
Location (Brgy, City,Region): Municipality of San Remigio, Antique Province

Survey Team: Antique Survey Team

Flow condition: low **normal** high

Weather Condition: **fair** raining

Latitude: 10d52'21.24251" **Longitude: 122d07'29.87589"**



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

Elevation: _______________ **Width:** _____________________ **Span (BA3-BA2):** ______________________

	Station	High Chord Elevation	Low Chord Elevation
1			
2			
3			
4			
5			

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	86.813	BA3	489.881	81.7732
BA2	116.031	77.8442	BA4	504.5387677	83.015

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

	Station (Distance from BA1)	Elevation
Ab1	n/a	n/a
Ab2	n/a	n/a

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

Shape: rectangular Number of Piers: 6 Height of column footing: _______________

	Station (Distance from BA1)	Elevation	Pier Width
Pier 1	87.36552	85.029	n/a
Pier 2	147.3857	79.069	n/a
Pier 3	209.3047	80.55	n/a
Pier 4	339.2011	79.049	n/a
Pier 5	394.218	80.001	n/a
Pier 6	451.2956	81.009	n/a

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

Figure 47. The Bugo Bridge as-built survey data.

4.6 Validation Points Acquisition Survey

The validation points acquisition survey was conducted on October 3, 5, and 6, 2014, using a survey grade GNSS rover receiver, Trimble® SPS 882 mounted on a pole which was attached in front of the vehicle. It was secured with a nylon rope to ensure that it was horizontally and vertically balanced as shown in Figure 48.

Figure 48. (A) Trimble™ SPS 882 attached to a vehicle and (B) Setting up of GNSS base station at ATQ-20

The survey acquired 9,787 ground validation points with an approximate length of 82.264 km as shown in Figure 49.

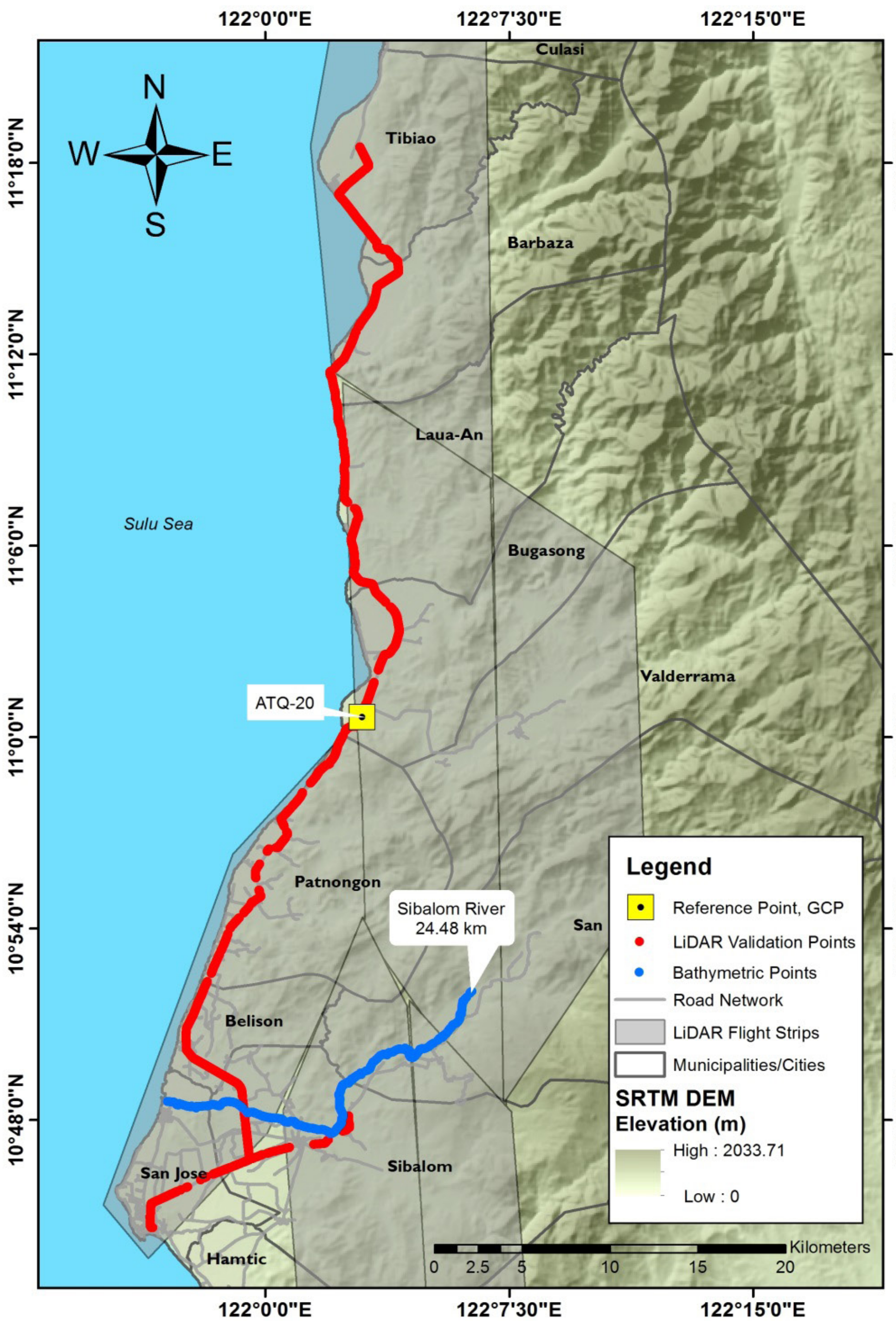


Figure 49. The extent of the LiDAR ground validation survey along Antique

4.7 River Bathymetric Survey

The bathymetric survey line has an estimated length of 24.48 km with a total of 630 points gathered using ATQ-20 and TPN-1 as GNSS base stations. The processed data was generated into map using GIS software and processed further using CAD for plotting the riverbed. The generated map, shown in Figure 51, exhibits the bathymetry survey coverage, while Figure 52 and Figure 53 illustrate the Sibalom 2river-bed profile. There was an abrupt change in elevation of about 20m within the 20 km. The highest elevation was 66.86 m in MSL in Brgy. Madalena, while the lowest elevation was -0.77 m below MSL in Brgy. San Pedro.

A manual bathymetric survey was executed on October 4, 5, and 8, 2014 using Trimble® SPS 882 in GNS PPK survey technique as shown in Figure 50. The survey began in the upstream part of the river in Brgy. Magdalena, Municipality of San Remigio, with coordinates 10°52'01.78720" 122°06'22.16921", traversed downstream by foot and ended at the mouth of the river in Brgy. San Pedro, Municipality of San Jose, Antique with coordinates 10°48'34.06230" 121°57'02.63833"

Figure 50. The setup for the manual Bathymetric Survey in Sibalom 2River

Figure 51. The extent of the Sibalom 2River Bathymetry Survey

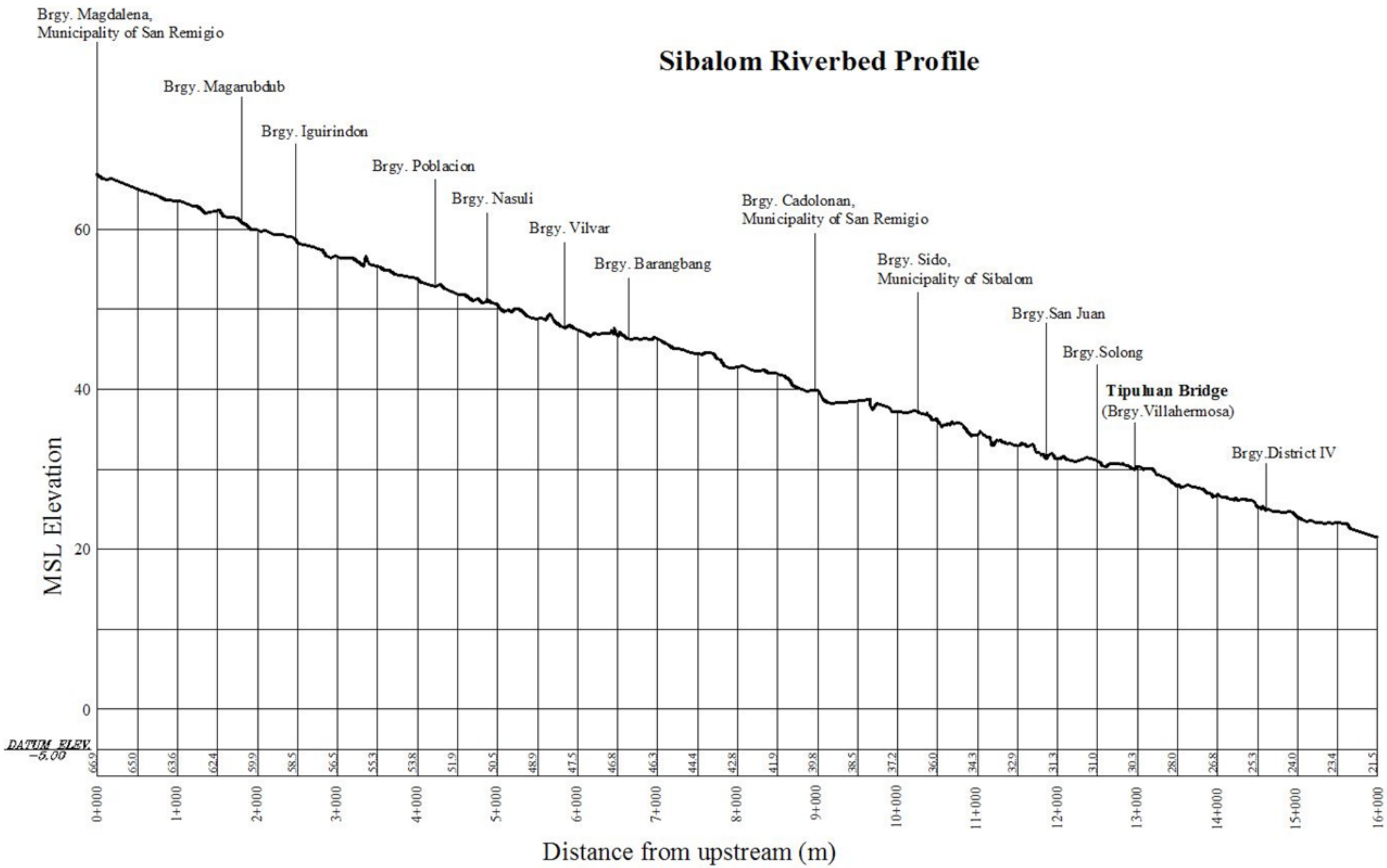


Figure 52. Sibalom Riverbed Profile from Brgy.Magdalena, Municipality of San Remigio down to Brgy. District IV, Municipality of Sibalom

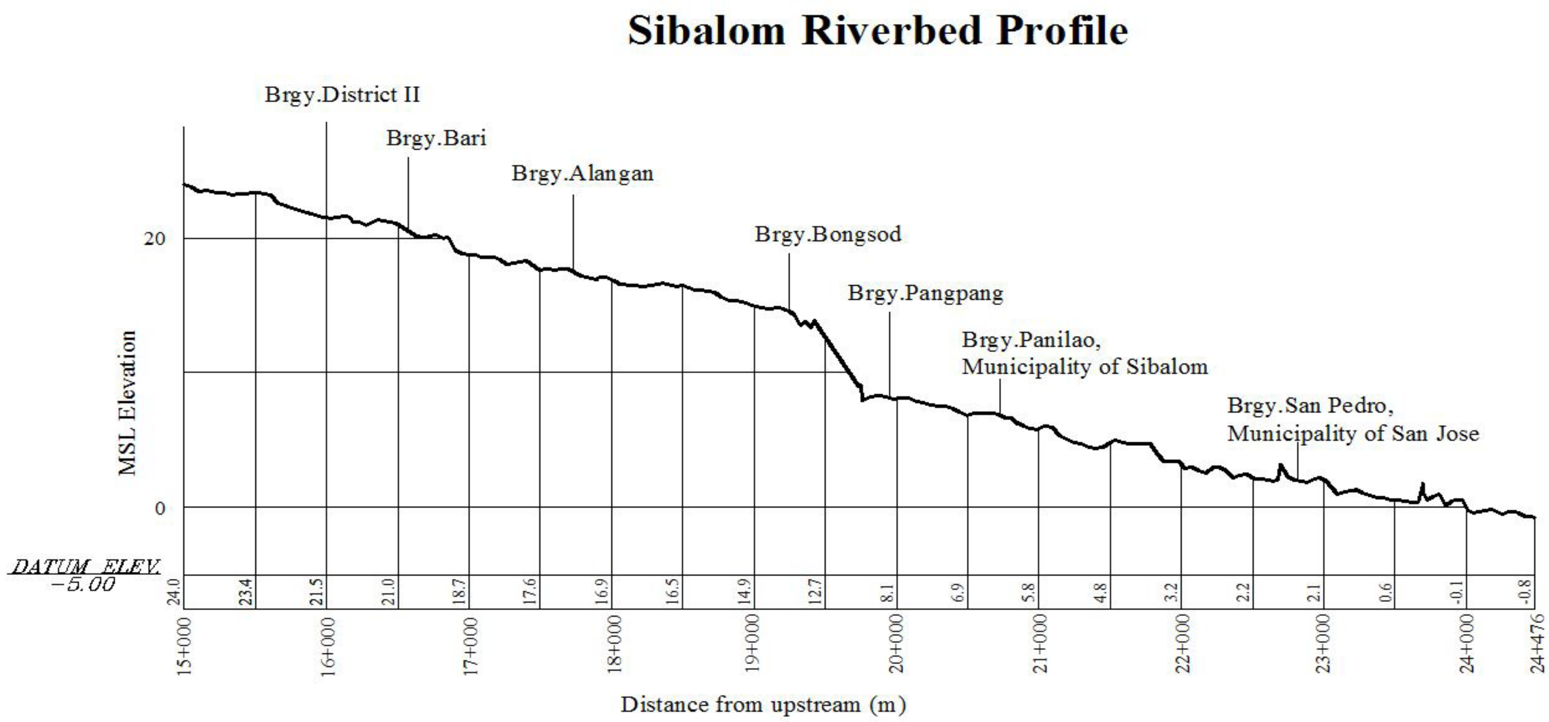


Figure 53. Continuation of Sibalom Riverbed Profile from Brgy. District II, Municipality of Sibalom down to Brgy. San Pedro, Municipality of San Jose

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, Narvin Clyd, Marvin Arias

The methods applied in this Chapter were based on the DREAM methods manual (Lagmay, 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 components and data that affect the hydrologic cycle of the Sibalom 2River Basin were monitored, collected, and analyzed. Rainfall, water level, and flow in a certain period of time, which may affect the hydrologic cycle of the Sibalom 2River Basin were monitored, collected, and analyzed.

5.1.2 Precipitation

Precipitation data was taken from an automatic rain gauge (ARG) deployed by the UP Cebu Flood Modeling Component (FMC) team. The ARG was installed Bugo Bridge, San Remegio, Antique. The precipitation data collection started from November 25, 2016 at 4:00 AM at 6:20 PM with a recording interval of 10 minutes.

The total precipitation for this event in Bugo Bridge ARG was 223 mm with a peak rainfall of 17 mm. on November 25, 2016 at 9:20 in the morning. The lag time between the peak rainfall and discharge is 1 hour and 30 minutes.

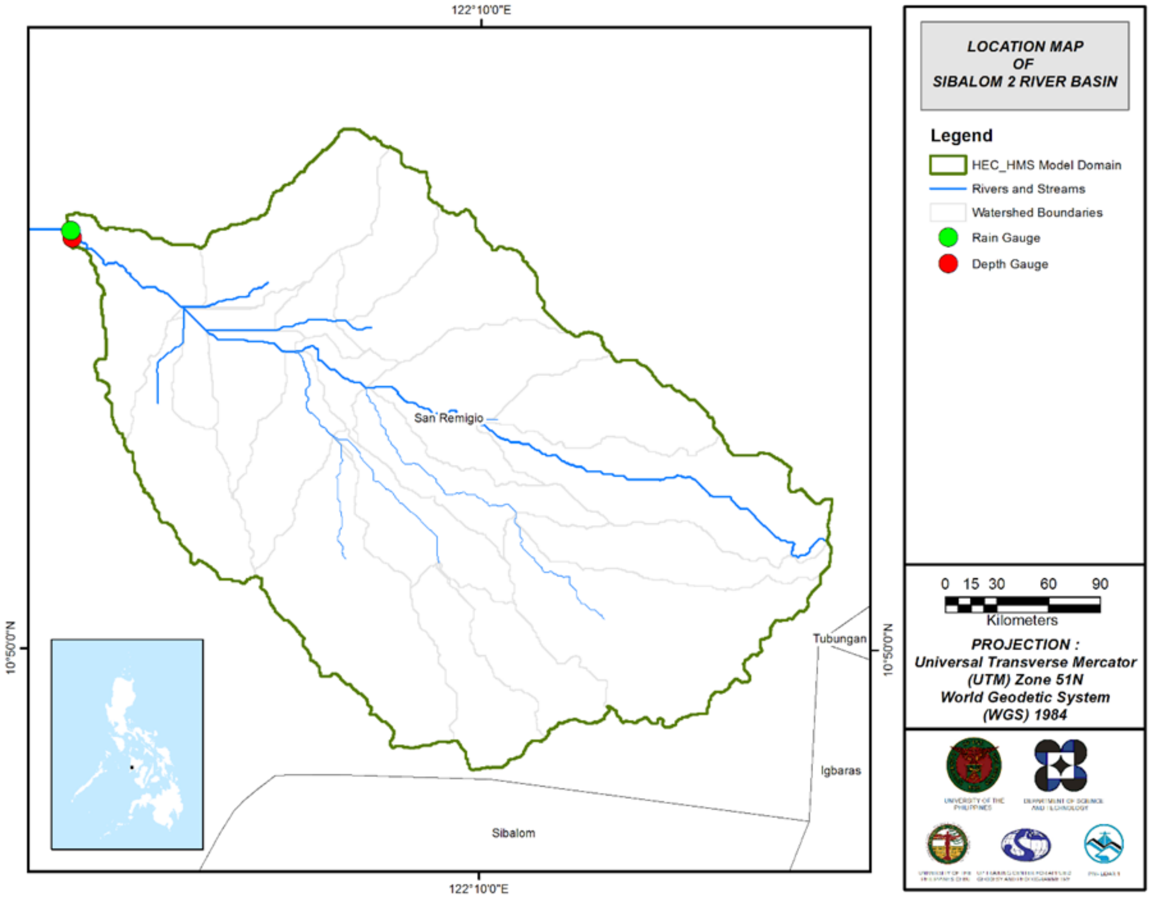


Figure 54. The location map of Sibalom 2HEC-HMS model used for calibration.

5.1.3 Rating Curves and River Outflow

A rating curve was computed using the prevailing cross-section at Bugo Bridge, San Remegio, Antique (10°52’29.59”N, 122° 7’29.20”E). It gives the relationship between the observed water levels at Bogo Bridge and outflow of the watershed at this location.

For Bugo Bridge, the rating curve is expressed as $Q = 7E\text{-}09e^{0..3182x}$ as shown in Figure 56.

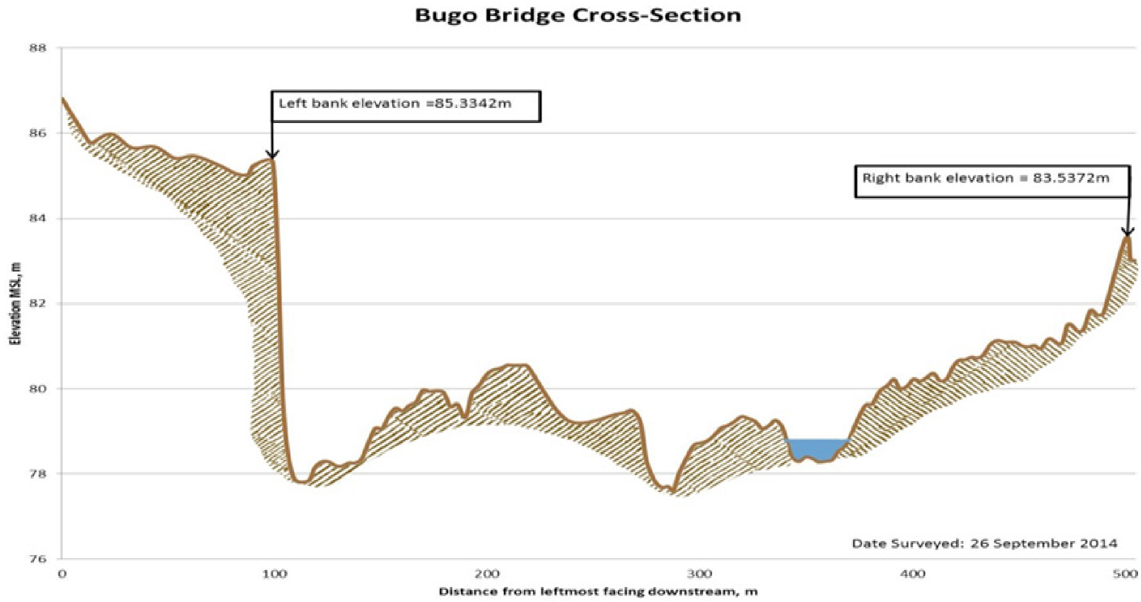


Figure 55. Cross-Section plot of Bugo Bridge.

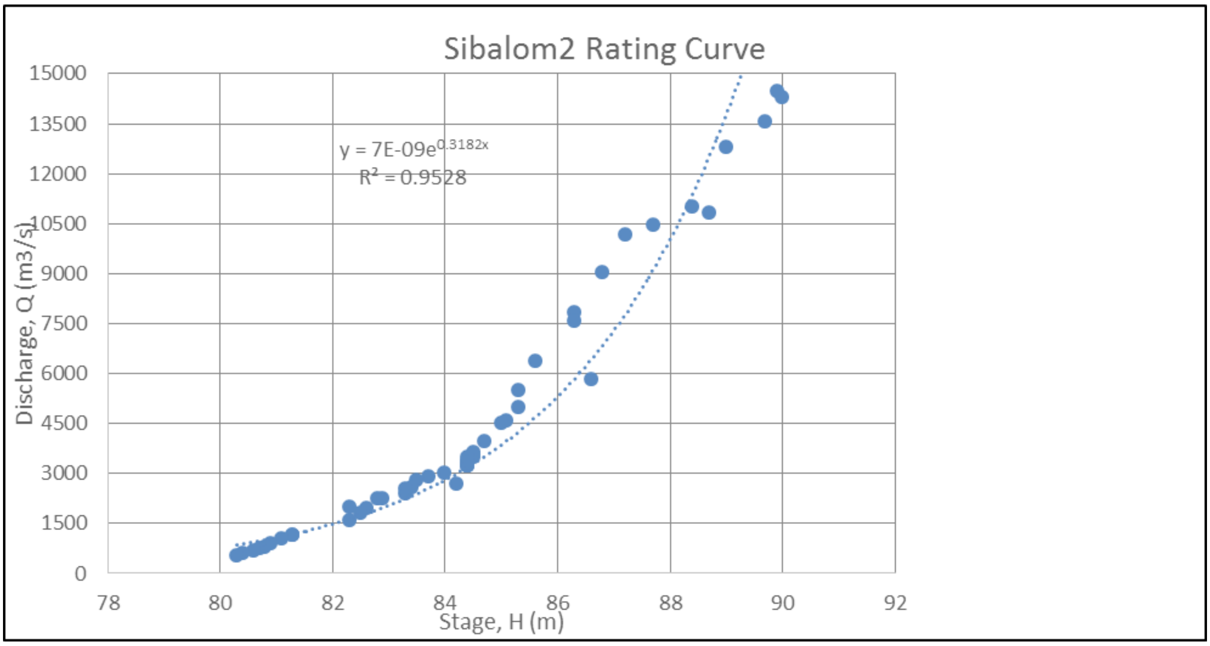


Figure 56. The rating curve at Bugo Bridge, San Remegio, Antique.

This rating curve equation was used to compute the river outflow at Bugo Bridge for the calibration of the HEC-HMS model shown in Figure 57. The total rainfall for this event is 223mm and the peak discharge is 14090.2 m^3 at 10:50 AM, November 25, 2016.

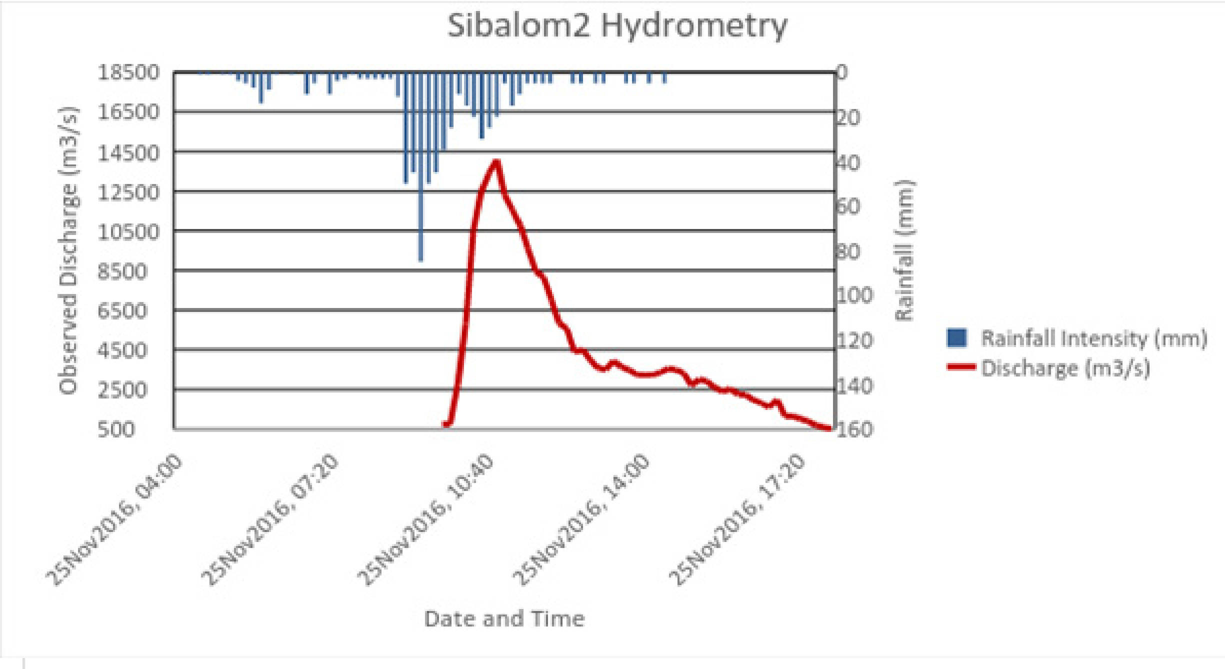


Figure 57. Rainfall and outflow data of the Sibalom 2River Basin, which was used for modeling.

5.2 RIDF Station

PAGASA computed the Rainfall Intensity Duration Frequency (RIDF) values for the Iloilo Rain Gauge (Table 34). The RIDF rainfall amount for 24 hours was converted into a synthetic storm by interpolating and re-arranging the values in such a way that certain peak values will be attained at a certain time (Figure 59). This station was selected based on its proximity to the Sibalom 2watershed (Figure 58). The extreme values for this watershed were computed based on a 59-year record.

Table 34. RIDF values for the Iloilo Rain Gauge, as computed by PAGASA

	COMPUTED EXTREME VALUES (in mm) OF PRECIPITATION							
T (yrs)	**10 mins**	**20 mins**	**30 mins**	**1 hr**	**2 hrs**	**3 hrs**	**6 hrs**	**12 hrs**	**24 hrs**
5	28.7	39.4	48	59.4	74.9	90	114.7	131.7	165.2
10	33.9	45.6	55.6	68.1	85	103.6	133.6	155.4	198.9
25	40.5	53.5	65.3	79.2	97.6	120.8	157.6	185.3	241.5
50	45.4	59.4	72.4	87.3	107	133.5	175.3	207.4	273.1
100	50.3	65.2	79.5	95.4	116.4	146.2	193	229.4	304.5

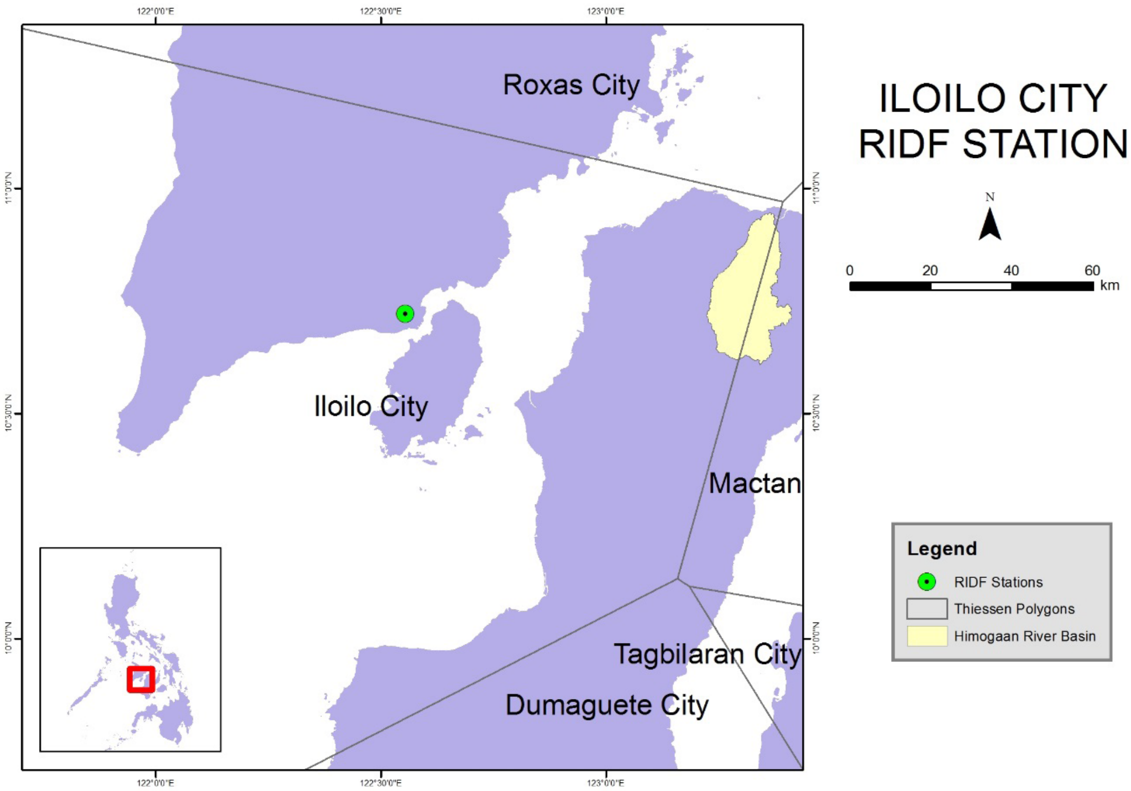


Figure 58. The location of the Iloilo RIDF station relative to the Sibalom 2River Basin.

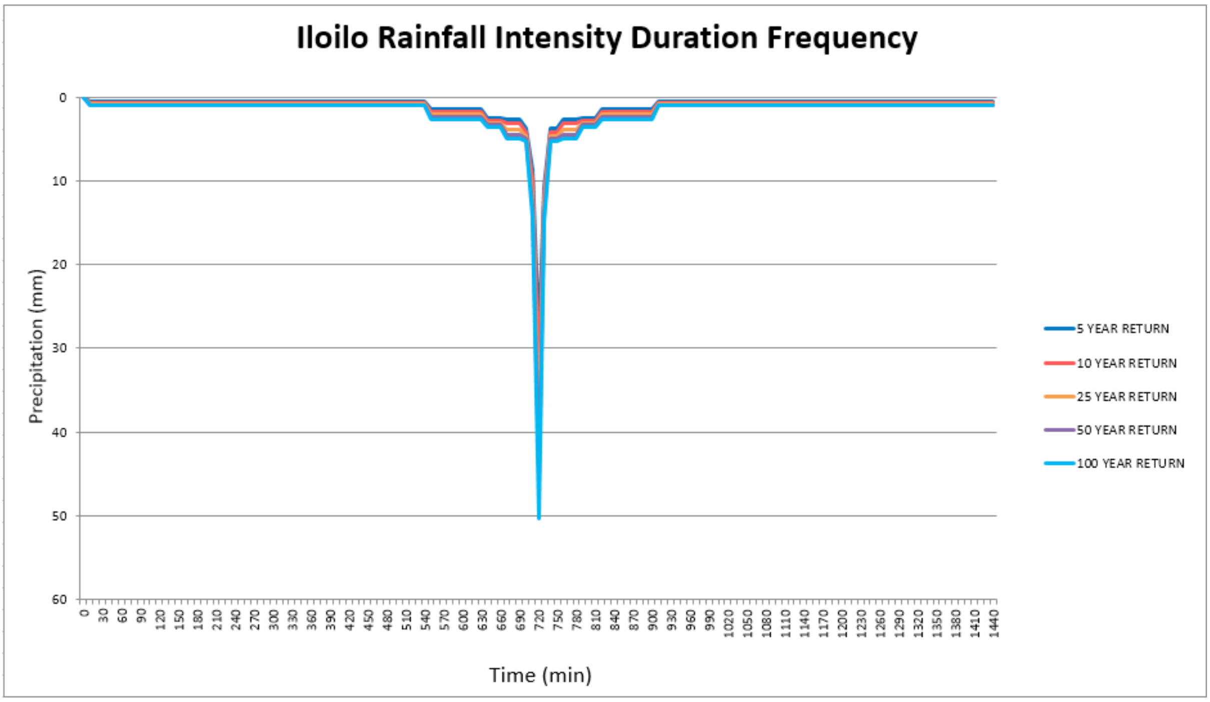


Figure 59. Synthetic storm generated for a 24-hour period rainfall for various return periods.

5.3 HMS Model

The soil shapefile was taken on 2004 from the Bureau of Soils; this is under the Department of Environment and Natural Resources Management. The land cover shape file is from the National Mapping and Resource information Authority (NAMRIA). The soil, land cover, and slope map of the Sibalom 2River Basin are shown in Figure 60 and Figure 61, respectively.

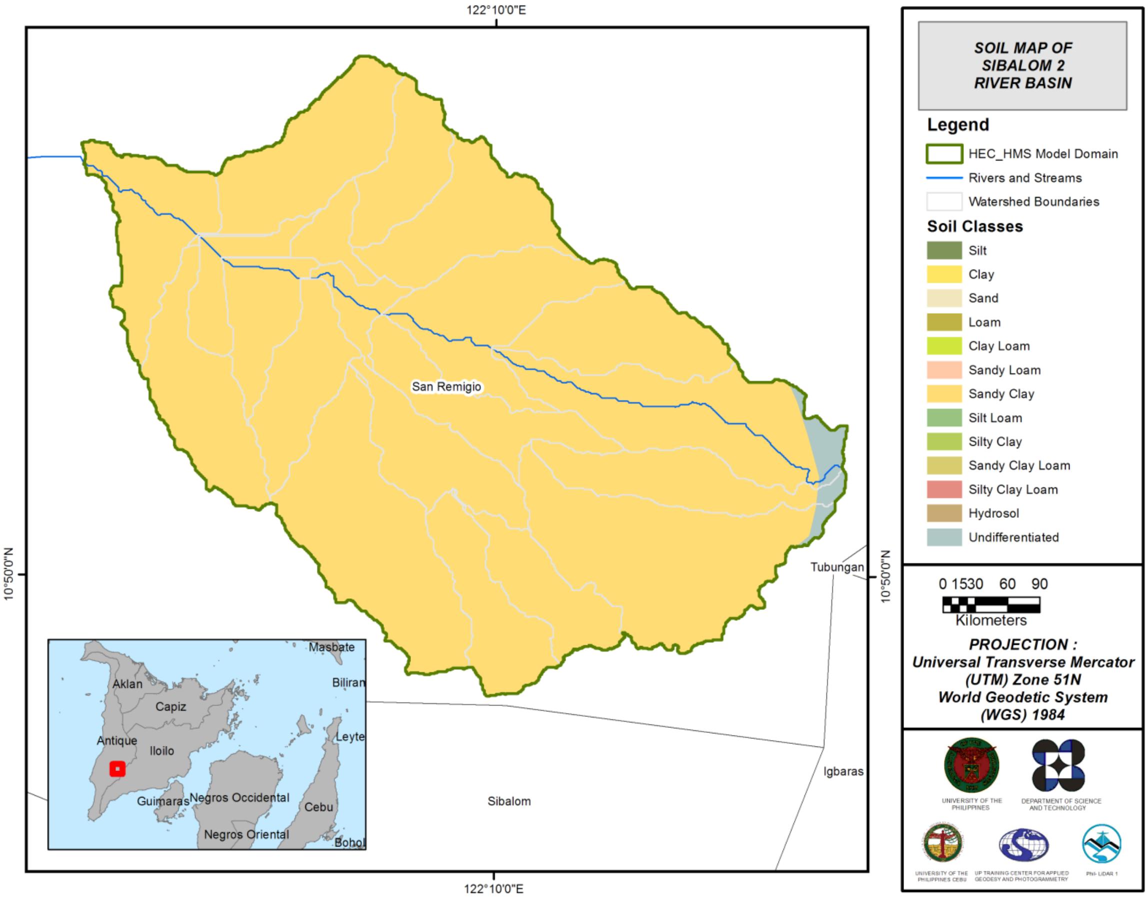


Figure 60. Soil map of the Sibalom 2River Basin.

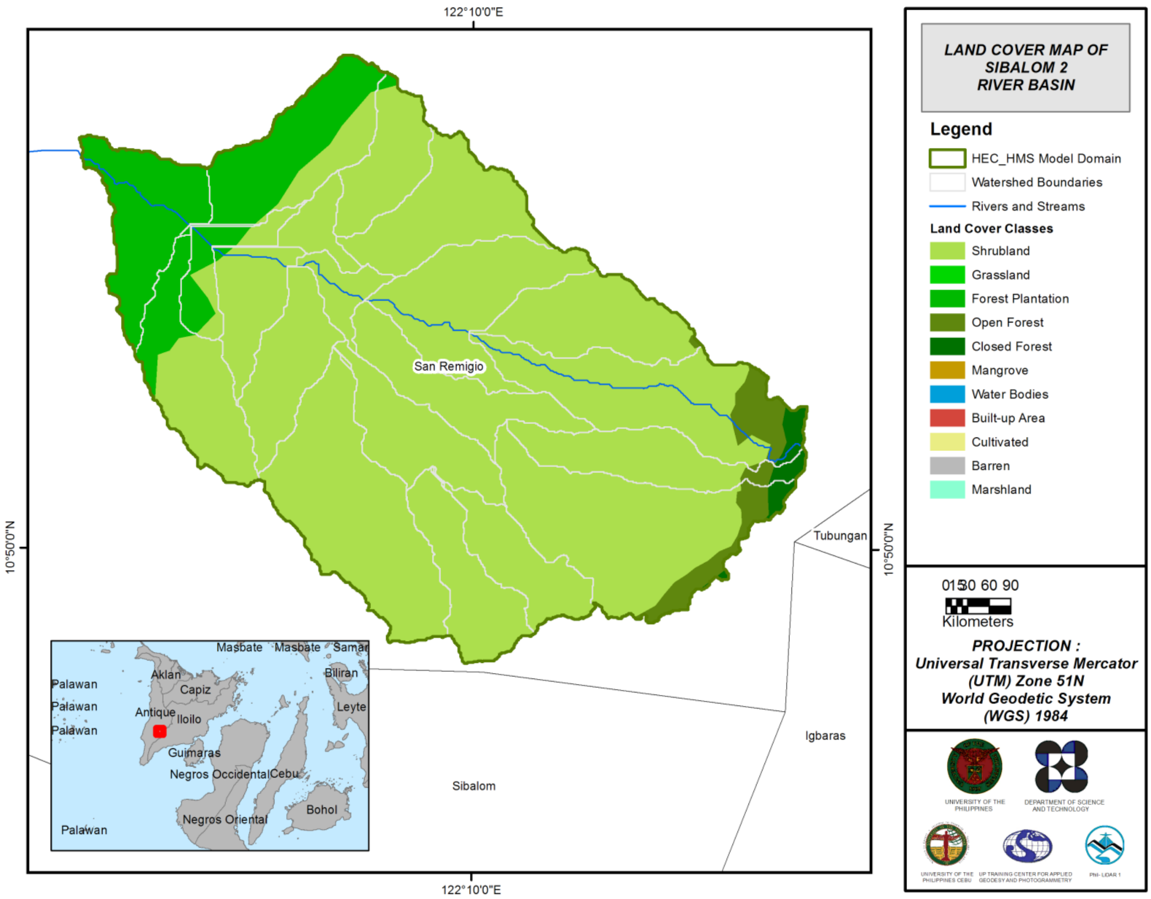


Figure 61. Land Cover Map of Sibalom 2River Basin.

For Sibalom2, two soil classes were identified. These are clay and undifferentiated soil. Moreover, four land cover classes were identified. These are open and closed forest, shubland, and forest plantation.

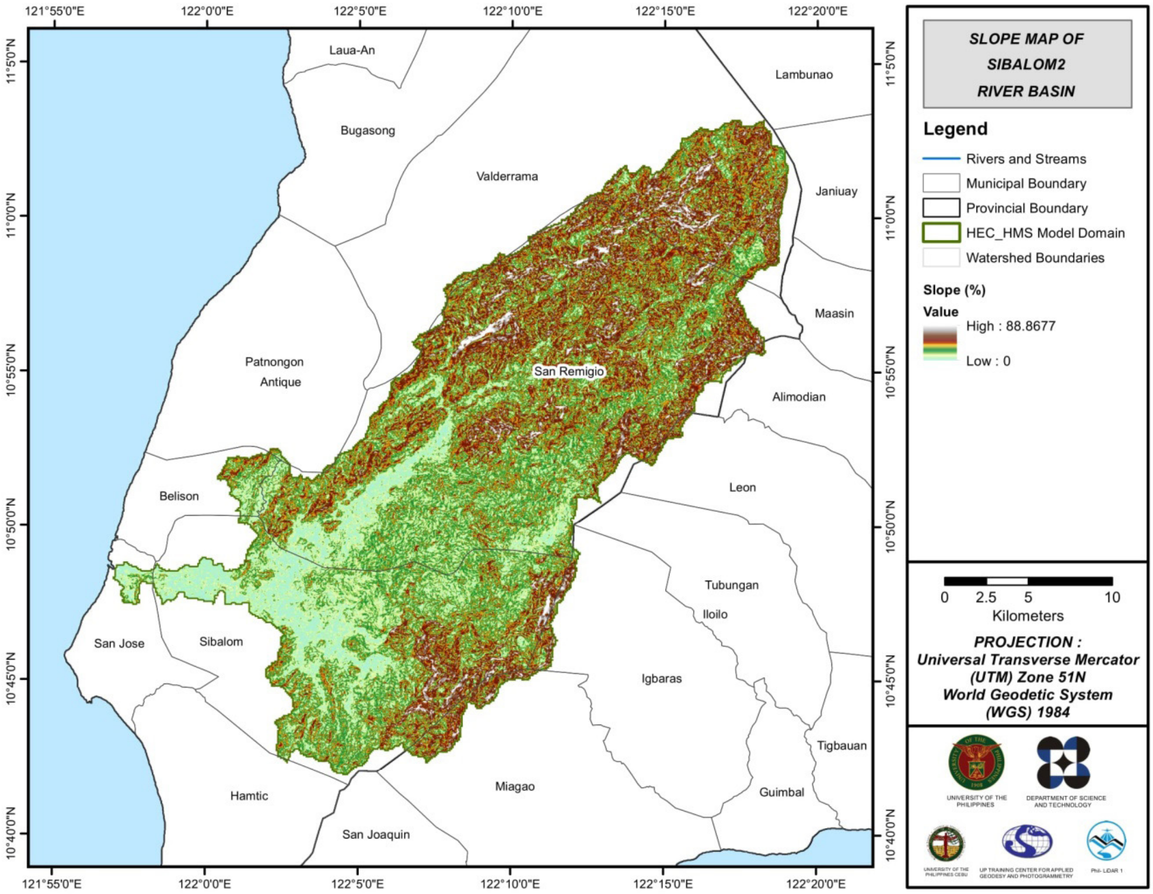


Figure 62. Slope Map of the Sibalom 2River Basin

Using the SAR-based DEM, the Sibalom 2basin was delineated and further subdivided into subbasins. The model consists of 21 sub basins, 10 reaches, and 10 junctions as shown in Figure 63. The main outlet is at Bugo Bridge.

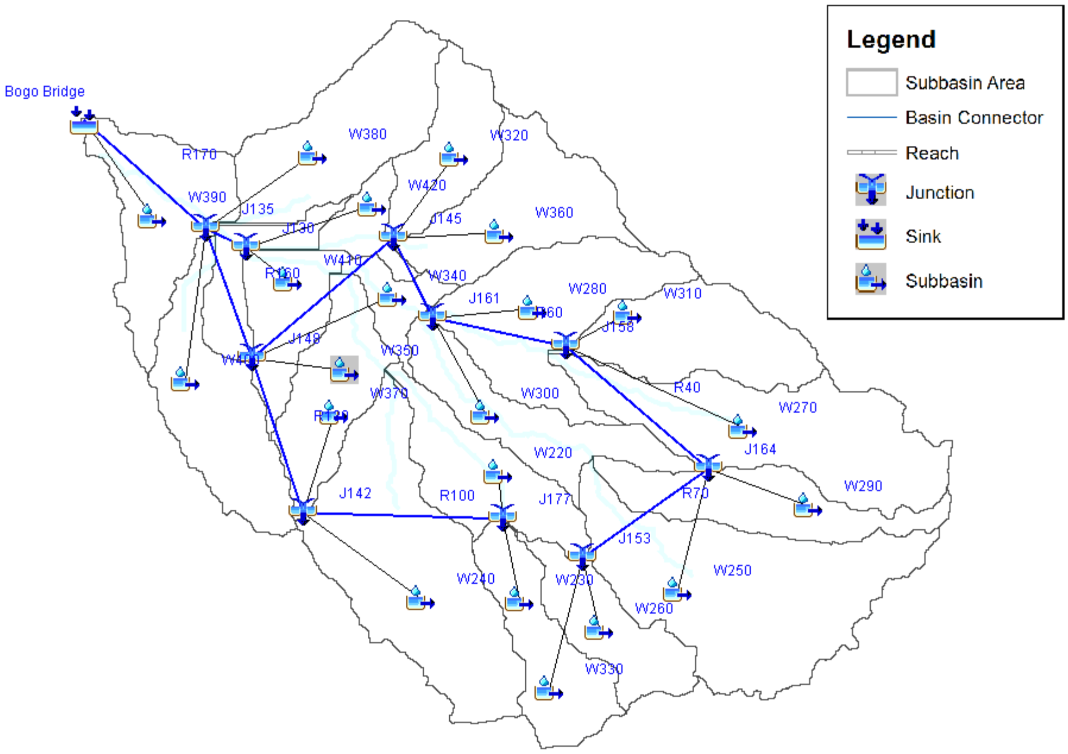


Figure 63. The Sibalom 2river basin model generated using HEC-HMS.

5.4 Cross-section Data

The 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, which was defined using the Arc GeoRAS tool and was post-processed in ArcGIS (Figure 64).

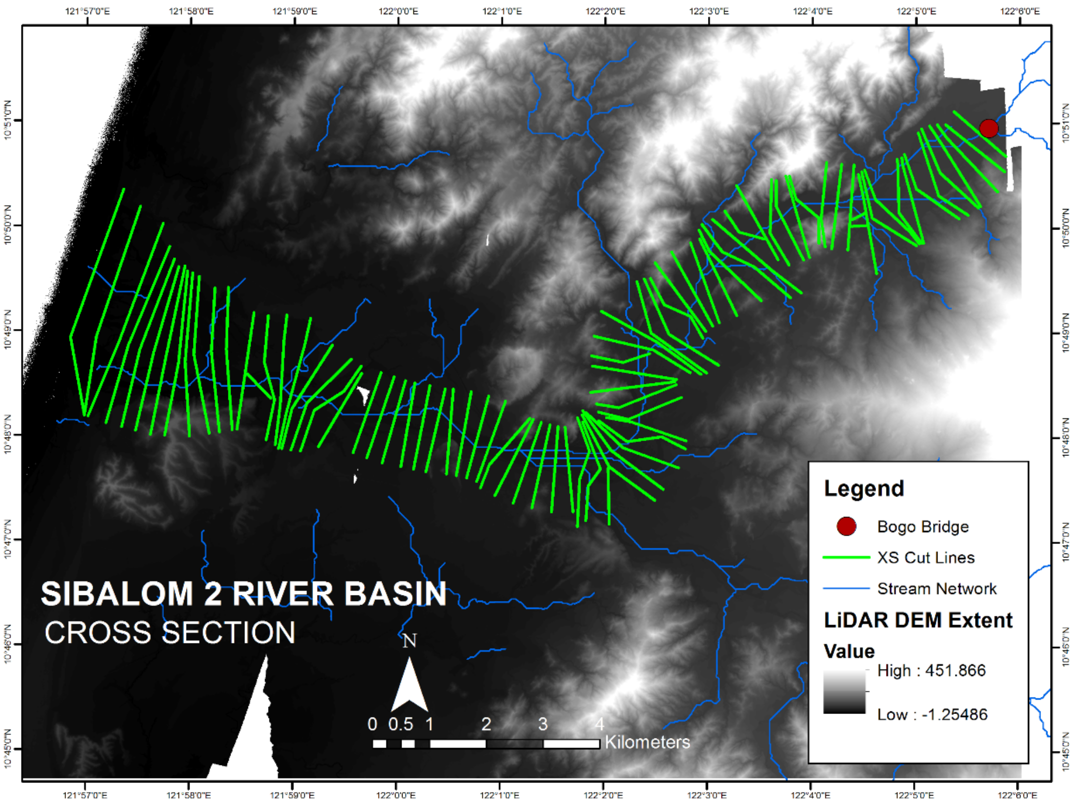


Figure 64. River cross-section of the Sibalom 2River through the ArcMap HEC GeoRas tool.

5.5 Flo 2D Model

The automated modelling process allows for the creation of a model with boundaries that are almost exactly coincidental with that of the catchment area. As such, they have approximately the same land area and location. The entire area is divided into square grid elements, 10 meter by 10 meter in size. Each element is assigned a unique grid element number which serves as its identifier, then attributed with the parameters required for modelling such as x-and y-coordinate of centroid, names of adjacent grid elements, Manning coefficient of roughness, infiltration, and elevation value. The elements are arranged spatially to form the model, allowing the software to simulate the flow of water across the grid elements and in eight directions (north, south, east, west, northeast, northwest, southeast, southwest).

Based on the elevation and flow direction, it is seen that the water will generally flow from the south of the model to the northeast, following the main channel. As such, boundary elements in those particular regions of the model are assigned as inflow and outflow elements respectively.

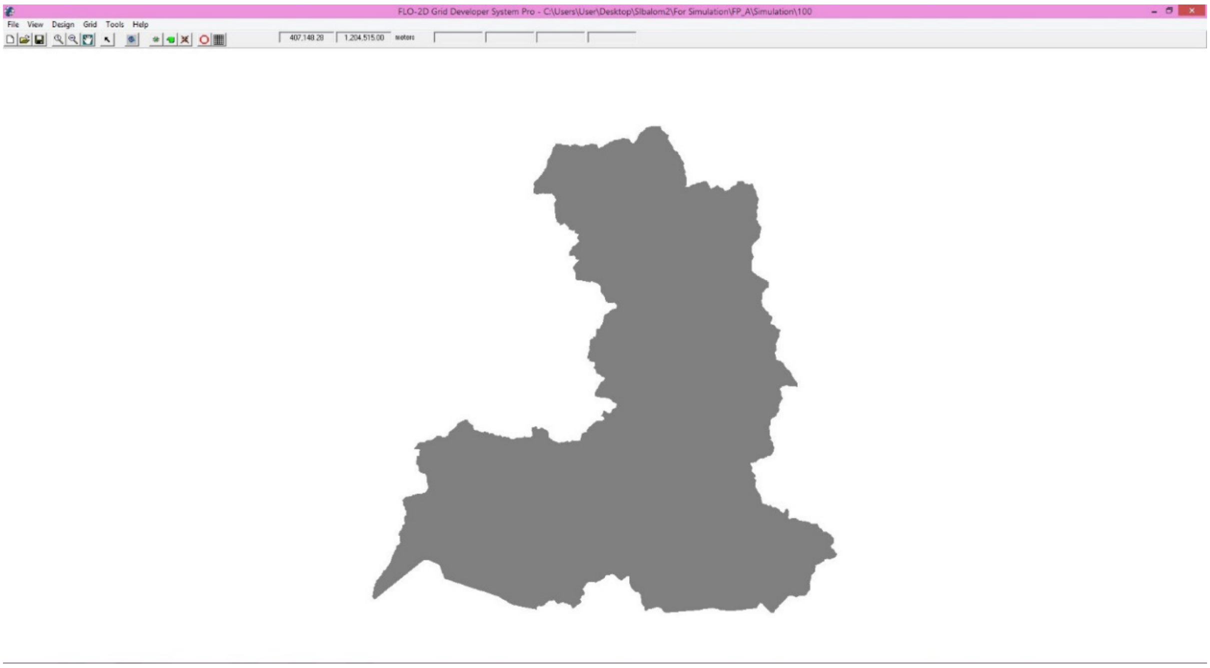


Figure 65. A screenshot of the river sub-catchment with the computational area to be modeled in FLO-2D Grid Developer System Pro (FLO-2D GDS Pro).

The simulation is then run through FLO-2D GDS Pro. This particular model had a computer run time of 39.55225 hours. After the simulation, FLO-2D Mapper Pro is used to transform the simulation results into spatial data that shows flood hazard levels, as well as the extent and inundation of the flood. Assigning the appropriate flood depth and velocity values for Low, Medium, and High creates the following food hazard map. Most of the default values given by FLO-2D Mapper Pro are used, except for those in the Low hazard level. For this particular level, the minimum h (Maximum depth) is set at 0.2 m while the minimum vh (Product of maximum velocity (v) times maximum depth (h)) is set at 0 m^2/s. The generated hazard maps for Sibalom 2are in Figure 69, 71, and 73.

The creation of a flood hazard map from the model also automatically creates a flow depth map depicting the maximum amount of inundation for every grid element. The legend used by default in Flo-2D Mapper is not a good representation of the range of flood inundation values, so a different legend is used for the layout. In this particular model, the inundated parts cover a maximum land area of 82,261,728 m^2. The generated flood depth maps for Sibalom 2are in Figure 70, 72, and 74.

There is a total of 18,419,757.72 m^3 of water entering the model. Of this amount, 10,725,727.85 m^3 is due to rainfall while 7,694,029.87 m^3 is inflow from other areas outside the model 3,960,626.75 m^3 of this water is lost to infiltration and interception, while 12,447,417.07 m^3 is stored by the flood plain. The rest, amounting up to 2,011,714.06 m^3, is outflow.

5.6 Results of HMS Calibration

After calibrating the Sibalom 2HEC-HMS river basin model, its accuracy was measured against the observed values. Figure 66 shows the comparison between the two discharge data.

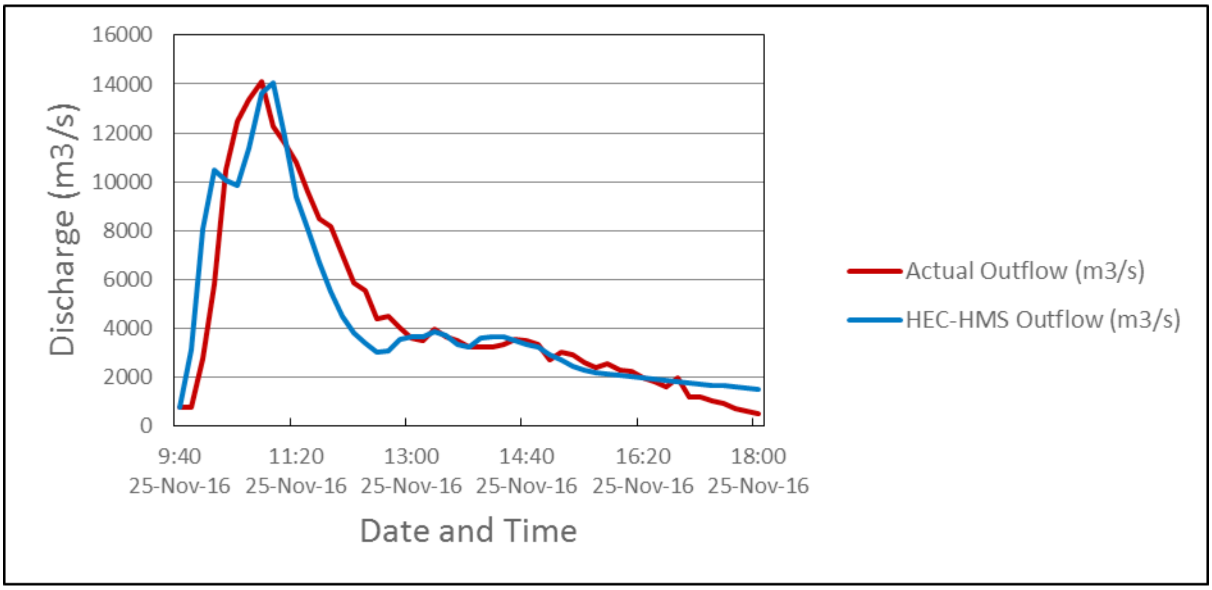


Figure 66. Outflow Hydrograph of Sibalom 2produced by the HEC-HMS model compared with observed outflow.

Table 35 shows adjusted ranges of values of the parameters used in calibrating the model.

Table 35. Range of calibrated values for the Sibalom 2River Basin.

Hydrologic Element	Calculation Type	Method	Parameter	Range of Calibrated Values
Basin	Loss	SCS Curve number	Initial Abstraction (mm)	0.03-0.195
			Curve Number	82.1-99
	Transform	Clark Unit Hydrograph	Time of Concentration (hr)	0.016-0.19
			Storage Coefficient (hr)	0.016-0.29
	Baseflow	Recession	Recession Constant	0.02
			Ratio to Peak	0.2
Reach	Routing	Muskingum-Cunge	Manning's Coefficient	0.0075

Initial 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 from 0.03 mm to 0.195 mm means that there is minimal to 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 82.1-99 for curve number is advisable for Philippine watersheds depending on the soil and land cover of the area (M. Horritt, personal communication, 2012). For Sibalom2, the basin mostly consists of closed and open forests, shurblands, and forest plantations, and the soil consists of clay, and undifferentiated soil.

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 from 0.016 hours to 0.29 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 0.02 indicates that the basin is unlikely to quickly go back to its original discharge and instead, will be higher. Ratio to peak of 0.2 indicates a smoother receding limb of the outflow hydrograph.

Manning's roughness coefficient of 0.0075 for the Sibalom 2river basin is lower than thei usual Manning's n value in the Philippines (Brunner, 2010).

Table 36. Summary of the Efficiency Test of the Sibalom 2HMS Model

Accuracy measure	Value
RMSE	1.5
r^2	0.9163
NSE	0.84
PBIAS	0.40
RSR	1.85

The Root Mean Square Error (RMSE) method aggregates the individual differences of these two measurements. It was computed as 1.5 (m3/s).

The Pearson correlation coefficient (r^2) 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 0.9163.

The Nash-Sutcliffe (E) method was also used to assess the predictive power of the model. Here the optimal value is 1. The model attained an efficiency coefficient of 0.84.

A positive Percent Bias (PBIAS) indicates a model's propensity towards under-prediction. Negative values indicate bias towards over-prediction. Again, the optimal value is 0. In the model, the PBIAS is 0.40.

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 1.85.

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 67) shows the Sibalom 2outflow using the Iloilo Rainfall Intensity-Duration-Frequency curves (RIDF) in 5 different return periods (5-year, 10-year, 25-year, 50-year, and 100-year rainfall time series) based on the Philippine Atmospheric Geophysical and Astronomical Services Administration (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 from 165.2m^3 in a 5-year return period to 304.5m^3 for a 100-year return period.

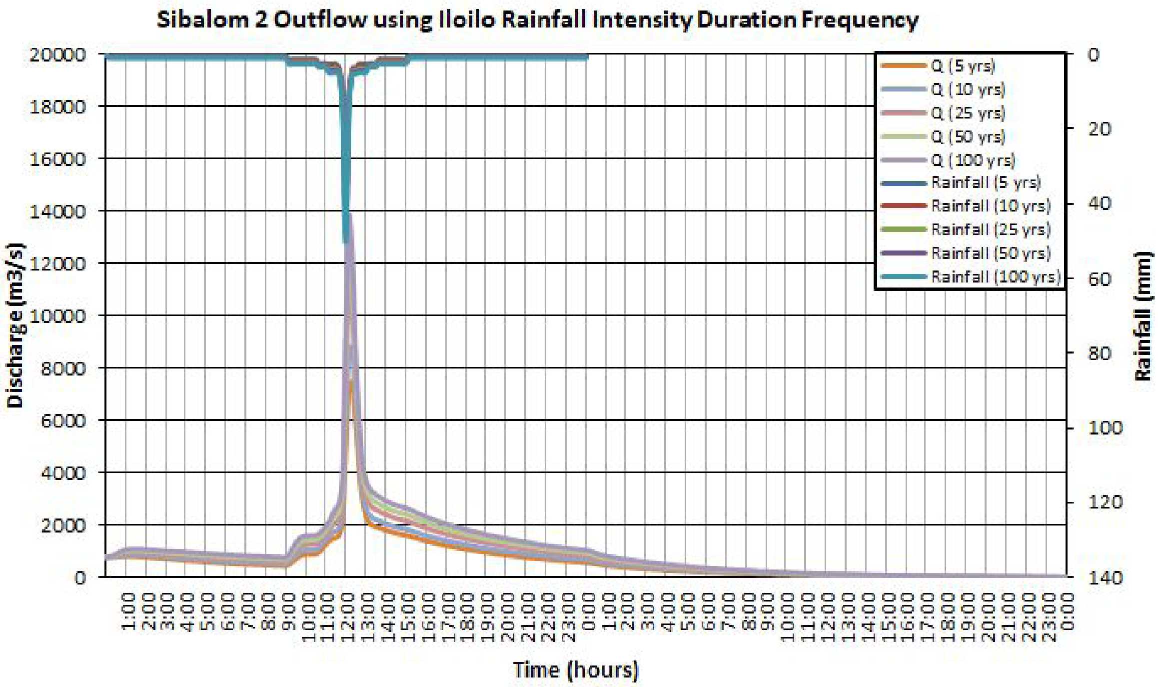


Figure 67. The Outflow hydrograph at the Simbalon2 Station generated using Iloilo RIDF simulated in HEC-HMS.

A summary of the total precipitation, peak rainfall, peak outflow and time to peak of the Sibalom 2discharge using the Iloilo Rainfall Intensity-Duration-Frequency curves (RIDF) in five different return periods is shown in Table 37.

Table 37. The peak values of the Sibalom 2HEC-HMS Model outflow using the Romblon RIDF.

RIDF Period	Total Precipitation (mm)	Peak rainfall (mm)	Peak outflow (m^3/s)	Time to Peak
5-Year	165.2	28.7	7465.2	20 minutes
10-Year	198.9	33.9	8800.6	10 minutes
25-Year	241.5	40.5	10762.4	10 minutes
50-Year	273.1	45.4	12281.4	10 minutes
100-Year	304.5	50.3	13721.9	10 minutes

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. Figure 68 shows a generated sample map of the Sibalom 2River using the calibrated HMS base flow.

Figure 68. The sample output map of the Sibalom 2RAS Model.

5.9 Flow Depth and Flood Hazard

The resulting hazard and flow depth maps have a 10m resolution. Figure 15 to Figure 20 shows the 5-, 25-, and 100-year rain return scenarios of the Sibalom 2floodplain. The floodplain, with an area of 183.06 sq.km., covers five municipalities namely, Belison, Patnongon, San Jose, San Remigio, and Sibalom. Table 38 shows the percentage of area affected by flooding per municipality.

Table 38. Municipalities affected in Sibalom 2floodplain

Municipality	Total Area	Area Flooded	% Flooded
Belison	29.81	35.22	118.15%
Patnongon	133.22	2.016	1.51%
San Jose	44.71	34.16	76.42%
San Remigio	394.42	19.14	4.85%
Sibalom	234.52	92.21	39.32%

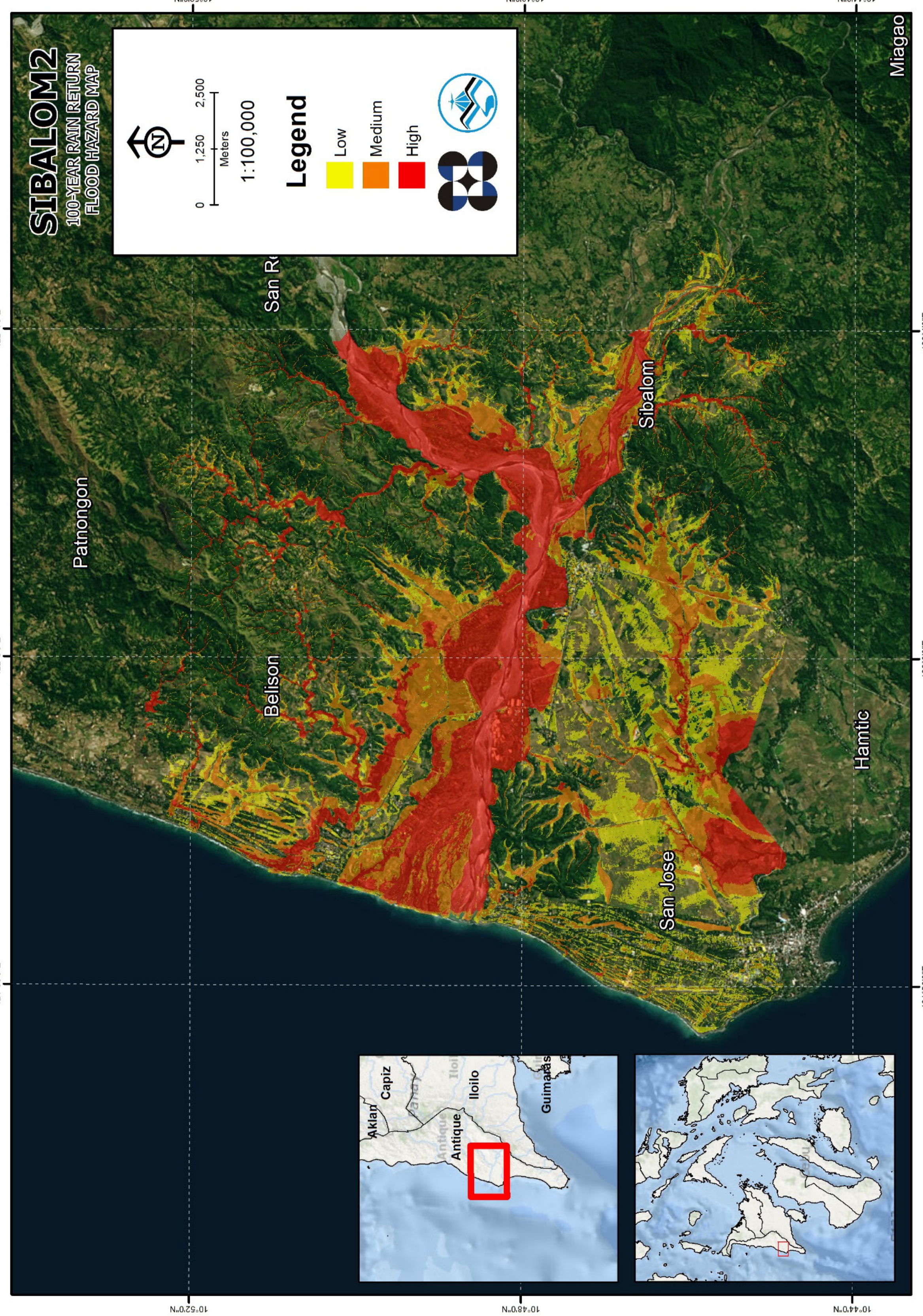


Figure 69. 100-year Flood Hazard Map for Sibalom 2Floodplain overlaid on Google Earth imagery.

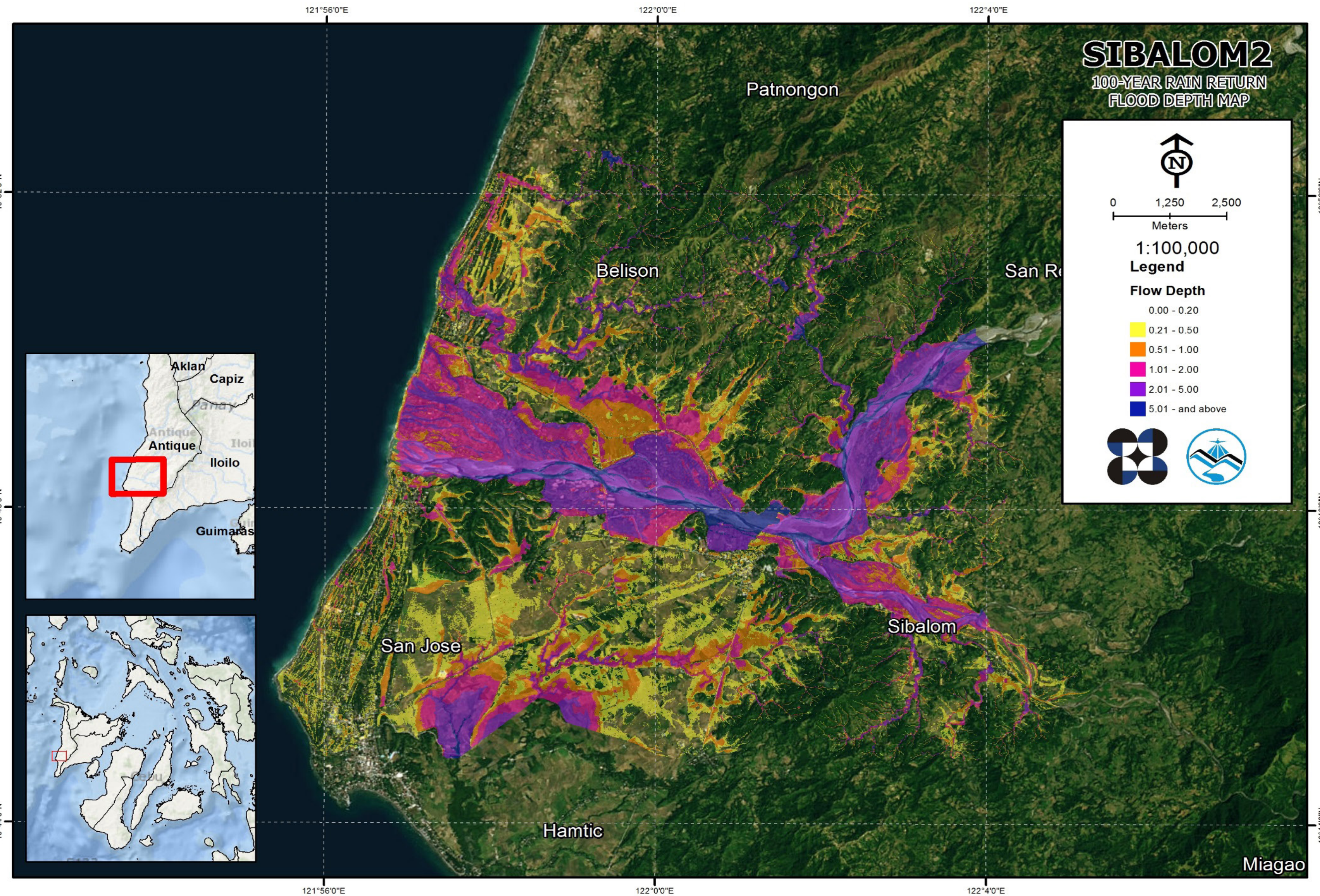


Figure 70. 100-year Flow Depth Map for Sibalom 2Floodplain overlaid on Google Earth imagery.

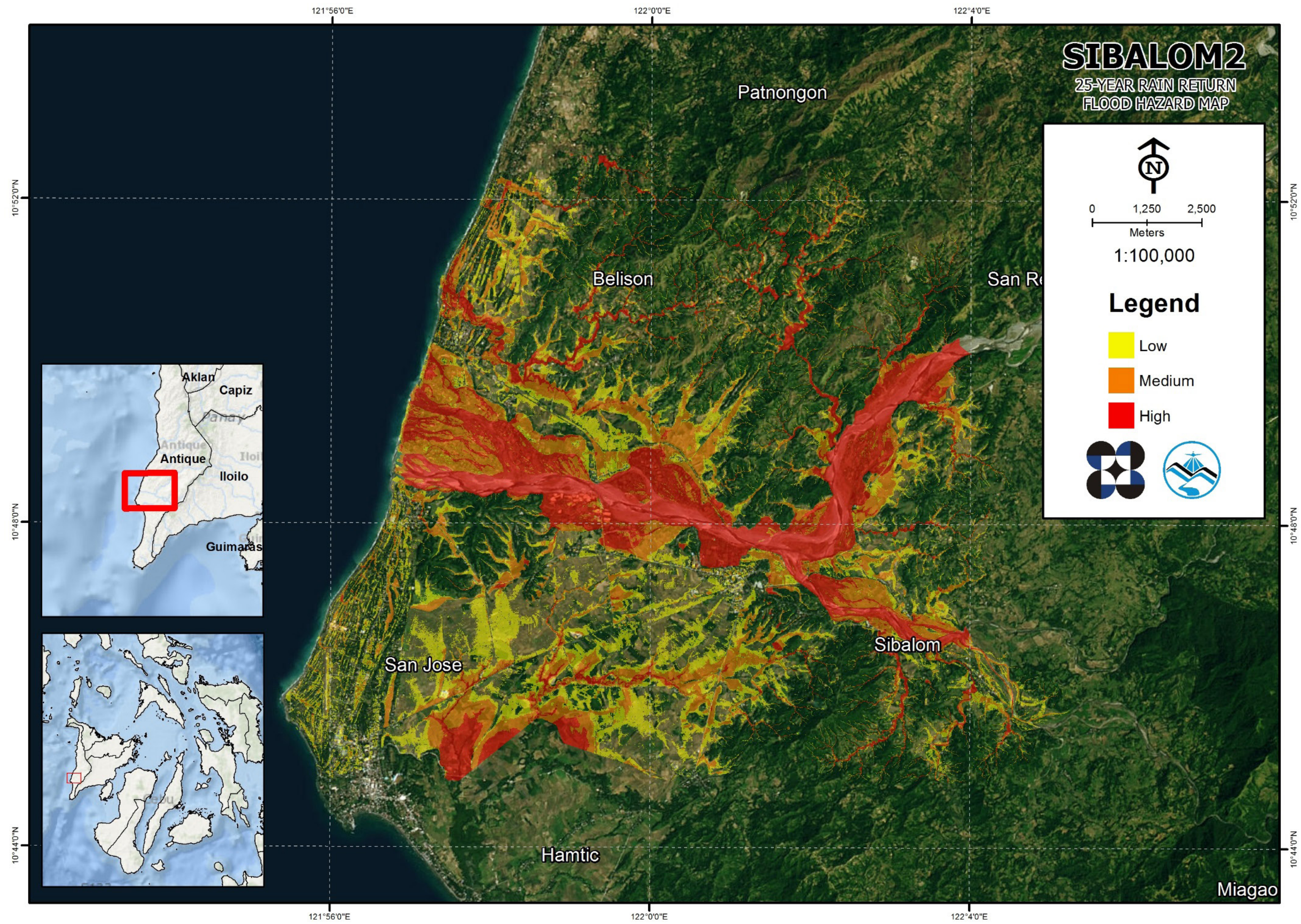


Figure 71. 25-year Flood Hazard Map for Sibalom 2Floodplain overlaid on Google Earth imagery.

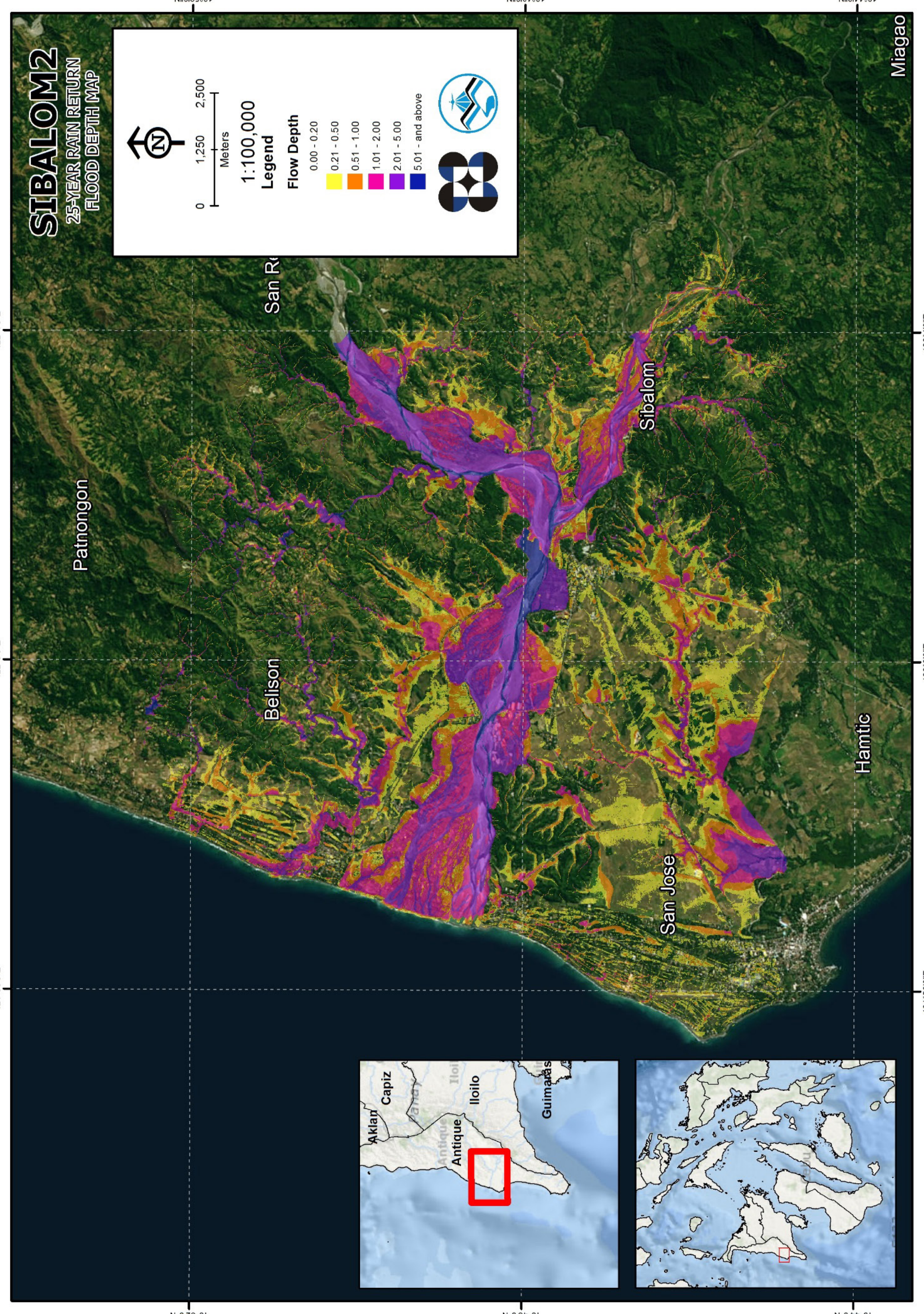


Figure 72. 25-year Flow Depth Map for Sibalom 2Floodplain overlaid on Google Earth imagery.

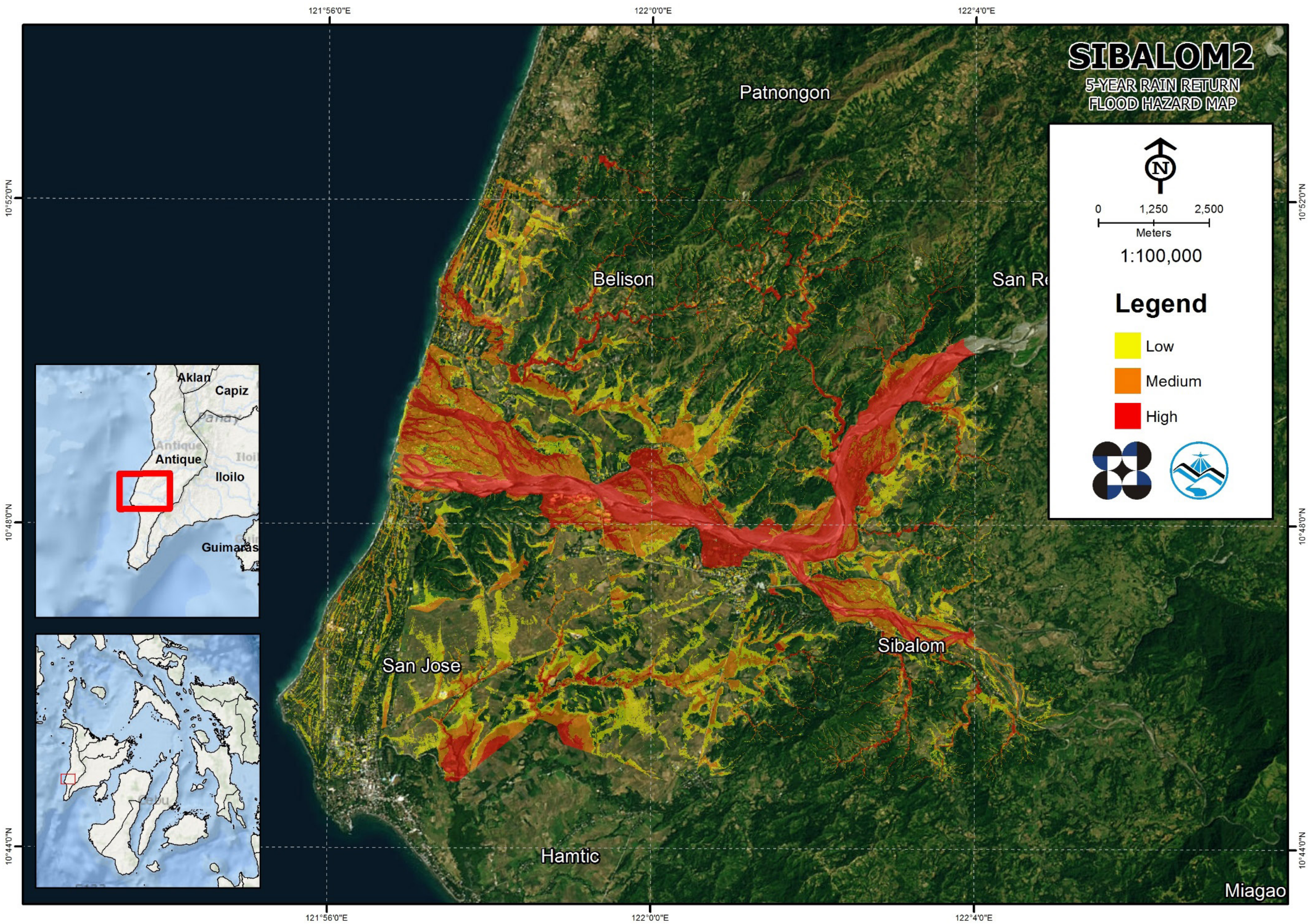


Figure 73. 5-year Flood Hazard Map for Sibalom 2Floodplain overlaid on Google Earth imagery.

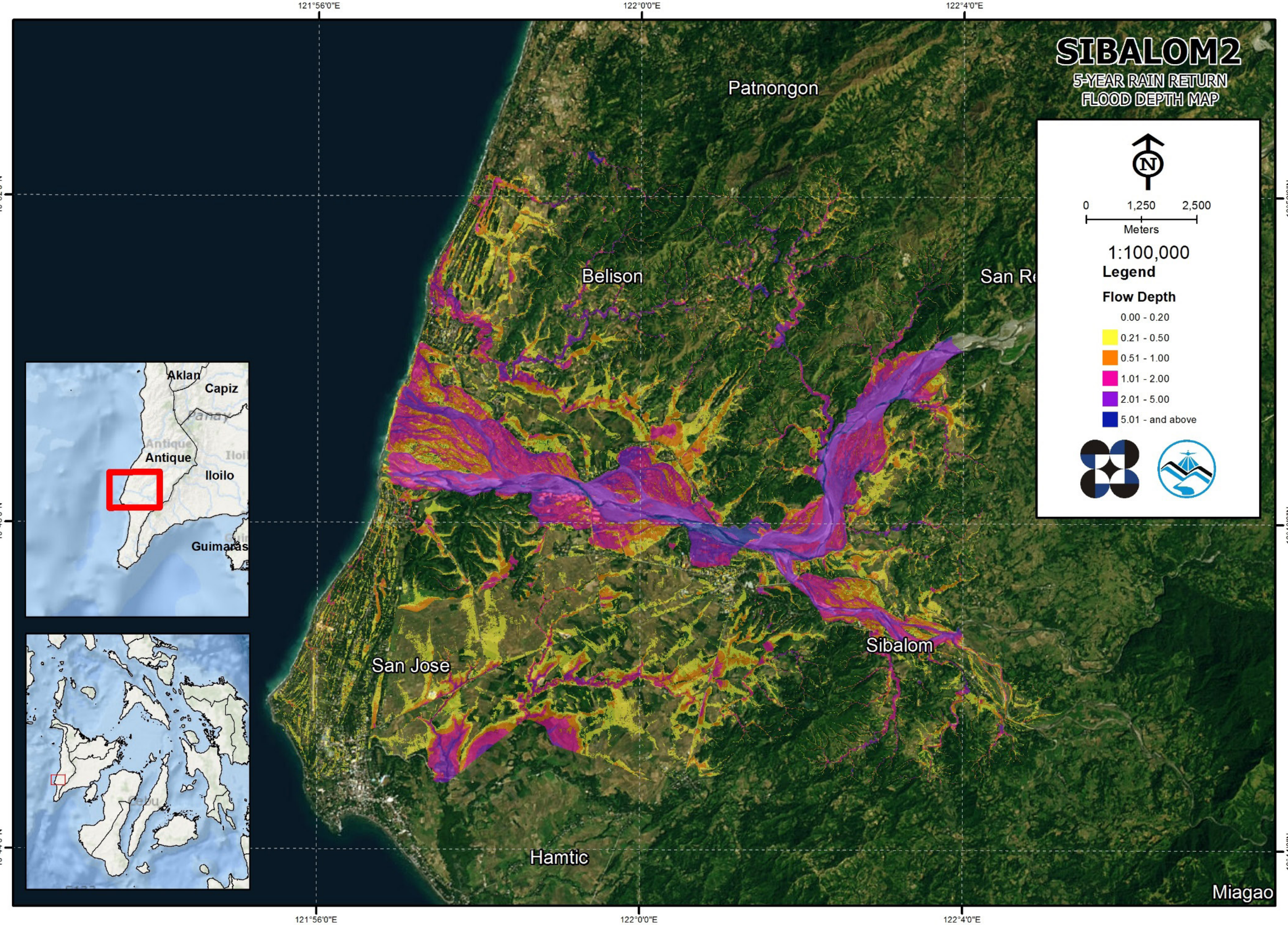


Figure 74. 5-year Flood Depth Map for Sibalom 2Floodplain overlaid on Google Earth imagery.

5.10 Inventory of Areas Exposed to Flooding

Listed below are the affected barangays in the Sibalom 2River Basin, grouped accordingly by municipality. For the said basin, five (5) municipalities consisting of ninety-six (96) barangays are expected to experience flooding when subjected to 5-yr rainfall return period.

For the 5-year return period, 89.12% of the municipality of Belison with an area of 29.81 sq. km. will experience flood levels of less 0.20 meters. 0.23% of the area will experience flood levels of 0.21 to 0.50 meters while 7.46%, 7.12%, 3.98%, and 0.22% 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. Table 39 depicts the areas affected in Sibalom 2in square kilometers by flood depth per barangay. ANNEX 12 and ANNEX 13 show the educational and health institutions exposed to flooding, respectively.

Table 39. Affected Areas in Belison, Antique during 5-Year Rainfall Return Period

	Affected Barangays in Belison						
	Sibalom 2BASIN	Borocboroc	Buenavista	Concepcion	Delima	Ipil	Maradiona
Affected Area (sq. km.)	**0.03-0.20**	0.71	18.71	0.29	1.01	0.57	0.65
	0.21-0.50	0.36	1.11	0.13	0.51	0.23	0.19
	0.51-1.00	0.29	0.76	0.11	0.32	0.18	0.099
	1.01-2.00	0.083	0.46	0.18	0.14	0.25	0.18
	2.01-5.00	0.0024	0.68	0.31	0.013	0.18	0.0078
	> 5.00	0	0.15	0.0019	0	0	0.000051

		Mojon	Poblacion	Rombang	Salvacion	Sinaja
Affected Area (sq. km.)	**0.03-0.20**	0.9	0.95	0.17	0.0098	0.29
	0.21-0.50	0.27	0.25	0.02	0.028	0.097
	0.51-1.00	0.22	0.25	0.054	0.089	0.19
	1.01-2.00	0.22	0.4	0.092	0.41	0.45
	2.01-5.00	0.22	0.24	0.12	0.11	0.27
	> 5.00	0.002	0.0006	0	0	0.00069

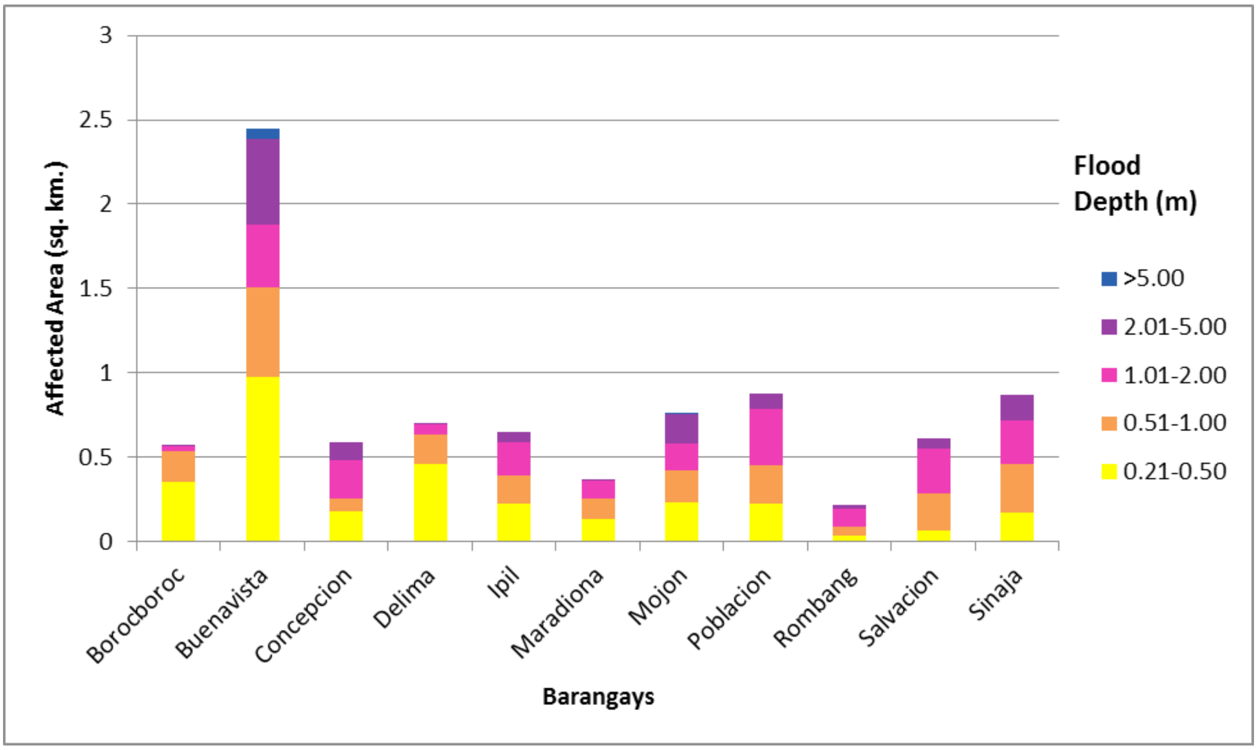


Figure 75. Affected Areas in Belison, Antique during 5-Year Rainfall Return Period.

For the municipality of Patnongon, with an area of 133.22 sq. km., 1.33% will experience flood levels of less 0.20 meters. 0.08% of the area will experience flood levels of 0.21 to 0.50 meters while 0.029%, 0.023%, 0.032%, and 0.023% 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 Table 40 are the affected areas in square kilometers by flood depth per barangay.

Table 40. Affected Areas in Patnongon, Antique during 5-Year Rainfall Return Period.

Sibalom 2BASIN		Affected Barangays in Patnongon		
		Aureliana	Magsaysay	Tobias Fornier
Affected Area (sq. km.)	0.03-0.20	0.49	0.84	0.43
	0.21-0.50	0.02	0.06	0.02
	0.51-1.00	0.01	0.02	0.01
	1.01-2.00	0.01	0.01	0.01
	2.01-5.00	0.01	0.03	0
	> 5.00	0.01	0.02	0

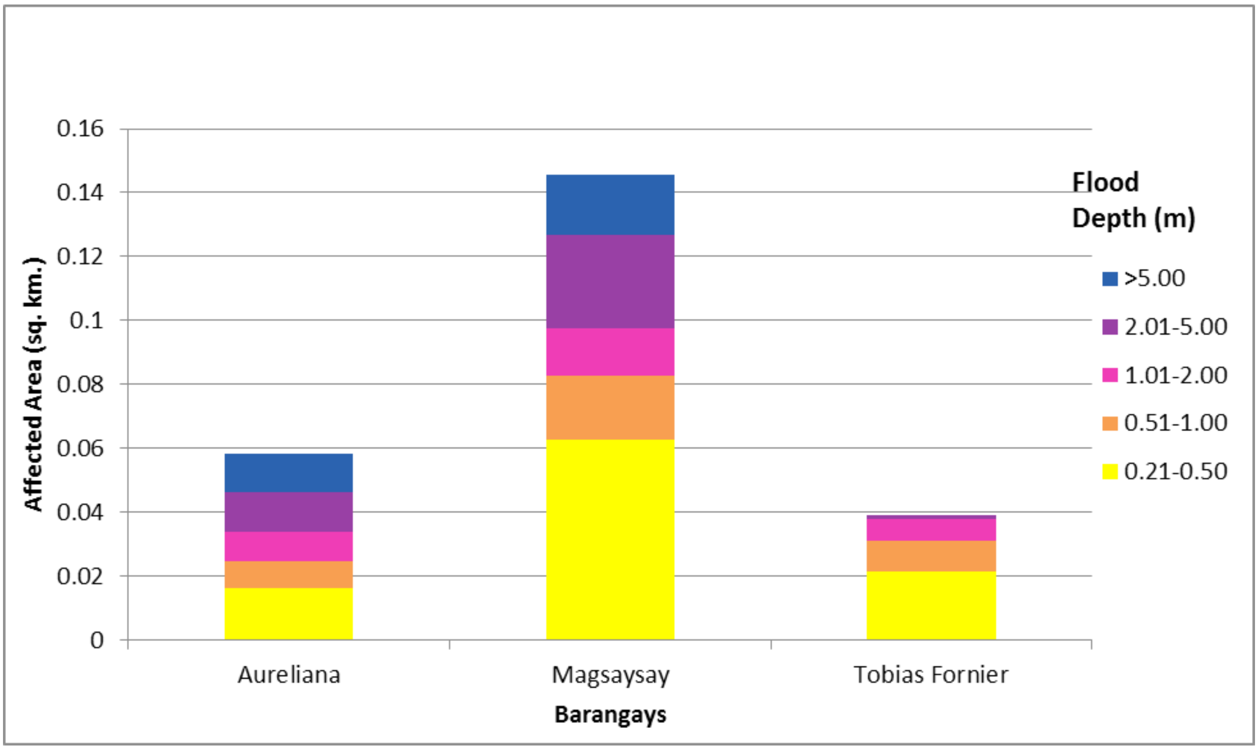


Figure 76. Affected Areas in Patnongon, Antique during 5-Year Rainfall Return Period.

For the municipality of San Jose, with an area of 44.71 sq. km., 46.12% will experience flood levels of less 0.20 meters. 12.59% of the area will experience flood levels of 0.21 to 0.50 meters while 6.86%, 7.33%, 3.49%, and 0.03% 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 Table 41 are the affected areas in square kilometers by flood depth per barangay.

Table 41. Affected Areas in San Jose, Antique during 5-Year Rainfall Return Period.

Sibalom 2BASIN		Affected Barangays in San Jose									
		Atabay	Badiang	Barangay 2	Bariri	Bugarot	Cansadan	Durog	Funda-Dalipe	Igbonglo	Inabasan
Affected Area (sq. km.)	**0.03-0.20**	0.88	0.9	0.085	0.023	0.021	0.26	0.0086	1.91	1.23	0.85
	0.21-0.50	0.38	0.31	0.053	0.02	0.17	0.14	0.023	0.87	1.01	0.32
	0.51-1.00	0.17	0.086	0.0016	0	0.38	0.12	0.21	0.15	0.3	0.12
	1.01-2.00	0.088	0	0	0	0.49	0.24	1.78	0.016	0.13	0.37
	2.01-5.00	0.018	0	0	0	0.25	0.85	1.4	0.0011	0.0026	0.29
	> 5.00	0	0	0	0	0.0003	0.054	0.00077	0	0	0
		Madrang-ca	Magcalon	Mojon	Pantao	San Fernando	San Pedro	Supa			
Affected Area (sq. km.)	**0.03-0.20**	0.77	1.89	1.21	0.97	1.28	2.47	0.76			
	0.21-0.50	0.28	0.66	0.35	0.098	0.77	0.59	1			
	0.51-1.00	0.044	0.22	0.15	0.11	0.15	0.4	0.75			
	1.01-2.00	0.0003	0.064	0.05	0.02	0.015	0.36	0.78			
	2.01-5.00	0	0.0034	0.002	0.24	0.00045	0.36	0.31			
	> 5.00	0	0	0	0.057	0	0.0068	0.0017			
		0	0	0	0.057	0	0.0068	0.0017			

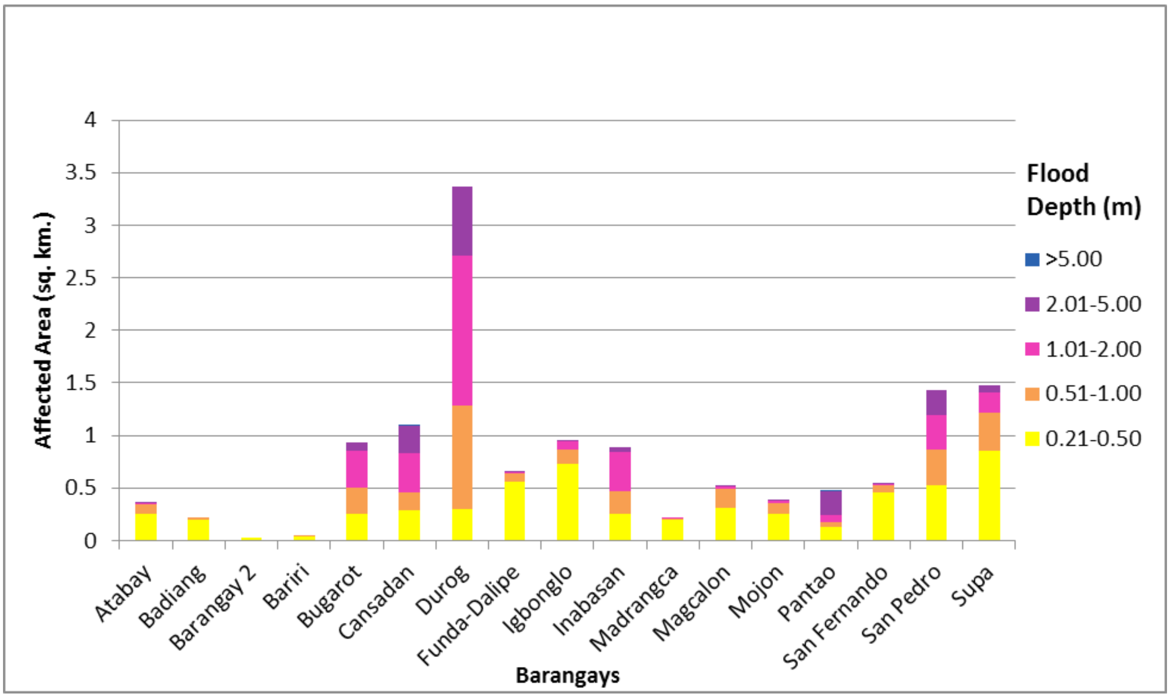


Figure 77. Affected Areas in San Jose, Antique during 5-Year Rainfall Return Period.

For the municipality of San Remigio, with an area of 394.42 sq. km., 3.68% will experience flood levels of less 0.20 meters. 0.23% of the area will experience flood levels of 0.21 to 0.50 meters while 0.19%, 0.27%, 0.46%, 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 Table 42 are the affected areas in square kilometers by flood depth per barangay.

Table 42. Affected Areas in San Remigio, Antique during 5-Year Rainfall Return Period.

Sibalom 2BASIN		Affected Barangays in San Remigio			
		Barangbang	Cadolonan	Carawisan I	Carawisan II
Affected Area (sq. km.)	0.03-0.20	0.75	1.06	6.39	1.83
	0.21-0.50	0.12	0.19	0.24	0.07
	0.51-1.00	0.15	0.079	0.12	0.053
	1.01-2.00	0.2	0.15	0.11	0.16
	2.01-5.00	0.66	0.28	0.29	0.87
	> 5.00	0.2	0.1	0.037	0.25
		Carmelo I	Carmelo II	General Luna	Ramon Magsaysay
Affected Area (sq. km.)	0.03-0.20	1.66	1.34	0.022	0.87
	0.21-0.50	0.094	0.09	0.0002	0.1
	0.51-1.00	0.081	0.073	0.0003	0.069
	1.01-2.00	0.099	0.052	0.0001	0.019
	2.01-5.00	0.13	0.035	0	0.013
	> 5.00	0.013	0.0028	0	0

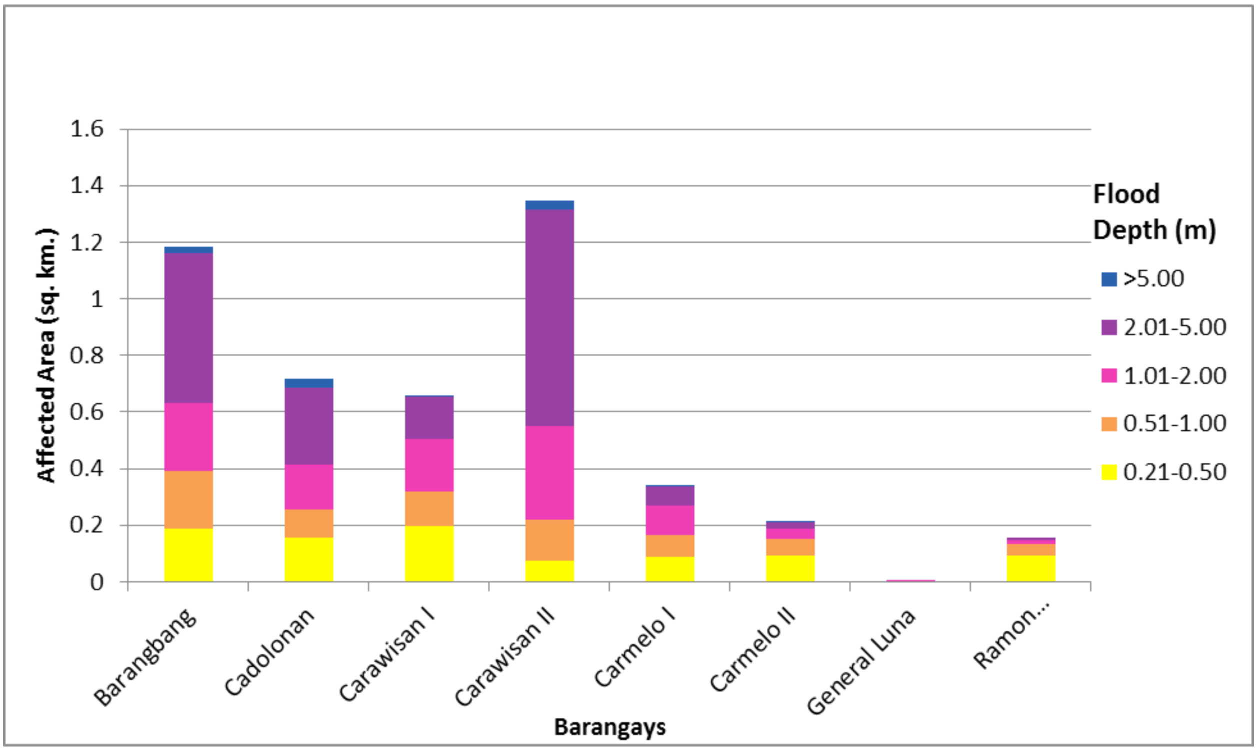


Figure 78. Affected Areas in San Remigio, Antique during 5-Year Rainfall Return Period.

For the municipality of Sibalom, with an area of 234.52 sq. km., 25.08% will experience flood levels of less 0.20 meters. 4.81% of the area will experience flood levels of 0.21 to 0.50 meters while 2.95%, 3.26%, 2.87%, and 0.35% 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 Table 43 are the affected areas in square kilometers by flood depth per barangay.

Table 43. Affected Areas in Sibalom, Antique during 5-Year Rainfall Return Period.

Sibalom 2BASIN		Affected Barangays in Sibalom									
		Alangan	Bari	Biga-A	Bongbongan I	Bongbongan II	Bongsod	Bontol	Cabariuan	Cadoldolan	Calog
Affected Area (sq. km.)	**0.03-0.20**	0.11	0.4	0.54	1.88	1.32	0.074	0.43	1.55	0.7	1.07
	0.21-0.50	0.026	0.11	0.19	0.072	0.2	0.022	0.072	0.17	0.097	0.027
	0.51-1.00	0.079	0.17	0.13	0.038	0.14	0.085	0.018	0.085	0.053	0.014
	1.01-2.00	0.36	0.15	0.026	0.057	0.096	0.52	0.002	0.0089	0.016	0.0096
	2.01-5.00	0.85	0.26	0	0.058	0.044	0.3	0	0.004	0.0068	0.009
	> 5.00	0.017	0.089	0	0.0029	0.0002	0.04	0	0.0003	0	0.0015
		Catmon	Catungan I	Catungan II	Catungan III	Catungan IV	Cubay-Napultan	Cubay-Sermon	District I	District II	District III
Affected Area (sq. km.)	**0.03-0.20**	0.71	1.73	1.05	1.82	0.67	1.25	0.72	0.66	0.028	3.8
	0.21-0.50	0.24	0.73	0.61	0.64	0.4	0.3	0.17	0.11	0.0017	0.78
	0.51-1.00	0.14	0.36	0.18	0.2	0.17	0.37	0.073	0.008	0.0038	0.091
	1.01-2.00	0.012	0.12	0.15	0.11	0.12	0.43	0.044	0.04	0.076	0.025
	2.01-5.00	0.007	0.0001	0.0074	0.032	0.035	0.049	0.071	0.061	0.31	0
	> 5.00	0	0	0	0	0	0	0.0013	0	0.13	0
		District IV	Egaña	Esperanza I	Esperanza II	Esperanza III	Igdagmay	Igdalaquit	Iglanot	Igsuming	Ilabas
Affected Area (sq. km.)	**0.03-0.20**	0.4	1.19	1.31	0.081	0.53	0.97	2.87	0.58	0.021	1.24
	0.21-0.50	0.099	0.11	0.31	0.073	0.15	0.2	0.43	0.41	0.00096	0.15
	0.51-1.00	0.06	0.064	0.17	0.22	0.17	0.11	0.17	0.53	0.00065	0.061
	1.01-2.00	0.11	0.054	0.023	0.49	0.18	0.0082	0.058	0.42	0.0003	0.06
	2.01-5.00	0.39	0.0003	0.00077	0.13	0.14	0.0003	0.012	0.15	0.0001	0.016
	> 5.00	0.32	0	0	0	0.017	0	0	0.017	0	0

SIBALOM2 BASIN		Affected Barangays in Sibalom									
		Inabasan	Indag-An	Initan	Insarayan	Lacaron	Lagdo	Luyang	Maasin	Mabini	Millamena
Affected Area (sq. km.)	0.03-0.20	0.17	0.77	0.25	1.58	1.29	1.02	0.14	1.97	3.28	3.29
	0.21-0.50	0.052	0.091	0.011	0.11	0.42	0.03	0.0044	0.099	0.16	0.32
	0.51-1.00	0.018	0.044	0.004	0.062	0.21	0.016	0.0021	0.031	0.098	0.18
	1.01-2.00	0.0004	0.019	0.0062	0.024	0.048	0.013	0.00094	0.014	0.14	0.1
	2.01-5.00	0	0.001	0.0003	0.005	0.015	0.011	0.0003	0.0043	0.058	0.041
	> 5.00	0	0.0001	0	0	0	0.0006	0	0	0.0014	0
		Mojon	Nagdayao	Nazareth	Odiong	Olaga	Pangpang	Pantao	Pasong	Pis-Anan	Rombang
Affected Area (sq. km.)	0.03-0.20	0.36	1.89	1.54	0.64	0.53	0.32	0.45	0.94	2.04	0.38
	0.21-0.50	0.058	0.15	0.3	0.095	0.12	0.15	0.028	0.11	0.5	0.17
	0.51-1.00	0.079	0.26	0.21	0.041	0.019	0.19	0.036	0.049	0.34	0.074
	1.01-2.00	0.054	0.39	0.085	0.024	0.067	0.38	0.18	0.068	0.37	0.064
	2.01-5.00	0.065	0.21	0.029	0.0007	0.21	0.36	0.31	0.11	0.34	0.025
	> 5.00	0.0012	0	0.0003	0	0.0012	0.018	0.0099	0	0.0077	0
		San Juan	Sido	Solong	Tigbalua I	Tigbalua II	Villahermosa	Villar			
Affected Area (sq. km.)	0.03-0.20	0.92	0.59	2.11	0.49	0.96	0.94	0.26			
	0.21-0.50	0.18	0.38	0.17	0.17	0.064	0.17	0.28			
	0.51-1.00	0.11	0.14	0.23	0.059	0.02	0.11	0.34			
	1.01-2.00	0.14	0.75	0.38	0.031	0.0097	0.33	0.19			
	2.01-5.00	0.26	0.78	0.51	0.0027	0.0045	0.39	0.039			
	> 5.00	0.0065	0.084	0.0008	0	0	0.052	0			

For the 25-year return period, 84.47% of the municipality of Belison with an area of 29.81 sq. km. will experience flood levels of less 0.20 meters. 10.77% of the area will experience flood levels of 0.21 to 0.50 meters while 8.36%, 8.65%, 5.53%, 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 Table are the affected areas in square kilometres by flood depth per barangay.

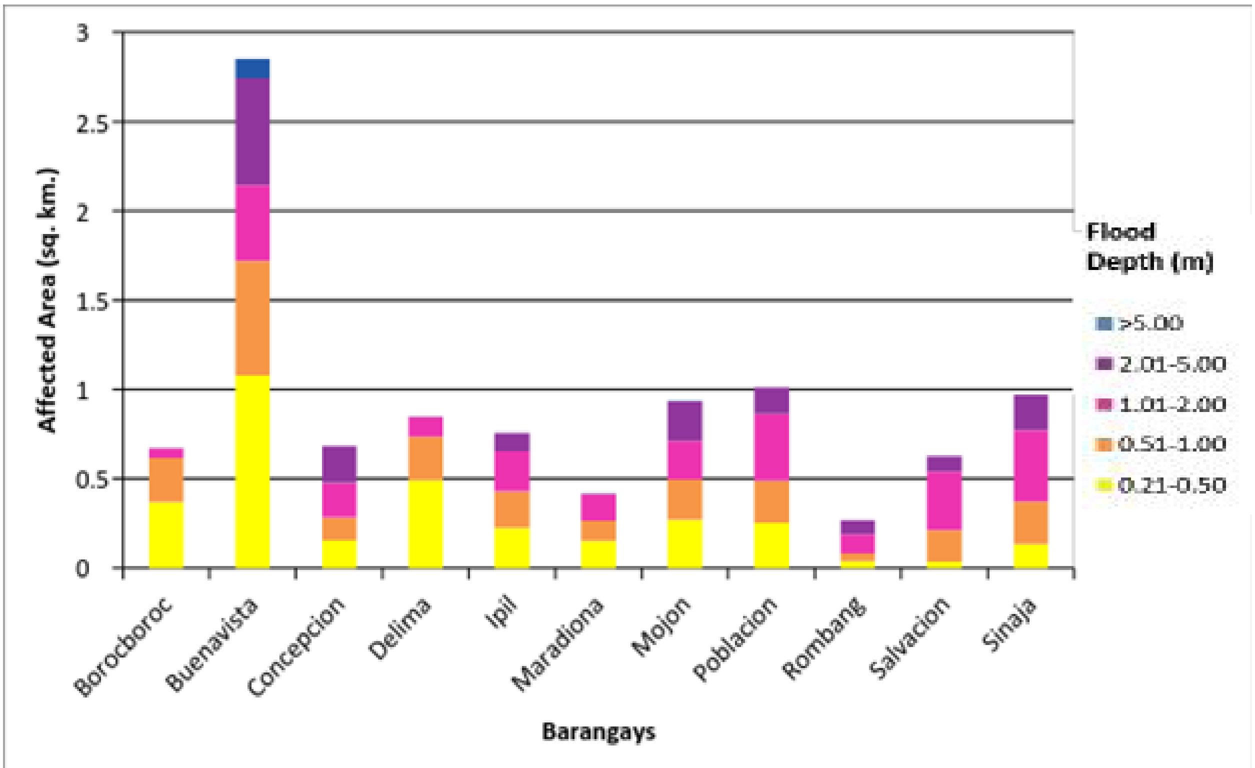


Figure 79. Affected Areas in Belison, Antique during 25-Year Rainfall Return Period

Table 44. Affected Areas in Beison, Antique during 25Year Rainfall Return Period

Affected Barangays in Belison							
	SIBALOM2 BASIN	**Borocboroc**	**Buenavista**	**Concepcion**	**Delima**	**Ipil**	**Maradiona**
Affected Area (sq. km.)	**0.03-0.20**	0.77	19.02	0.34	1.15	0.66	0.71
	0.21-0.50	0.37	1.08	0.16	0.49	0.23	0.15
	0.51-1.00	0.25	0.64	0.13	0.24	0.2	0.11
	1.01-2.00	0.053	0.42	0.19	0.11	0.22	0.15
	2.01-5.00	0.0023	0.6	0.21	0.0023	0.11	0.0037
	> 5.00	0	0.11	0	0	0	0

		Mojon	**Poblacion**	**Rombang**	**Salvacion**	**Sinaja**
Affected Area (sq. km.)	**0.03-0.20**	0.9	1.09	0.19	0.02	0.33
	0.21-0.50	0.27	0.25	0.036	0.034	0.14
	0.51-1.00	0.22	0.24	0.048	0.18	0.24
	1.01-2.00	0.22	0.37	0.1	0.33	0.4
	2.01-5.00	0.22	0.15	0.078	0.084	0.2
	> 5.00	0.002	0	0	0	0.0001

For the municipality of Patnongon, with an area of 133.22 sq. km., 1.29% will experience flood levels of less 0.20 meters. 0.1% of the area will experience flood levels of 0.21 to 0.50 meters while 0.03%, 0.025%, 0.036%, and 0.03% 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 Table are the affected areas in square kilometres by flood depth per barangay

Table 45. Affected Areas in Patnongon, Antique during 25-Year Rainfall Return Period

SIBALOM2 BASIN		Affected Barangays in Patnongon		
		Aureliana	Magsaysay	Tobias Fornier
Affected Area (sq. km.)	0.03-0.20	0.49	0.8	0.43
	0.21-0.50	0.02	0.09	0.02
	0.51-1.00	0.01	0.02	0.01
	1.01-2.00	0.01	0.02	0.01
	2.01-5.00	0.02	0.03	0
	> 5.00	0.01	0.03	0

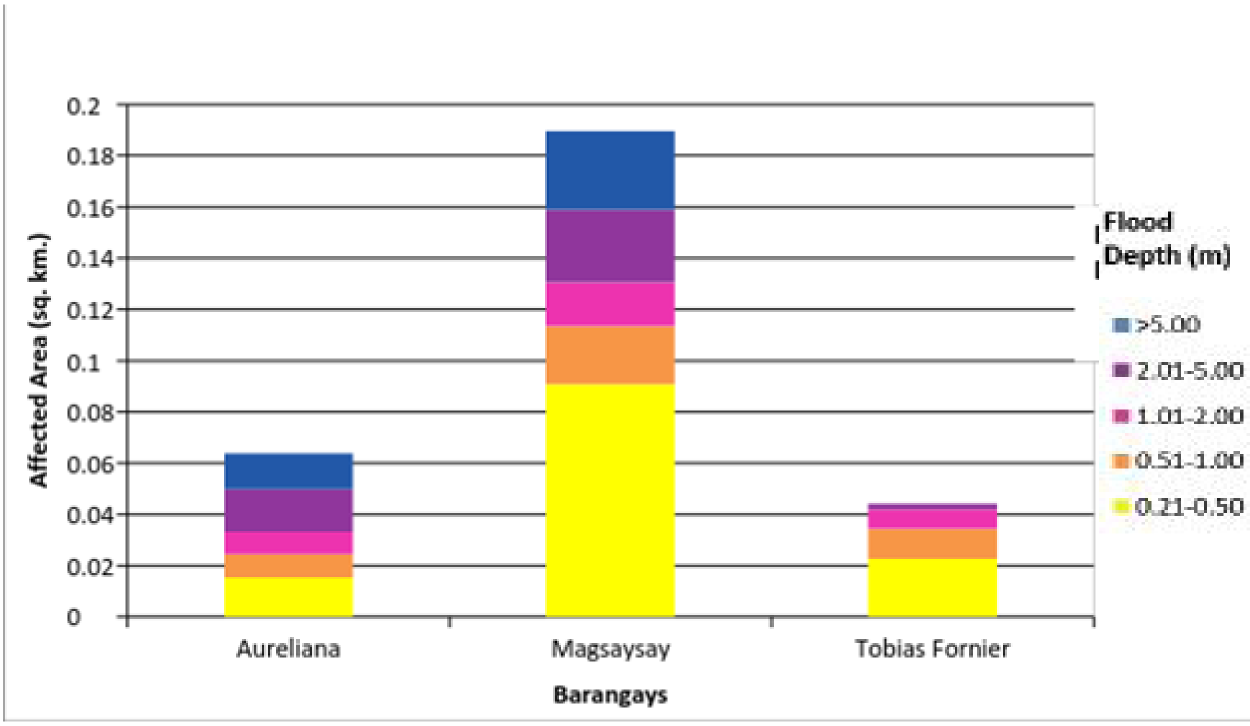


Figure 80. Affected Areas in Patnongon, Antique during 25-Year Rainfall Return Period

For the municipality of San Jose, with an area of 44.71 sq. km., 39.57% will experience flood levels of less 0.20 meters. 14.58% of the area will experience flood levels of 0.21 to 0.50 meters while 7.37%, 9.08%, 5.77%, and 0.09% 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 Table are the affected areas in square kilometres by flood depth per barangay

Table 46. Affected Areas in San Jose, Antique during 25-Year Rainfall Return Period.

SIBALOM2 BASIN		Affected Barangays in San Jose									
		Atabay	Badiang	Barangay 2	Bariri	Bugarot	Cansadan	Durog	Funda-Dalipe	Igbonglo	Inabasan
Affected Area (sq. km.)	**0.03-0.20**	0.88	0.9	0.085	0.023	0.021	0.26	0.0086	1.91	1.23	0.85
	0.21-0.50	0.38	0.31	0.053	0.02	0.17	0.14	0.023	0.87	1.01	0.32
	0.51-1.00	0.17	0.086	0.0016	0	0.38	0.12	0.21	0.15	0.3	0.12
	1.01-2.00	0.088	0	0	0	0.49	0.24	1.78	0.016	0.13	0.37
	2.01-5.00	0.018	0	0	0	0.25	0.85	1.4	0.0011	0.0026	0.29
	> 5.00	0	0	0	0	0.0003	0.054	0.00077	0	0	0
		Madrang-ca	Magcalon	Mojon	Pantao	San Fernando	San Pedro	Supa			
Affected Area (sq. km.)	**0.03-0.20**	0.77	1.89	1.21	0.97	1.28	2.47	0.76			
	0.21-0.50	0.28	0.66	0.35	0.098	0.77	0.59	1			
	0.51-1.00	0.044	0.22	0.15	0.11	0.15	0.4	0.75			
	1.01-2.00	0.0003	0.064	0.05	0.02	0.015	0.36	0.78			
	2.01-5.00	0	0.0034	0.002	0.24	0.00045	0.36	0.31			
	> 5.00	0	0	0	0.057	0	0.0068	0.0017			
		0	0	0	0.057	0	0.0068	0.0017			

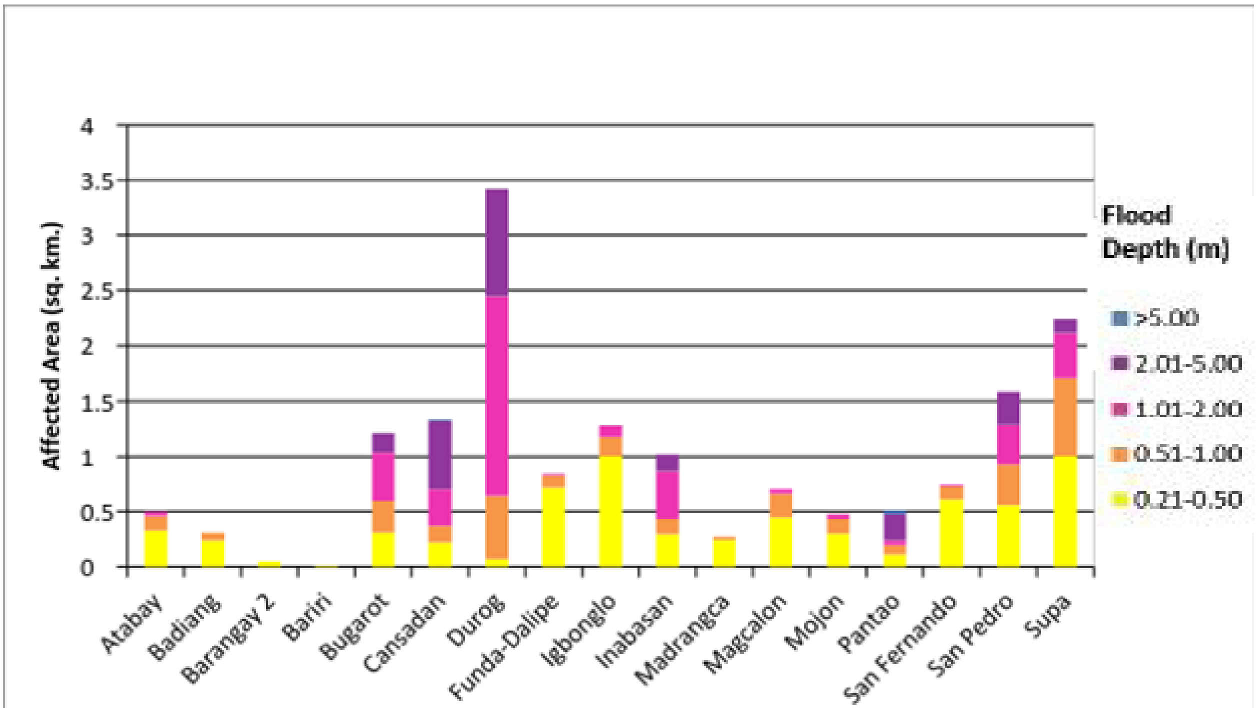


Figure 81 . Affected Areas in San Jose, Antique during 25-Year Rainfall Return Period

For the municipality of San Remigio, with an area of 394.42 sq. km., 3.60% will experience flood levels of less 0.20 meters. 0.23% of the area will experience flood levels of 0.21 to 0.50 meters while 0.17%, 0.26%, 0.54%, and 0.06% 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 Table are the affected areas in square kilometres by flood depth per barangay

Table 47. Affected Areas in San Remigio, Antique during 25-Year Rainfall Return Period

SIBALOM2 BASIN		Affected Barangays in San Remigio			
		Barangbang	Cadolonan	Carawisan I	Carawisan II
Affected Area (sq. km.)	0.03-0.20	0.75	1.06	6.39	1.83
	0.21-0.50	0.12	0.19	0.24	0.07
	0.51-1.00	0.15	0.079	0.12	0.053
	1.01-2.00	0.2	0.15	0.11	0.16
	2.01-5.00	0.66	0.28	0.29	0.87
	> 5.00	0.2	0.1	0.037	0.25
		Carmelo I	Carmelo II	General Luna	Ramon Magsaysay
Affected Area (sq. km.)	0.03-0.20	1.66	1.34	0.022	0.87
	0.21-0.50	0.094	0.09	0.0002	0.1
	0.51-1.00	0.081	0.073	0.0003	0.069
	1.01-2.00	0.099	0.052	0.0001	0.019
	2.01-5.00	0.13	0.035	0	0.013
	> 5.00	0.013	0.0028	0	0

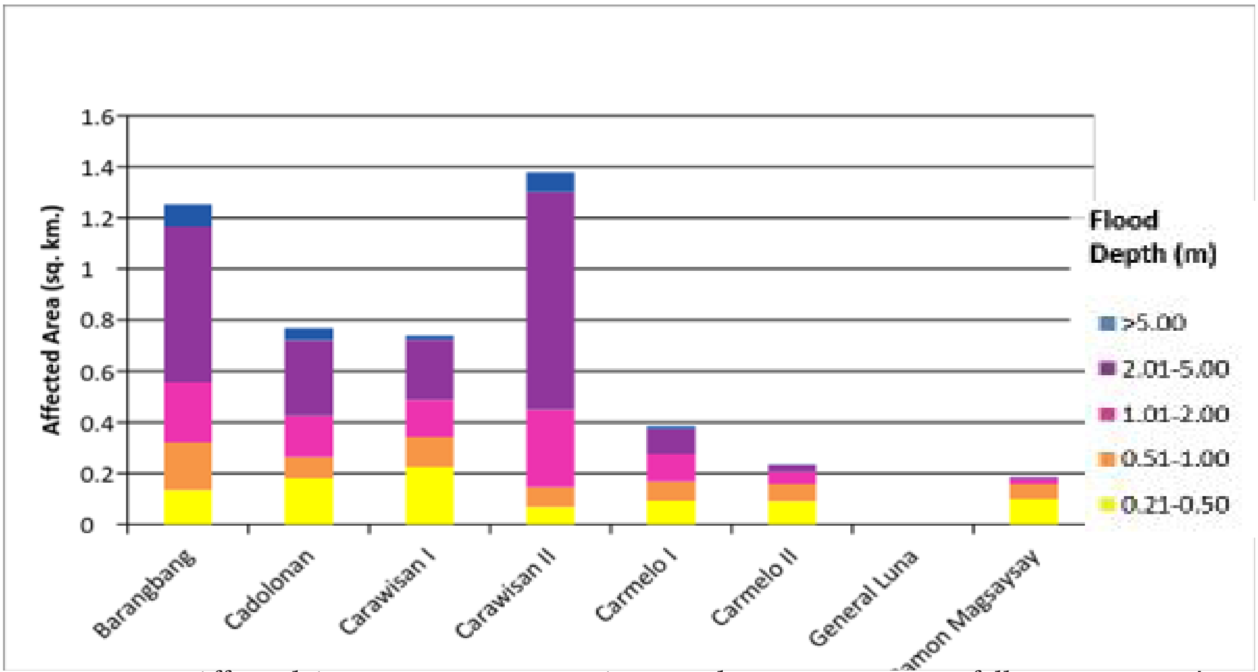


Figure 82. Affected Areas in San Remigio, Antique during 25-Year Rainfall Return Period

For the municipality of Sibalom, with an area of 234.52 sq. km., 25.08% will experience flood levels of less 0.20 meters. 4.81% of the area will experience flood levels of 0.21 to 0.50 meters while 2.95%, 3.26%, 2.87%, and 0.35% 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 Table are the affected areas in square kilometres by flood depth per barangay

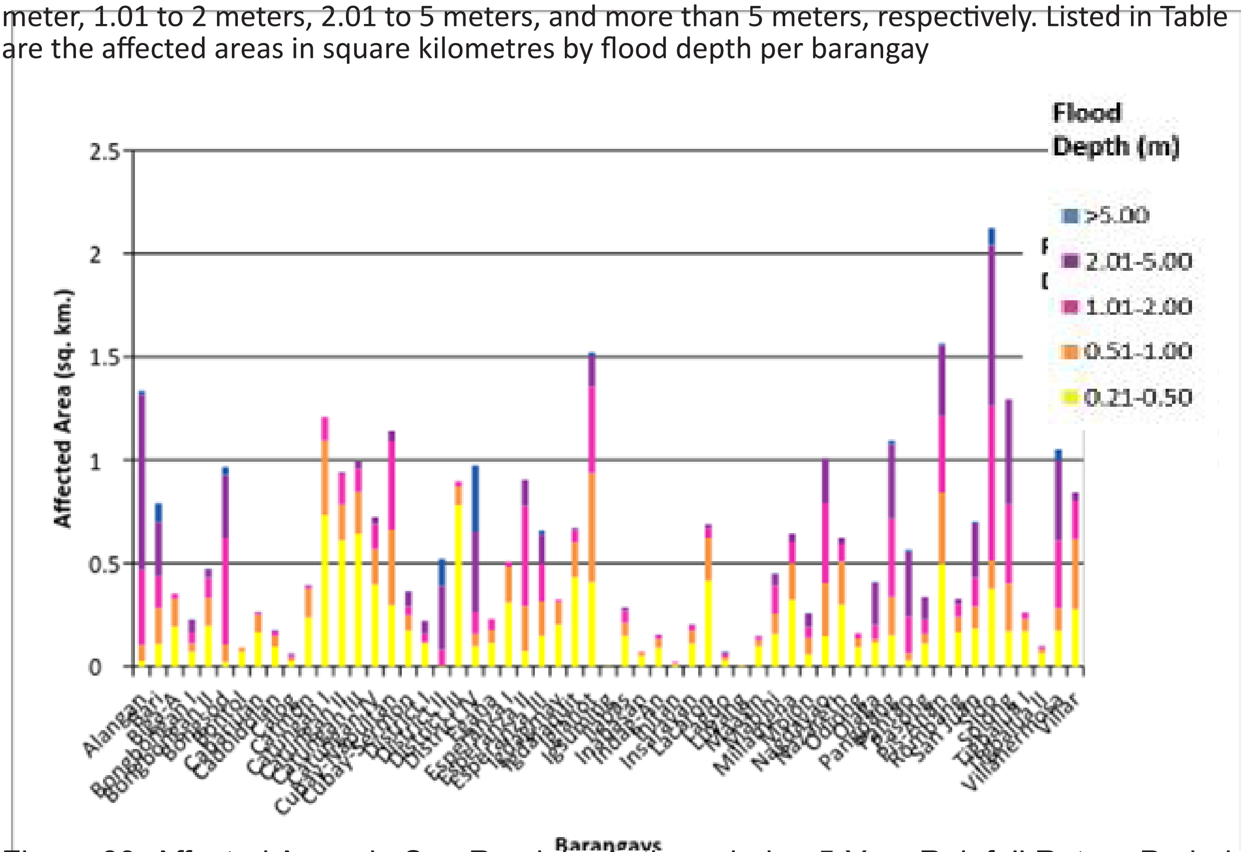


Figure 83. Affected Areas in San Remigio, Antique during 5-Year Rainfall Return Period.

Table 48. Affected Areas in Sibalom, Antique during 25-Year Rainfall Return Period.

SIBALOM 2 BASIN		Affected Barangays in Sibalom									
		Alangan	Bari	Biga-A	Bongbongan I	Bongbongan II	Bongsod	Bontol	Cabariuan	Cadoldolan	Calog
Affected Area (sq. km.)	0.03-0.20	0.024	0.35	0.41	1.85	1.26	0.05	0.4	1.5	0.68	1.06
	0.21-0.50	0.076	0.059	0.23	0.077	0.16	0.021	0.089	0.18	0.095	0.032
	0.51-1.00	0.029	0.13	0.21	0.045	0.17	0.026	0.027	0.11	0.076	0.016
	1.01-2.00	0.23	0.22	0.052	0.045	0.13	0.31	0.0027	0.014	0.023	0.012
	2.01-5.00	0.99	0.29	0.0003	0.071	0.067	0.57	0	0.0049	0.008	0.01
	> 5.00	0.093	0.15	0	0.018	0.00092	0.069	0	0.0008	0.0003	0.0017

		Catungan I	Catungan II	Catungan III	Catungan III	Catungan IV	Cubay-Napultan	Cubay-Sermon	District I	District II	District III
Affected Area (sq. km.)	0.03-0.20	0.63	1.51	0.77	1.46	0.42	1.09	0.57	0.56	0.025	3.27
	0.21-0.50	0.23	0.74	0.71	0.85	0.5	0.26	0.19	0.2	0.0011	1.26
	0.51-1.00	0.21	0.53	0.29	0.33	0.28	0.27	0.15	0.014	0.0017	0.11
	1.01-2.00	0.02	0.16	0.2	0.13	0.15	0.53	0.092	0.0042	0.0056	0.042
	2.01-5.00	0.01	0.0002	0.018	0.042	0.044	0.25	0.073	0.1	0.35	0.000005
	> 5.00	0	0	0	0	0	0	0.013	0	0.16	0

		Egaña	Esperanza I	Esperanza II	Esperanza II	Esperanza III	Igdagmay	Igdalaquit	Iglanot	Igsuming	Ilabas
Affected Area (sq. km.)	0.03-0.20	0.29	1.15	1.24	0.031	0.46	0.92	2.73	0.43	0.021	1.12
	0.21-0.50	0.095	0.13	0.31	0.046	0.14	0.2	0.46	0.29	0.00096	0.18
	0.51-1.00	0.097	0.068	0.21	0.093	0.17	0.15	0.25	0.56	0.00065	0.12
	1.01-2.00	0.097	0.07	0.059	0.4	0.12	0.013	0.089	0.53	0.0005	0.077
	2.01-5.00	0.35	0.0016	0.0017	0.41	0.27	0.0005	0.017	0.26	0.0001	0.033
	> 5.00	0.44	0	0	0	0.025	0	0	0.034	0	0

SIBALOM 2 BASIN		Affected Barangays in Sibalom									
		Inabasan	Indag-An	Initan	Insarayan	Lacaron	Lagdo	Luyang	Maasin	Mabini	Millamena
Affected Area (sq. km.)	**0.03-0.20**	0.16	0.74	0.24	1.55	1.13	1.01	0.14	1.94	3.2	3.18
	0.21-0.50	0.057	0.11	0.015	0.12	0.45	0.037	0.0045	0.12	0.19	0.35
	0.51-1.00	0.026	0.05	0.0055	0.075	0.31	0.016	0.0032	0.041	0.11	0.21
	1.01-2.00	0.0003	0.026	0.0066	0.028	0.069	0.015	0.00095	0.017	0.14	0.12
	2.01-5.00	0.0001	0.0015	0.0006	0.0083	0.019	0.014	0.00039	0.0056	0.088	0.059
	> 5.00	0	0.0001	0	0.0001	0	0.0011	0	0	0.0027	0
		Mojon	Nagdayao	Nazareth	Odiong	Olaga	Pangpang	Pantao	Pasong	Pis-Anan	Rombang
Affected Area (sq. km.)	**0.03-0.20**	0.25	1.81	1.42	0.6	0.13	0.11	0.43	0.91	1.82	0.29
	0.21-0.50	0.1	0.17	0.34	0.12	0.33	0.12	0.027	0.11	0.48	0.11
	0.51-1.00	0.089	0.18	0.27	0.052	0.19	0.23	0.024	0.066	0.36	0.096
	1.01-2.00	0.087	0.43	0.1	0.03	0.024	0.48	0.12	0.046	0.45	0.15
	2.01-5.00	0.085	0.31	0.033	0.0015	0.26	0.41	0.38	0.14	0.48	0.067
	> 5.00	0.0025	0	0.0004	0	0.0059	0.061	0.026	0.0037	0.012	0
		San Juan	Sido	Solong	Tigbalua I	Tigbalua II	Villahermosa	Villar			
Affected Area (sq. km.)	**0.03-0.20**	0.82	0.41	2.05	0.43	0.94	0.86	0.18			
	0.21-0.50	0.11	0.32	0.15	0.2	0.084	0.2	0.16			
	0.51-1.00	0.18	0.29	0.14	0.077	0.023	0.12	0.39			
	1.01-2.00	0.16	0.53	0.39	0.044	0.013	0.23	0.29			
	2.01-5.00	0.33	1.04	0.66	0.0034	0.0055	0.49	0.071			

For the 100-year return period, 81.38% of the municipality of Belison with an area of 29.81 sq. km. will experience flood levels of less 0.20 meters. 10.77% of the area will experience flood levels of 0.21 to 0.50 meters while 8.63%, 9.57%, 7.27%, and 0.53% 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 Table are the affected areas in square kilometres by flood depth per barangay.

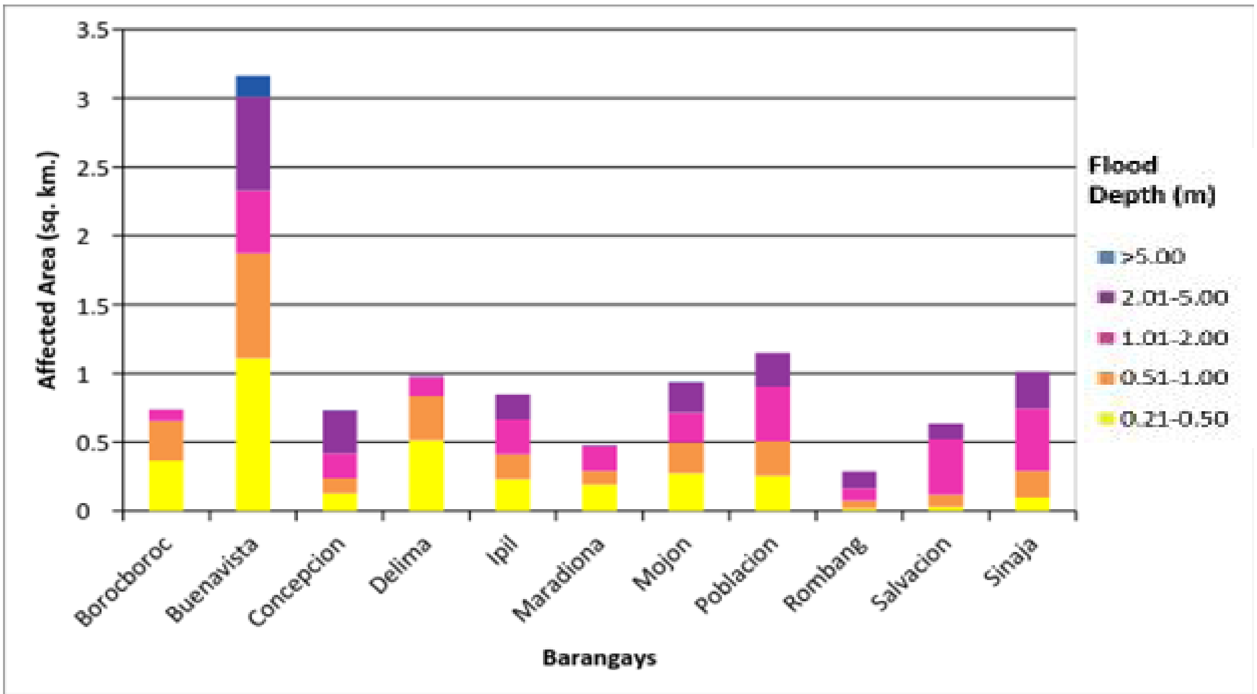


Figure 84. Affected Areas in Belison, Antique during 100-Year Rainfall Return Period

Table 49 . Affected Areas in Beison, Antique during 100Year Rainfall Return Period

	Affected Barangays in Belison						
	SIBALOM2 BASIN	Borocboroc	Buenavista	Concepcion	Delima	Ipil	Maradiona
Affected Area (sq. km.)	**0.03-0.20**	0.71	18.71	0.29	1.01	0.57	0.65
	0.21-0.50	0.36	1.11	0.13	0.51	0.23	0.19
	0.51-1.00	0.29	0.76	0.11	0.32	0.18	0.099
	1.01-2.00	0.083	0.46	0.18	0.14	0.25	0.18
	2.01-5.00	0.0024	0.68	0.31	0.013	0.18	0.0078
	> 5.00	0	0.15	0.0019	0	0	0.000051

		Mojon	Poblacion	Rombang	Salvacion	Sinaja	
Affected Area (sq. km.)	**0.03-0.20**	0.9	0.95	0.17	0.0098	0.29	
	0.21-0.50	0.27	0.25	0.02	0.028	0.097	
	0.51-1.00	0.22	0.25	0.054	0.089	0.19	
	1.01-2.00	0.22	0.4	0.092	0.41	0.45	
	2.01-5.00	0.22	0.24	0.12	0.11	0.27	
	> 5.00	0.002	0.0006	0	0	0.00069	

For the municipality of Patnongon, with an area of 133.22 sq. km., 1.25% will experience flood levels of less 0.20 meters. 0.1% of the area will experience flood levels of 0.21 to 0.50 meters while 0.04%, 0.024%, 0.04%, and 0.05% 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 Table are the affected areas in square kilometres by flood depth per barangay

Table 50. Affected Areas in Patnongon, Antique during 100-Year Rainfall Return Period

SIBALOM2 BASIN		Affected Barangays in Patnongon		
		Aureliana	Magsaysay	Tobias Fornier
Affected Area (sq. km.)	**0.03-0.20**	0.48	0.76	0.43
	0.21-0.50	0.017	0.11	0.022
	0.51-1.00	0.01	0.026	0.014
	1.01-2.00	0.0084	0.015	0.0086
	2.01-5.00	0.017	0.036	0.0031
	> 5.00	0.02	0.046	0

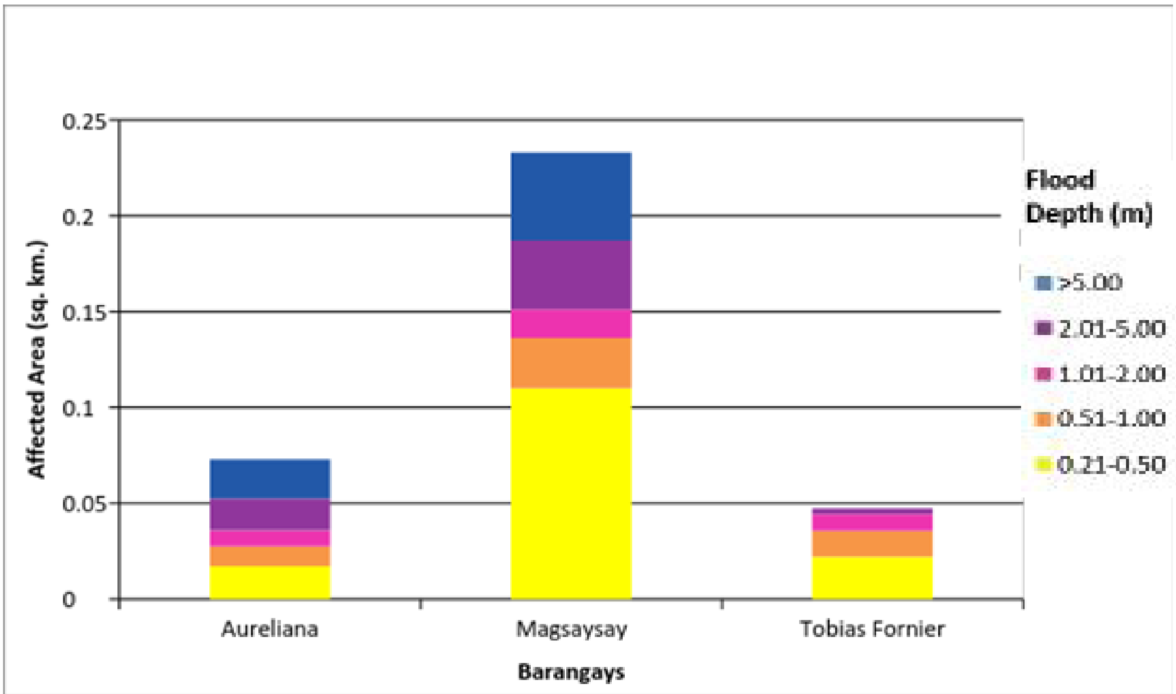


Figure 85. Affected Areas in Patnongon, Antique during 100-Year Rainfall Return Period

For the municipality of San Jose, with an area of 44.71 sq. km., 34.71% will experience flood levels of less 0.20 meters. 15.76% of the area will experience flood levels of 0.21 to 0.50 meters while 7.53%, 9.86%, 8.37%, and 0.27% 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 Table are the affected areas in square kilometres by flood depth per barangay

Table 51. Affected Areas in San Jose, Antique during 100-Year Rainfall Return Period.

SIBALOM2 BASIN		Affected Barangays in San Jose									
		Atabay	Badiang	Barangay 2	Bariri	Bugarot	Cansadan	Durog	Funda-Dalipe	Igbonglo	Inabasan
Affected Area (sq. km.)	**0.03-0.20**	0.88	0.9	0.085	0.023	0.021	0.26	0.0086	1.91	1.23	0.85
	0.21-0.50	0.38	0.31	0.053	0.02	0.17	0.14	0.023	0.87	1.01	0.32
	0.51-1.00	0.17	0.086	0.0016	0	0.38	0.12	0.21	0.15	0.3	0.12
	1.01-2.00	0.088	0	0	0	0.49	0.24	1.78	0.016	0.13	0.37
	2.01-5.00	0.018	0	0	0	0.25	0.85	1.4	0.0011	0.0026	0.29
	> 5.00	0	0	0	0	0.0003	0.054	0.00077	0	0	0
		Madrang-ca	Magcalon	Mojon	Pantao	San Fernando	San Pedro	Supa			
Affected Area (sq. km.)	**0.03-0.20**	0.77	1.89	1.21	0.97	1.28	2.47	0.76			
	0.21-0.50	0.28	0.66	0.35	0.098	0.77	0.59	1			
	0.51-1.00	0.044	0.22	0.15	0.11	0.15	0.4	0.75			
	1.01-2.00	0.0003	0.064	0.05	0.02	0.015	0.36	0.78			
	2.01-5.00	0	0.0034	0.002	0.24	0.00045	0.36	0.31			
	> 5.00	0	0	0	0.057	0	0.0068	0.0017			
		0	0	0	0.057	0	0.0068	0.0017			

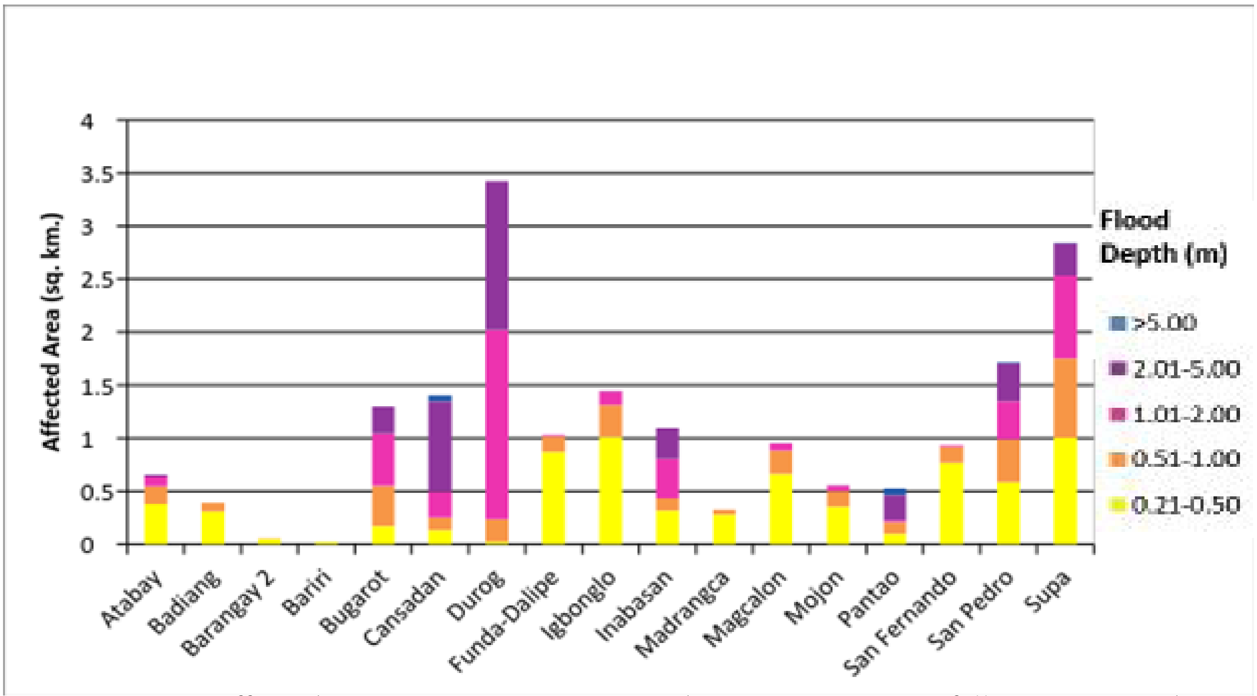


Figure 86. Affected Areas in San Jose, Antique during 100-Year Rainfall Return Period

For the municipality of San Remigio, with an area of 394.42 sq. km., 3.53% will experience flood levels of less 0.20 meters. 0.23% of the area will experience flood levels of 0.21 to 0.50 meters while 0.16%, 0.20%, 0.58%, and 0.16% 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 Table are the affected areas in square kilometres by flood depth per barangay

Table 52. Affected Areas in San Remigio, Antique during 100-Year Rainfall Return Period.

SIBALOM2 BASIN					
		Barangbang	Cadolonan	Carawisan I	Carawisan II
Affected Area (sq. km.)	0.03-0.20	0.75	1.06	6.39	1.83
	0.21-0.50	0.12	0.19	0.24	0.07
	0.51-1.00	0.15	0.079	0.12	0.053
	1.01-2.00	0.2	0.15	0.11	0.16
	2.01-5.00	0.66	0.28	0.29	0.87
	> 5.00	0.2	0.1	0.037	0.25
		Carmelo I	Carmelo II	General Luna	Ramon Magsaysay
	0.03-0.20	1.66	1.34	0.022	0.87
	0.21-0.50	0.094	0.09	0.0002	0.1
	0.51-1.00	0.081	0.073	0.0003	0.069
Affected Area (sq. km.)	1.01-2.00	0.099	0.052	0.0001	0.019
	2.01-5.00	0.13	0.035	0	0.013
	> 5.00	0.013	0.0028	0	0

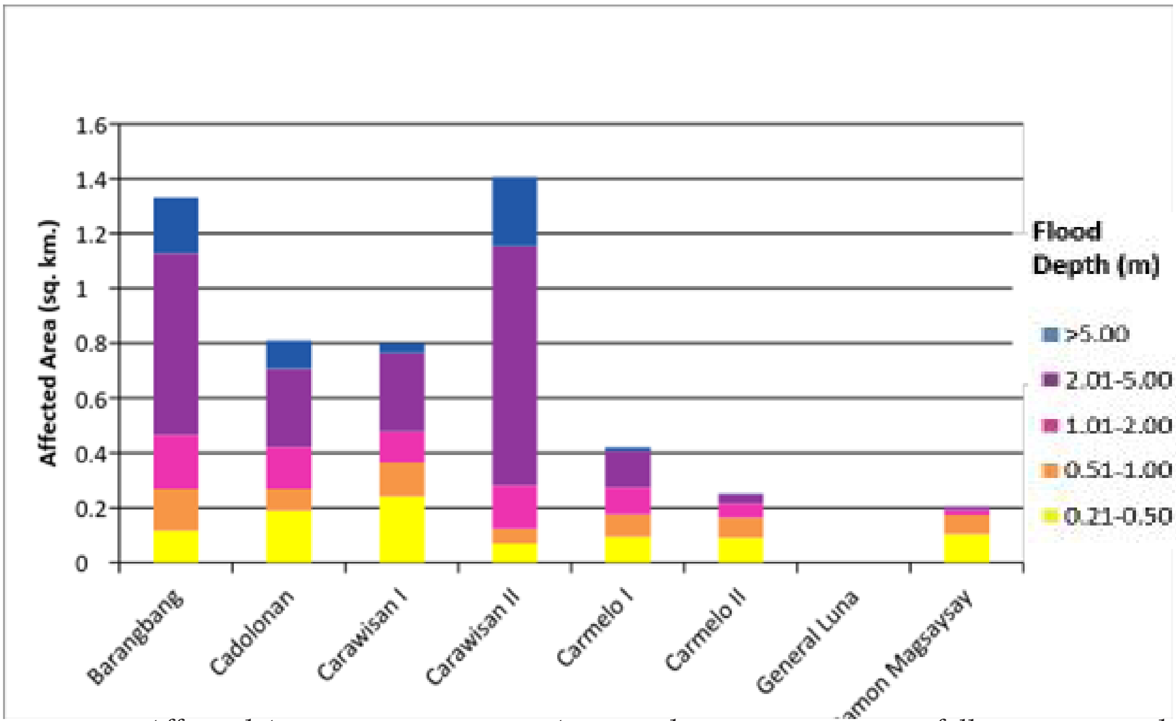


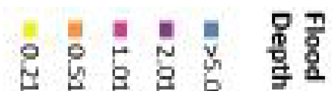
Figure 87. Affected Areas in San Remigio, Antique during 100-Year Rainfall Return Period

For the municipality of Sibalom, with an area of 234.52 sq. km., 20.79% will experience flood levels of less 0.20 meters. 5.04% of the area will experience flood levels of 0.21 to 0.50 meters while 4.06%, 3.57%, 4.98%, and 0.90% 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 Table are the affected areas in square kilometres by flood depth per barangay

Table 53. Affected Areas in Sibalom, Antique during 100-Year Rainfall Return Period

SIBALOM 2 BASIN		Affected Barangays in Sibalom									
		Alangan	Bari	Biga-A	Bongbongan I	Bongbongan II	Bongsod	Bontol	Cabariuan	Cadoldolan	Calog
Affected Area (sq. km.)	0.03-0.20	0.0026	0.3	0.051	1.83	1.23	0.031	0.39	1.47	0.65	1.05
	0.21-0.50	0.013	0.056	0.052	0.081	0.14	0.014	0.096	0.19	0.088	0.038
	0.51-1.00	0.092	0.053	0.46	0.051	0.16	0.028	0.031	0.13	0.097	0.017
	1.01-2.00	0.07	0.27	0.31	0.034	0.15	0.092	0.0047	0.02	0.031	0.013
	2.01-5.00	1.06	0.33	0.024	0.078	0.11	0.76	0	0.0057	0.0089	0.012
	> 5.00	0.2	0.18	0	0.038	0.0024	0.11	0	0.0011	0.0007	0.0021
		Catungan I	Catungan II	Catungan III	Catungan III	Catungan IV	Cubay-Napultan	Cubay-Sermon	District I	District II	District III
Affected Area (sq. km.)	0.03-0.20	0.57	1.35	0.59	1.09	0.28	0.95	0.52	0.48	0.023	2.79
	0.21-0.50	0.22	0.71	0.71	1.05	0.44	0.32	0.14	0.23	0.00092	1.67
	0.51-1.00	0.27	0.66	0.4	0.46	0.42	0.18	0.15	0.048	0.0014	0.17
	1.01-2.00	0.046	0.22	0.24	0.16	0.2	0.35	0.17	0.015	0.0032	0.06
	2.01-5.00	0.012	0.0004	0.037	0.052	0.054	0.61	0.082	0.1	0.28	0.000029
	> 5.00	0	0	0	0	0	0	0.022	0.00056	0.24	0
		Egaña	Esperanza I	Esperanza II	Esperanza II	Esperanza III	Igdagmay	Igdalaquit	Iglanot	Igsuming	Ilabas
Affected Area (sq. km.)	0.03-0.20	0.23	1.11	1.19	0.0042	0.42	0.88	2.64	0.27	0.021	1.03
	0.21-0.50	0.082	0.15	0.27	0.013	0.13	0.2	0.43	0.26	0.00066	0.24
	0.51-1.00	0.089	0.07	0.26	0.08	0.16	0.19	0.34	0.51	0.00085	0.071
	1.01-2.00	0.13	0.084	0.085	0.21	0.13	0.022	0.11	0.62	0.0007	0.14
	2.01-5.00	0.34	0.0063	0.0037	0.68	0.3	0.0007	0.024	0.39	0.0001	0.048
	> 5.00	0.5	0	0.0001	0.00086	0.048	0	0.0001	0.053	0	0

SIBALOM 2 BASIN		Affected Barangays in Sibalom									
		Inabasan	Indag-An	Initan	Insarayan	Lacaron	Lagdo	Luyang	Maasin	Mabini	Millamena
Affected Area (sq. km.)	0.03-0.20	0.15	0.71	0.24	1.53	0.98	1	0.14	1.91	3.15	3.1
	0.21-0.50	0.06	0.13	0.02	0.13	0.15	0.04	0.0043	0.13	0.21	0.38
	0.51-1.00	0.033	0.057	0.0061	0.088	0.36	0.019	0.0037	0.046	0.12	0.23
	1.01-2.00	0.0003	0.031	0.0068	0.031	0.39	0.016	0.0011	0.02	0.13	0.15
	2.01-5.00	0.0001	0.0018	0.0012	0.011	0.095	0.016	0.00029	0.0073	0.12	0.076
	> 5.00	0	0.0001	0	0.0001	0	0.0014	0.0001	0	0.0032	0
		Mojon	Nagdayao	Nazareth	Odiong	Olaga	Pangpang	Pantao	Pasong	Pis-Anan	Rombang
Affected Area (sq. km.)	0.03-0.20	0.18	1.72	1.31	0.55	0.012	0.059	0.42	0.9	1.65	0.22
	0.21-0.50	0.028	0.21	0.36	0.15	0.044	0.048	0.028	0.095	0.52	0.058
	0.51-1.00	0.11	0.15	0.33	0.06	0.55	0.14	0.02	0.088	0.32	0.1
	1.01-2.00	0.16	0.43	0.12	0.035	0.059	0.48	0.067	0.024	0.48	0.18
	2.01-5.00	0.13	0.39	0.042	0.0025	0.25	0.56	0.4	0.16	0.61	0.14
	> 5.00	0.004	0	0.0004	0	0.021	0.13	0.071	0.012	0.019	0
		San Juan	Sido	Solong	Tigbalua I	Tigbalua II	Villahermosa	Villar			
Affected Area (sq. km.)	0.03-0.20	0.78	0.35	2.01	0.39	0.92	0.79	0.12			
	0.21-0.50	0.074	0.19	0.15	0.21	0.093	0.22	0.067			
	0.51-1.00	0.098	0.3	0.12	0.1	0.029	0.14	0.26			
	1.01-2.00	0.25	0.35	0.25	0.052	0.015	0.1	0.55			
	2.01-5.00	0.38	1.34	0.83	0.0037	0.0063	0.6	0.098			



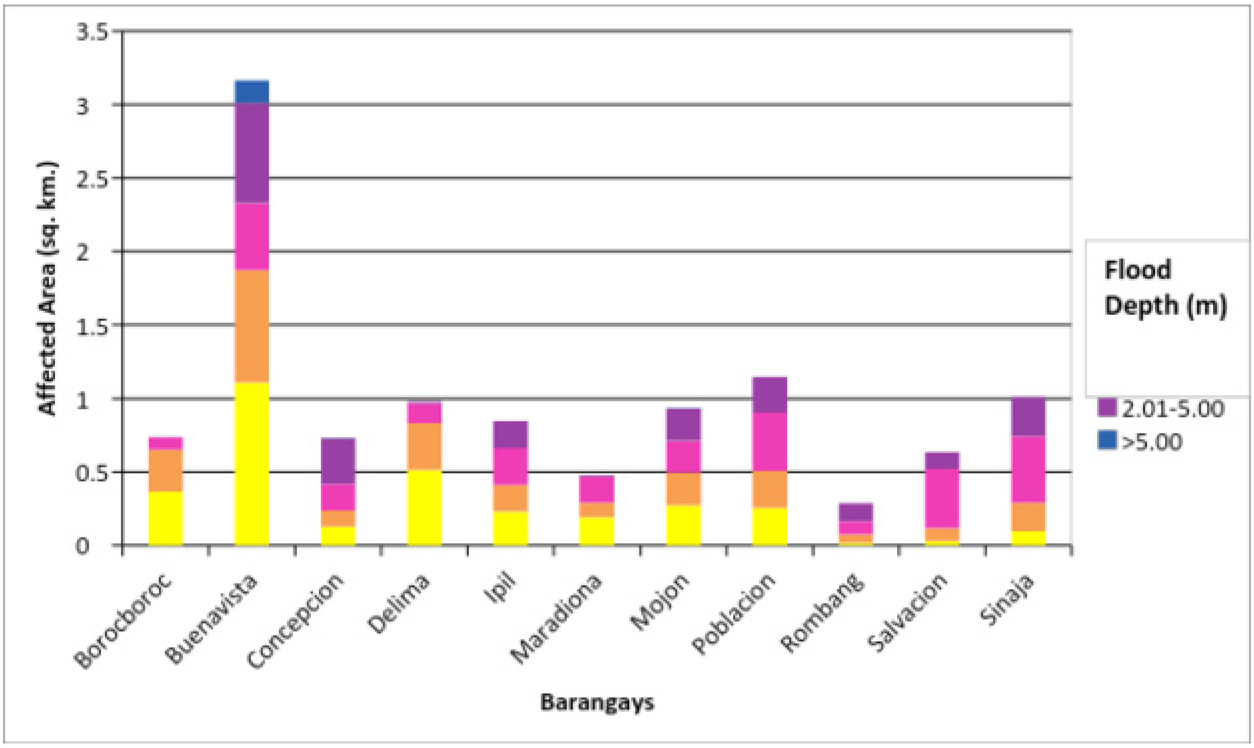
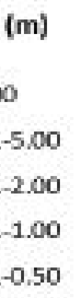


Figure 88. Affected Areas in Sibalom, Antique during 100-Year Rainfall Return Period.

Among the barangays in the municipality of Belison, Buenavista is projected to have the highest percentage of area that will experience flood levels at 73.37%. Meanwhile, Borocboroc posted the second highest percentage of area that may be affected by flood depths at 4.84%.



Among the barangays in the municipality of Patnongon, Magsaysay is projected to have the highest percentage of area that will experience flood levels at 0.74%. Meanwhile, Aureliana posted the second highest percentage of area that may be affected by flood depths at 0.41%.

Among the barangays in the municipality of San Jose, San Pedro is projected to have the highest percentage of area that will experience flood levels at 9.36%. Meanwhile, Supa posted the second highest percentage of area that may be affected by flood depths at 8.02%.

Among the barangays in the municipality of San Remigio, Carawisan I is projected to have the highest percentage of area that will experience flood levels at 1.82%. Meanwhile, Barangbang posted the second highest percentage of area that may be affected by flood depths at 0.53%.

Among the barangays in the municipality of Sibalom, District III is projected to have the highest percentage of area that will experience flood levels at 2.002%. Meanwhile, Millamena posted the second highest percentage of area that may be affected by flood depths at 1.68%.

Moreover, the generated flood hazard maps for the Dalanas Floodplain were used to assess the vulnerability of the educational and medical institutions in the floodplain. Using the flood depth units of PAG-ASA 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 54. Areas covered by each warning level with respect to the rainfall scenario.

Warning Level	Area Covered in sq. km.		
	5 year	25 year	100 year
Low	21.70	23.95	23.71
Medium	21.44	23.73	25.47
High	18.74	24.84	31.18
TOTAL	**61.88**	**72.52**	**80.36**

Of the one hundred (100) identified Education Institutions in the Sibalom 2 Flood plain, 13 schools were assessed to be exposed to the low level flooding during a 5 year scenario, 9 schools were assessed to be exposed to medium level flooding, while 1 school was assessed to be exposed to high level flooding in the same scenario. In the 25 year scenario, 20 schools were assessed to be exposed to the low level flooding scenario, 10 schools were assessed to be exposed to medium level flooding, while 2 schools were assessed to be exposed to high level flooding in the same scenario. In the 100 year scenario, 20 schools were assessed to be exposed to the low level flooding scenario, 15 schools were assessed to be exposed to medium level flooding, while 5 schools were assessed to be exposed to high level flooding in the same scenario. See Appendix D for a detailed enumeration of schools in the Sibalom 2 floodplain.
Twenty-nine (29) Medical Institutions were identified in the Sibalom 2 Floodplain. In the 5 year scenario, 4 were assessed to be exposed to the low level flooding scenario, while 1 was assessed to be exposed to medium level flooding. In the 25 year scenario, 6 were assessed to be exposed to the low level flooding scenario, 4 were assessed to be exposed to medium level flooding, while 1 was assessed to be exposed to high level flooding in the same scenario. In the 100 year scenario, 5 were assessed to be exposed to the low level flooding scenario, 6 were assessed to be exposed to medium level flooding, while 1 was assessed to be exposed to high level flooding in the same scenario. See Appendix E for a detailed enumeration of hospitals and clinics in the Sibalom 2 floodplain.

5.11 Flood Validation

In order to check and validate the extent of flooding in different river systems, performing validation survey work was needed. 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 personnel then 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 to obtain maps or situation reports about the past flooding events or interviewing some residents with knowledge of or have 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 points in the flood map versus its corresponding validation depths are shown in Figure 87.

The flood validation consists of 180 points randomly selected all over the Sibalom2 flood plain (Figure 86). Comparing it with the flood depth map of the nearest storm event, the map has an RMSE value of 0.99m. Table 50 shows a contingency matrix of the comparison. The validation points are found in ANNEX 11.

The validation pointe were obtained on February 8, 2017.

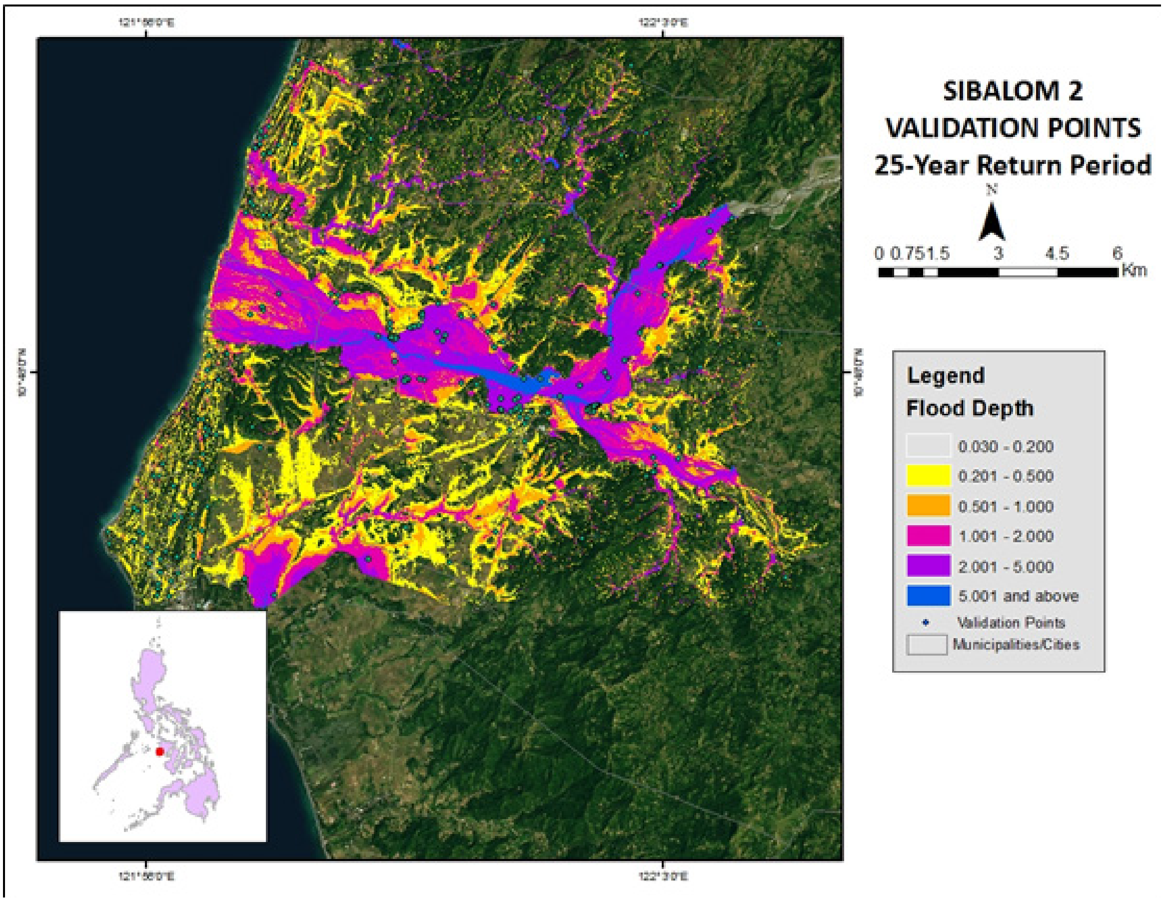


Figure 89. The Validation Points for a 5-year Flood Depth Map of the Sibalom2 Floodplain

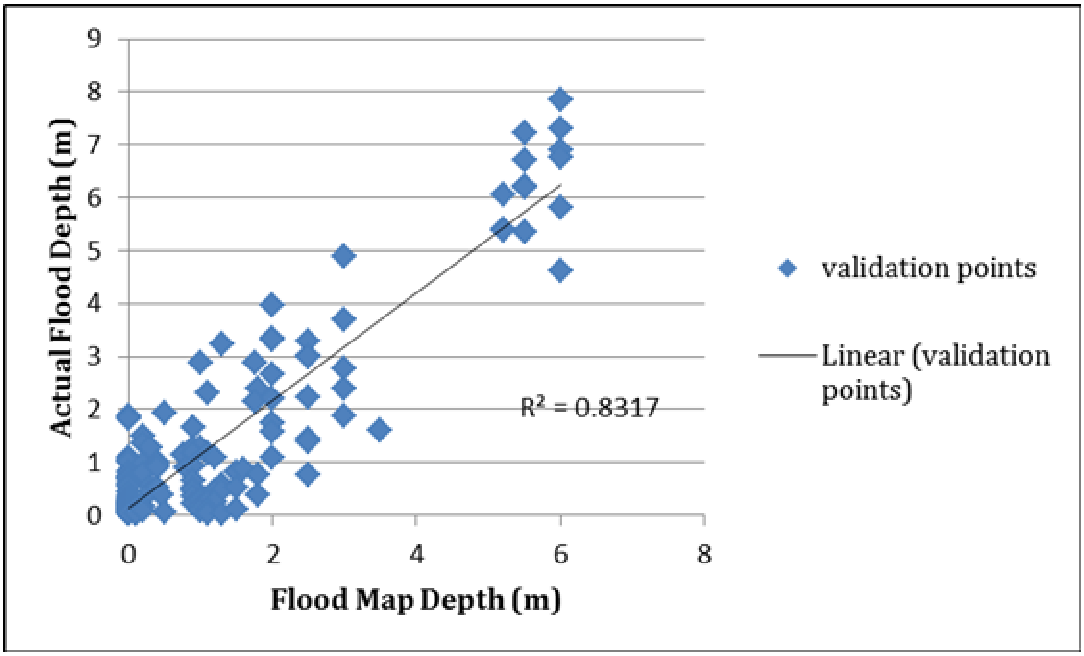


Figure 89. Flood map depth versus actual flood depth.

Table 55. Actual flood versus simulated flood depth at different levels in the Sibalom2 River

SIBALOM2	Modeled Flood Depth (m) 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	44	10	8	7	0	0	69
0.21-0.50	2	2	4	3	2	0	13
0.51-1.00	3	6	4	5	1	0	19
1.01-2.00	6	5	5	5	12	0	33
2.01-5.00	10	0	2	4	9	3	28
> 5.00	2	0	0	1	1	14	18
Total	67	23	23	25	25	17	180

On the whole, the overall accuracy generated by the flood model is estimated at 43.33%, with 78 points correctly matching the actual flood depths. In addition, there were 121 points estimated one level above and below the correct flood depths while there were 150 points and 21 points estimated two levels above and below, and three or more levels above and below the correct flood. A total of 55 points were overestimated while a total of 47 points were underestimated in the modelled flood depths of Sibalom2. Table 51 depicts the summary of the Accuracy Assessment in the Sibalom2 River Basin Flood Depth Map.

Table 56. Summary of the Accuracy Assessment in the Sibalom2 River Basin Survey.

	No. of Points	%
Correct	78	**43.33**
Overestimated	55	30.56
Underestimated	47	26.11
Total	180	100

REFERENCES

Ang M.O., Paringit E.C., et al. 2014. *DREAM Data Processing Component Manual*. Quezon City, Philippines: UP Training Center for Applied Geodesy and Photogrammetry.

Balicanta L.P., Paringit E.C., et al. 2014. *DREAM Data Validation Component Manual*. Quezon City, Philippines: UP Training Center for Applied Geodesy and Photogrammetry.

Brunner, G. H. 2010a. HEC-RAS River Analysis System Hydraulic Reference Manual. Davis, CA: U.S. Army Corps of Engineers, Institute for Water Resources, Hydrologic Engineering Center.

Lagmay A.F., Paringit E.C., et al. 2014. *DREAM Flood Modeling Component Manual*. Quezon City, Philippines: UP Training Center for Applied Geodesy and Photogrammetry.

Paringit E.C, Balicanta L.P., Ang, M.O., Sarmiento, C. 2017. *Flood Mapping of Rivers in the Philippines Using Airborne Lidar: Methods*. Quezon City, Philippines: UP Training Center for Applied Geodesy and Photogrammetry.

Sarmiento C., Paringit E.C., et al. 2014. *DREAM Data Acquisition Component Manual*. Quezon City, Philippines: UP Training Center for Applied Geodesy and Photogrammetry.

UP TCAGP 2016, *Acceptance and Evaluation of Synthetic Aperture Radar Digital Surface Model (SAR DSM) and Ground Control Points (GCP)*. Quezon City, Philippines: UP Training Center for Applied Geodesy and Photogrammetry.

ANNEXES

ANNEX 1. Technical Specifications of the LIDAR Sensors used in the Sibalom 2Floodplain Survey

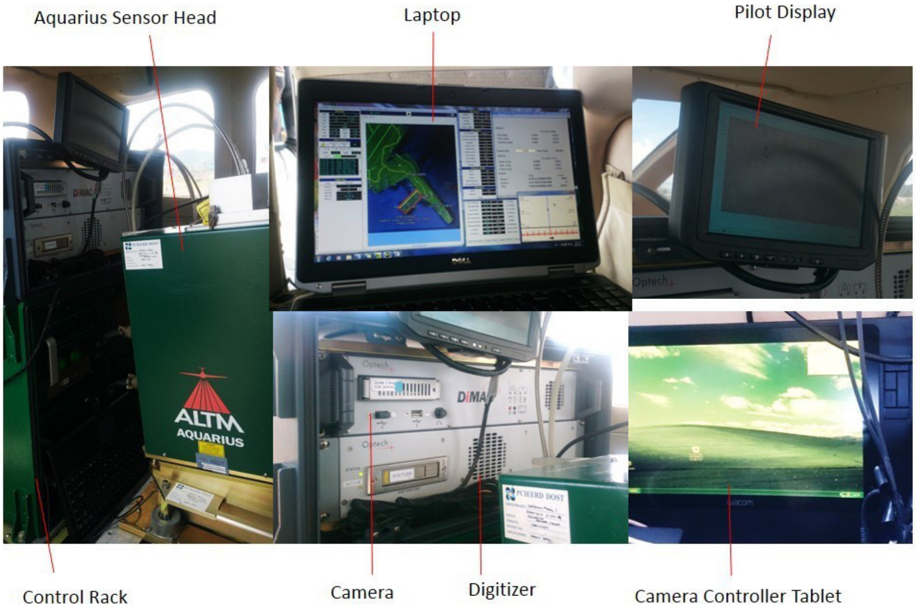
1. GEMINI SENSOR

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

2. PEGASUS SENSOR

Parameter	Specification
Operational envelope (1,2,3,4)	150-5000 m AGL, nominal
Laser wavelength	1064 nm
Horizontal accuracy (2)	1/5,500 x altitude, 1Ó
Elevation accuracy (2)	< 5-20 cm, 1Ó
Effective laser repetition rate	Programmable, 100-500 kHz
Position and orientation system	POS AV ™AP50 (OEM)
Scan width (FOV)	Programmable, 0-75 ˚
Scan frequency (5)	Programmable, 0-140 Hz (effective)
Sensor scan product	800 maximum
Beam divergence	0.25 mrad (1/e)
Roll compensation	Programmable, ±37˚ (FOV dependent)
Vertical target separation distance	<0.7 m
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)
Image capture	5 MP interline camera (standard); 60 MP full frame (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, 800 W, 30 A
Dimensions and weight	Sensor: 630 x 540 x 450 mm; 65 kg;
	Control rack: 650 x 590 x 490 mm; 46 kg

3. AQUARIUS SENSOR



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 altitude	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 (op-tional)
Full waveform capture	12-bit Optech IWD-2 Intelligent Waveform Digitizer (op-tional)
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

ANNEX 2. NAMRIA Certificate of Reference Points Used in the LiDAR Survey

1. ATQ-18

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

March 02, 2015

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: **ANTIQUE**	
	Station Name: **ATQ-18**	
	Order: **2nd**	
Island: **VISAYAS**	Barangay: **CUBAY**	
Municipality: **BARBAZA**	MSL Elevation:	
	PRS92 Coordinates	
Latitude: **11° 11' 58.67081"**	Longitude: **122° 2' 22.83300"**	Ellipsoidal Hgt: **10.90200 m.**
	WGS84 Coordinates	
Latitude: **11° 11' 54.16068"**	Longitude: **122° 2' 28.01549"**	Ellipsoidal Hgt: **65.96100 m.**
	PTM / PRS92 Coordinates	
Northing: **1238579.674 m.**	Easting: **395119.157 m.**	Zone: **4**
	UTM / PRS92 Coordinates	
Northing: **1,238,146.15**	Easting: **395,155.87**	Zone: **51**

Location Description

ATQ-18
From San Jose, travel N to the Mun. of Barbaza. Then from the town proper, proceed to Brgy. Cubay. Station is located on the NE approach of Binangbang Bridge, about 600 m. NE of Barbaza Town Hall, 4 m. from the road centerline, 50 m. SE of Barbaza Multi-Purpose Coop./Natco Network and 25 m. SE of a funeral service outlet. Mark is the head of a 4 in. copper nail centered on a 30 cm. x 30 cm. cement putty, with inscriptions "ATQ-18 2007 NAMRIA".

Requesting Party:	**PHIL-LIDAR 1**
Purpose:	**Reference**
OR Number:	**8077754 I**
T.N.:	**2015-0504**

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

9 9 0 3 0 2 2 0 1 5 1 3 1 3 4 6

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

2. ATQ-20

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

November 14, 2016

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: **ANTIQUE**	
	Station Name: **ATQ-20**	
	Order: **2nd**	
Island: **VISAYAS**	Barangay: **ZARAGOZA**	
Municipality: **BUGASONG**	MSL Elevation:	
	PRS92 Coordinates	
Latitude: **11° 0' 42.90484"**	Longitude: **122° 2' 54.07144"**	Ellipsoidal Hgt: **10.56200 m.**
	WGS84 Coordinates	
Latitude: **11° 0' 38.44240"**	Longitude: **122° 2' 59.27039"**	Ellipsoidal Hgt: **66.09400 m.**
	PTM / PRS92 Coordinates	
Northing: **1217812.272 m.**	Easting: **396000.488 m.**	Zone: **4**
	UTM / PRS92 Coordinates	
Northing: **1,217,386.02**	Easting: **396,036.89**	Zone: **51**

Location Description

ATQ-20
From San Jose, travel N for about 45 km. to Brgy. Zaragoza, Mun. of Bugasong. Station is located on the left side of the first approach of Cangaranan Bridge. Mark is the head of a 4 in. copper nail centered on a 30 cm. x 30 cm. cement putty, with inscriptions "ATQ-20 2007 NAMRIA".

Requesting Party: **Phil Lidar 1**
Purpose: **Reference**
OR Number: **FREE ISSUE**
T.N.: **2016-2057**

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

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ISO 9001: 2008 CERTIFIED FOR MAPPING AND GEOSPATIAL INFORMATION MANAGEMENT

3. ATQ-22

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

March 02, 2015

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: **ANTIQUE**
Station Name: **ATQ-22**
Order: **2nd**

Island: **VISAYAS**	Barangay: **CONCEPCION**	
Municipality: **BELISON**	MSL Elevation:	
	PRS92 Coordinates	
Latitude: **10° 49' 46.66618"**	Longitude: **121° 58' 11.90221"**	Ellipsoidal Hgt: **12.25000 m.**
	WGS84 Coordinates	
Latitude: **10° 49' 42.24271"**	Longitude: **121° 58' 17.11770"**	Ellipsoidal Hgt: **68.02200 m.**
	PTM / PRS92 Coordinates	
Northing: **1197676.056 m.**	Easting: **387365.279 m.**	Zone: **4**
	UTM / PRS92 Coordinates	
Northing: **1,197,256.85**	Easting: **387,404.70**	Zone: **51**

Location Description

ATQ-22

From San Jose, travel N to Belison for about 20 km. Station is located on top of the N edge of the NW draft on an irrigation canal, 60 m. NE to the nat'l. highway centerline, 120 m. N of the road going to the brgy. proper and about 300 m. E of Km. Post No. 110. Mark is the head of a 4 in. copper nail centered on a 30 cm. x 30 cm. cement putty, with inscriptions "ATQ-22 2007 NAMRIA".

Requesting Party: **PHIL-LIDAR 1**
Purpose: **Reference**
OR Number: **8077754 I**
T.N.: **2015-0503**

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

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CIP/4701/12/09/814

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4. ILO-1

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

April 10, 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: **ILOILO**
Station Name: **ILO-1**
Order: **1st**

Island: **VISAYAS**
Municipality: **ILOILO CITY**
Barangay: **LA PAZ**

	PRS92 Coordinates	
Latitude: **10° 42' 40.74251"**	Longitude: **122° 33' 48.38302"**	Ellipsoidal Hgt: **28.93600 m.**
	WGS84 Coordinates	
Latitude: **10° 42' 36.40006"**	Longitude: **122° 33' 53.60515"**	Ellipsoidal Hgt: **86.45300 m.**
	PTM Coordinates	
Northing: **1184434.202 m.**	Easting: **452244.945 m.**	Zone: **4**
	UTM Coordinates	
Northing: **1,184,019.63**	Easting: **452,261.66**	Zone: **51**

Location Description

ILO-1
From Iloilo Capitol Bldg., travel W towards Jaro for 2.2 km. along Luna St. in La Paz, Iloilo. The station is located on top of St. Clemente Church bell tower which is across Western Institute of Technology. Station mark; cross cut on top of a 0.15 m. x 0.01 m. dia. brass rod drilled on center top of concrete floor of St. Clemente Church bell tower with 0.30 cm. x 0.30 cm. cement patty, 0.01 m. above surface and inscribed on top with station name. Reference mark numbers 1, 3 and 4 are 0.05 m. dia. holes on top of ledge, reference number 2 is 0.07 m. dia. hole on top of ledge.

recomputed 3/19/2014

Requesting Party: **UP-DREAM**
Pupose: **Reference**
OR Number: **8795949 A**
T.N.: **2014-834**

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

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CERTIFICATION INTERNATIONAL ISO 9001:2008
CIP/4701/12/09/814

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5. ILO-85

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

April 10, 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: **ILOILO**
Station Name: **ILO-85**
Order: **2nd**

Island: **VISAYAS**
Municipality: **MIAG-AO**
Barangay: **UBOS ILAWOD (POB.)**

	PRS92 Coordinates	
Latitude: **10° 38' 33.11352"**	Longitude: **122° 14' 3.70560"**	Ellipsoidal Hgt: **21.96200 m.**
	WGS84 Coordinates	
Latitude: **10° 38' 28.75996"**	Longitude: **122° 14' 8.93597"**	Ellipsoidal Hgt: **78.82800 m.**
	PTM Coordinates	
Northing: **1176896.034 m.**	Easting: **416226.997 m.**	Zone: **4**
	UTM Coordinates	
Northing: **1,176,484.10**	Easting: **416,256.32**	Zone: **51**

Location Description

ILO-85
From Iloilo City, travel W for about 40 km. to the Mun. of Miag-ao. Then proceed directly to the Town Plaza, where the station is located. Station is located at the corner of a planting strip and sidewalk, about 14 m. fronting the Rizal monument. Mark is the head of a 4 in. copper nail set flushed on top of a 30 cm. x 30 cm. concrete monument protruding 20 cm. above the ground, with inscriptions "ILO-85 2007 NAMRIA".

Requesting Party: **UP-DREAM**
Pupose: **Reference**
OR Number: **8795949 A**
T.N.: **2014-836**

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

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CIP/4701/12/09/814

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6. ILO-86

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

April 10, 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: **ILOILO**
Station Name: **ILO-86**
Order: **2nd**

Island: **VISAYAS**
Municipality: **IGBARAS**
Barangay: **BARANGAY 3 POBLACION**

	PRS92 Coordinates	
Latitude: **10° 43' 4.36044"**	Longitude: **122° 15' 48.62123"**	Ellipsoidal Hgt: **47.31500 m.**
	WGS84 Coordinates	
Latitude: **10° 42' 59.99043"**	Longitude: **122° 15' 53.84473"**	Ellipsoidal Hgt: **104.07600 m.**
	PTM Coordinates	
Northing: **1185222.285 m.**	Easting: **419435.758 m.**	Zone: **4**
	UTM Coordinates	
Northing: **1,184,807.44**	Easting: **419,463.96**	Zone: **51**

Location Description

ILO-86
From Iloilo City, travel W to the Mun. of Igbaras. Then proceed directly to the Town Plaza, where the station is located. Station is located about 12 m. from the circular fountain at the center of the said plaza.

Mark is the head of a 4 in. copper nail set flushed on top of a 30 cm. x 30 cm. concrete monument protruding 20 cm. above the ground, with inscriptions "ILO-86 2007 NAMRIA".

Requesting Party: **UP-DREAM**
Pupose: **Reference**
OR Number: **8795949 A**
T.N.: **2014-837**

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

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ISO 9001: 2008 CERTIFIED FOR MAPPING AND GEOSPATIAL INFORMATION MANAGEMENT

CIP/4701/12/09/814

7. IL-533

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

March 02, 2015

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: **ILOILO**
Station Name: **IL-533**

Island: **PANAY**	Municipality: **SAN JOAQUIN**	Barangay: **AMBOYU-AN**
Elevation: **8.0971 m.**	Order: **1st Order**	Datum: **Mean Sea Level**
Latitude: **10° 32' 45.00000"**	Longitude: **122° 4' 42.48000"**	

Location Description

BM IL-533
Station is located at the sidewalk of Ambuyuan bridge 0.30m. from thr edge. Mark is the head of a 4in. copper nail set flush on a cement putty with inscriptions " IL-533, 2007, NAMRIA."

Requesting Party: **PHIL-LIDAR 1**
Purpose: **Reference**
OR Number: **8077754 I**
T.N.: **2015-0505**

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

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CIP/4701/12/04/814

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

1. AQ-10

Vector Components (Mark to Mark)

From:	ATQ-20				
Grid		Local		Global	
Easting	396036.890 m	Latitude	N11°00'42.90484"	Latitude	N11°00'38.44240"
Northing	1217386.017 m	Longitude	E122°02'54.07144"	Longitude	E122°02'59.27039"
Elevation	10.798 m	Height	10.563 m	Height	66.094 m

To:	AQ-				
Grid		Local		Global	
Easting	396235.105 m	Latitude	N11°01'03.59755"	Latitude	N11°00'59.13382"
Northing	1218020.995 m	Longitude	E122°03'00.53639"	Longitude	E122°03'05.73482"
Elevation	11.276 m	Height	11.054 m	Height	66.576 m

Vector					
ΔEasting	198.215 m	NS Fwd Azimuth	17°09'16"	ΔX	-102.123 m
ΔNorthing	634.978 m	Ellipsoid Dist.	665.374 m	ΔY	-206.684 m
ΔElevation	0.478 m	ΔHeight	0.491 m	ΔZ	624.160 m

Standard Errors

Vector errors:					
σ ΔEasting	0.001 m	σ NS fwd Azimuth	0°00'00"	σ ΔX	0.001 m
σ ΔNorthing	0.000 m	σ Ellipsoid Dist.	0.000 m	σ ΔY	0.001 m
σ ΔElevation	0.001 m	σ ΔHeight	0.001 m	σ ΔZ	0.000 m

Aposteriori Covariance Matrix (Meter²)

	X	Y	Z
X	0.0000003727		
Y	-0.0000004068	0.0000012949	
Z	-0.0000001072	0.0000002886	0.0000002405

2. IIAP-01

Baseline Processing Report

Processing Summary

Observation	From	To	Solution Type	H. Prec. (Meter)	V. Prec. (Meter)	Geodetic Az.	Ellipsoid Dist. (Meter)	ΔHeight (Meter)
IIAP-01 --- ILO-85 (B1)	ILO-85	IIAP-01	Fixed	0.005	0.021	53°20'16"	35787.597	21.428
IIAP-01 --- ILO-85 (B2)	ILO-85	IIAP-01	Fixed	0.004	0.019	53°20'16"	35787.597	21.398

Acceptance Summary

Processed	Passed	Flag	Fail
2	2	0	0

Vector Components (Mark to Mark)

From:	ILO-85				
Grid		Local		Global	
Easting	416256.319 m	Latitude	N10°38'33.11352"	Latitude	N10°38'28.75996"
Northing	1176484.099 m	Longitude	E122°14'03.70561"	Longitude	E122°14'08.93597"
Elevation	22.539 m	Height	21.962 m	Height	78.828 m

To:	IIAP-01				
Grid		Local		Global	
Easting	445007.365 m	Latitude	N10°50'08.21923"	Latitude	N10°50'03.83971"
Northing	1197773.997 m	Longitude	E122°29'48.82359"	Longitude	E122°29'54.03518"
Elevation	42.806 m	Height	43.390 m	Height	100.449 m

Vector					
ΔEasting	28751.046 m	NS Fwd Azimuth	53°20'16"	ΔX	-22136.041 m
ΔNorthing	21289.898 m	Ellipsoid Dist.	35787.597 m	ΔY	-18716.081 m
ΔElevation	20.268 m	ΔHeight	21.428 m	ΔZ	20987.226 m

Standard Errors

Vector errors:					
σ ΔEasting	0.002 m	σ NS fwd Azimuth	0°00'00"	σ ΔX	0.006 m
σ ΔNorthing	0.002 m	σ Ellipsoid Dist.	0.002 m	σ ΔY	0.009 m
σ ΔElevation	0.011 m	σ ΔHeight	0.011 m	σ ΔZ	0.003 m

ANNEX 4. The LiDAR Survey Team Composition

Data Acquisition Component Sub-team	Designation	Name	Agency/Affiliation
Data Acquisition Component Leader	Data Component Program Leader	ENRICO C. PARINGIT	UP-TCAGP
Data Acquisition Component Leader	Data Component Project Leader -I	ENGR. CZAR JAKIRI S. SARMIENTO ENGR. LOUIE P. BALICANTA	UP-TCAGP
Survey Supervisor	Chief Science Research Specialist (CSRS)	ENGR. CHRISTOPHER CRUZ	UP TCAGP
LiDAR Operation	Senior Science Research Specialist	ENGR. LOVELYN ASUNCION ENGR. GEROME HIPOLITO ENGR. IRO NIEL ROXAS	UP TCAGP
LiDAR Operation	Research Associate	PAULINE JOANNE ARCEO VERLINA TONGA REGINA FELISMINO MARY CATHERINE ELIZABETH BALIGUAS	UP TCAGP
	Research Associate	RENAN PUNTO MA. REMEDIOS VILLANUEVA KRISTINE ANDAYA	UP TCAGP
Ground Survey	Research Associate	JERIEL PAUL ALAMBAN KENNETH QUISADO IRO NIEL ROXAS SANDRA POBLETE	UP TCAGP
Data Download and Transfer	Senior Science Research Specialist	RENAN PUNTO VERLINA TONGA MA. REMEDIOS VILLANUEVA	UP TCAGP
LiDAR Operation	Airborne Security	SSG. LEE JAY PUNZALAN SSG. DAVE GUMBAN	PILIPPINE AIR FORCE (PAF)
LiDAR Operation	Pilot	CAPT. JACKSON JAVIER CAPT. JEFFREY ALAJAR CAPT. BRYAN	ASIAN AEROSPACE CORPORATION (AAC)
LiDAR Operation	Co-Pilot	CAPT. NEIL ACHILLES AGAWIN CAPT. ALBERT LIM CAPT. HOYA	AAC

ANNEX 5. Data Transfer Sheet for Sibalom 2Floodplain

DATA TRANSFER SHEET
03/23/2015(Iloilo-gem)

	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	
-15	2566G	2BLK37V047A	gemini	na	1517	1.13	209	28	206	13	1.36	10.7	1KB	1KB	19	19	Z:\DAC\RAW DATA
-15	2568G	2BLK37GSIV047B	gemini	na	952	1.34	222	46.8	383	21.9	2.12	6.61	1KB	1KB	7/4	15/12	Z:\DAC\RAW DATA
-15	2570G	2BLK43H048A	gemini	na	1078	1.43	222	48.5	342	21.7	3.4	14.4	1KB	1KB	3	3	Z:\DAC\RAW DATA
-15	2578G	2BLK43GV050A	gemini	na	586	891	184	8.07	67.8	19.4	na	11.1	1KB	1KB	7	na	Z:\DAC\RAW DATA
-15	2580G	2BLK43F050B	gemini	na	740	990	163	25.6	203	16.2	3.29	4.11	1KB	1KB	4	8	Z:\DAC\RAW DATA
-15	2582G	2BLK43A051A	gemini	na	169	254	106	6.84	57.4	4.65	ns	11	1KB	1KB	6	13	Z:\DAC\RAW DATA
-15	2586G	2BLK43A052A	gemini	na	613	670	182	15.4	63.9	8.3	1.43	11.5	1KB	1KB	5	10	Z:\DAC\RAW DATA
-15	2590G	2BLK43A053A	gemini	na	694	0.97	198	21.2	94.4/628	12.1	na	17	1KB	1KB	5	10	Z:\DAC\RAW DATA
-15	2594G	2BLK43C054A	gemini	na	856	1.05	240	28.2	17.2/163	16.3	na	11.6	1KB	1KB	6	14	Z:\DAC\RAW DATA

Received from

Name C-Joaquin
Position FA
Signature

Received by

Name JOIDA F. PRIETO
Position SCRS
Signature 3/23/2015

DATA TRANSFER SHEET
03/23/2015(Iloilo-peg)

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	
14-Feb-15	2569P	1BLK43DO45A	pegasus	1.28	940	6.06	196	30.5	35/45	14.4	na	10.5	1KB	1KB	76	na	Z:\DAC\RAW DATA
16-Feb-15	2579P	1BLK43MO47B	pegasus	1.77	1.21	10.4	221	26.4	251	19.5	na	12.2	1KB	1KB	77/18	na	Z:\DAC\RAW DATA
17-Feb-15	2581P	1BLK43MNO48A	pegasus	2.06	1.35	9.99	263	34.3	265	21.4	na	20.2	1KB	1KB	76/77/21	na	Z:\DAC\RAW DATA
17-Feb-15	2583P	1BLK43DO48B	pegasus	1.11	716	6.06	170	14	127	11.4	na	20.2	1KB	1KB	96/70	na	Z:\DAC\RAW DATA
18-Feb-15	2585P	1BLK43EFO49A	pegasus	2.91	1.71	9.97	283	42	314	27.8	na	14.3	1KB	1KB	99/117	na	Z:\DAC\RAW DATA
18-Feb-15	2587P	1BLK43EDO49B	pegasus	1.7	1.02	9.05	190	19.9	16/71	17.4	na	7.46	1KB	1KB	1/907/77	na	Z:\DAC\RAW DATA
19-Feb-15	2589P	1BLK43EFDO50A	pegasus	1.2	739	7.74	417	17.3	133	12.3	na	16.7	1KB	1KB	86/77/826/82 1	na	Z:\DAC\RAW DATA
19-Feb-15	2591P	1BLK37IO50B	pegasus	5.53	1.02	9.47	199	49.9	343	25.3	na	9.75	1KB	1KB	64	na	Z:\DAC\RAW DATA
20-Feb-15	2593P	1BLK43BDGO51A	pegasus	3.14	1.01	7.62	213	27	218	16.3	na	11	1KB	1KB	114	na	Z:\DAC\RAW DATA
21-Feb-15	2597P	1BLK43NO52A	pegasus	2.09	1.29	8.69	257	37.9	274	21	na	11.5	1KB	1KB	52	na	Z:\DAC\RAW DATA
22-Feb-15	2601P	1BLK37IFVO53A	pegasus	2.13	1.27	9.06	225	32.2	256	20.7	na	17.7	1KB	1KB	101/76	na	Z:\DAC\RAW DATA

Received from

Name C. JOAQUIN
Position RA
Signature

Received by

Name JOIDA F. PRIETO
Position SSRS
Signature 3/23/2015

DATA TRANSFER SHEET
7/3/2014(Iloilo)

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	
25-Feb-15	2602G	2BLK43B056A	GEMINI	NA	278	402	167	8.44	61	5.95	NA	9.49	1KB	1KB	12	17	Z:\DAC\RAW DATA
26-Feb-15	2606G	2BLK43BV057A	GEMINI	NA	739	932	208	22.5	92	12.6	NA	9.26	1KB	1KB	12	18	Z:\DAC\RAW DATA
27-Feb-15	2610G	2BLK43BV058A	GEMINI	NA	100	190	173	2.88	25	2.95	NA	8.94	1KB	1KB	NA	NA	Z:\DAC\RAW DATA
5-Mar-15	2634G	2BLK37FV064A	GEMINI	NA	298	532	170	14.6	122	5.2	NA	22.7	1KB	1KB	8	13	Z:\DAC\RAW DATA
5-Mar-15	2636G	2BLK43OS064B	GEMINI	NA	468	770	205	23.2	105	5.05	NA	22.7	1KB	1KB	8	18	Z:\DAC\RAW DATA
6-Mar-15	2638G	2BLK43OS065A	GEMINI	NA	581	894	234	27.5	190	12.5	NA	20.1	1KB	1KB	13	21	Z:\DAC\RAW DATA
25-Feb-15	2613P	1BLK37IFV056A	PEGASUS	1.94	652	6.14	151	17.6	134	10	NA	16.6	1KB	1KB	101/76	NA	Z:\DAC\RAW DATA
26-Feb-15	2617P	1BLK37OP057A	PEGASUS	7.28	2.14	12.3	260	55.2	457	34.5	NA	18.7	1KB	1KB	196	NA	Z:\DAC\RAW DATA
27-Feb-15	2621P	1BLK37P058A	PEGASUS	3.11	1.93	12.8	245	48.1	414	27.3	NA	15.5	1KB	1KB	160	NA	Z:\DAC\RAW DATA
3-Mar-15	2637P	1BLK43NO062A	PEGASUS	1.82	1.15	9.81	245	32.8	237	18.3	NA	10.7	1KB	1KB	21/107	NA	Z:\DAC\RAW DATA
3-Mar-15	2639P	1BLK37M062B	PEGASUS	858	510	4.92	114	9.94	89	8.09	1.65	10.7	1KB	1KB	172	NA	Z:\DAC\RAW DATA
5-Mar-15	2645P	1BLK37Q064A	PEGASUS	2.74	.99	10.1	263	35.8	264	18.3	53.5	22.7	1KB	1KB	185/188	NA	Z:\DAC\RAW DATA
5-Mar-15	2647P	1BLK37MQ064B	PEGASUS	NA	1.16	9.62	235	71.5	4	17.8	NA	22.7	1KB	1KB	238/154	NA	Z:\DAC\RAW DATA
6-Mar-15	2649P	1BLK37Q065A	PEGASUS	582	505	5.92	202	15.1	105	7.9	50.4	20.1	1KB	1KB	231/210	NA	Z:\DAC\RAW DATA

Received from

Name C. Joaquin
Position [illegible]
Signature [illegible]

Received by

Name Angelo, Carlo Bongat
Position [illegible]
Signature [illegible]

DATA TRANSFER SHEET
ILOILO 11/14/2016

DATE	FLIGHT NO.	MISSION NAME	SENSOR	RAW LAS		LOGS	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	
October 23, 2016	8507AC	3BLK37C297A	AQUA CASI	NA	198	686	206	NA	NA	8.18	NA	134	1KB	1KB	16	NA	Z:\DAC\RAW DATA
October 24, 2016	8509AC	3BLK37A298A	AQUA CASI	NA	105	311	204	NA	NA	5.27	NA	127	1KB	1KB	8	20	Z:\DAC\RAW DATA
October 24, 2016	8510AC	3BLK37B298B	AQUA CASI	NA	116	642	160	NA	NA	5.11	NA	127	1KB	1KB	23	NA	Z:\DAC\RAW DATA
October 25, 2016	8511AC	3BLK43KJ299A	AQUA CASI	NA	92	337	217	NA	NA	4.91	NA	71.7	1KB	1KB	9	NA	Z:\DAC\RAW DATA
October 26, 2016	8513AC	3BLK43D300A	AQUA CASI	NA	316	664	244	NA	NA	13.2	NA	208	1KB	1KB	66	NA	Z:\DAC\RAW DATA
October 26, 2016	8514AC	3BLK43G300B	AQUA CASI	NA	41	127	142	NA	NA	2.7	NA	208	1KB	1KB	6	NA	Z:\DAC\RAW DATA
October 27, 2016	8515AC	3BLK43K301A	AQUA CASI	NA	156	273	189	NA	NA	3.35	NA	104	1KB	1KB	5	NA	Z:\DAC\RAW DATA

Received from

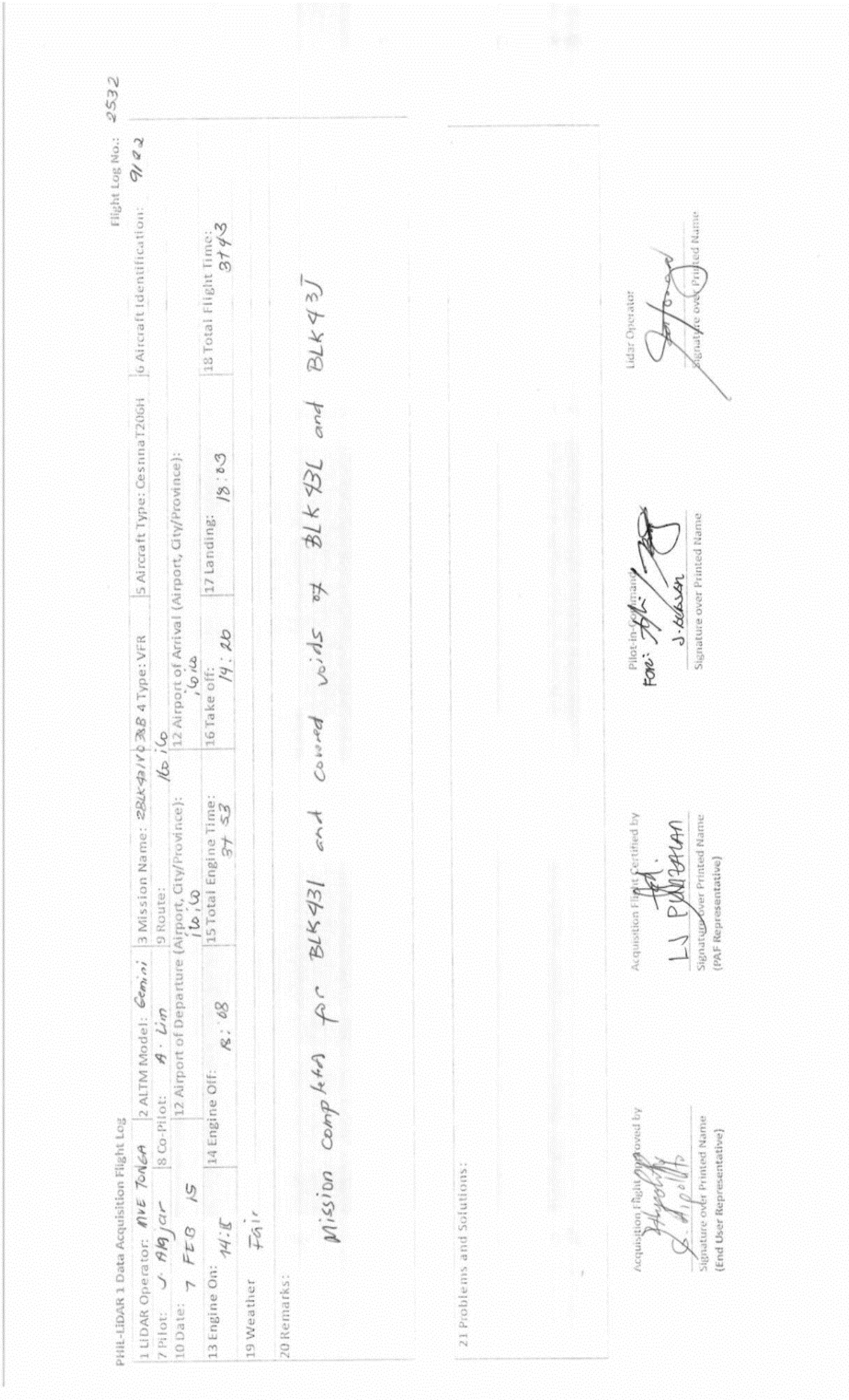
Name R. Punto
Position RA
Signature [signature]

Received by

Name AC Bongat
Position SSRS
Signature [signature] 11/22/16

ANNEX 6. Flight logs for the flight missions

1. Flight Log for 2532G Mission


PHIL-LIDAR 1 Data Acquisition Flight Log

Flight Log No.: 2532

1 LIDAR Operator: ALE TONGA	2 ALTM Model: Gemini	3 Mission Name: 2BLK43IV038B	4 Type: VFR	5 Aircraft Type: Cesnna T206H	6 Aircraft Identification: 9122
7 Pilot: J. Albjar	8 Co-Pilot: A. Lim	9 Route: Iloilo			
10 Date: 7 FEB 15	12 Airport of Departure (Airport, City/Province): Iloilo		12 Airport of Arrival (Airport, City/Province): Iloilo		
13 Engine On: 14:15	14 Engine Off: 18:08	15 Total Engine Time: 3+53	16 Take off: 14:20	17 Landing: 18:03	18 Total Flight Time: 3+43
19 Weather: Fair					

20 Remarks:

Mission completed for BLK43I and covered voids of BLK43L and BLK43J

21 Problems and Solutions:

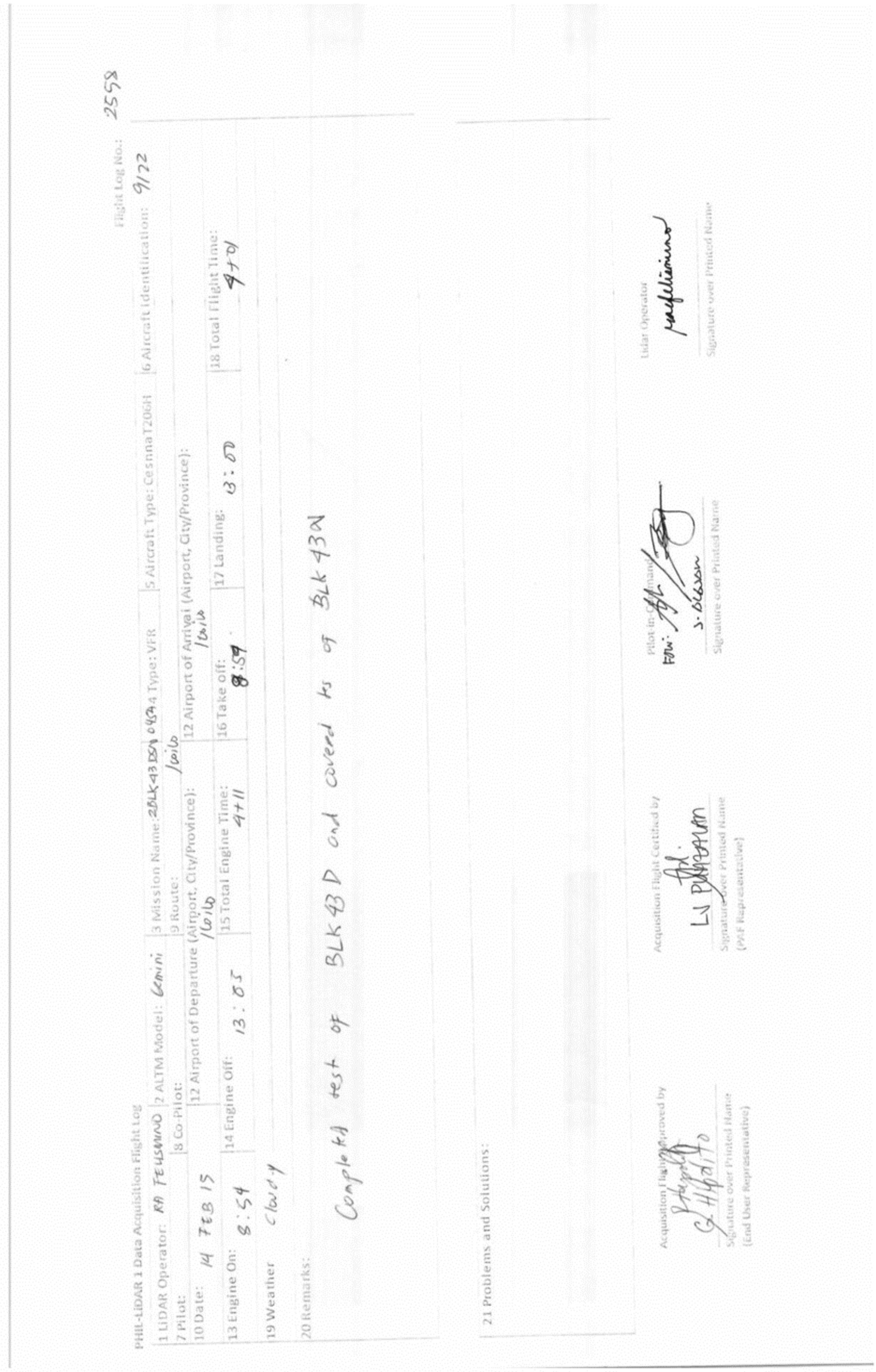
Acquisition Flight Approved by — Signature over Printed Name (End User Representative)

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

Pilot-in-Command — For: J. Albaran — Signature over Printed Name

Lidar Operator — Signature over Printed Name

2. Flight Log for 2558G Mission



PHIL-LIDAR 1 Data Acquisition Flight Log

Flight Log No.: 2558

1 LiDAR Operator: RA FELISMINO	2 ALTM Model: Gemini	3 Mission Name: 2BLK43DS045A	4 Type: VFR	5 Aircraft Type: Cesnna T206H	6 Aircraft Identification: 9122
7 Pilot:	8 Co-Pilot:	9 Route: Iloilo			
10 Date: 14 FEB 15	12 Airport of Departure (Airport, City/Province): Iloilo		12 Airport of Arrival (Airport, City/Province): Iloilo		
13 Engine On: 8:54	14 Engine Off: 13:05	15 Total Engine Time: 4+11	16 Take off: 8:59	17 Landing: 13:00	18 Total Flight Time: 4+01
19 Weather: Cloudy					
20 Remarks: Completed test of BLK 43D and covered ks of BLK 43N					
21 Problems and Solutions:					

Acquisition Flight Approved by: G. Hipolito
Signature over Printed Name (End User Representative)

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

Pilot-in-Command: FOR: S. Bleeson
Signature over Printed Name

Lidar Operator
Signature over Printed Name

3. Flight Log for 2569P Mission

PHIL-LiDAR 1 Data Acquisition Flight Log

Flight Log No.: 2569

1 LiDAR Operator: V. Tonga	2 ALTM Model: Pegasus	3 Mission Name: 1BLK43D045A	4 Type: VFR	5 Aircraft Type: Cesnna T206H	6 Aircraft Identification: RP-9022
7 Pilot: C. Alfonso	8 Co-Pilot: B. Donguines	9 Route:			
10 Date: 02-14-2015	12 Airport of Departure (Airport, City/Province): Iloilo		12 Airport of Arrival (Airport, City/Province):		
13 Engine On: 1021	14 Engine Off: 1356	15 Total Engine Time: 3+29	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather	cloudy				
20 Remarks: Moved to and surveyed BLK43D.					

21 Problems and Solutions:

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

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

Pilot-in-Command
C. Alfonso III
Signature over Printed Name

Lidar Operator
Signature over Printed Name

4. Flight Log for 2570G Mission

PHIL-LiDAR 1 Data Acquisition Flight Log

Flight Log No.: 2570

1 LiDAR Operator: MVE Tongo	2 ALTM Model: Gemini	3 Mission Name: 2BLK49A048A	4 Type: VFR	5 Aircraft Type: CesnnaT206H	6 Aircraft Identification: 9122
7 Pilot: J. Alajar	8 Co-Pilot: A. Lim	9 Route: ILOILO			
10 Date: 11 Feb 15	12 Airport of Departure (Airport, City/Province): ILOILO		12 Airport of Arrival (Airport, City/Province): ILOILO		
13 Engine On: 8:58	14 Engine Off: 13:33	15 Total Engine Time: 4+35	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather: Fair					
20 Remarks: Mission completed					

21 Problems and Solutions:

Acquisition Flight Approved by	Acquisition Flight Certified by	Pilot-in-Command	Lidar Operator
Signature over Printed Name (End User Representative)	SSG PANTALLAN Signature over Printed Name (PAF Representative)	PB DOOCAMPO Signature over Printed Name	Signature over Printed Name

5. Flight Log for 2580G Mission

PHIL-LiDAR 1 Data Acquisition Flight Log

MVE Tonga 2BLK43T050B

Flight Log No.: 2580

1 LiDAR Operator: MVE TONGA	2 ALTM Model: [illegible]	3 Mission Name:	4 Type: VFR	5 Aircraft Type: Cesnna T206H	6 Aircraft Identification: 9122
7 Pilot: B. Donguines	8 Co-Pilot: A. Lim	9 Route: Iloilo			
10 Date: 19 FEB 15	12 Airport of Departure (Airport, City/Province): Iloilo		12 Airport of Arrival (Airport, City/Province): Iloilo		
13 Engine On: 14:14	14 Engine Off: 17:55	15 Total Engine Time: 3+41	16 Take off: 14:19	17 Landing: 17:50	18 Total Flight Time: 3+31
19 Weather: Fair					

20 Remarks:

Completed BLK43F but with voids due to high terrain at low altitude

21 Problems and Solutions:

Acquisition Flight Approved by	Acquisition Flight Certified by	Pilot-in-Command	Lidar Operator
G. Apol. Jr	LJ PUNZALAN	B. DONGUINES	MVE TONGA
Signature over Printed Name (End User Representative)	Signature over Printed Name (PAF Representative)	Signature over Printed Name	Signature over Printed Name

6. Flight Log for 2583P Mission

PHIL-LiDAR 1 Data Acquisition Flight Log

Flight Log No.: 2583

1 LiDAR Operator: MR Villanueva	2 ALTM Model: Pegasus	3 Mission Name: 1BLK43D048B	4 Type: VFR	5 Aircraft Type: CesnnaT206H	6 Aircraft Identification: RP-9022
7 Pilot: A. Alfonso	8 Co-Pilot: J. Joya	9 Route:			
10 Date: 02-17-2015	12 Airport of Departure (Airport, City/Province): Iloilo		12 Airport of Arrival (Airport, City/Province):		
13 Engine On: 1428	14 Engine Off: 1721	15 Total Engine Time: 2+53	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather	cloudy				

20 Remarks:

Moved to and surveyed BLK 43D

21 Problems and Solutions:

Acquisition Flight Approved by	Acquisition Flight Certified by	Pilot-in-Command	Lidar Operator
C. Hipolito	LJ Pumarian	C. Alfonso III	MR Villanueva
Signature over Printed Name (End User Representative)	Signature over Printed Name (PAF Representative)	Signature over Printed Name	Signature over Printed Name

7. Flight Log for 2585P Mission

PHIL-LiDAR 1 Data Acquisition Flight Log

Flight Log No.: 2585

1 LiDAR Operator: I. Roxas	2 ALTM Model: Pegasus	3 Mission Name: 1BLK43EF049A	4 Type: VFR	5 Aircraft Type: CesnnaT206H	6 Aircraft Identification: RP- 9022
7 Pilot: C. Alfonso	8 Co-Pilot: J. Joya	9 Route:			
10 Date: 02 - 18 - 2015	12 Airport of Departure (Airport, City/Province): Iloilo		12 Airport of Arrival (Airport, City/Province):		
13 Engine On: 0816	14 Engine Off: 1227	15 Total Engine Time: 4+11	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather: fair					
20 Remarks: Surveyed BLK 43 E and some voids.					

21 Problems and Solutions:

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

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

Pilot-in-Command
C. Alfonso III
Signature over Printed Name

Lidar Operator
I. Roxas
Signature over Printed Name

8. Flight Log for 2589P Mission

PHIL-LiDAR 1 Data Acquisition Flight Log

Flight Log No.: 2589

1 LiDAR Operator: MR Villanueva	2 ALTM Model: Pegasus	3 Mission Name: 1BLK43EFD050A	4 Type: VFR	5 Aircraft Type: CesnnaT206H	6 Aircraft Identification: RP-9022
7 Pilot: C. Alfonso	8 Co-Pilot: J. Joya	9 Route:			
10 Date: 02-19-2015	12 Airport of Departure (Airport, City/Province): Iloilo		12 Airport of Arrival (Airport, City/Province):		
13 Engine On: 0818	14 Engine Off: 1159	15 Total Engine Time: 3+41	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather: fair					

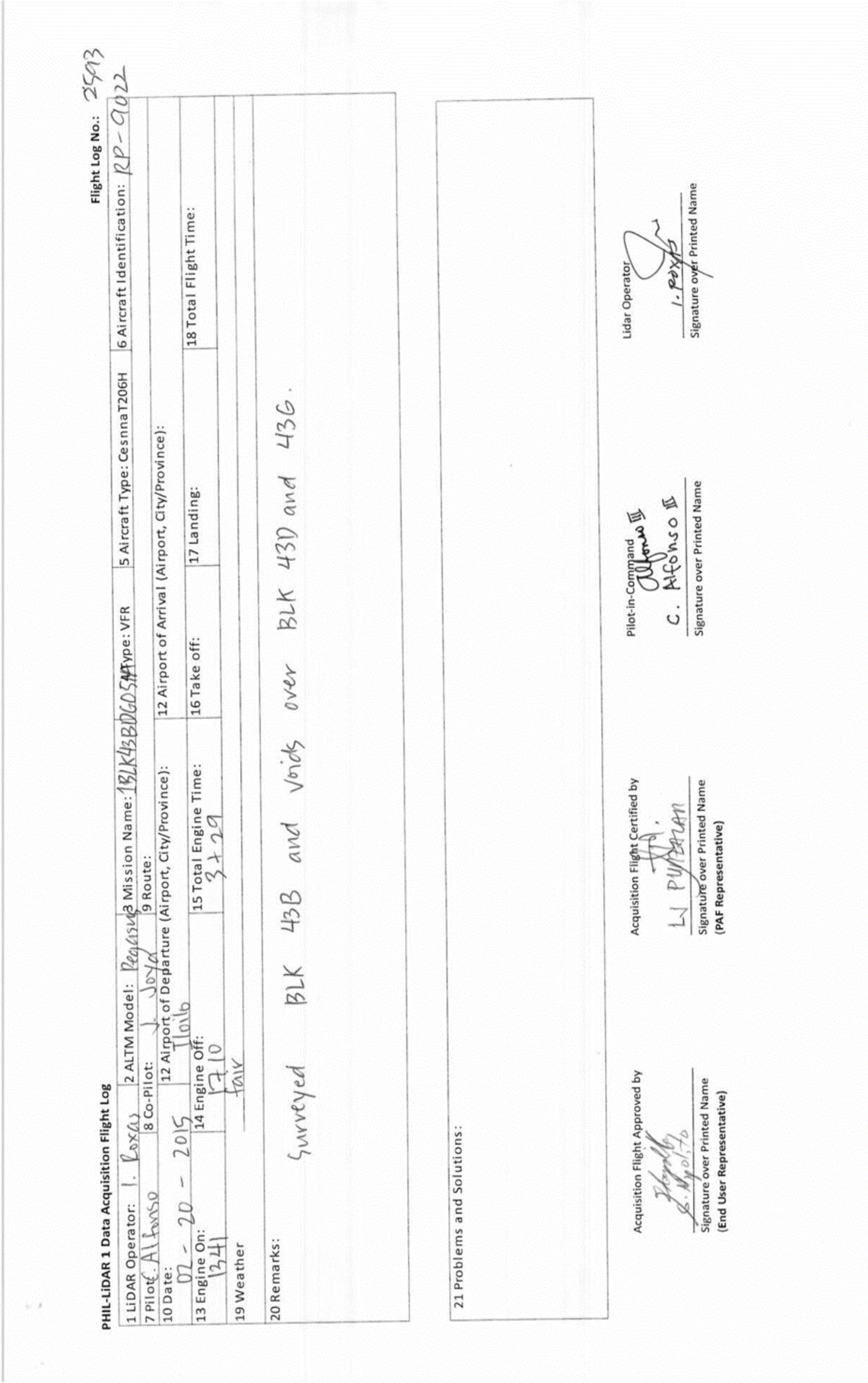
20 Remarks:

Surveyed BLK 43EF and voids over BLK 43D.

21 Problems and Solutions:

Acquisition Flight Approved by	Acquisition Flight Certified by	Pilot-in-Command	Lidar Operator
Signature over Printed Name (End User Representative)	LJ Pugayan Signature over Printed Name (PAF Representative)	C. Alfonso III Signature over Printed Name	MR Villanueva Signature over Printed Name

9. Flight Log for 2593P Mission



PHIL-LiDAR 1 Data Acquisition Flight Log

Flight Log No.: 2593

1 LiDAR Operator: I. Roxas	2 ALTM Model: Pegasus	3 Mission Name: 1BLK43BDG051A	4 Type: VFR	5 Aircraft Type: Cesnna T206H	6 Aircraft Identification: RP-C9022
7 Pilot: C. Alfonso	8 Co-Pilot: J. Joyo	9 Route:			
10 Date: 02-20-2015	12 Airport of Departure (Airport, City/Province): Iloilo		12 Airport of Arrival (Airport, City/Province):		
13 Engine On: 1341	14 Engine Off: 1710	15 Total Engine Time: 3+29	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather: fair					
20 Remarks: Surveyed BLK 43B and voids over BLK 43D and 43G.					

21 Problems and Solutions:

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

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

Pilot-in-Command: C. Alfonso III — Signature over Printed Name

Lidar Operator: I. Roxas — Signature over Printed Name

10. Flight Log for 8511AC Mission

PHIL-LiDAR 1 Data Acquisition Flight Log

Flight Log No.: 8511AC

1 LiDAR Operator: MS REYES	2 ALTM Model: AQUARIUS + CASI	3 Mission Name: 3BLK43KJ299A	4 Type: VFR	5 Aircraft Type: CesnnaT206H	6 Aircraft Identification: RP-C9322
7 Pilot: D. LOGRONIO	8 Co-Pilot: J. NASTOR	9 Route: BUGASONG, VALDERRAMA, BELISON, SIBALOM			
10 Date: OCT. 25, 2016	12 Airport of Departure (Airport, City/Province): ILOILO CITY		12 Airport of Arrival (Airport, City/Province): ILOILO CITY		
13 Engine On: 09 00	14 Engine Off: 12 35	15 Total Engine Time: 3+35	16 Take off: 09 05	17 Landing: 12 30	18 Total Flight Time: 3+25
19 Weather	FAIR				

20 Flight Classification

20.a Billable
- ● Acquisition Flight
- ○ Ferry Flight
- ○ System Test Flight
- ○ Calibration Flight

20.b Non Billable
- ○ Aircraft Test Flight
- ○ AAC Admin Flight
- ○ Others: ____________

20.c Others
- ○ LiDAR System Maintenance
- ○ Aircraft Maintenance
- ○ Phil-LiDAR Admin Activities

21 Remarks

COVERED VOIDS IN ANTIQUE

22 Problems and Solutions

- ○ Weather Problem
- ○ System Problem
- ○ Aircraft Problem
- ○ Pilot Problem
- ○ Others: ____________

Acquisition Flight Approved by	Acquisition Flight Certified by	Pilot-in-Command	LiDAR Operator	Aircraft Mechanic/ LiDAR Technician
L. POYAS	TSgt Antonio T Valenciano II PAF	D ANTHONY LOGRONIO	MS REYES	-
Signature over Printed Name (End User Representative)	Signature over Printed Name (PAF Representative)	Signature over Printed Name	Signature over Printed Name	Signature over Printed Name

ANNEX 7. Flight status reports

SIBALOM (February 2015 and October 2016)					
FLIGHT NO	**AREA**	**MISSION**	**OPERATOR**	**DATE FLOWN**	**REMARKS**
2532G	BLK 43I	2BLK43IV038B	MVE TONGA & RA FELIS-MINO	7-Feb-15	Mission completed for BLK43I and covered voids of BLK43L and BLK43J
2558G	BLK 43G	2BLK43G045A	RA FELISMINO	14-Feb-15	2 lines in BLK43N, with voids
2569P	BLK 43D	1BLK43D045A	MVE TONGA	14-Feb-15	Moved to and surveyed BLK 43D
2570G	BLK 43H	2BLK43H048A	MVE TONGA	17-Feb-15	Mission complete at 1000m AGL
2580G	BLK 43F	2BLK43F050B	MVE TONGA	19-Feb-15	Completed BLK43F but w/ voids due to high terrain with low altitude
2583P	BLK 43D	1BLK43D048B	MR VILLAN-UEVA	17-Feb-15	Moved to and surveyed BLK43D
2585P	BLK 43E, 43F	1BLK43EF049A	IRO ROXAS	18-Feb-15	Surveyed BLK43E w/ some voids due to high terrain w/ low altitude
2587P	BLK 43E, 43D	1BLK43ED049B	KJ AN-DAYA	18- Feb-15	Surveyed voids on BLK43E and gaps on BLK43D
2589P	BLK 43E, 43F, 43D	1BLK43EFD050A	MR VIL-LANUE-VA	19- Feb-15	Surveyed BLK 43E to 43F and voids on BLK43D
2593P	BLK 43B, 43D, 43G	1BLK43BDG051A	IRO ROXAS	20-Feb-15	Surveyed BLK43B and voids on BLK 43D and 43G
8511AC	BLK43K, Sibalom 2FP	3BLK43KJ299A	MS REYES	25-Oct-16	Covered voids over Cairawan, Paliwan, and Sibalom 2Floodplains

SWATH BOUNDARIES PER MISSION FLIGHT

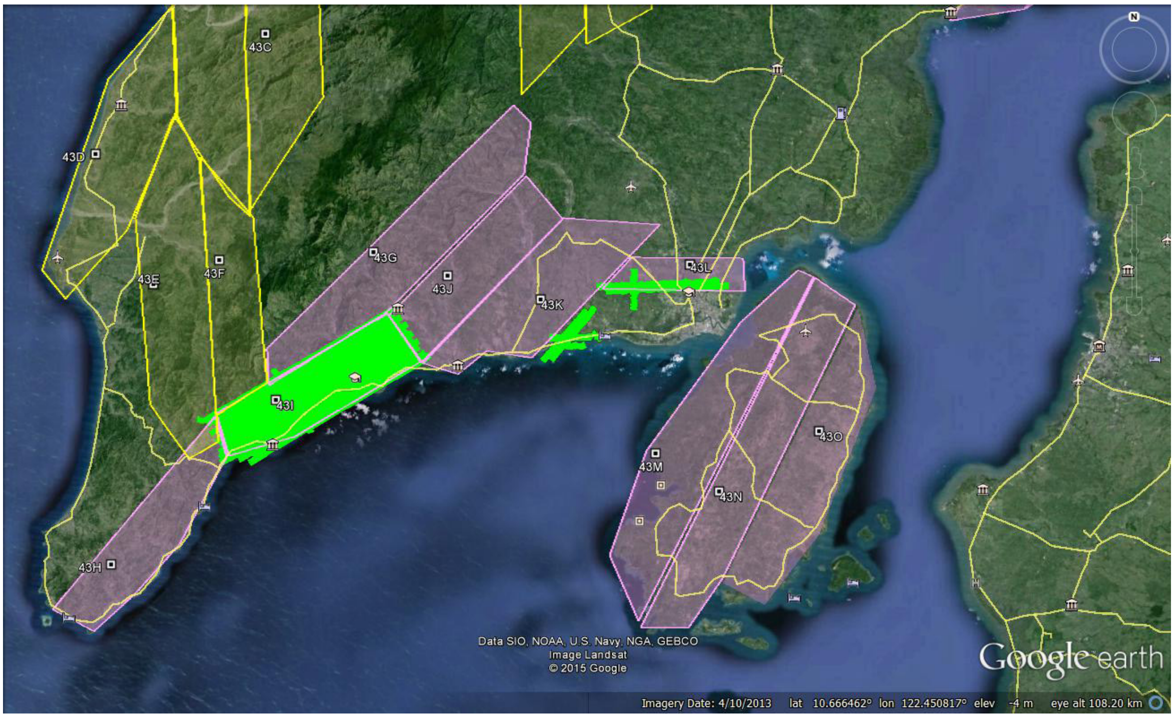
Flight No. : 2532G

Area: BLK 43I

Base: ILO-1 & ILO-85

Mission Name: 2BLK43IV038B

Total Area Surveyed: 198.854 sq km



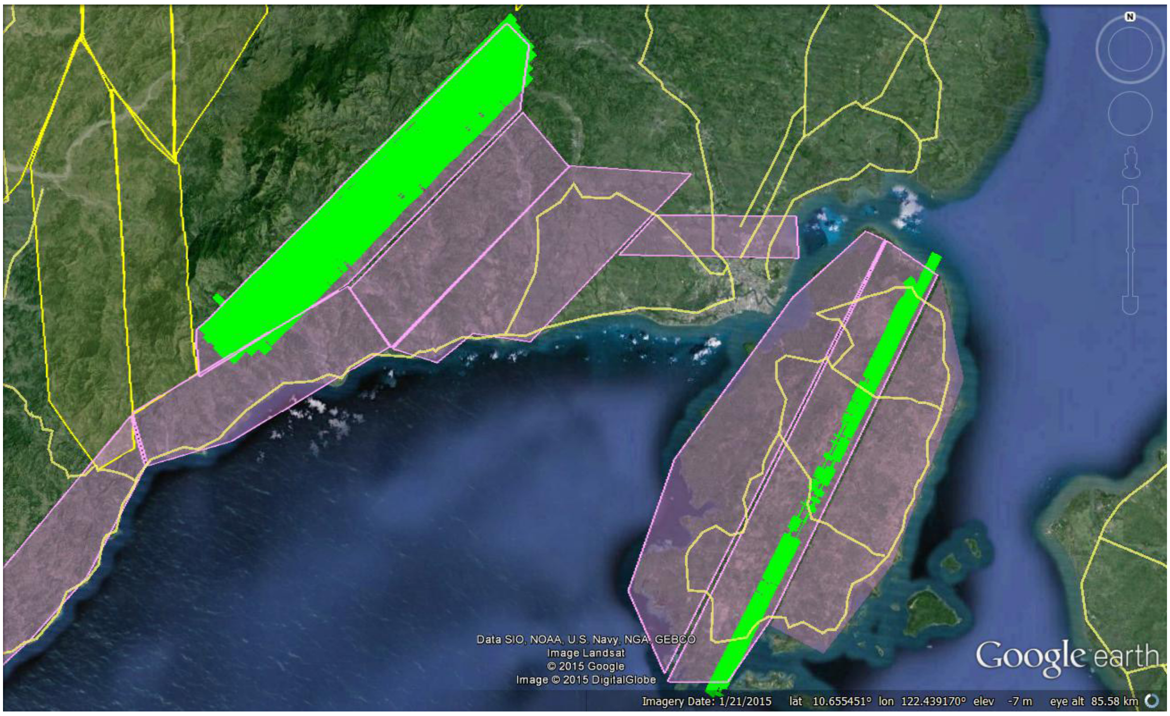
Flight No. : 2558G

Area: BLK 43G

Base: ILO

Mission Name: 2BLK43G045A

Total Area Surveyed: 249.685 sq km

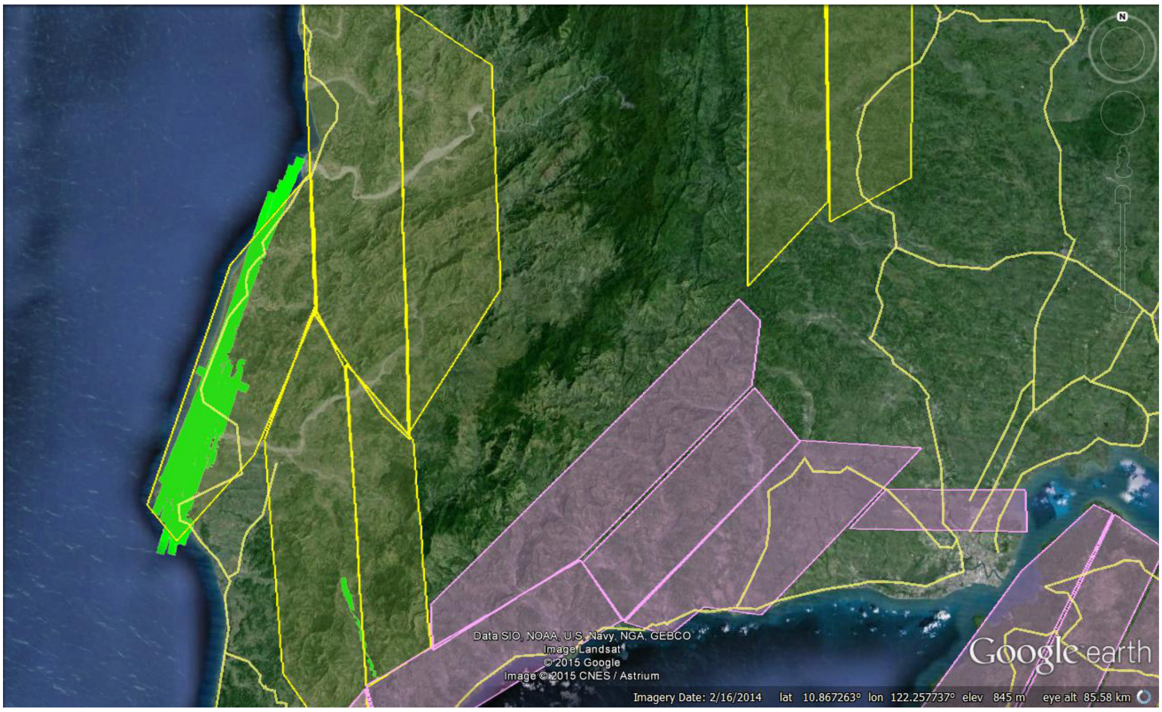


Flight No. : 2569P

Area: BLK 43D

Mission Name: 1BLK43D045A

Total Area Surveyed: 79.3627 sq km

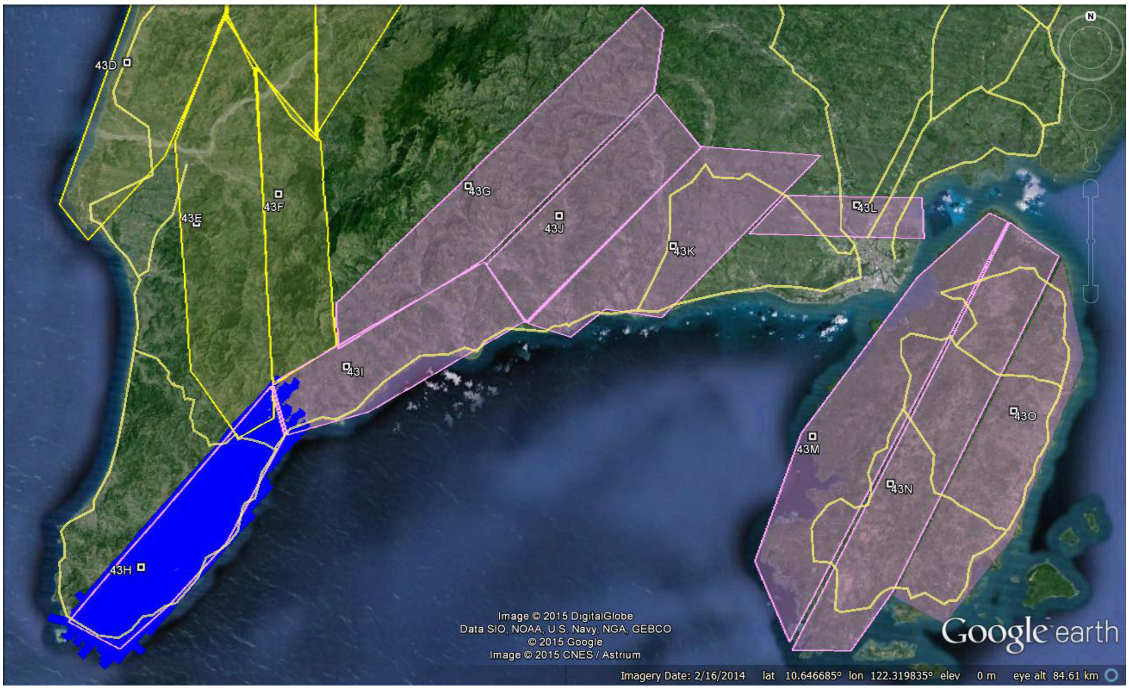


Flight No. : 2570G

Area: BLK 43H

Mission Name: 2BLK43H048A

Total Area Surveyed: 175.41 sq km

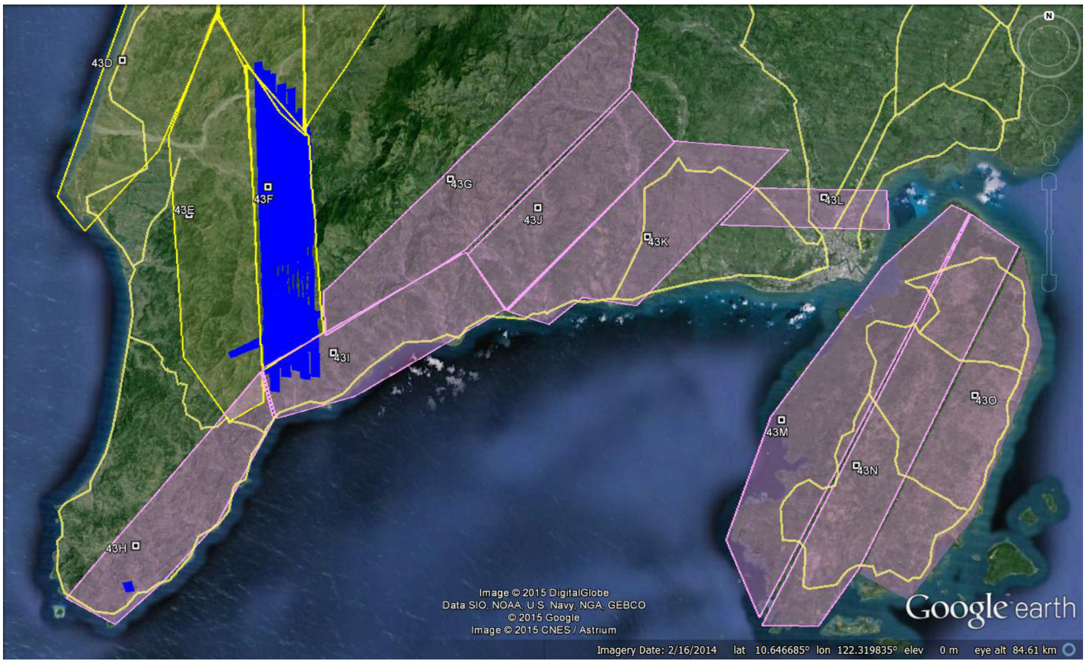


Flight No. : 2580G

Area: BLK 43F

Mission Name: 2BLK43F050B

Total Area Surveyed: 131.702 sq km

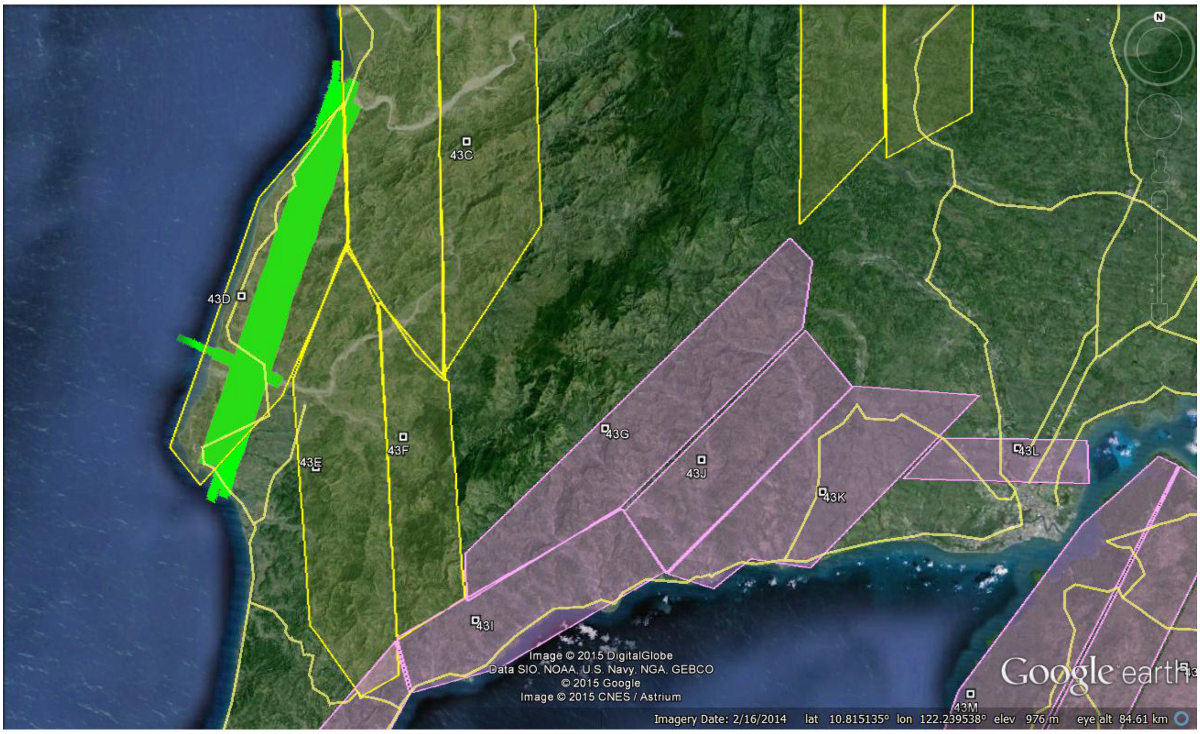


Flight No. : 2583P

Area: BLK 43D

Mission Name: 1BLK43D048B

Total Area Surveyed: 114.061 sq km

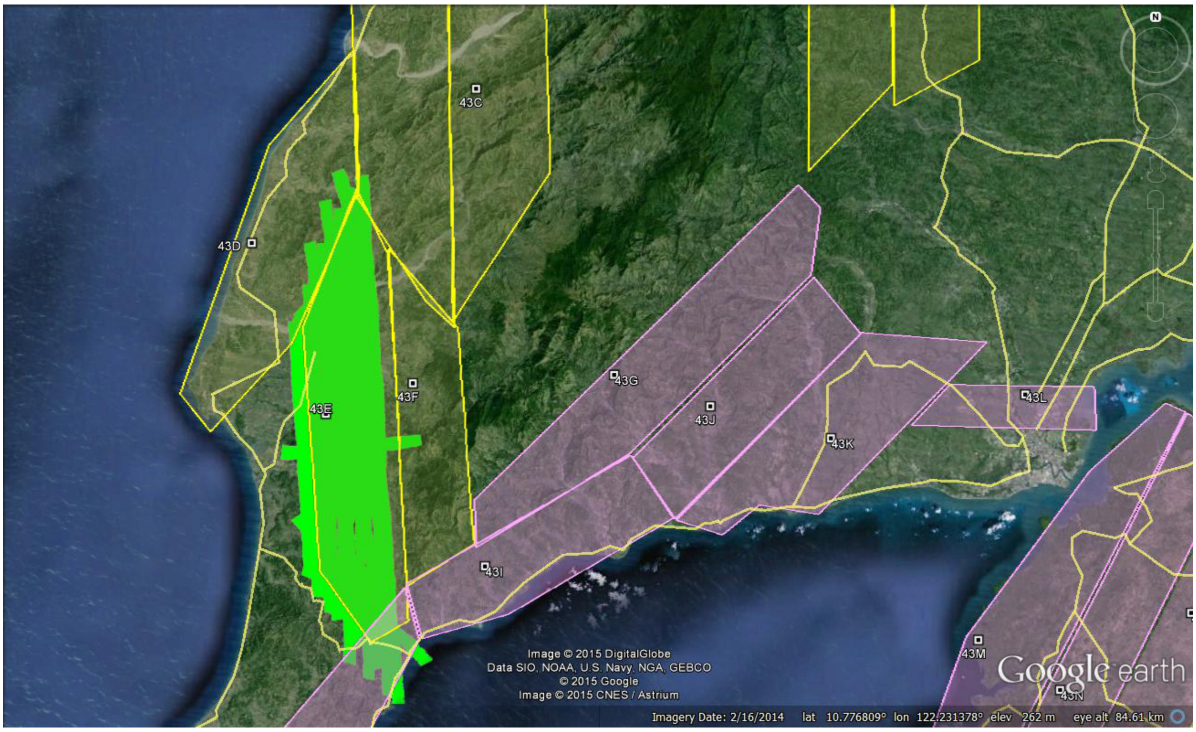


Flight No. : 2585P

Area: BLK 43E, 43F

Mission Name: 1BLK43EF049A

Total Area Surveyed: 261.892 sq km

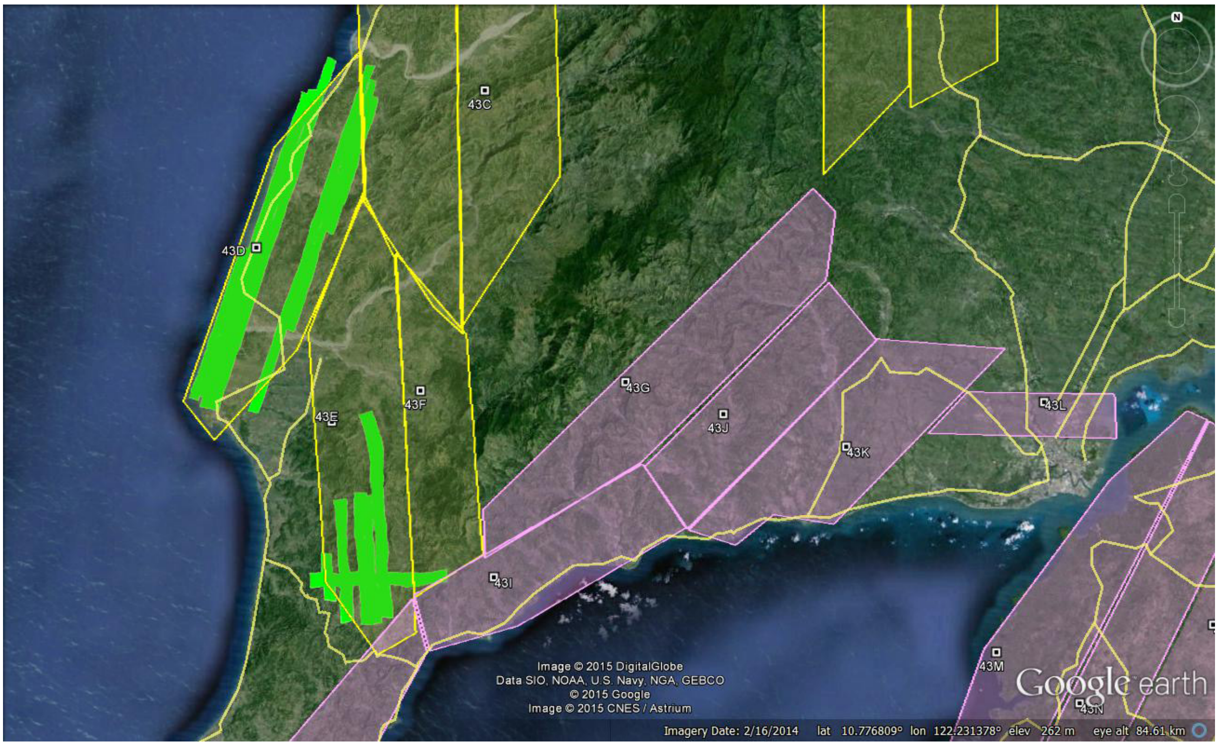


Flight No. : 2587P

Area: BLK 43E, 43D

Mission Name: 1BLK43EF049B

Total Area Surveyed: 153.076 sq km

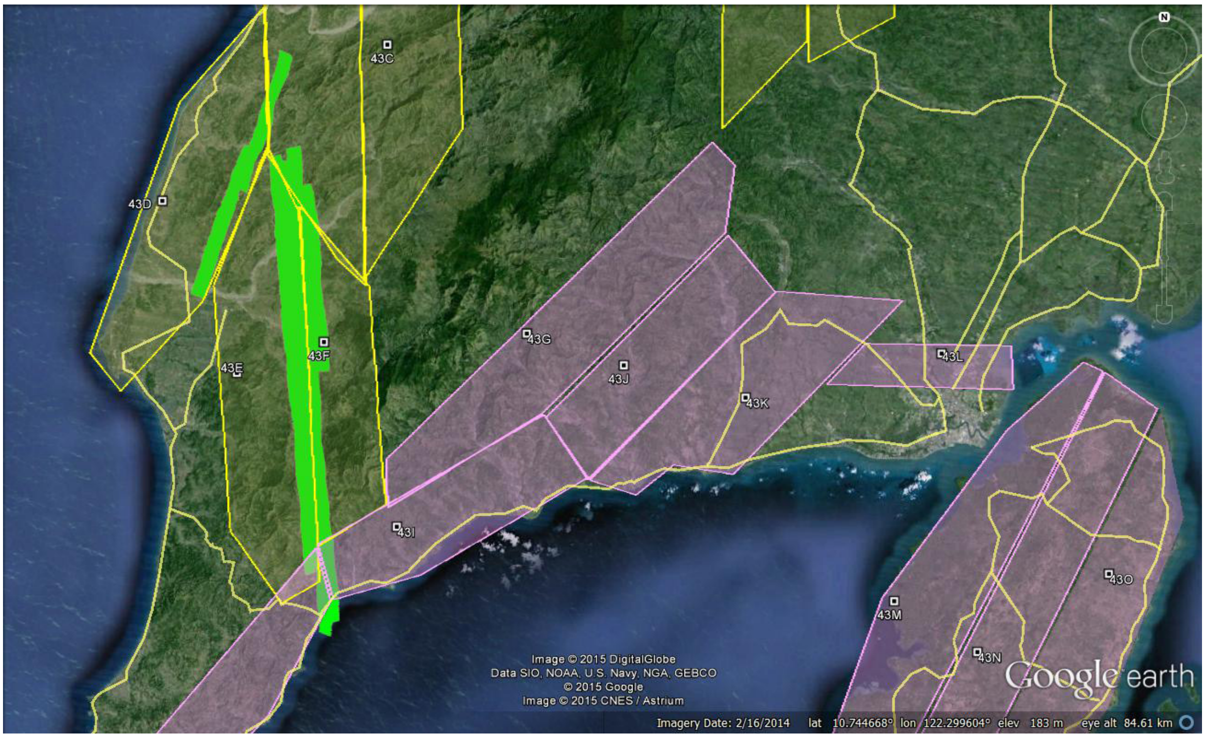


Flight No. : 2589P

Area: BLK 43E, 43F, 43D

Mission Name: 1BLK43EF050A

Total Area Surveyed: 132.258 sq km

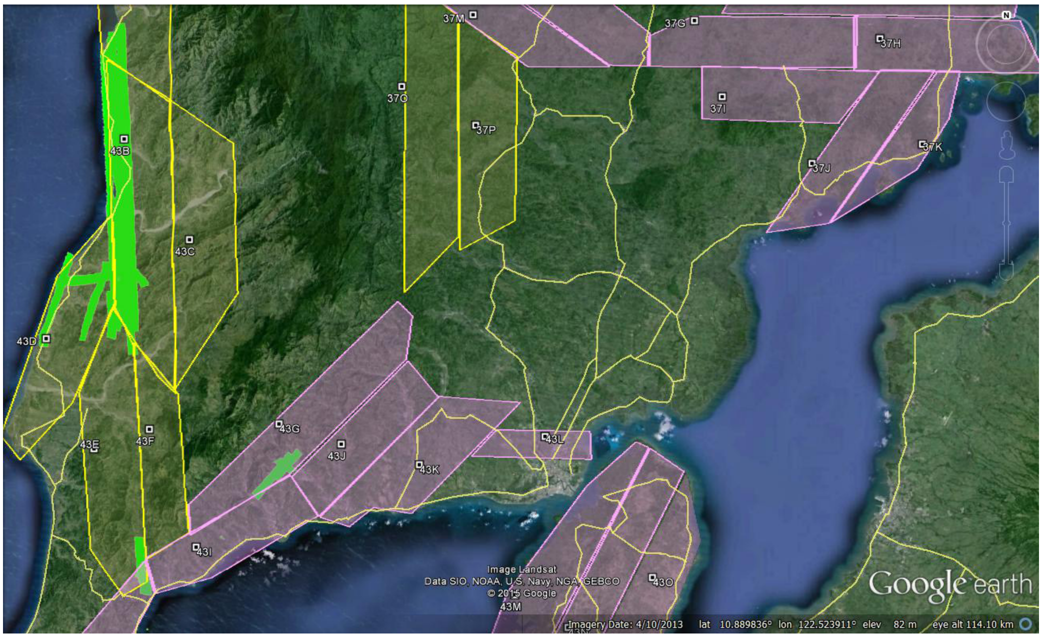


Flight No. 2593P

Area: BLK 43B, 43D, 43G

Mission Name: 1BLK43BC051A

Total Area Surveyed: 181.2 sq km



Flight No: 8511AC

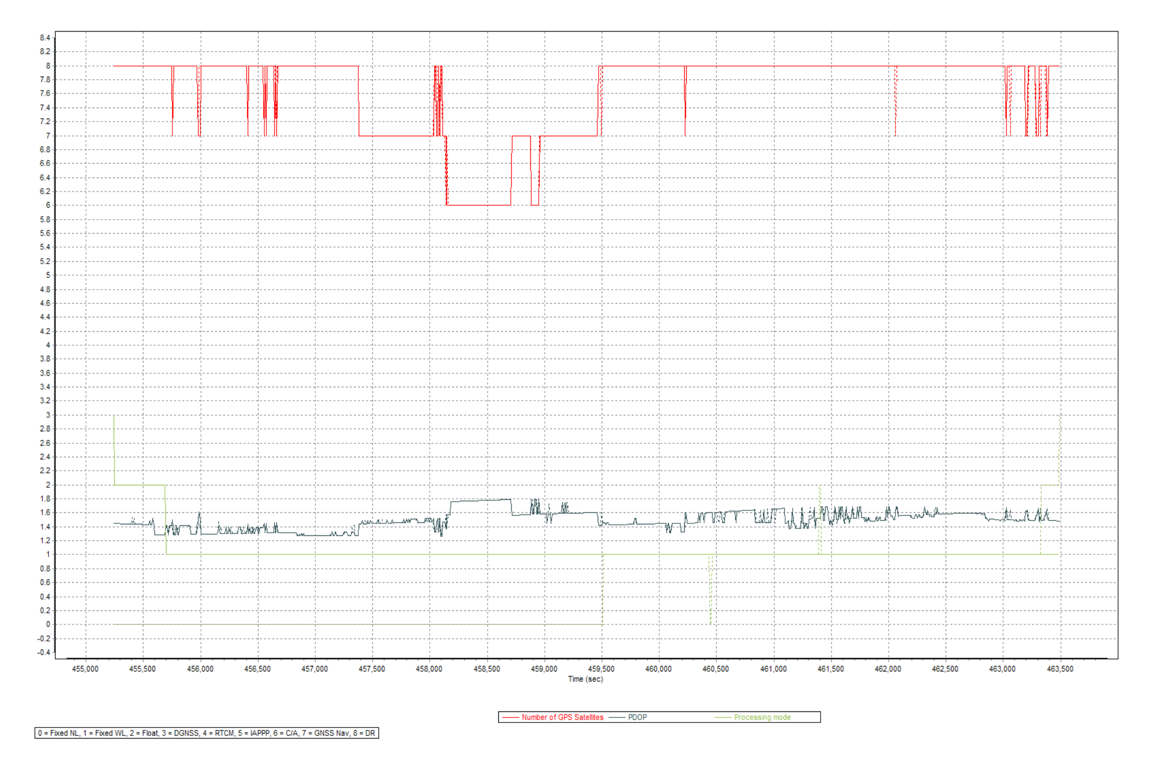
Mission Name: 3BLK43J299A

Area: BLK43K, Sibalom 2FP

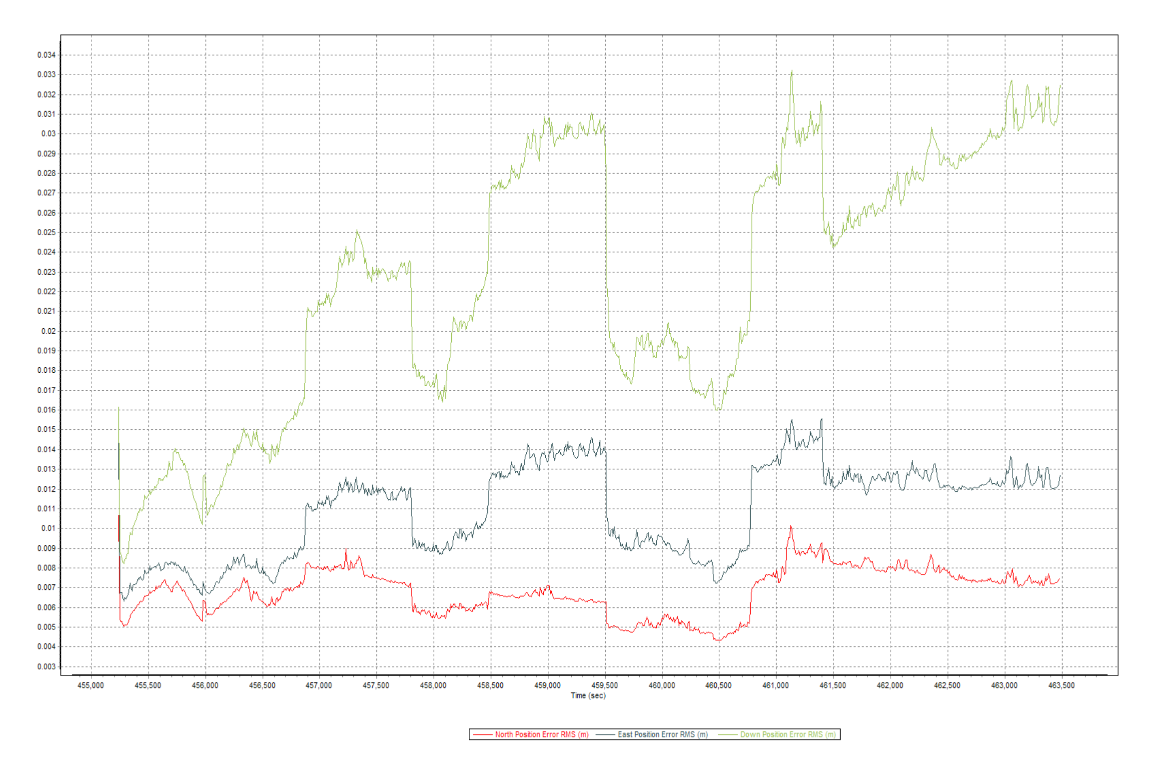
Total Area Surveyed: 18.2km2

ANNEX 8. Mission Summary Reports

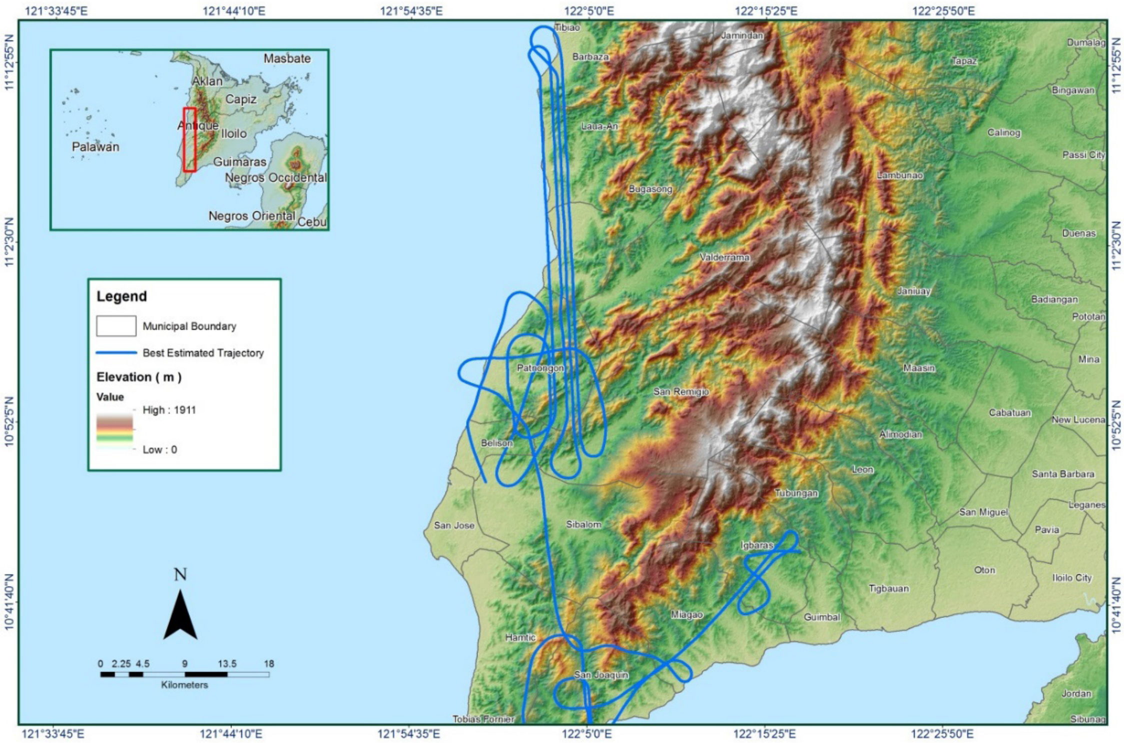
Flight Area	**Iloilo**
Mission Name	Blk43B
Inclusive Flights	2593P
Range data size	16.3 GB
POS	213 MB
Base data size	11 MB
Image	27 GB
Transfer date	March 23, 2015
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	No
Processing Mode (<=1)	No
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	1.01
RMSE for East Position (<4.0 cm)	1.56
RMSE for Down Position (<8.0 cm)	3.33
Boresight correction stdev (<0.001deg)	0.000371
IMU attitude correction stdev (<0.001deg)	0.000661
GPS position stdev (<0.01m)	0.0091
Minimum % overlap (>25)	25.93%
Ave point cloud density per sq.m. (>2.0)	2.57
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	200
Maximum Height	594.49 m
Minimum Height	54.70 m
Classification (# of points)	
Ground	152,186,273
Low vegetation	75,056,947
Medium vegetation	152,053,797
High vegetation	281,227,721
Building	4,634,683
Orthophoto	Yes
Processed by	Engr. Analyn Naldo, Engr. Harmond Santos, Engr. Melissa Fernandez



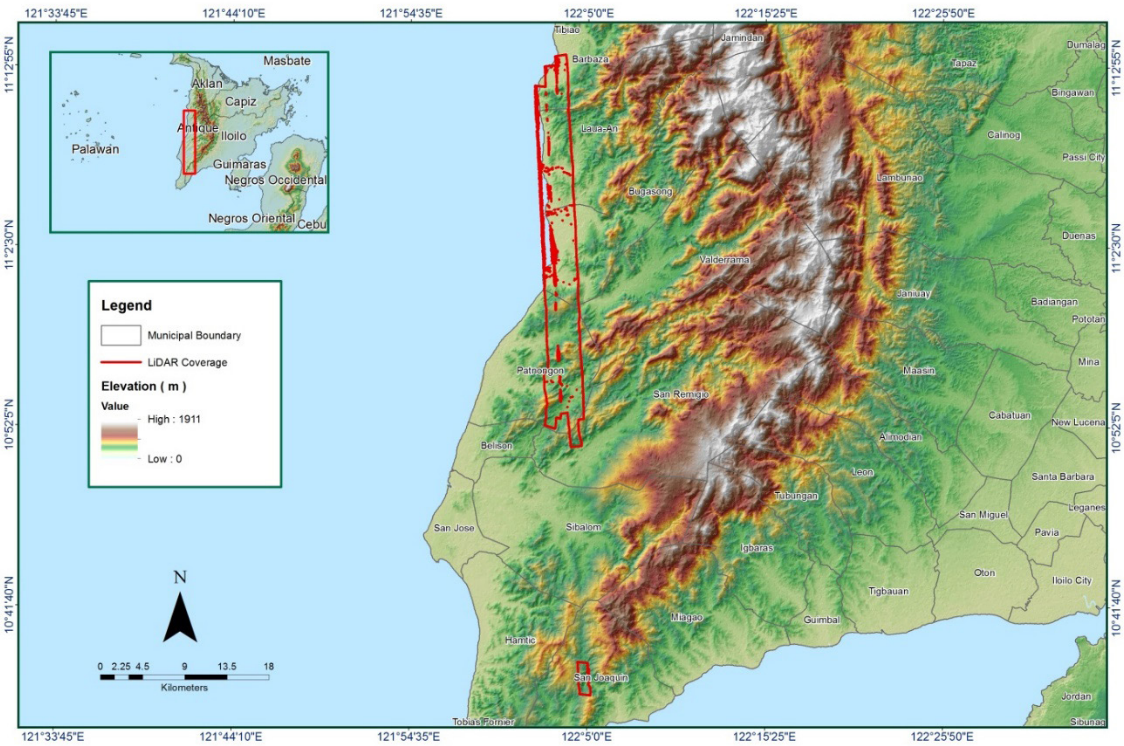
Solution Status



Smoothed Performance Metric Parameters



Best Estimated Trajectory



Coverage of LiDAR data

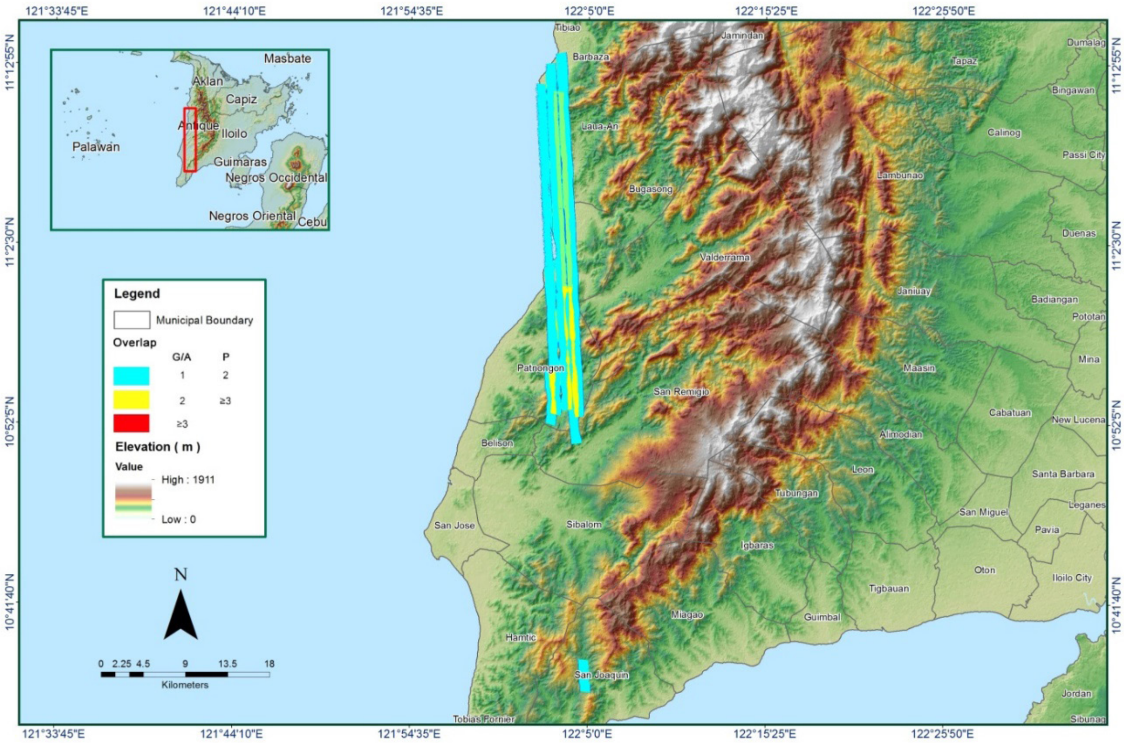
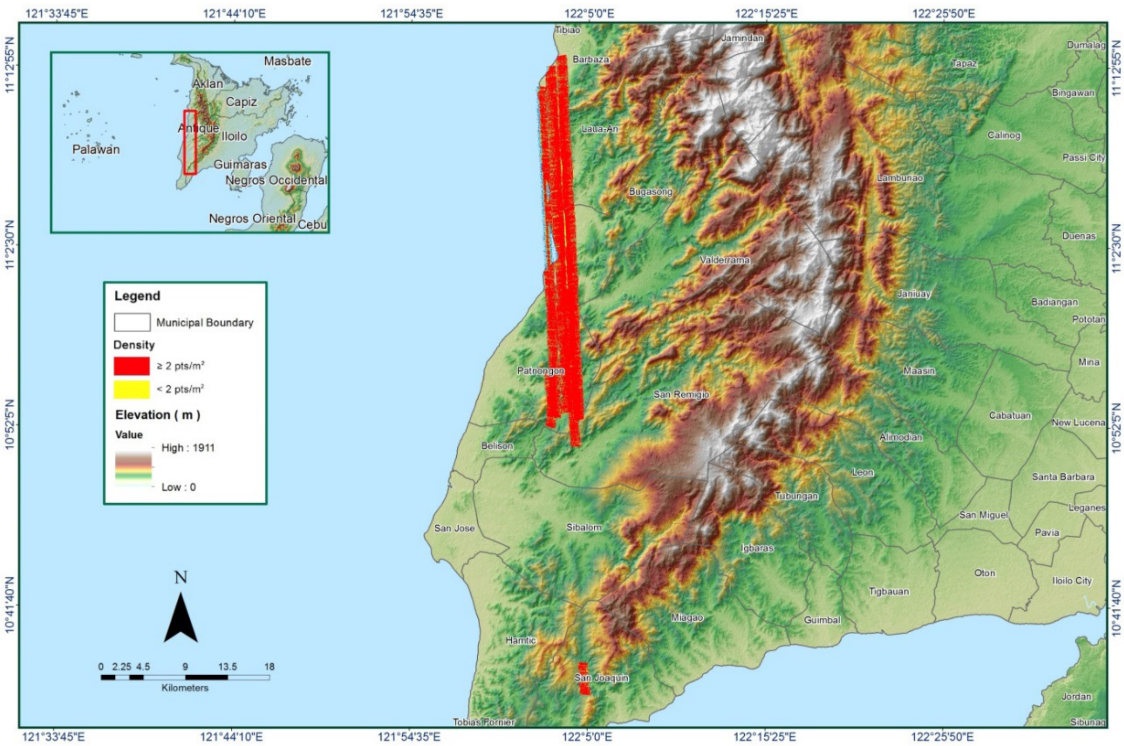
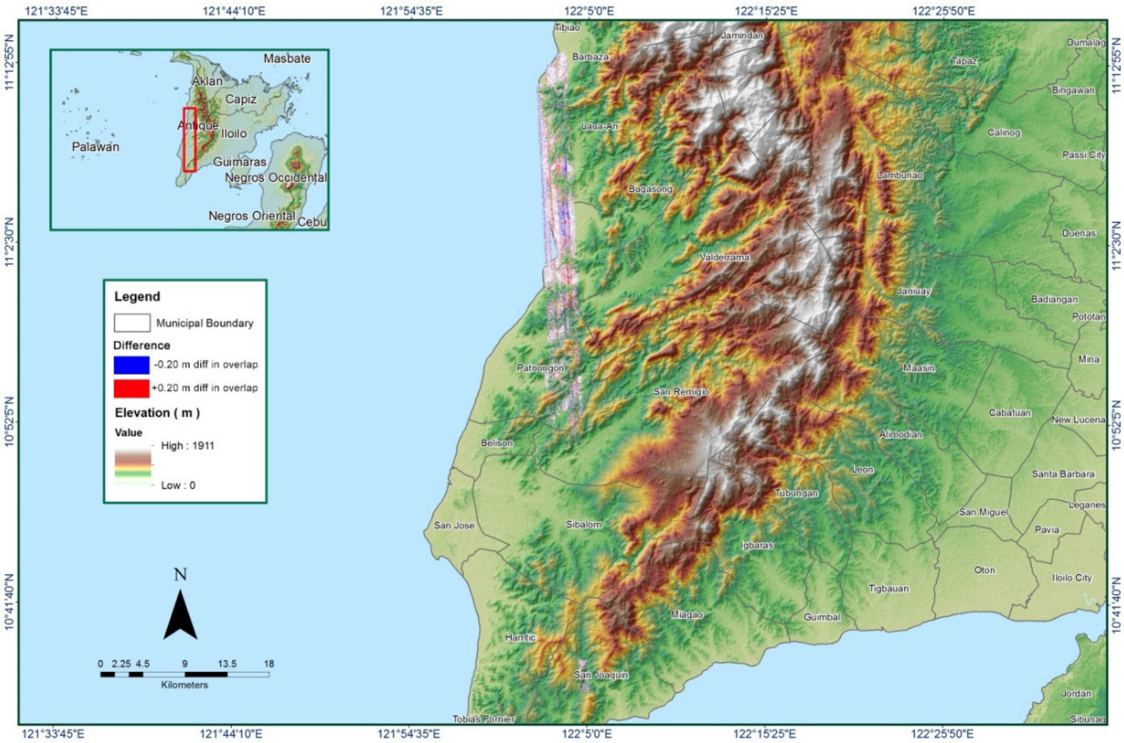


Image of data overlap

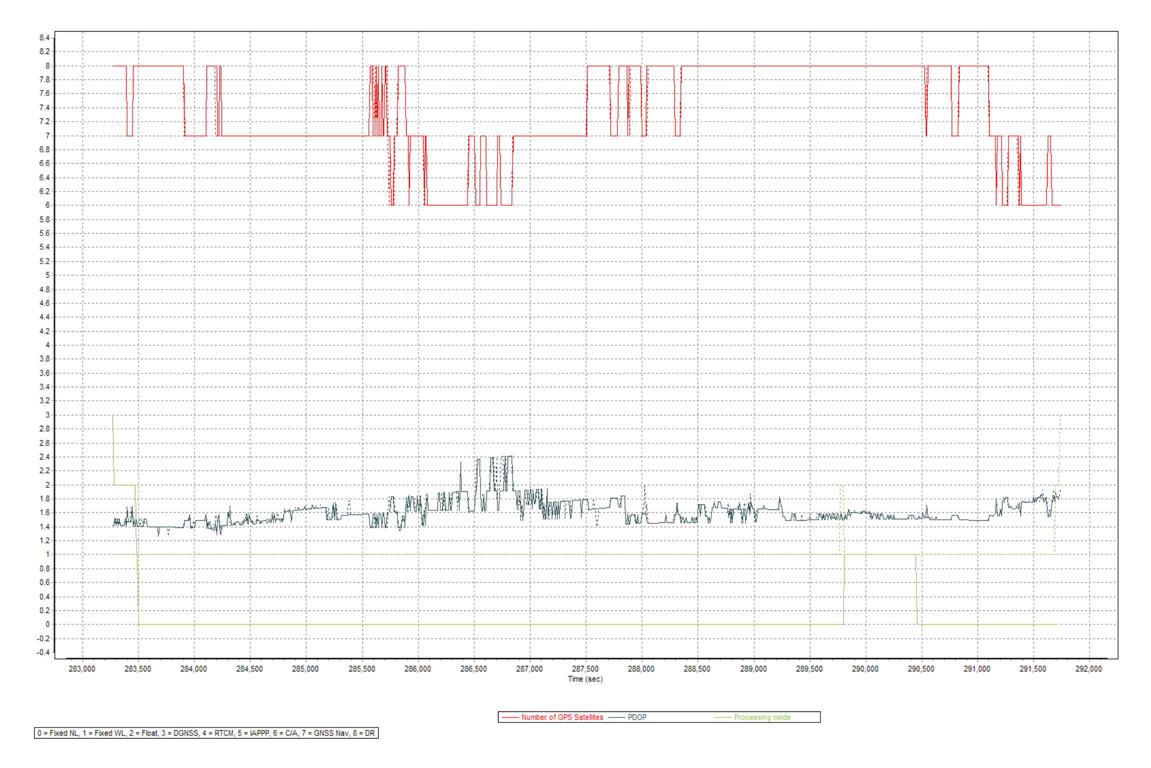


Density map of merged LiDAR data

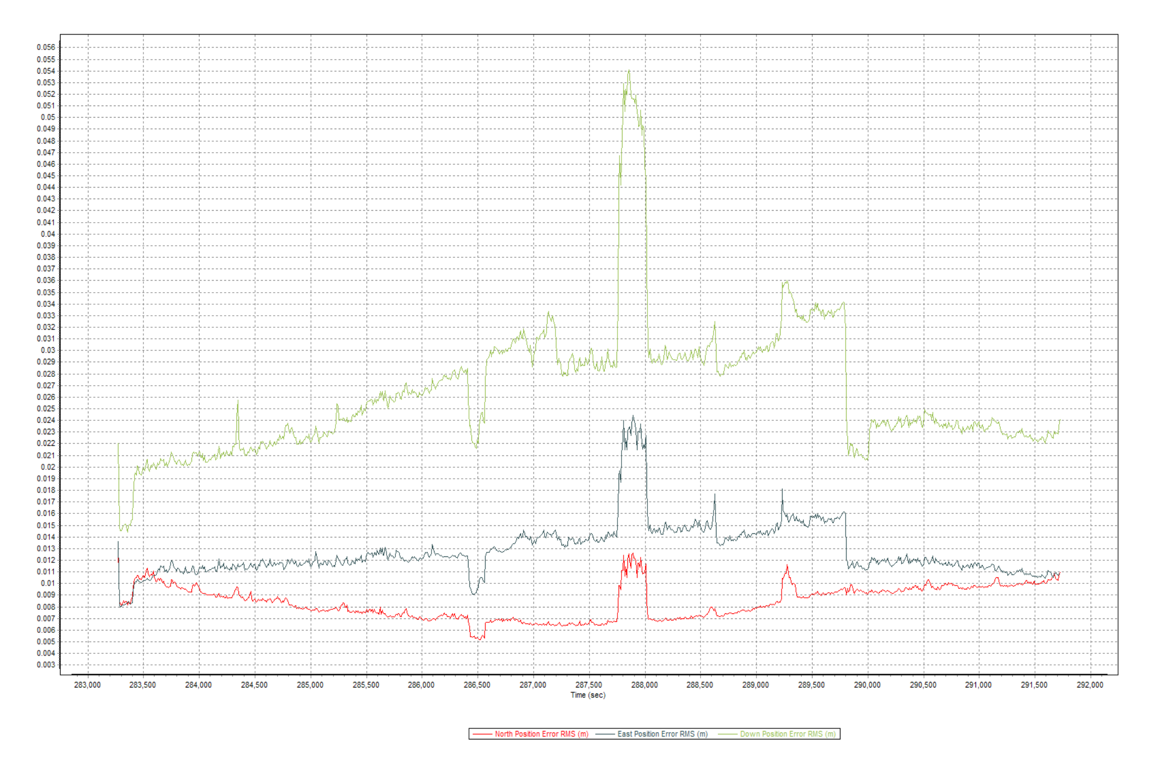


Elevation difference between flight lines

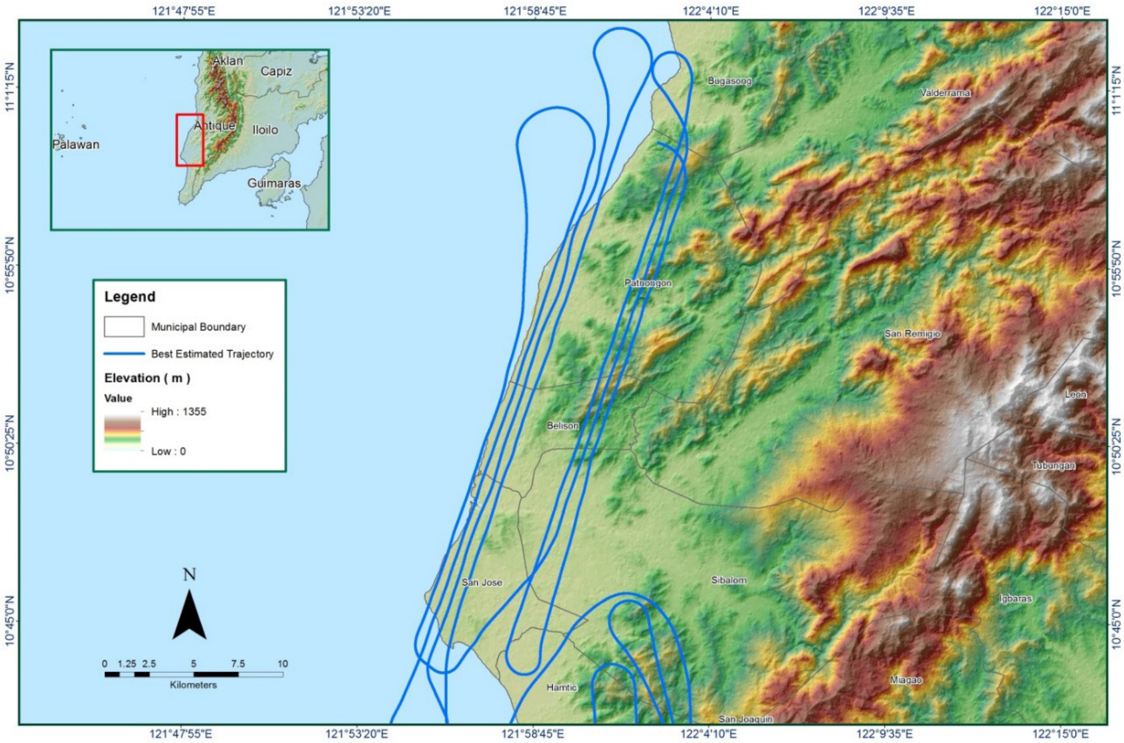
Flight Area	**Iloilo**
Mission Name	Blk43D
Inclusive Flights	2569P, 2583P, 2587P, 2589P, 2593P
Range data size	71.8 GB
POS	999 MB
Base data size	65.86 MB
Image	88.8 GB
Transfer date	March 23, 2015
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	No
Processing Mode (<=1)	No
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	1.26
RMSE for East Position (<4.0 cm)	2.44
RMSE for Down Position (<8.0 cm)	5.4
Boresight correction stdev (<0.001deg)	0.000352
IMU attitude correction stdev (<0.001deg)	0.001171
GPS position stdev (<0.01m)	0.0021
Minimum % overlap (>25)	42.59%
Ave point cloud density per sq.m. (>2.0)	3.67
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	280
Maximum Height	545.37 m
Minimum Height	52.12 m
Classification (# of points)	
Ground	301,021,823
Low vegetation	227,535,345
Medium vegetation	270,806,989
High vegetation	177,871,908
Building	13,231,101
Orthophoto	Yes
Processed by	Engr. Sheila-Maye Santillan, Engr. Melissa Fernandez, Engr. Edgardo Gubatanga, Jr., Engr. Krisha Marie Bautista



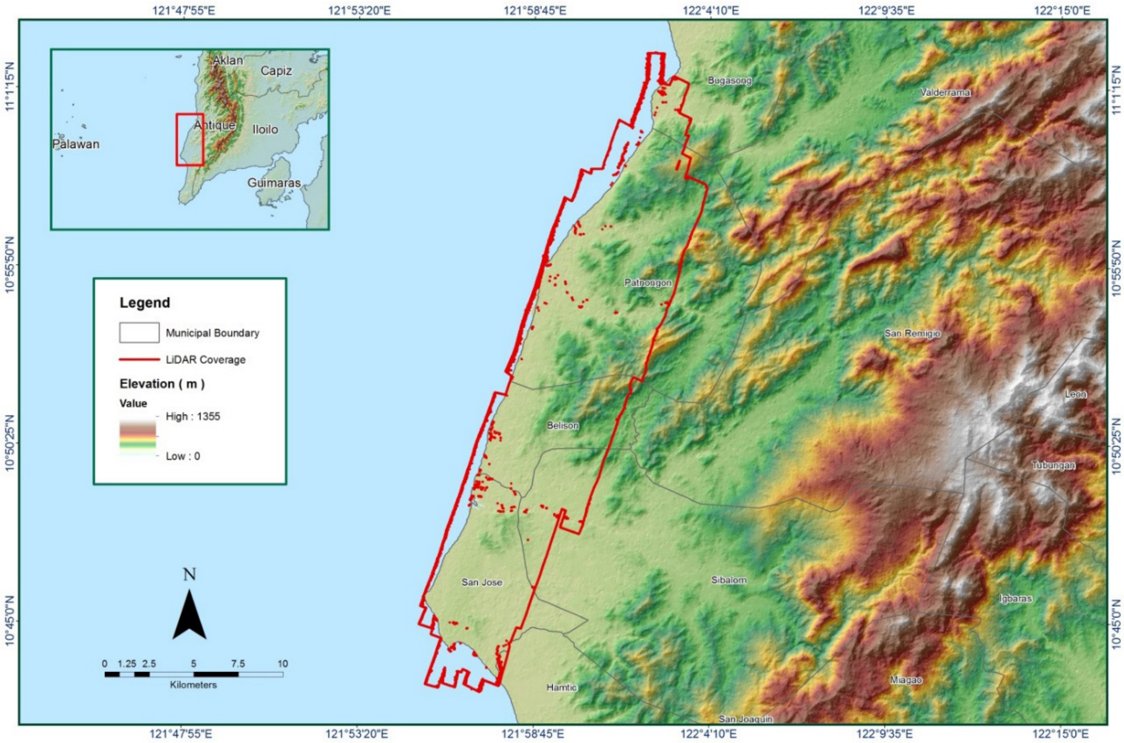
Solution Status



Smoothed Performance Metric Parameters



Best Estimated Trajectory



Coverage of LiDAR data

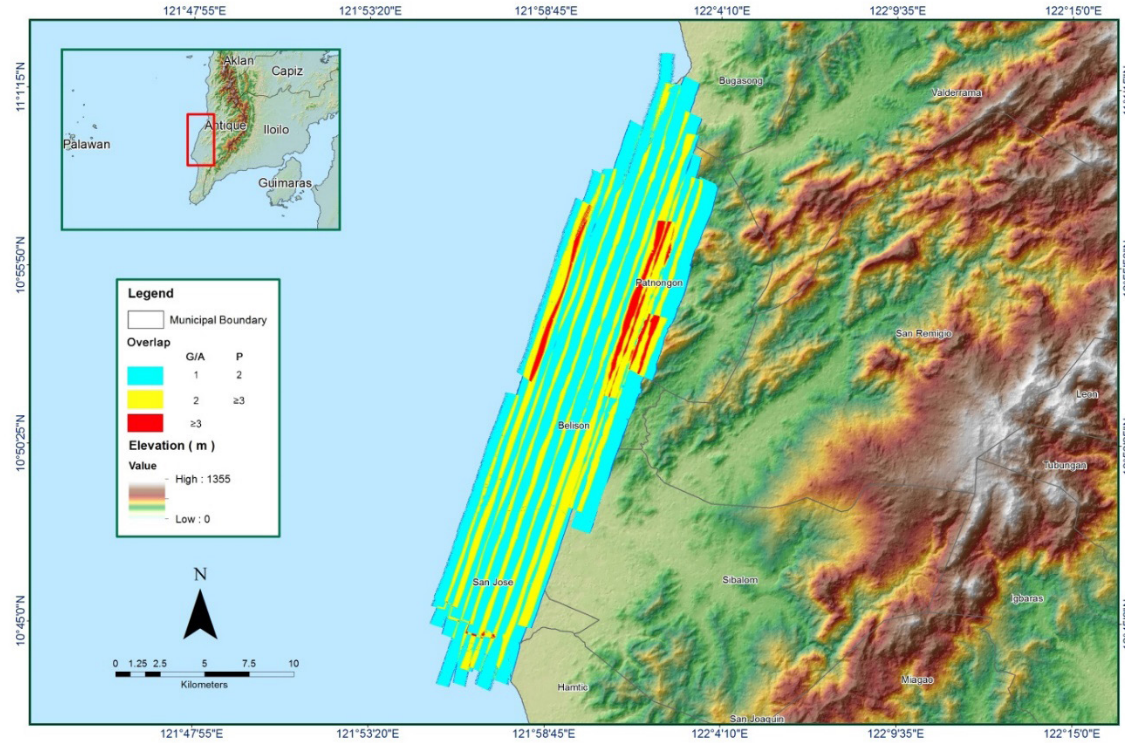
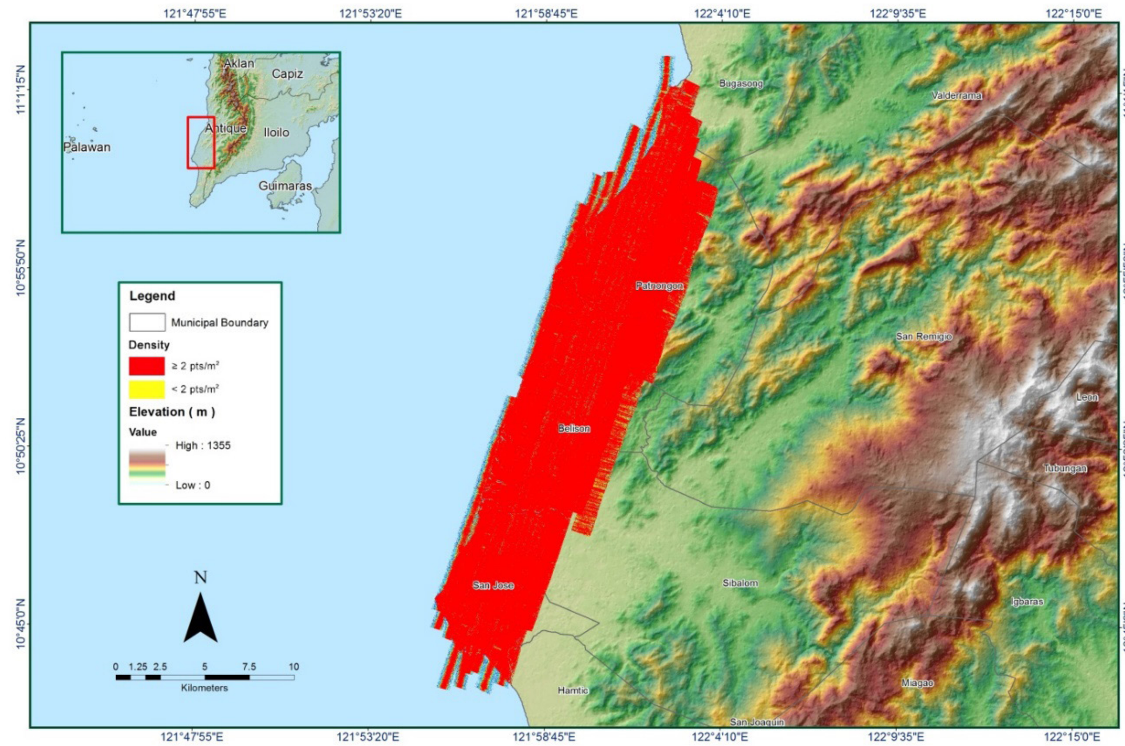
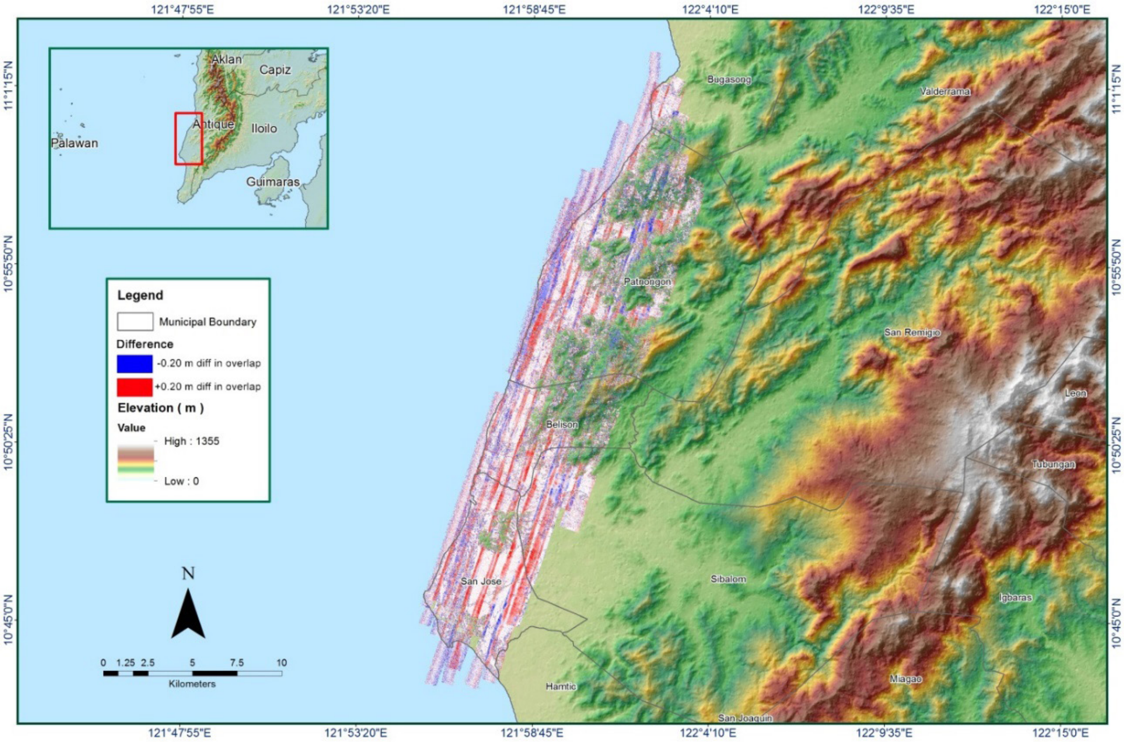


Image of data overlap



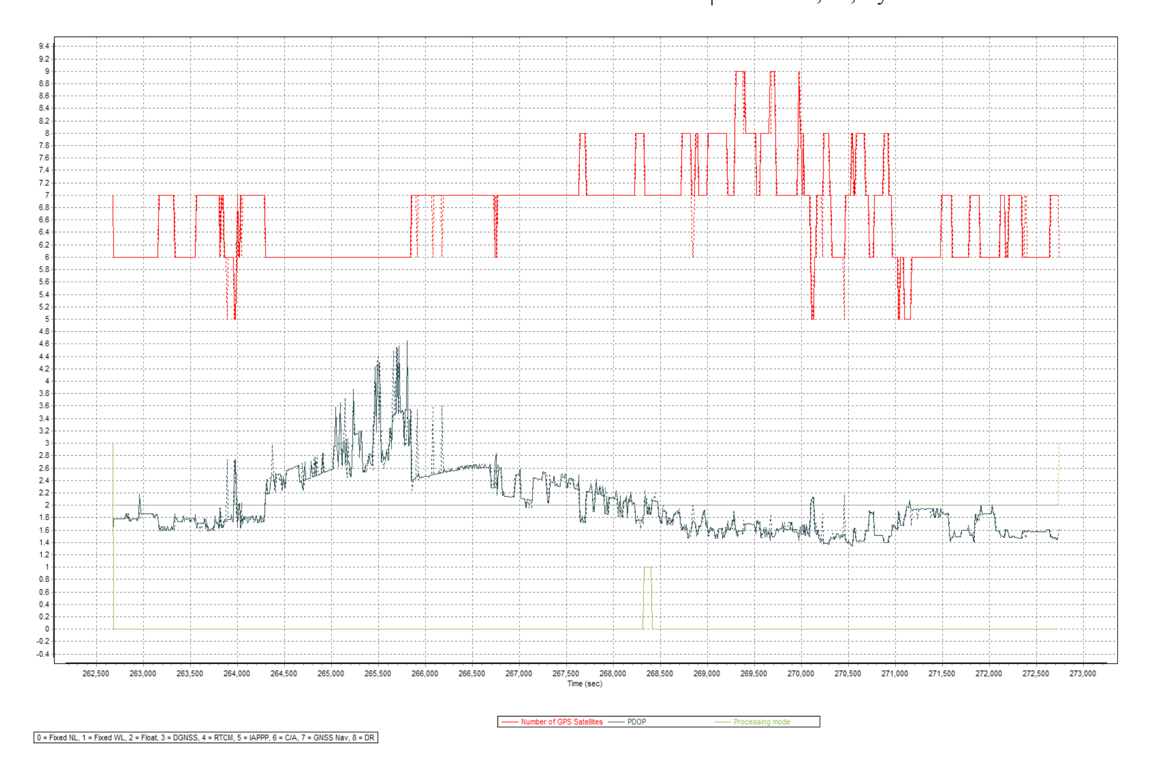
Density map of merged LiDAR data



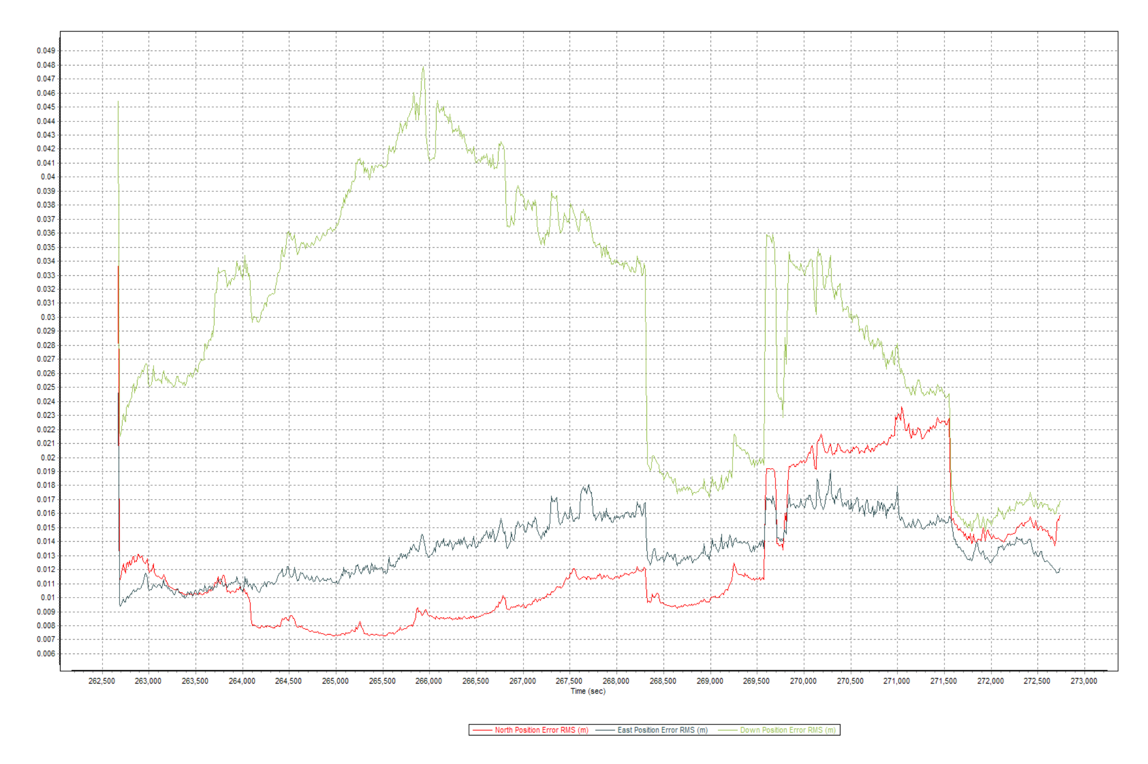
Elevation difference between flight lines

Flight Area	Iloilo
Mission Name	Blk43E
Inclusive Flights	2585P, 2587P, 2589P
Range data size	57.5 GB
Base data size	38.46 MB
POS	683 MB
Image	79.2 GB
Transfer date	March 23, 2015
Solution Status	
Number of Satellites (>6)	No
PDOP (<3)	No
Baseline Length (<30km)	No
Processing Mode (<=1)	No
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	2.36
RMSE for East Position (<4.0 cm)	1.91
RMSE for Down Position (<8.0 cm)	4.79
Boresight correction stdev (<0.001deg)	0.000211
IMU attitude correction stdev (<0.001deg)	0.000782

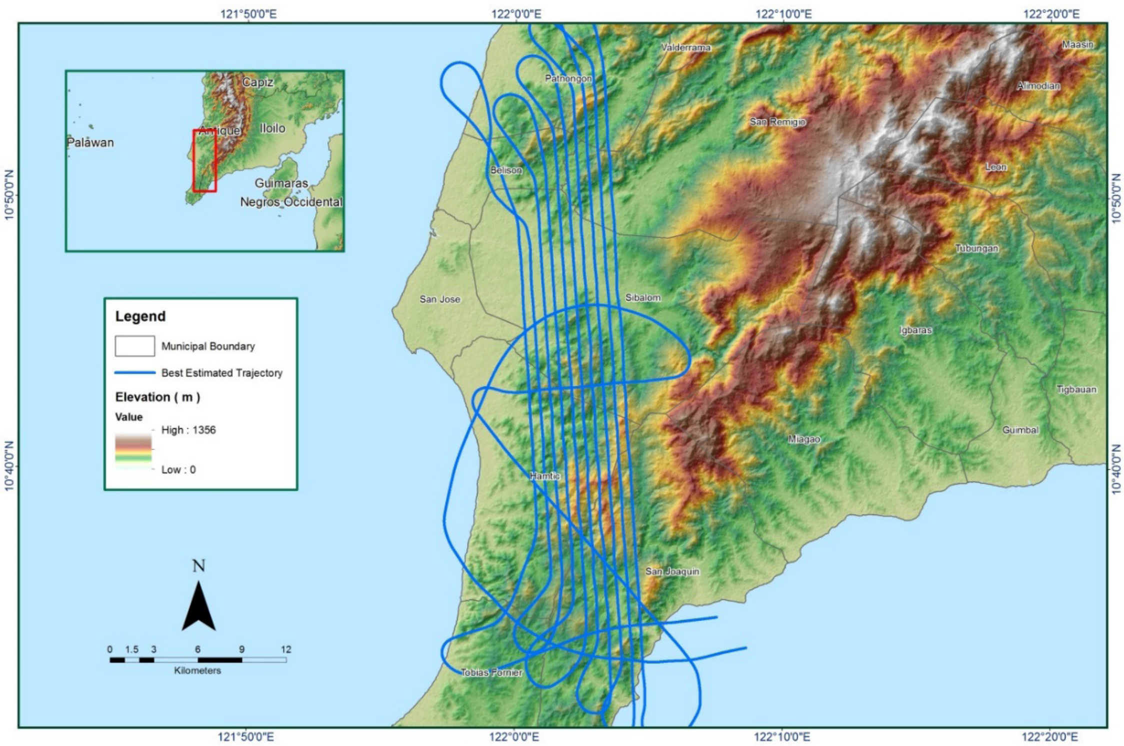
GPS position stdev (<0.01m)	0.002
Minimum % overlap (>25)	49.01%
Ave point cloud density per sq.m. (>2.0)	3.91
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	407
Maximum Height	662.37 m
Minimum Height	55.71 m
Classification (# of points)	
Ground	353,975,824
Low vegetation	224,279,530
Medium vegetation	517,674,786
High vegetation	1,254,044,800
Building	13,013,616
Orthophoto	Yes
Processed by	Engr. Sheila-Maye Santillan, Engr. Antonio Chua, Jr., Ryan James Nicholai Dizon



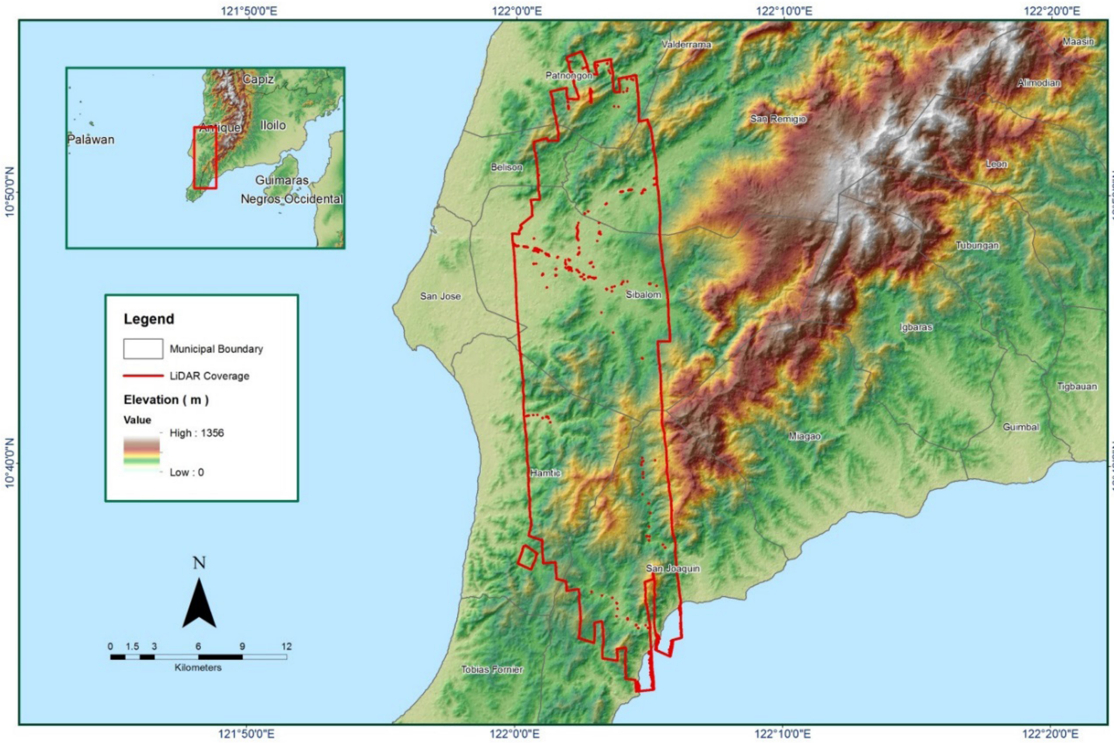
Solution Status



Smoothed Performance Metric Parameters



Best Estimated Trajectory



Coverage of LiDAR data

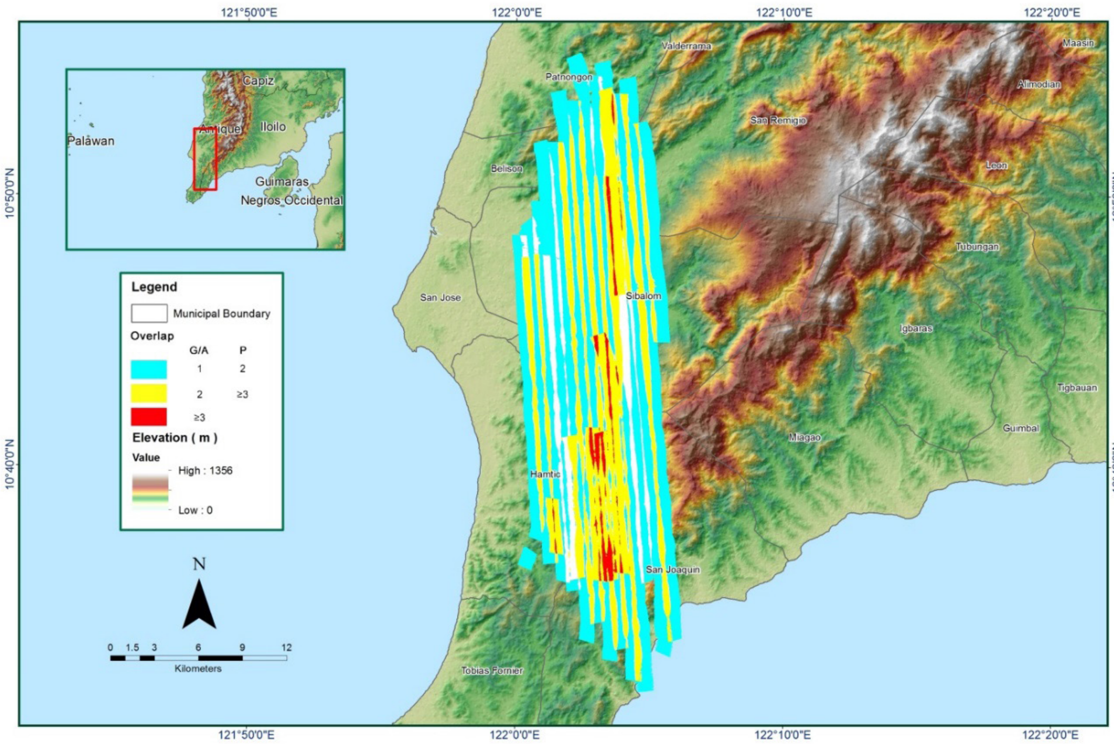
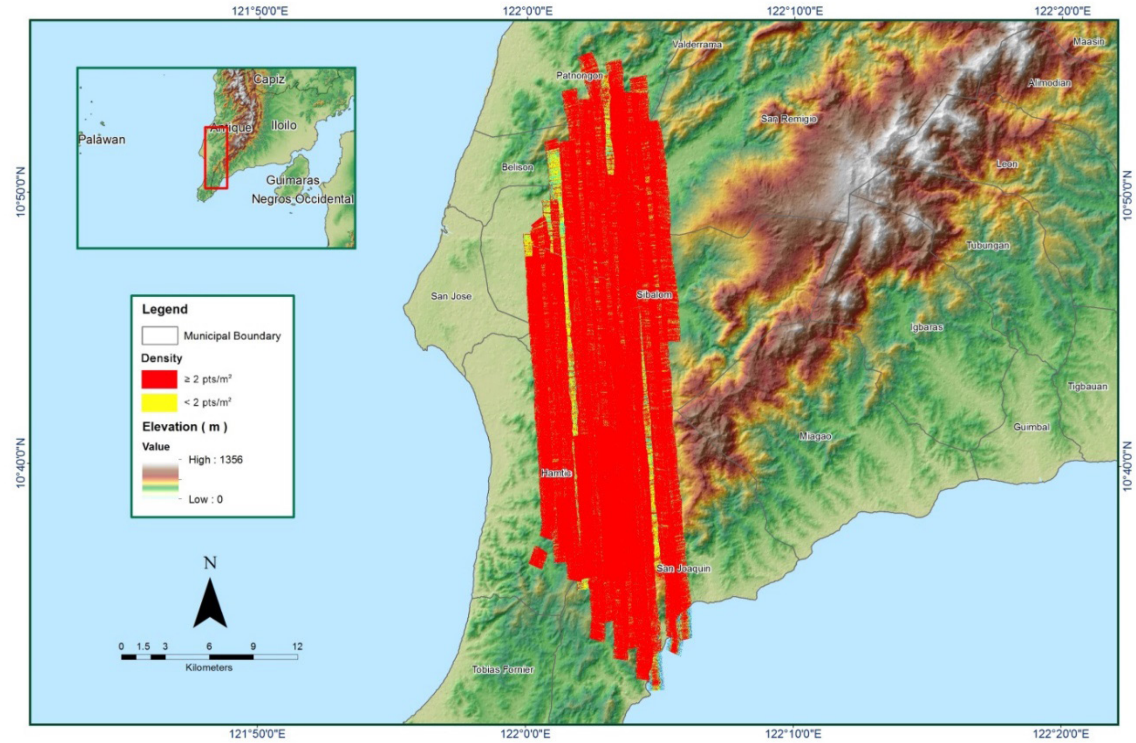
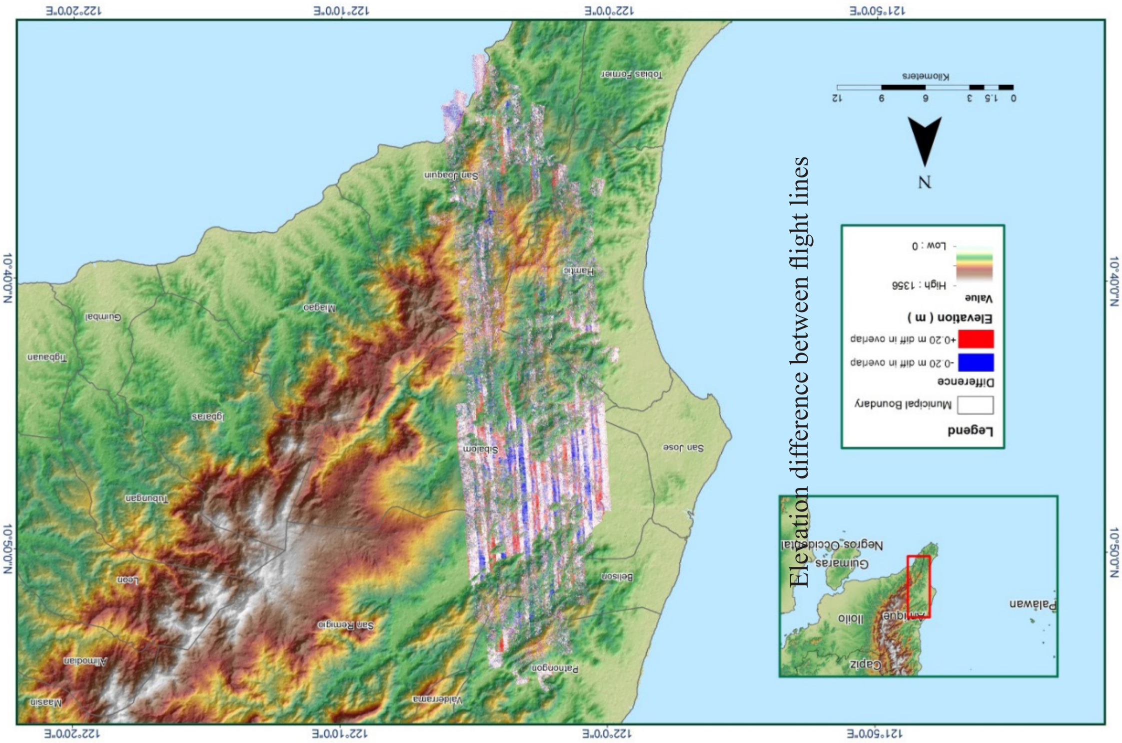


Image of data overlap

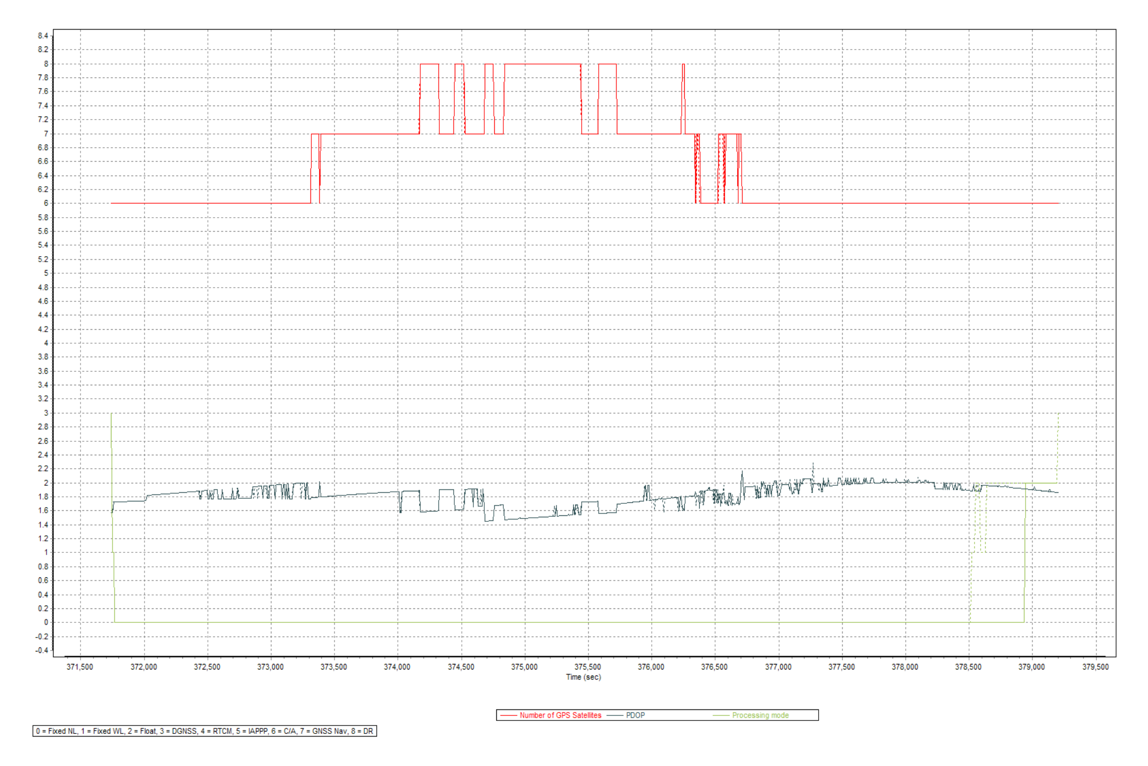


Density map of merged LiDAR data

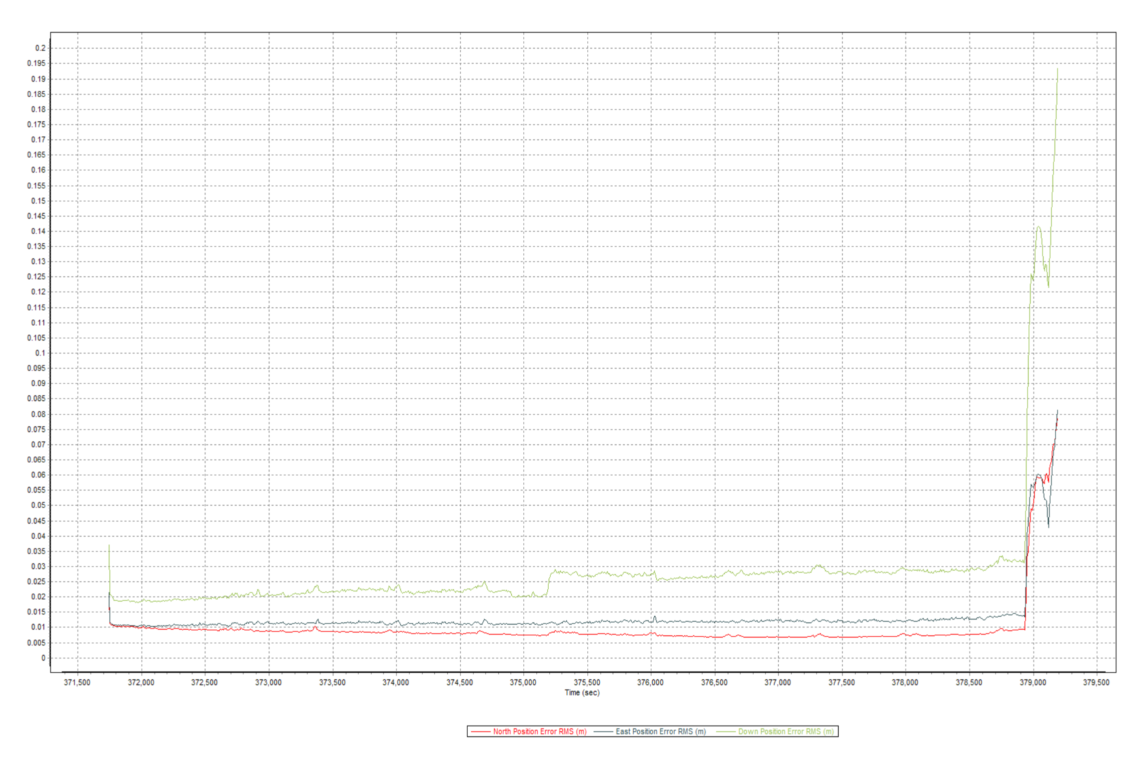


Elevation difference between flight lines

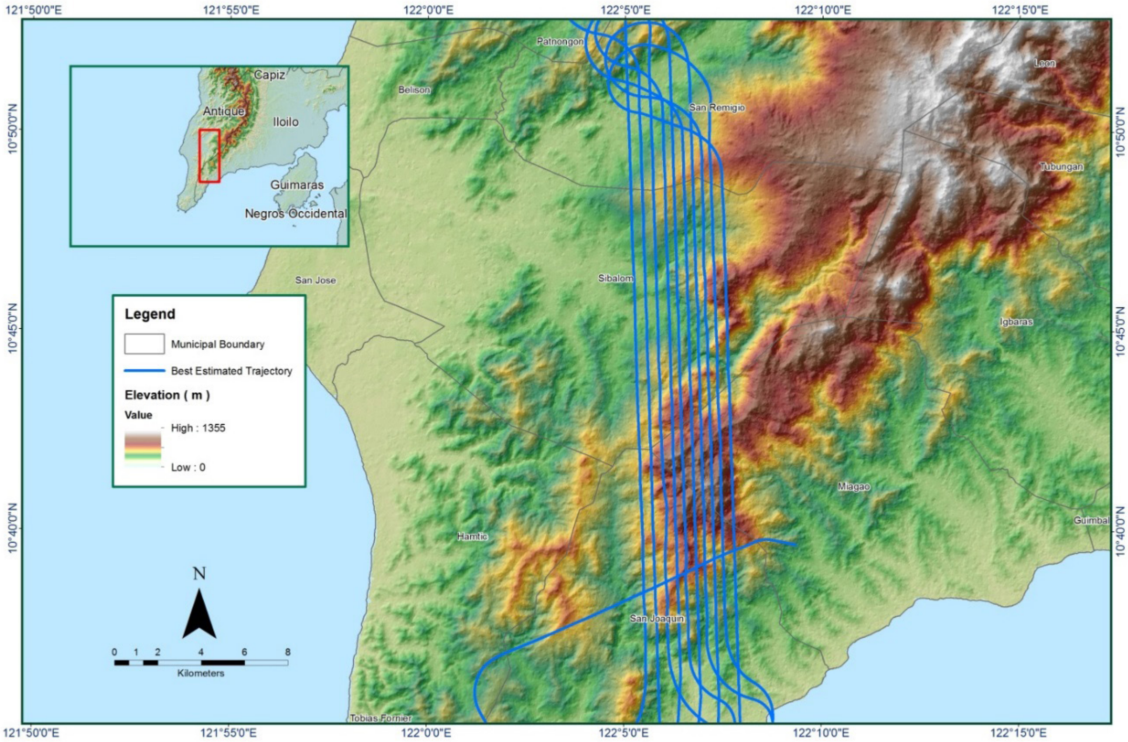
Flight Area	**Iloilo**
Mission Name	Blk43F
Inclusive Flights	2580G
Range data size	16.2 GB
Base data size	4.11 MB
POS	163 MB
Image	25.6 GB
Transfer date	March 23, 2015
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	Yes
Baseline Length (<30km)	No
Processing Mode (<=1)	Yes
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	1.03
RMSE for East Position (<4.0 cm)	1.36
RMSE for Down Position (<8.0 cm)	3.05
Boresight correction stdev (<0.001deg)	0.000214
IMU attitude correction stdev (<0.001deg)	0.000657
GPS position stdev (<0.01m)	0.0018
Minimum % overlap (>25)	33.03%
Ave point cloud density per sq.m. (>2.0)	4.63
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	174
Maximum Height	1093.82 m
Minimum Height	77.00 m
Classification (# of points)	
Ground	82,299,457
Low vegetation	47,811,205
Medium vegetation	112,917,636
High vegetation	314,579,068
Building	1,966,389
Orthophoto	Yes
Processed by	Engr. Irish Cortez, Engr. Velina Angela Bemida, Engr. Melissa Fernandez



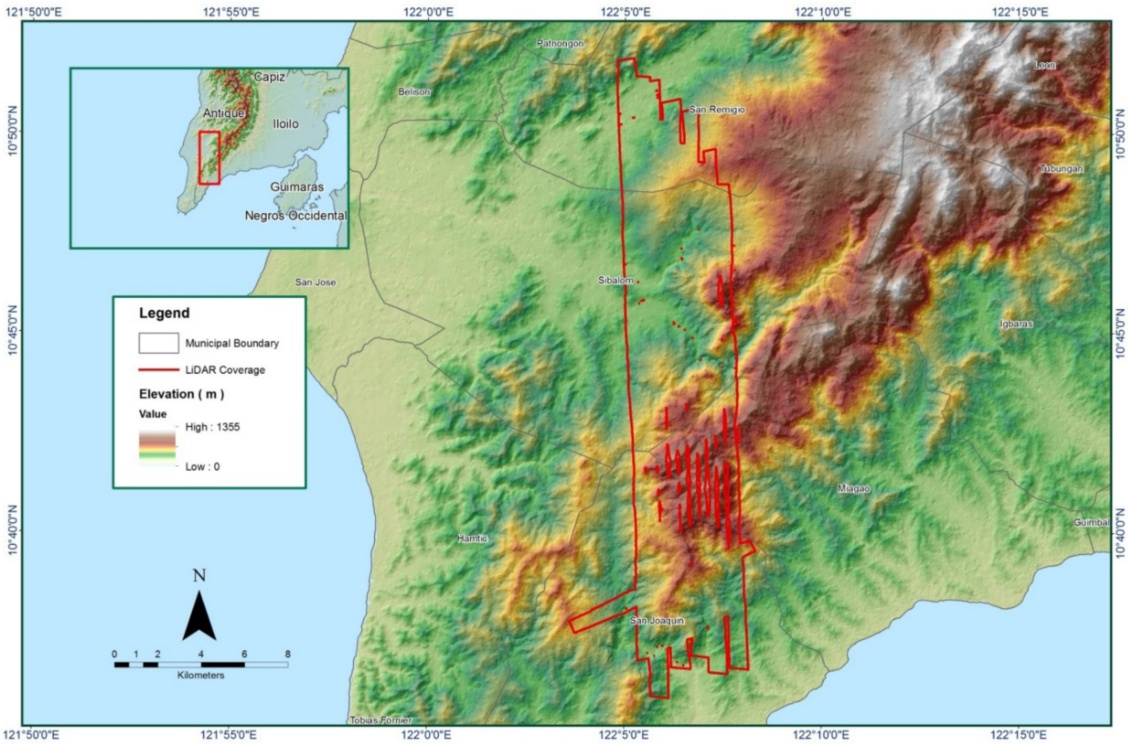
Solution Status



Smoothed Performance Metric Parameters



Best Estimated Trajectory



Coverage of LiDAR data

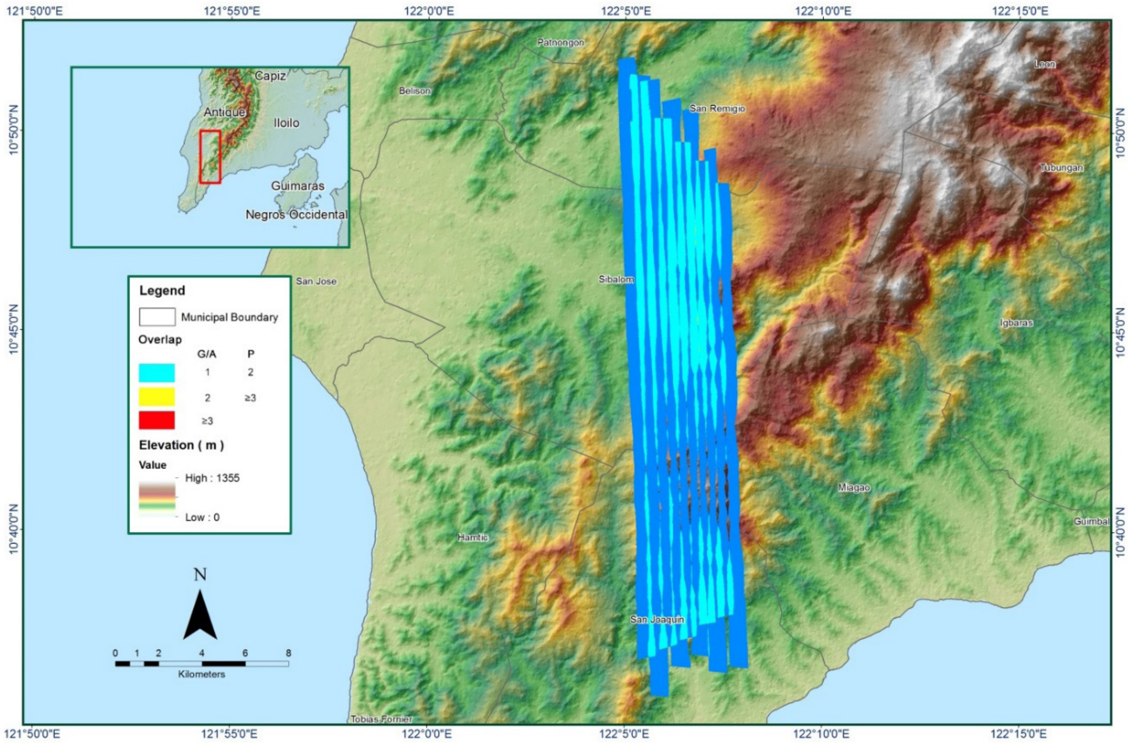
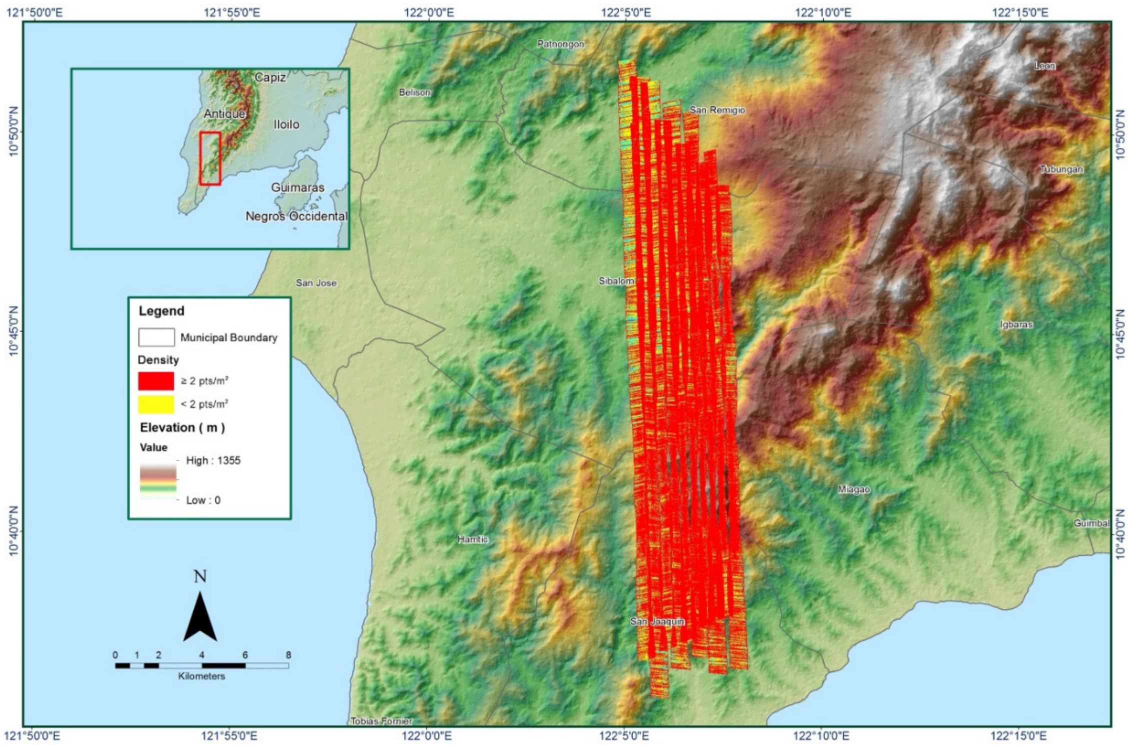
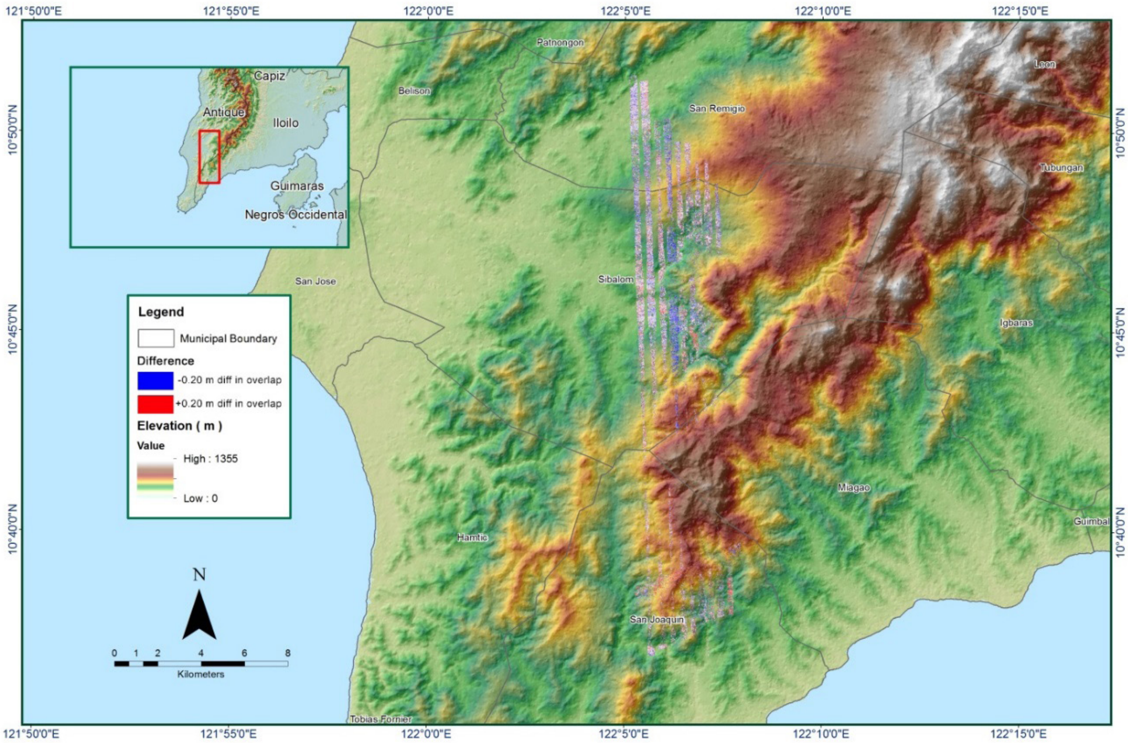


Image of data overlap

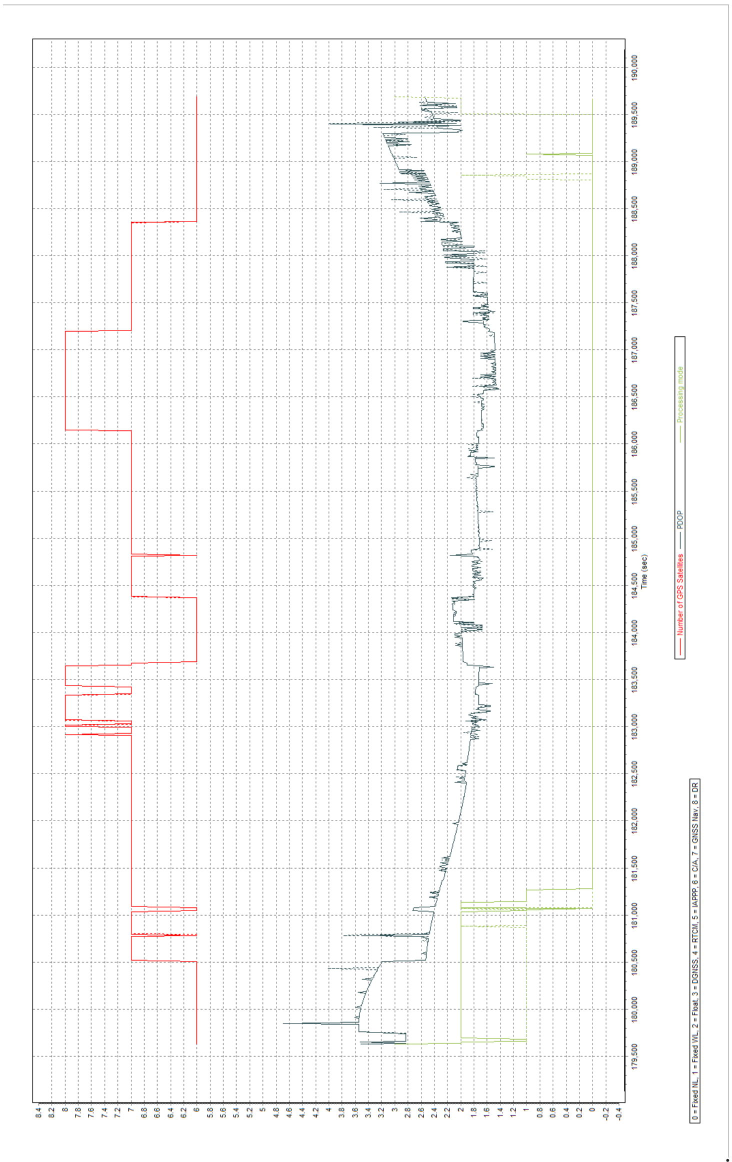


Density map of merged LiDAR data



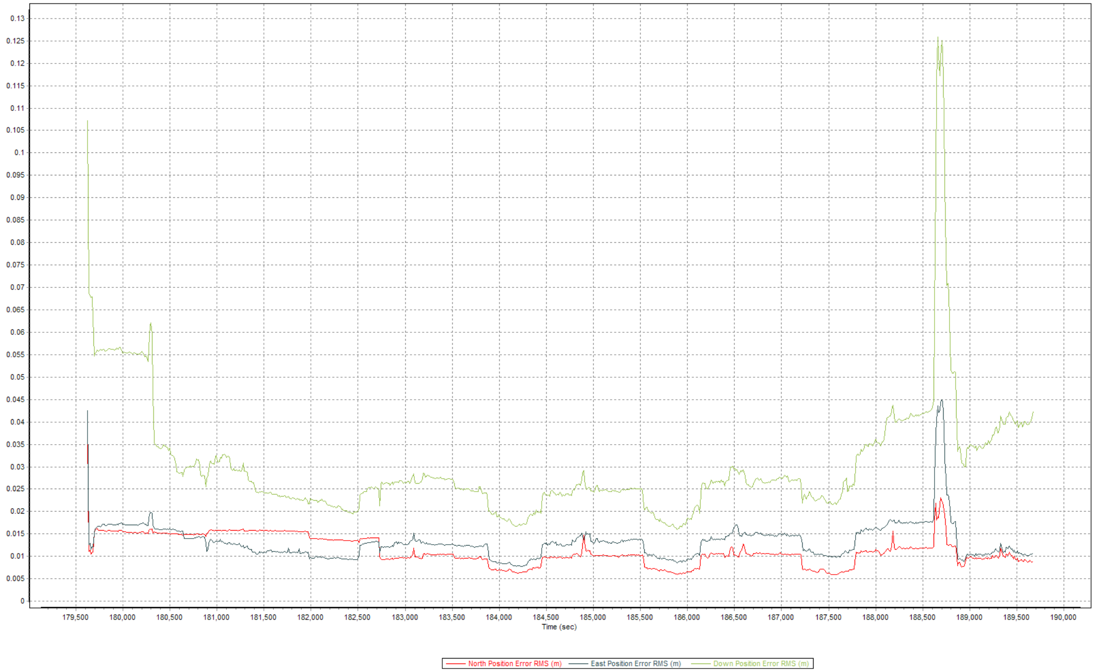
Elevation difference between flight lines

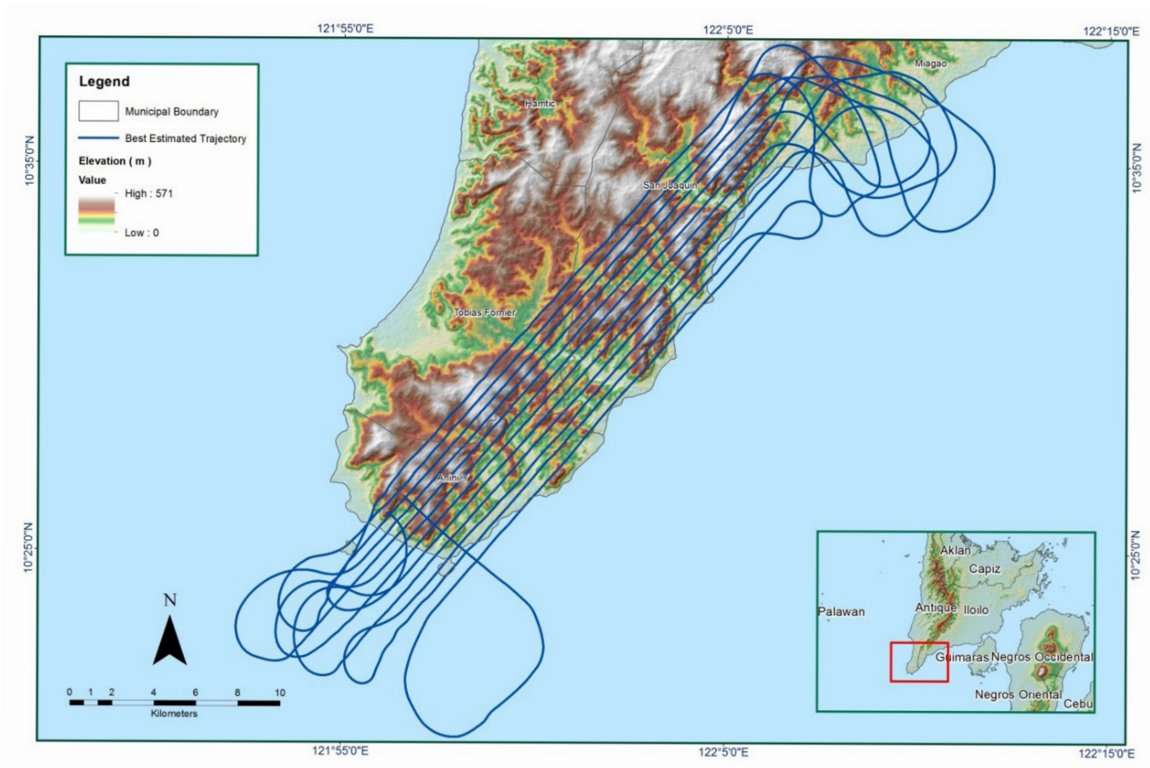
Flight Area	Iloilo
Mission Name	Blk43H
Inclusive Flights	2570G
Range data size	21.7 GB
POS	222 MB
Image	48.5 GB
Transfer date	March 23, 2015
Solution Status	
Number of Satellites (>6)	Yes
PDOP (<3)	No
Baseline Length (<30km)	No
Processing Mode (<=1)	No
Smoothed Performance Metrics (in cm)	
RMSE for North Position (<4.0 cm)	2.31
RMSE for East Position (<4.0 cm)	1.71
RMSE for Down Position (<8.0 cm)	3
Boresight correction stdev (<0.001deg)	0.000267
IMU attitude correction stdev (<0.001deg)	0.000681
GPS position stdev (<0.01m)	0.0021
Minimum % overlap (>25)	32.57%
Ave point cloud density per sq.m. (>2.0)	4.43
Elevation difference between strips (<0.20 m)	Yes
Number of 1km x 1km blocks	212
Maximum Height	613.99 m
Minimum Height	54.29 m
Classification (# of points)	
Ground	108,534,543
Low vegetation	79,766,900
Medium vegetation	153,063,695
High vegetation	333,632,882
Building	2,427,463
Orthophoto	Yes
Processed by	Engr. Irish Cortez, Aljon Rei Araneta, Engr.Melissa T. Fernandez



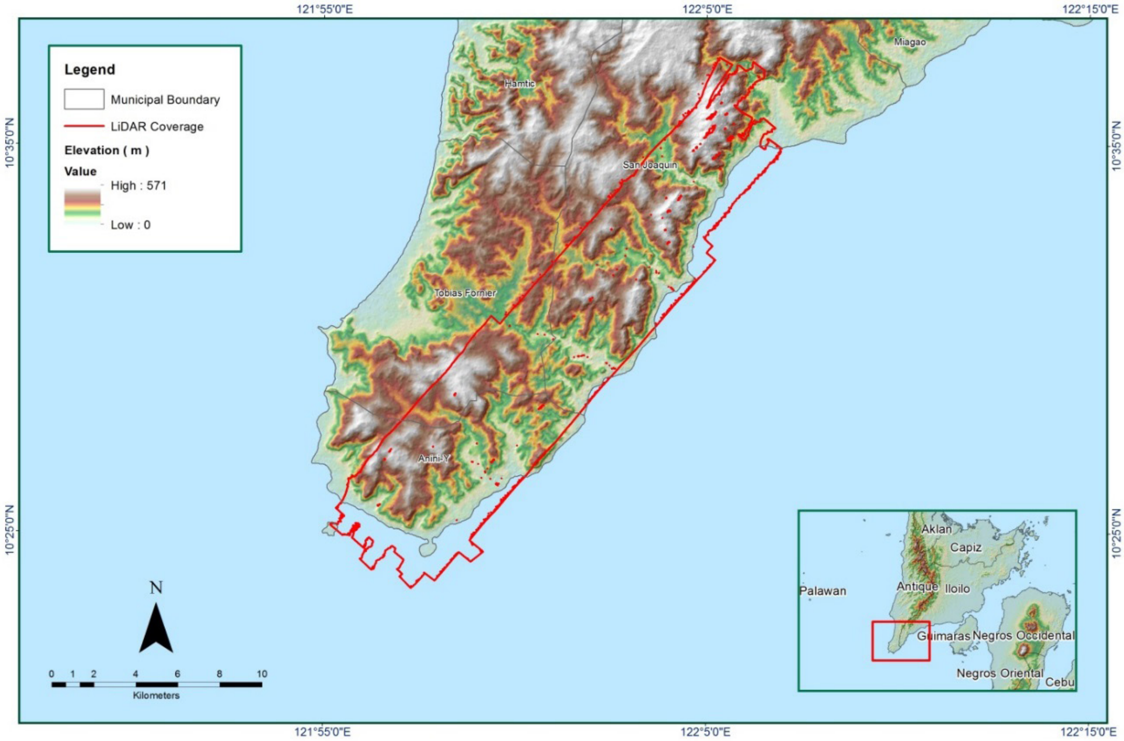
Solution Status

Smoothed Performance Metric Parameters

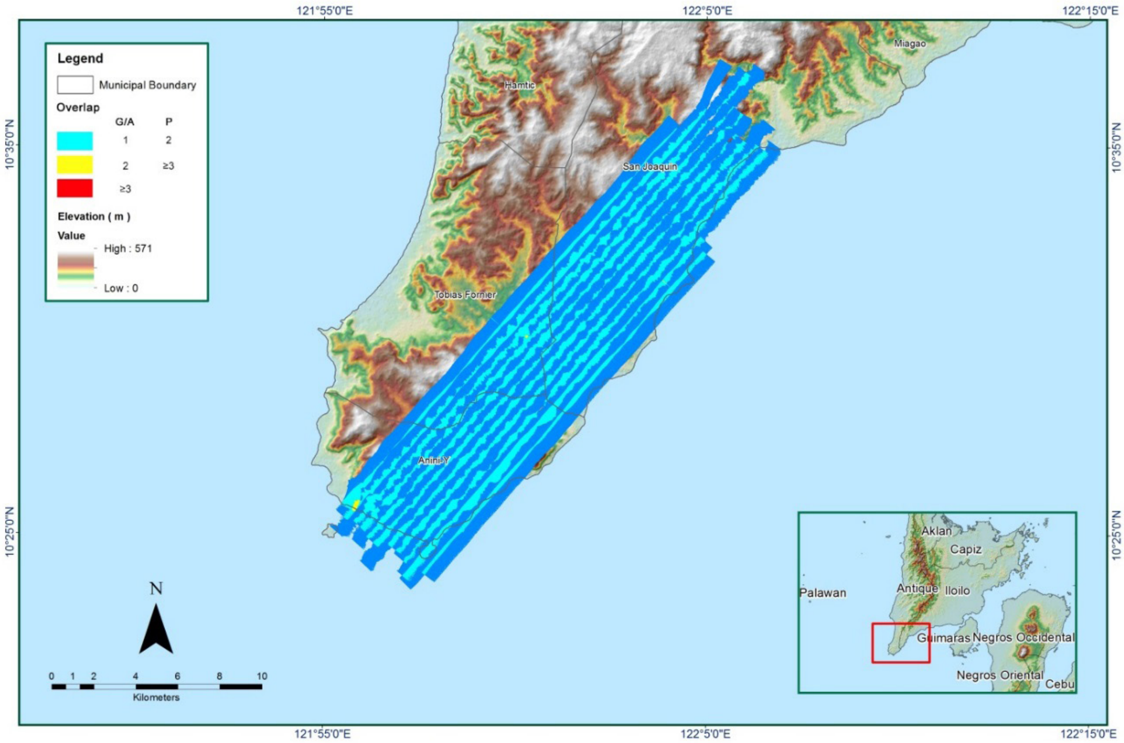




Best Estimated Trajectory



Coverage of LiDAR data



ANNEX 9. Sibalom2 Model Basin Parameters

Basin Number	SCS Curve Number Loss			Clark Unit Hydrograph Transform		Recession Baseflow				
	Initial Abstraction (mm)	Curve Number	Impervious (%)	Time of Concentration (HR)	Storage Coefficient (HR)	Initial Type	Initial Discharge (M3/S)	Reces-sion Con-stant	Threshold Type	Ratio to Peak
W220	0.10576	90.611	0	0.0410528	0.1303	Discharge	63.173	0.02	Ratio to Peak	0.2
W230	0.13372	99	0	0.0997	0.072	Discharge	73.681	0.02	Ratio to Peak	0.2
W240	0.0956507	99	0	0.18139	0.28308	Discharge		0.02	Ratio to Peak	0.2
W250	0.17223	99	0	0.0476056	0.23598	Discharge	79.127	0.02	Ratio to Peak	0.2
W260	0.11321	99	0	0.0478139	0.074615	Discharge	54.588	0.02	Ratio to Peak	0.2
W270	0.19496	82.198	0	0.0462	0.0166667	Discharge	0.69611	0.02	Ratio to Peak	0.2
W280	0.12709	99	0	0.0404028	0.0908283	Discharge	15.21	0.02	Ratio to Peak	0.2
W290	0.19496	99	0	0.0970861	0.10307	Discharge	23.552	0.02	Ratio to Peak	0.2
W300	0.17781	86.173	0	0.0604556	0.0399067	Discharge	11.919	0.02	Ratio to Peak	0.2
W310	0.18623	99	0	0.0410861	0.13855	Discharge	62.989	0.02	Ratio to Peak	0.2
W320	0.0921387	99	0	0.0523778	0.111615	Discharge	47.313	0.02	Ratio to Peak	0.2
W330	0.10393	92.643	0	0.0534417	0.0797233	Discharge	32.394	0.02	Ratio to Peak	0.2
W340	0.0369493	94.891	0	0.0324778	0.0448967	Discharge	6.2302	0.02	Ratio to Peak	0.2
W350	0.0407733	94.848	0	0.0166667	0.0420833	Discharge	3.581	0.02	Ratio to Peak	0.2
W360	0.0659213	99	0	0.0461472	0.10586	Discharge	44.877	0.02	Ratio to Peak	0.2

ANNEX 10. Sibalom2 Model Reach Parameters

Reach Number	MuskingumCunge Channel Routing						
	Time Step Method	Length (m)	Slope	Manning's n	Shape	Width	Side Slope
R40	Automatic Fixed Interval	317.99	0.001474	0.0075	Trapezoid	200	1
R60	Automatic Fixed Interval	2716.6	0.015689	0.0075	Trapezoid	200	1
R70	Automatic Fixed Interval	5032.7	2.23E-02	0.0075	Trapezoid	200	1
R90	Automatic Fixed Interval	6017.4	0.0112129	0.0075	Trapezoid	200	1
R100	Automatic Fixed Interval	20703	0.0165748	0.0075	Trapezoid	200	1
R130	Automatic Fixed Interval		0.000763	0.0075	Trapezoid	200	1
R140	Automatic Fixed Interval	1854.1	0.0011607	0.0075	Trapezoid	200	1
R160	Automatic Fixed Interval	2726.5	0.0099608	0.0075	Trapezoid	200	1
R170	Automatic Fixed Interval	239.85	0.029791	0.0075	Trapezoid	200	1
R190	Automatic Fixed Interval	2946.1	0.0326135	0.0075	Trapezoid	200	1
R290	Automatic Fixed Interval	1624.1	0.0369025	0.025	Trapezoid	30.928	0.3517
R30	Automatic Fixed Interval	113.14	0.001	0.025	Trapezoid	30.928	0.3517
R310	Automatic Fixed Interval	878.11	0.0657445	0.025	Trapezoid	30.928	0.3517
R40	Automatic Fixed Interval	2482.5	0.0078475	0.025	Trapezoid	30.928	0.3517
R50	Automatic Fixed Interval	1242.0	0.0058146	0.025	Trapezoid	30.928	0.3517
R70	Automatic Fixed Interval	2064.1	0.0096041	0.025	Trapezoid	30.928	0.3517

ANNEX 11. Sibalom2 Field Validation Points

Point No.	Validation Coordinates Lat	Long	Model Var (m)	Validation Points (m)	Error	Event/Date	Rain Return/ Scenario
Point Number	Validation Coordinates	Model var (m)	Validation Points (m)	Error	Event/ Date		5 Yr
	Lat	Long					
0	10.79598	121.94714	0.13	0	0.017	NA	
1	10.74984	121.93567	0.14	0	0.020	NA	
2	10.78712	122.01522	0.26	1.2	0.884	Frank	100-Year
3	10.79027	122.02372	0.03	0	0.001	NA	
4	10.78857	122.01875	0.08	1	0.846	Frank	100-Year
5	10.75845	121.94031	0.03	0	0.001	NA	
6	10.75507	121.93656	0.04	0	0.002	NA	
7	10.74942	121.93839	0.15	0	0.023	NA	
8	10.80902	122.0448	0.03	0	0.001	NA	
9	10.82343	122.05631	0.06	0	0.004	NA	
10	10.76136	121.92494	0.22	0	0.048	NA	
11	10.77681	122.04619	0.03	0	0.001	NA	
12	10.76503	121.94322	0.09	0.2	0.012	Yolanda	5-Year
13	10.75803	121.93646	0.12	0	0.014	NA	
14	10.77758	121.94606	0.21	0	0.044	NA	
15	10.7746	121.93939	0.29	0	0.084	NA	
16	10.75477	121.94039	0.03	0	0.001	NA	
17	10.7642	121.93176	0.2	0	0.040	NA	
18	10.75124	121.93612	0.03	0	0.001	NA	
19	10.78597	121.9491	0.03	0.1	0.005	Yolanda	5-Year
20	10.78793	121.95723	0.03	0	0.001	NA	
21	10.80664	122.07615	0.03	0	0.001	NA	
22	10.77943	121.9371	0.03	0	0.001	NA	
23	10.79047	122.0203	0.03	1.1	1.145	Frank	100-Year
24	10.75144	121.96296	0.04	0	0.002	NA	
25	10.79114	122.03584	0.25	1.1	0.723	Frank	100-Year
26	10.79027	122.02372	0	0	0.000	NA	
27	10.76424	122.00419	0.11	0	0.012	NA	
28	10.76518	122.00473	0.03	0	0.001	NA	
29	10.7663	122.00483	0.07	0	0.005	NA	
30	10.76188	121.93052	0.16	0.2	0.002	Yolanda	5-Year
31	10.78472	122.01891	0.07	0.5	0.185	Frank	100-Year
32	10.75968	121.93424	0.03	0.1	0.005	Yolanda	5-Year
33	10.7921	122.04269	0.12	0	0.014	NA	
34	10.76353	121.93256	0.27	0	0.073	NA	

Point No.	Validation Coordinates		Model Var (m)	Validation Points (m)	Error	Event/Date	Rain Return/ Scenario
	Lat	Long					
Point Number	Validation Coordinates	Model var (m)	Validation Points (m)	Error	Event/ Date		5 Yr
	Lat	Long					
35	10.75687	121.93416	0.19	0	0.036	NA	
36	10.79738	121.94615	0.9	0.4	0.250	Auring	5-Year
37	10.7796	121.94354	0.04	0	0.002	NA	
38	10.78987	122.01934	0.12	1.5	1.904	Frank	100-Year
39	10.76058	121.93363	0.14	0.1	0.002	Yolanda	5-Year
40	10.75876	121.94395	0.05	0	0.003	NA	
41	10.76414	121.92471	0.23	0	0.053	NA	
42	10.75221	121.93607	0.04	0	0.002	NA	
43	10.77817	121.94627	0.03	0	0.001	NA	
44	10.7531	121.9391	0.19	0	0.036	NA	
45	10.75977	121.93766	0.26	0	0.068	NA	
46	10.79002	122.01763	0.16	1	0.706	Frank	100-Year
47	10.76888	121.93133	0.37	0	0.137	NA	
48	10.76812	121.94379	0.21	0	0.044	NA	
49	10.75364	122.07754	0.03	0	0.001	NA	
50	10.82127	122.06586	0.21	0	0.044	NA	
51	10.7741	122.06113	0.46	0.9	0.194	Frank	100-Year
52	10.77714	121.96717	0.47	1.3	0.689	Frank	100-Year
53	10.77739	121.96703	0.03	1.3	1.613	Frank	100-Year
54	10.77553	121.96669	0.3	1	0.490	Frank	100-Year
55	10.77427	121.96783	0.52	0.9	0.144	Frank	100-Year
56	10.77603	121.96689	0.28	1	0.518	Frank	100-Year
57	10.77695	121.96655	0.58	1.3	0.518	Frank	100-Year
58	10.77667	121.96657	0	1.3	1.690	Frank	100-Year
59	10.79208	122.03524	0.86	1.6	0.548	Frank	100-Year
60	10.78572	121.9468	0.66	0.9	0.058	Frank	100-Year
61	10.78962	121.94617	0.43	0	0.185	NA	
62	10.79834	121.9494	0.78	0.2	0.336	Frank	100-Year
63	10.77982	121.94545	0.46	1.2	0.548	Yolanda	5-Year
64	10.79121	122.02038	0.1	1.1	1.000	Frank	100-Year
65	10.78675	121.9474	0.03	0.1	0.005	Yolanda	5-Year
66	10.78701	122.04839	0.38	1.8	2.016	Undang	5-Year
67	10.77913	121.94532	0.56	0.3	0.068	Yolanda	5-Year
68	10.77906	122.0482	0.22	0.9	0.462	Ruping	5-Year
34	10.76353	121.93256	0.27	0	0.073	NA	

Point No.	Validation Coordinates		Model Var (m)	Validation Points (m)	Error	Event/Date	Rain Return/
	Lat	Long					
Point Num-ber	Validation Coordinates	Model var (m)	Vali-dation Points (m)	Error	Event/ Date		5 Yr
	Lat	Long					
64	10.79121	122.02038	0.1	1.1	1.000	Frank	100-Year
65	10.78675	121.9474	0.03	0.1	0.005	Yolanda	5-Year
66	10.78701	122.04839	0.38	1.8	2.016	Undang	5-Year
67	10.77913	121.94532	0.56	0.3	0.068	Yolanda	5-Year
68	10.77906	122.0482	0.22	0.9	0.462	Ruping	5-Year
69	10.80393	121.94731	0.59	0	0.348	NA	
70	10.77691	121.93486	0.09	0	0.008	NA	
71	10.77682	121.93615	0.04	0	0.002	NA	
72	10.79142	122.03277	0.82	1.5	0.462	Frank	100-Year
73	10.79737	122.00794	0.03	0	0.001	NA	
74	10.79847	121.94955	0	0.2	0.040	Frank	100-Year
75	10.8112	122.07157	0.03	0	0.001	NA	
76	10.76424	121.94597	0.47	0.9	0.185	Yolanda	5-Year
77	10.80553	122.04883	1.09	2	0.828	Frank	100-Year
78	10.77993	122.04888	0.76	1.8	1.082	Yolanda	5-Year
79	10.77089	122.01513	0.52	0.4	0.014	Frank	100-Year
80	10.79229	122.03426	1.09	0	1.188	NA	
81	10.81303	122.00802	1.27	0.3	0.941	Frank	100-Year
82	10.76332	122.01381	0.35	0.9	0.303	Frank	100-Year
83	10.75213	121.96439	1.01	0	1.020	NA	
84	10.81429	122.00618	0.44	0.3	0.020	Frank	100-Year
85	10.81349	122.00366	1.29	1	0.084	Frank	100-Year
86	10.76468	121.95805	1.1	1.2	0.010	Frank	100-Year
87	10.75084	121.9637	1.4	2.5	1.210	Frank	100-Year
88	10.75238	121.96412	0	0	0.000	NA	
89	10.77093	122.01369	0.97	0.2	0.593	Frank	100-Year
90	10.7984	121.99604	2.24	2.5	0.068	Frank	100-Year
91	10.78754	121.94728	0.96	0.4	0.314	Yolanda	5-Year
93	10.85148	121.95906	1.17	0.9	0.073	Frank	100-Year
94	10.85188	121.95902	1.27	0.9	0.137	Frank	100-Year
95	10.79266	122.01044	1.83	0	3.349	NA	
31	10.78472	122.01891	0.07	0.5	0.185	Frank	100-Year
32	10.75968	121.93424	0.03	0.1	0.005	Yolanda	5-Year
33	10.7921	122.04269	0.12	0	0.014	NA	
34	10.76353	121.93256	0.27	0	0.073	NA	

Point No.	Validation Coordinates		Model Var (m)	Validation Points (m)	Error	Event/Date	Rain Return/ Scenario
	Lat	Long					
Point Num-ber	Validation Coordinates	Model var (m)	Vali-dation Points (m)	Error	Event/ Date		5 Yr
	Lat	Long					
94	10.85188	121.95902	1.27	0.9	0.137	Frank	100-Year
95	10.79266	122.01044	1.83	0	3.349	NA	
96	10.85487	121.95927	1.51	0.2	1.716	Frank	100-Year
97	10.78768	122.04783	0.54	0	0.292	NA	
98	10.80462	121.95137	1.04	0	1.082	NA	
99	10.78053	122.05341	0.82	0	0.672	NA	
100	10.77675	121.93496	0.13	0	0.017	NA	
101	10.80446	121.95152	0.67	0	0.449	NA	
102	10.82517	122.05955	0.03	0	0.001	NA	
103	10.85586	121.96096	0.74	0	0.548	NA	
104	10.76952	121.93063	0.03	0	0.001	NA	
105	10.85355	121.96029	0.71	0	0.504	NA	
106	10.78784	121.94699	1.02	0.4	0.384	Yolanda	5-Year
107	10.78759	121.94675	0	0.4	0.160	Yolanda	5-Year
108	10.75794	121.9835	1.14	0.75	0.152	Yolanda	5-Year
109	10.80264	121.98945	0.9	0.8	0.010	Yolanda	5-Year
110	10.79835	121.99513	2.15	1.75	0.160	Frank	100-Year
111	10.79174	122.03207	1.61	3.5	3.572	Frank	100-Year
112	10.75072	121.96381	0	2.5	6.250	Frank	100-Year
113	10.81335	122.00226	1.89	3	1.232	Frank	100-Year
114	10.81257	122.00439	2.89	1	3.572	Frank	100-Year
115	10.81353	122.00273	2.19	2	0.036	Frank	100-Year
116	10.76275	122.01316	0.92	0.9	0.000	Frank	100-Year
117	10.77244	122.01627	1.17	1.1	0.005	Frank	100-Year
118	10.8121	122.00638	1.67	0.9	0.593	Frank	100-Year
119	10.79164	122.03179	1.58	2	0.176	Frank	100-Year
120	10.79263	122.01744	3.32	2	1.742	Frank	100-Year
121	10.79863	121.995	2.88	1.75	1.277	Frank	100-Year
122	10.79401	122.01653	4.64	2	6.970	Frank	100-Year
123	10.79424	122.01337	3.69	3	0.476	Frank	100-Year
124	10.79892	121.99194	2.77	3	0.053	Frank	100-Year
125	10.79412	122.01334	0	3	9.000	Frank	100-Year
126	10.81246	121.99547	0.85	3.5	7.023	Frank	100-Year
127	10.79127	122.01549	3.98	2	3.920	Frank	100-Year
128	10.79868	121.99229	0	3	9.000	Frank	100-Year
129	10.79194	122.01693	4.34	2.2	4.580	Frank	100-Year
130	10.79829	121.99165	2.38	3	0.384	Frank	100-Year
131	10.82438	122.05874	1.88	0	3.534	NA	

Point No.	Validation Coordinates		Model Var (m)	Validation Points (m)	Error	Event/Date	Rain Return/ Scenario
	Lat	Long					
Point Number	Validation Coordinates	Model var (m)	Validation Points (m)	Error	Event/ Date		5 Yr
	Lat	Long					
122	10.79401	122.01653	4.64	2	6.970	Frank	100-Year
123	10.79424	122.01337	3.69	3	0.476	Frank	100-Year
124	10.79892	121.99194	2.77	3	0.053	Frank	100-Year
125	10.79412	122.01334	0	3	9.000	Frank	100-Year
126	10.81246	121.99547	0.85	3.5	7.023	Frank	100-Year
127	10.79127	122.01549	3.98	2	3.920	Frank	100-Year
128	10.79868	121.99229	0	3	9.000	Frank	100-Year
129	10.79194	122.01693	4.34	2.2	4.580	Frank	100-Year
130	10.79829	121.99165	2.38	3	0.384	Frank	100-Year
131	10.82438	122.05874	1.88	0	3.534	NA	
132	10.80296	122.0413	3.24	1.3	3.764	Frank	100-Year
133	10.80173	122.01461	3.01	2.5	0.260	Frank	100-Year
134	10.81524	121.99874	3.52	1.3	4.928	Frank	100-Year
135	10.79929	122.04263	0.39	0.45	0.004	Frank	100-Year
136	10.81393	122.00038	2.67	2	0.449	Frank	100-Year
137	10.80148	122.0143	3.88	0.3	12.816	Frank	100-Year
138	10.76698	121.98829	0.53	1.5	0.941	Frank	100-Year
139	10.81503	121.99996	1.93	0.5	2.045	Undang	5-Year
140	10.76832	121.98529	2.32	1.1	1.488	Frank	100-Year
141	10.81522	121.99735	2.98	2.5	0.230	Frank	100-Year
142	10.81541	121.99996	2.85	0.5	5.523	Undang	5-Year
143	10.80217	122.01497	0	2	4.000	Frank	100-Year
144	10.7755	121.98176	1.35	0.2	1.323	Frank	100-Year
145	10.79841	121.9954	0	1	1.000	Frank	100-Year
146	10.79224	122.01084	3.35	2	1.823	Frank	100-Year
147	10.79149	122.01427	3.3	2.5	0.640	Frank	100-Year
148	10.79441	122.01369	4.88	3	3.534	Frank	100-Year
149	10.7944	122.0176	2.38	1.8	0.336	Yolanda	5-Year
150	10.79249	122.0342	5.92	2.5	11.696	Frank	100-Year
151	10.79258	122.03498	1.45	2.5	1.103	Frank	100-Year
152	10.79258	122.03451	0	2.5	6.250	Frank	100-Year
153	10.79255	122.03434	0	2.5	6.250	Frank	100-Year
154	10.79282	122.03523	0.76	2.5	3.028	Frank	100-Year
155	10.79272	122.03502	0	2.5	6.250	Frank	100-Year
156	10.79248	122.03419	0	2.5	6.250	Frank	100-Year
157	10.79279	122.03508	0	2.5	6.250	Frank	100-Year
158	10.79272	122.03489	0	2.5	6.250	Frank	100-Year

Point No.	Validation Coordinates		Model Var (m)	Validation Points (m)	Error	Event/Date	Rain Return/ Scenario
	Lat	Long					
Point Number	Validation Coordinates	Model var (m)	Vali-dation Points (m)	Error	Event/ Date		5 Yr
	Lat	Long					
147	10.79149	122.01427	3.3	2.5	0.640	Frank	100-Year
148	10.79441	122.01369	4.88	3	3.534	Frank	100-Year
149	10.7944	122.0176	2.38	1.8	0.336	Yolanda	5-Year
150	10.79249	122.0342	5.92	2.5	11.696	Frank	100-Year
151	10.79258	122.03498	1.45	2.5	1.103	Frank	100-Year
152	10.79258	122.03451	0	2.5	6.250	Frank	100-Year
153	10.79255	122.03434	0	2.5	6.250	Frank	100-Year
154	10.79282	122.03523	0.76	2.5	3.028	Frank	100-Year
155	10.79272	122.03502	0	2.5	6.250	Frank	100-Year
156	10.79248	122.03419	0	2.5	6.250	Frank	100-Year
157	10.79279	122.03508	0	2.5	6.250	Frank	100-Year
158	10.79272	122.03489	0	2.5	6.250	Frank	100-Year
159	10.79248	122.03431	0	2.5	6.250	Frank	100-Year
160	10.79543	122.02074	5.4	5.2	0.040	Frank	100-Year
161	10.79916	122.0159	7.86	6	3.460	Frank	100-Year
163	10.81117	122.03797	7.32	6	1.742	Frank	100-Year
164	10.80649	121.98841	6.22	5.5	0.518	Frank	100-Year
165	10.81097	122.03785	6.89	6	0.792	Frank	100-Year
166	10.79339	122.0377	1.73	2	0.073	Frank	100-Year
167	10.79477	122.02438	5.37	5.2	0.029	Frank	100-Year
168	10.81249	122.03911	4.63	6	1.877	Frank	100-Year
169	10.82682	122.05433	6.76	6	0.578	Frank	100-Year
170	10.7967	122.01114	6.21	4	4.884	Frank	100-Year
171	10.79538	122.01863	6.05	5.2	0.722	Frank	100-Year
172	10.79709	122.01031	6.4	4	5.760	Frank	100-Year
173	10.80757	121.989	5.35	5.5	0.023	Frank	100-Year
174	10.82698	122.05526	5.81	6	0.036	Frank	100-Year
175	10.80431	121.99022	7.23	5.5	2.993	Frank	100-Year
176	10.81276	122.03764	8.1	6	4.410	Frank	100-Year
177	10.80554	121.98922	6.7	5.5	1.440	Frank	100-Year
152	10.79258	122.03451	0	2.5	6.250	Frank	100-Year
153	10.79255	122.03434	0	2.5	6.250	Frank	100-Year
154	10.79282	122.03523	0.76	2.5	3.028	Frank	100-Year
155	10.79272	122.03502	0	2.5	6.250	Frank	100-Year
156	10.79248	122.03419	0	2.5	6.250	Frank	100-Year
157	10.79279	122.03508	0	2.5	6.250	Frank	100-Year
158	10.79272	122.03489	0	2.5	6.250	Frank	100-Year

Point No.	Validation Coordinates		Model Var (m)	Validation Points (m)	Error	Event/Date	Rain Return/
	Lat	Long					
Point Number	Validation Coordinates	Model var (m)	Validation Points (m)	Error	Event/ Date		5 Yr
	Lat	Long					
171	10.79538	122.01863	6.05	5.2	0.722	Frank	100-Year
172	10.79709	122.01031	6.4	4	5.760	Frank	100-Year
173	10.80757	121.989	5.35	5.5	0.023	Frank	100-Year
174	10.82698	122.05526	5.81	6	0.036	Frank	100-Year
175	10.80431	121.99022	7.23	5.5	2.993	Frank	100-Year
176	10.81276	122.03764	8.1	6	4.410	Frank	100-Year
177	10.80554	121.98922	6.7	5.5	1.440	Frank	100-Year
178	10.80773	121.98724	6.19	5.5	0.476	Frank	100-Year

ANNEX 12. Educational Institutions Affected by flooding in Sibalom2 Flood Plain

Antique				
Belison				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
Bongbongan I Elementary School	Buenavista			
Lagdo Daycare Center	Buenavista			
Lagdo Elementary School	Buenavista			
Concepcion Elementary School	Concepcion			
Mojon Barangay Stage	Mojon			
Mojon Day Care Center	Mojon			
Mojon Elementary School	Mojon			
Belison Central School	Poblacion			Low
Belison National High School	Poblacion			
School	Poblacion			
Rombang Elementary School	Rombang			
Sinaja-Salvacion Elementary School	Sinaja	Medium	Medium	High

San Jose				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
Durog Elementary School	Durog	Low	Medium	Medium
Durog Elementary School Stage	Durog	Medium	Medium	Medium
Lugutan Elementary School	Igbonglo			
Lugutan Elementary School Stage	Igbonglo			
Sitio Lugutan Day Care Center	Igbonglo		Low	Low
Magcalon Day Care Center	Magcalon			
Rosario Javier Moscoso Memorial Ele-memtary School	Magcalon		Low	Low
Eufrosino Q. Moscoso Elementary School	Mojon			
Mojon Day Care Center	Mojon			
Sitio Su-ong Day Care Center	Pantao			
San Fernando Elementary School	San Fernando	Low	Low	Low
Assemblyman Segundo Moscoso Memo-rial School	San Pedro	Low	Low	Low
San Pedro Day Care Center	San Pedro	Low	Low	Low
San Pedro National High School	San Pedro	Medium	Medium	Medium

San Remigio				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
Barangbang Elementary School	Barangbang			
Barangbang Elementary School	Cadolonan			
Barangbang National High School	Cadolonan			
Cadolonan Elementary School	Cadolonan			
Bongbongan I Day Care Center	Carmelo I			
Carmelo II Elementary School	Carmelo II			

Sibalom				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
University of Antique	Bari			
Bongbongan Elementary School	Bongbongan II			
Bongbongan II Day Care Center	Bongbongan II			
Pangpang Elementary School	Bongsod		Low	Medium
Pangpang National High School	Bongsod			Low
Catungan I Day Care Center	Catungan I	Low	Low	Medium
Lotilla Elementary School	Catungan I	Low	Low	Medium
Odiong Elementary School	Catungan IV		Low	Low
Alangan-Bungsod-Cubay Elementary School	Cubay-Napultan	Medium	High	High
Alangan Daycare Center	Cubay-Napultan	Medium	Medium	High
Barangay Cubay Napultan Day Care Center	Cubay-Napultan			Low
Bungsod Day Care Center	Cubay-Napultan			
Fornier Elementary School	Cubay-Sermon			
Sitio Tunnel Child Development Center	Cubay-Sermon	Low	Medium	Medium
University of Antique	District I	Low	Low	Low
District II Day Care Center	District III	Low	Low	Low
District III Day Care Center	District III		Low	Low
Sibalom Central Elementary School	District III	Low	Low	Low
Sibalom National Highschool	District III			Low
Barangay Igbonglo Day Care Center	Egaña			
Igbonglo Elementary School	Egaña			
Igbonglo Elementary School Stage	Egaña			
Nahum Christian Center	Egaña			
New Barangay Pantao Day Care Center	Egaña			
Pantao - Igbonglo Elementary School	Egaña			
Pantao Day Care Center	Egaña			
Villar Day Care Center	Esperanza II		Low	Medium

Sibalom				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
Pantao - Igbonglo Elementary School	Bari			
Pantao Day Care Center	Bongbongan II			
Villar Day Care Center	Bongbongan II			
Villar Elementary School	Bongsod		Low	Medium
Esperanza Daycare Center	Esperanza III			
Esperanza Elementary School	Esperanza III			
Esperanza I Day Care Center	Esperanza III	High	High	High
Cadoldolan-Igdagmay Elementary School	Igdagmay			
Cadoldolan Day Care Center	Igdagmay			
Igdagmay Daycare Center	Igdagmay			
Iglanot Child Friendly School	Igdalaquit		Low	Low
Maasin Elementary School	Igdalaquit			
Maasin Elementary School Stage	Igdalaquit			
Barangay Iglanot Day Care Center	Iglanot	Medium	Medium	Medium
Iglanot Child Friendly School	Iglanot		Low	Medium
Ilabas Daycare Center	Ilabas			Low
Ilabas Elementary School	Ilabas	Medium	Medium	Medium
Lacaron Integrated School	Lacaron			
Barangay Maasin Day Care Center	Maasin			
Barangay Mabini Day Care Center	Mabini			
Mabini Elementary School	Mabini			
Barangay Pis-anan Day Care Center 2 - Sitio Ambayanan	Millamena			
Mojon Barangay Stage	Mojon			
Mojon Day Care Center	Mojon			
Barangay Nagdayao Day Care Center	Nagdayao	Medium	Medium	High
Nagdayao Elementary School	Nagdayao			Low
Pangpang Day Care Center	Pangpang			
Pangpang National High School	Pangpang	Low	Low	Medium
Bartolomi Bertolano Child Development Center	Pasong			
Catmon Elementary School	Pasong			
Miguel BePaegas Day Care Center	Pasong			
Barangay Pis-anan Day Care Center	Pis-Anan	Low	Low	Low
Igdalaquit Day Care Center	Pis-Anan			
Panlagangan Day Care Center	Pis-Anan			
Panlagangan Elementary School	Pis-Anan			
Pis-anan Central School	Pis-Anan			
Pis-anan Central School Stage	Pis-Anan			
Pis-anan National High School	Pis-Anan	Low	Low	Low
Sido-San Juan National High School	San Juan	Medium	Medium	Medium

Sibalom				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
Sido Day Care Center	Sido		Low	Medium
Juan Vego Elementary School	Solong			
Solong Day Care Center	Solong			
San Juan Day Care Center	Villahermosa			Low
Cabariuan Elementary School	Villar			

ANNEX 13. Health Institutions affected by flooding in Sibalom2 Floodplain

Antique				
Belison				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
Bongbongan Health Center New	Belison			
Bongbongan Health Center Old	Belison			
Belison Rural Health Unit	Belison			
Residential	Paradise	Low	Low	Low
Gonzaga Municipal Health Office	Smart			
Medical Institution	Smart	Low	Low	Low

San Jose				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
San Fernando Barangay Health Center	San Fernan-do			
San Fernando Day Care Center	San Fernan-do			
San Pedro Rural Health Unit	San Pedro	Low	Medium	Medium

San Remigio				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
Barangbang Health Center	Barangbang	Low	Medium	Medium

Sibalom				
Building Name	Barangay	Rainfall Scenario		
		5-year	25-year	100-year
Bongbongan II Health Center	Bongbon-gan II			
Alangan Health Center	Cubay-Na-pultan	Medium	High	High
District IV Health Center	Cubay-Ser-mon			
Ramon Masa Senior Memorial District Hospital	District III	Low	Low	Low
Rural Health Unit	District III		Low	Low
Barangay Igbonglo Health Center	Egaña			
Pantao Barangay Health Center	Egaña			
Villar Health Center	Esperanza II		Medium	Medium
Birthing Clinic	Esperanza III		Medium	Medium
Barangay Iglanot Health Center and Birth-ing Clinic	Iglanot			
Lacaraon Day Care Center	Lacaron			
Lacaron Health Center	Lacaron			
Barangay Mabini Health Center	Mabini			